

Exploring Electrosurgical Smoke Control Practices among New Zealand

Operating Theatre Personnel:

A Qualitative Study

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Abstract

Background: Inconsistent electrosurgical smoke evacuation is a concern among operating theatre personnel at a large District Health Board in New Zealand. Despite a growing body of evidence on the hazardous nature of electrosurgical smoke and its harmful effects on operating theatre patients and personnel, there is a paucity of research on electrosurgical smoke control practices among diverse operating theatre personnel. Currently, there are no government regulations that mandate electrosurgical smoke evacuation in New Zealand.

Objectives: This study explores and describes electrosurgical smoke control practices at a large District Health Board in New Zealand. It aims to gain a better understanding of diverse operating theatre personnel's attitudes towards electrosurgical smoke, and how it influences their compliance with electrosurgical smoke evacuation. The goal is to apply the knowledge gained to develop key recommendations to mitigate operating theatre patients' and personnel's risk of exposure to hazardous electrosurgical smoke, promoting a healthy surgical smoke-free operating theatre environment for patients and personnel.

Methods: An exploratory-descriptive qualitative methodological framework guides this study with individual semi-structured virtual interviews for data collection. A purposeful sample of six diverse operating theatre personnel, comprising of two surgeons, two nurses, an anaesthetist and an anaesthetic technician were voluntarily recruited from a large District Health Board in New Zealand. The researcher conducted the interviews which were audio-recorded. Notes were taken during the interviews. Furthermore, interviews were transcribed verbatim and analysed utilising reflexive thematic data analysis approach.

Findings: Research findings suggest that compliance with electrosurgical smoke evacuation is an important yet complex issue. Three major themes emerged from the data analysis. Firstly, education on electrosurgical smoke and electrosurgical smoke evacuation across disciplines. Secondly, attitudes and perceptions about electrosurgical smoke and electrosurgical smoke evacuation. Lastly, barriers and facilitators to electrosurgical smoke evacuation. This study highlights that effective electrosurgical smoke control methods are not being consistently

practiced by diverse operating theatre personnel at the District Health Board with an inherent risk of exposure to hazardous electrosurgical smoke for operating theatre patients and personnel. Findings identified that although electrosurgical smoke evacuation is routine in open surgical procedures, it is poorly upheld in laparoscopies. The data analysis indicates that certain aspects of the District Health Board policy on electrosurgical smoke evacuation are ambiguous and require updating.

Conclusion: This study revealed that the education of operating theatre personnel on electrosurgical smoke and electrosurgical smoke evacuation across disciplines with strong leadership support, is the key to influence positive attitude towards electrosurgical smoke evacuation. This knowledge is vital to overcome barriers for effective and consistent compliance with electrosurgical smoke evacuation to mitigate the effects of hazardous electrosurgical smoke on operating theatre patients and personnel.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature

Date: 17th May 2022

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Ethics approval

This study was granted ethical approval by the Auckland University of Technology Ethics Committee, reference number 21/276 on 20th August 2021 (Appendix A) and an amendment approval to the data collection protocol (online interviews) on 14th September 2021 (Appendix B).

Table of abbreviations

Abbreviation	Term
AORN	Association of periOperative Registered Nurses
AUTEC	Auckland University of Technology Ethics Committee
COVID-19	Coronavirus Disease
DHB	District Health Board
EQD	Exploratory-Descriptive Qualitative
ESC	Elective Surgical Centre
ESS	Electrosurgical Smoke
ESSE	Electrosurgical Smoke Evacuation
HEPA	High-Efficiency Particulate Air
HPV	Human papillomavirus
JHEBP	Johns Hopkins Evidence-Based Practice
LEV	Local Exhaust Ventilation
MOH	Ministry of Health
NSH	North Shore Hospital
NZ	New Zealand
NZNO	New Zealand Nurses Organisation
OSHA	Occupational Safety and Health Administration
OT	Operating Theatre
PDSA	Plan-Do-Study-Act
PICO	Population, Intervention, Comparison, Outcome
PNC	Perioperative Nurses College
PPE	Personal Protective Equipment
QI	Quality Improvement
SARS-CoV-2	COVID-19 Virus
TA	Thematic Analysis
ULPA	Ultra-Low Particulate Air

Chapter 1: Introduction

1.1 Introduction

Inconsistent electrosurgical smoke evacuation (ESSE) is a health hazard to operating theatre (OT) patients and personnel (Bree et al., 2017; York & Autry, 2018). Yet, some operating theatres at a large District Health Board (DHB) in New Zealand (NZ) are inconsistent with ESSE, despite an existing DHB policy that mandates ESSE for all electrosurgical smoke (ESS) generating procedures (Waitematā DHB, 2017). A growing body of evidence exists that ESS, also known as surgical smoke/plume contains toxic chemicals and by-products of combustion (Hsu et al., 2022; Tan & Russell, 2019). Aerosolised particles of blood, tissue, viruses, bacteria, carcinogens, mutagens, and metastatic cells have been found in ESS (Bree et al., 2017; Ogg, 2021). Respiratory problems are more common in OT nurses compared to the general population (Ball, 2012). Furthermore, there are concerns about coronavirus disease (COVID-19) transmission risk through ESS to OT personnel from COVID-19 positive patients (Mowbray et al., 2020). Moreover, Marsh (2012) demonstrates that ineffective ESSE in laparoscopies increase the patient's risk of carbon monoxide toxicity and a systematic review by Mowbray et al. (2013) identified port-site metastasis in patients undergoing tumour resection laparoscopies. Despite the hazardous nature of ESS and its potential harmful effects on OT patients and personnel (Stanley, 2019; Zakka et al., 2020), barriers exist to establish consistent ESSE in NZ operating theatres (Matthews, 2016).

Although there is an abundance of research on the composition and harmful effects of ESS, there is a dearth of qualitative research on ESS control practices among diverse OT personnel such as nurses, surgeons, anaesthetists, and anaesthetic technicians, which represents an important research gap (Ball & Gilder, 2022; Bree et al., 2017; Stanley, 2019). Additionally, most of the research on ESS and ESSE was carried out overseas, with an apparent gap in the NZ-based research on this topic.

1.2 Researcher's position

As an Associate Clinical Charge Nurse, OT Coordinator for North Shore Hospital (NSH) at Waitemata DHB, with 28 years of experience in NZ and overseas, I have encountered ESS in various surgical procedures in both private and public hospitals. A key focus of my role is to provide clinical leadership, take actions to identify and resolve any problems that put the OT patient and personnel at risk. I am concerned that if hazardous ESS is not consistently and effectively evacuated at source, it is a health and safety risk to OT patients and personnel (Croke, 2020; Dobbie et al., 2017; Ogg, 2021).

My passion for a healthier smoke-free OT environment has led me to be actively involved in conducting teaching sessions on ESS and ESSE over the past few years. I have audited ESSE practice at the hospital; developed, published, and implemented an evidence-based ESSE policy at the DHB in 2017. During my post-graduate studies, I had the opportunity to focus on aspects of ESS and ESSE. As toxic ESS is hazardous to OT patients and personnel (Stanley, 2019; Vortman., 2021), it is imperative to utilise ESSE consistently and effectively for laparoscopic and open procedures (Okoshi et al., 2015; York & Autry, 2018). This prompted further conversation and discussion with OT nurses and management, from which emerged the idea of this practice project. This project aligns with my professional trajectory of improving knowledge and skills, with a keen interest in quality and patient safety; and the Waitemata DHB goal for a smoke-free OT environment (Waitemata DHB, n.d.).

Tokuda et al. (2020) highlight the usefulness of ESSE to prevent the cumulative exposure of hazardous ESS on OT personnel. Although there is currently inadequate evidence to link ESS to increased morbidity and mortality among OT personnel, we cannot support or refute the hazardous short and long-term consequences of ESS on OT personnel (Bree et al., 2017). My commitment and determination to undertake this practice project increased with the recent loss of two nurses to lung disease in our OT department. I strongly believe we have a duty of care to our patients, towards each other as OT personnel and to the organisation to eliminate, isolate and minimise hazards such as ESS in the OT. Hence, it is vital to ensure OT personnel consistently and effectively evacuate ESS which laid the foundation for this practice project.

1.3 Johns Hopkins Evidence-Based Practice (JHEBP) model

This project plan of exploring ESS control practices among OT personnel is based on the JHEBP model for nurses and healthcare practitioners, composed of three interrelated components: inquiry, practice, and learning in the context of interprofessional collaborative practice in the OT (Dang et al., 2021, p. 43). Additionally, the JHEBP decision-tree justifies the need for the research project due to paucity of research on compliance with ESSE among diverse OT personnel. In this project, the JHEBP model, which is an inquiry-based learning framework utilises the quality improvement (QI) PICO (acronym for population, intervention, comparison, outcome) tool to identify the problem statement, formulate the practice questions, and develop a search strategy for appropriate literature review with keywords, seeking concrete evidence (Dang et al., 2021, p. 57). The study utilises an exploratory-descriptive qualitative (EDQ) methodological approach, seeking to reveal themes from which discussion and recommendations can be drawn (Hunter et al., 2019).

1.4 Research Objective

This research aims to gain a better understanding of the diverse OT personnel's attitudes towards ESS, and the perceived facilitators and barriers associated with their consistent and effective ESSE. The purpose is to mitigate OT patients' and personnel's health risk of exposure to hazardous ESS by identifying key recommendations and endeavour to be fully compliant with the DHB policy on ESSE (Waitematā DHB, 2017) as well as best practice guidelines on surgical smoke safety (Ogg, 2021). This project will improve the researcher's professional knowledge and skills, enabling the researcher to attain the qualification of Master of Health Practice. The main objective is to establish a safe and healthy smoke-free OT environment for patients and personnel at Waitematā DHB, in line with the hospital's smoke-free policy (Waitematā DHB, n.d.) as well as the NZ Government's goal of a smoke-free nation by 2025 (Ministry of Health [MOH], 2021). Although the NZ Government's smoke-free goal by 2025 is related to tobacco smoking, ESS contains chemical compounds that are similar to tobacco smoke and one gram of electrosurgically

dissected tissue produced ESS that has the mutagenic potency of smoking six unfiltered cigarettes (Tomita et al., 1981).

1.5 Structure of the dissertation

This dissertation is organised into five chapters. Each chapter provides a specific phase of the practice project which is outlined as follows:

Chapter one constitutes the overall introduction to the practice project. The researcher's position is discussed. The underlying problem of inconsistent ESSE clearly articulates the identified research objective for the project plan of exploring ESS control practices among OT personnel, based on the JHEBP model, utilising the EDQ methodological approach and the significance of the study to current OT nursing practice and the wider community.

Chapter two provides background information to support the practice project. It focuses on the literature of compliance with ESSE in the OT and utilises surrounding literature on ESS as an intellectual anchor following the EDQ methodology. However, very few studies have addressed this complex issue of compliance with ESSE. This gap in literature justifies the use of EDQ research. Hence, the literature review is brief and succinct compared to other qualitative studies with the greatest energy devoted to the literature on compliance with ESS control practices.

Chapter three presents an overview of the methodology and describes how the EDQ research has been conducted, the participant's recruitment process, the data collection method, findings with data analysis utilising the thematic analysis (TA) process. It states the ethical consideration and rigour of the EDQ study.

Chapter four presents the results with main themes and quotes the raw data.

Chapter five discusses the three major themes that emerge through data analysis, by comparing them with appropriate literature. It presents the researcher's reflection and evaluates the significance of the EDQ research in the perioperative nursing discipline. It discusses the strengths and limitations of the study, the implications for practice and the wider perioperative

community. It makes recommendations in relation to the research questions and the need for further research on the topic.

1.6 Summary

Inconsistent ESSE creates an unsafe and unhealthy OT environment for patients and personnel. Research has proven the hazardous nature of ESS and its potential consequences on OT patients and personnel. Despite the abundance of research on ESS, there is a paucity of research on compliance with ESSE among diverse OT personnel. The research objective highlights significance of the research, to create a safe and healthy, smoke-free OT environment for patients and personnel. To achieve these goals, the foundation of this practice project will be a comprehensive literature review that focuses on compliance with ESSE.

Chapter 2: Literature Review

2.1 Introduction

This chapter sets the scene and provides the background for the research. It describes, analyses, and synthesises the literature on ESS and ESSE, identifying gaps in knowledge related to compliance with ESSE to justify the study. CINAHL, SCOPUS, PubMed and Google Scholar databases were accessed for English, peer-reviewed, academic journal articles between the years 2010 to 2022. This included original research studies, systematic literature reviews, international guidelines on ESSE, documents from web sites, and the researcher's hospital policy. Studies that did not discuss ESSE compliance were excluded.

Keywords: electrosurgical smoke, surgical smoke/plume, smoke evacuation, diathermy smoke and compliance.

Although the literature search pointed to overwhelming evidence of the hazardous nature of ESS, the full chemical and biological composition of ESS cannot yet be confirmed (Stanley, 2019). Due to the hazardous nature of ESS, best practice guidelines as well as research suggests, it is imperative that OT personnel implement effective ESSE and precautionary measures for all ESS generating procedures (Lindsey et al., 2015; Ogg, 2021; Tokuda et al., 2020). Despite an abundance of research on ESS, there is a dearth of research on compliance with ESSE among diverse OT personnel such as surgeons, nurses, anaesthetists, and anaesthetic technicians, which represents an important research gap (Bree et al., 2017; Stanley, 2019). In the last few years there have been very few studies published on ESSE in nursing literature (Vortman et al., 2021). There is an apparent gap in NZ-based research on this topic, as most research on ESS control practices has only been carried out overseas.

According to Hunter et al. (2019), it is vital to identify this knowledge gap in the literature to justify utilisation of EDQ research methodology over other methodologies to explore ESS control practices among OT personnel. Hunter et al. (2019) argue that although literature on its own can inform practice, it should be short and focused on the topic to prevent distraction with marginal studies. However, in this literature review the greatest energy is dedicated to manuscripts

focused on compliance with ESSE, utilising other marginal studies on ESS and ESSE as an intellectual anchorage to support and contradict the study (Hunter et al., 2019).

2.2 The International Best Practice Guidelines on ESSE

The Association of periOperative Registered Nurses (AORN) guidelines for ESSE (Ogg, 2021) suggest that a surgical smoke-free OT environment should be provided by the healthcare organisation utilising hierarchy of controls and eliminate the hazard if possible. Hierarchy of controls include engineering, work practice, and administrative controls as well as the use of personal protective equipment (PPE). An ESSE or in-line filter should be utilised by OT personnel to evacuate all surgical smoke in combination with OT ventilation with a minimum of 20 air exchanges. All OT personnel should receive initial and ongoing education with competency verification on ESS safety. ESSE policies should be developed, reviewed and easily accessible. OT personnel should participate in QI activities, to identify and improve compliance with ESSE (Ogg, 2021).

2.3 The DHB Policy

The DHB policy on ESSE (Waitematā DHB, 2017) was developed following a series of audits that measured staff compliance with ESSE recommendations, based on the AORN guidelines (Rodrigues, 2018). The policy mandates effective intraoperative ESSE for all electrosurgical procedures that generate ESS and states that all surgical smoke should be evacuated with a smoke evacuator/in-line filter by the operating team. OT personnel who use ESSE should be trained and competent in the use of ESSE. The OT nurse should assess each surgical procedure that could potentially generate ESS and implement an appropriate ESSE method. A smoke evacuator with a 0.1 micron filter such as an ultra-low particulate air (ULPA) or high-efficiency particulate air (HEPA) filter which is 99.999% efficacious should be used when ESS is anticipated. Additionally, PPE such as a 0.1micron filter mask, gloves and eye shields should be worn depending on the type of surgical procedure. Furthermore, the capture device/suction wand should be placed no greater than 5.08 cms (two inches) from the ESS source (Waitematā DHB, 2017).

2.4 Background

Worldwide, ESS is generated regularly during electrosurgical tissue dissection and haemostasis in the OT. Inconsistent ESSE is a concern among OT personnel in a large DHB in NZ, despite an existing DHB policy on ESSE (Waitematā DHB, 2017) and a growing body of evidence on the toxic and harmful effects of ESS on OT patients and personnel (Ball & Gilder, 2022; Bree et al., 2017; Zakka et al., 2020). Although in the mid-1980s Wyman Stackhouse introduced the first smoke evacuator for evacuating laser smoke, subsequently it has been utilised for ESSE (Schultz, 2014). Electrosurgical pencils generating hazardous ESS have been used for tissue dissection in the OT at the DHB for many years. Subsequently, ESSE has been introduced in the last decade at the DHB to ensure a healthy smoke-free OT environment for patients and personnel (Ogg, 2021). ESSE pencils extract ESS at the point of use and transport it to a fluid trap connected to a triple filter of the smoke evacuator machine for filtration during open surgical procedures, and an in-line smoke filter for laparoscopies to filter ESS, remove odour, particulates, and potentially hazardous by-products of ESS (Ogg, 2021; York & Autry, 2018). The DHB policy on ESSE mandates effective intraoperative ESSE utilising local exhaust ventilation (LEV) to extract smoke directly at source from the surgical field (Waitematā DHB, 2017). Currently, all operating theatres at the DHB have ESSE equipment. Yet, the noxious ESS can be smelt in the OT corridor at times. This indicates that OT personnel appear to inconsistently comply with effective ESSE, despite availability of resources. This concurs with literature that suggests OT personnel inconsistently comply with ESSE recommendations (Holmes, 2016; Steege et al., 2016).

2.5 Definition of ESS

ESS is defined as visible smoke of aerosolised by-products of combustion, produced during electrosurgery, a phenomenon unique to procedural areas such as the OT which creates an occupational hazard (Vortman et al., 2021). ESS is produced when heat generated during electrosurgical tissue dissection causes intracellular fluid to boil to 100° C (212° F) or higher,

rupturing the cell membrane, converting cellular fluid to steam, and expelling cellular contents into the environment (Ogg, 2021; Tan & Russell, 2019).

2.6 Composition of ESS

Seminal research by Dr. Tomita and colleagues identified that one gram of electro Surgically dissected tissue produced ESS equal to the mutagenic potency of smoking six unfiltered cigarettes (Tomita et al., 1981). Additionally, Hill et al. (2012) proved that on a daily average ESS produced in their plastic surgery theatre was equivalent to 27-30 cigarettes. Tan and Russel (2019) identified that ESS contains more than 80 different toxic chemicals and by-products of combustion. Specifically, research has proven that ESS contains formaldehyde, hydrogen, cyanide, benzene, bioaerosol, blood fragments, cellular material, malignant cells, and infectious viruses (Bree et al., 2017; Schultz, 2015; Zakka et al., 2020). A recent study identified 140 organic compounds in surgical smoke during cholecystectomy (Hsu et al., 2022). A further issue related to the recent COVID-19 pandemic is the concern about the virus transmission risk through ESS to OT personnel (Mowbray et al., 2020). It could be argued that despite growing evidence of the toxic and hazardous nature of ESS, OT personnel fail to comply with ESSE (Bree et al., 2017; Stanley, 2019; York & Autry, 2018). Although international best practice guidelines on ESSE exist (Ogg, 2021), exposure to hazardous ESS is an inherent risk among OT personnel and patients in NZ (Matthews, 2016).

2.7 Exposure of OT Patients and Personnel to Hazards of ESS

Regulatory bodies such as the Australian College of Operating Room Nurses and the AORN have been strong supporters of ESSE (Rodrigues, 2018). ESS was acknowledged as a health hazard by WorkSafe NZ by awarding Mercy Hospital in Dunedin a national occupational safety award in 2014 for improving the OT environment by getting rid of hazardous ESS (Goodwin, 2014). Matthews (2016) argues that it should be documented in the OT hazard register when staff are exposed to ESS due to ineffective or lack of appropriate ESSE. To strengthen this argument, the Perioperative Nurses College (PNC) of the NZ Nurses Organisation (NZNO) is a member of the International Council on Surgical Plume, where the council provides resources to

promote a safe, healthy, smoke-free OT environment for patients and personnel (Perioperative Nurses College of NZNO, 2015).

Thousands of OT personnel worldwide are exposed to ESS every year (Tan & Russell, 2019). In NZ approximately 600 to 900 employees in the general workforce suffer premature death due to various occupational diseases and many more are affected annually by occupational hazards imposing a significant cost to the NZ economy; an estimated \$ 3.5 billion is spent on work-related deaths or injuries annually in NZ (New Zealand Government, 2018). Although the 'NZ Health and Safety at Work Strategy' states that work-related respiratory diseases and cancers caused by airborne exposures are preventable by utilising appropriate control measures, data is lacking on work-related carcinogens, airborne exposures, or the workplace control measures (New Zealand Government, 2018). Approximately 19,786 surgical patients attended the researcher's DHB between July 2018 to March 2019 (MOH, 2019); currently, neither the number of OT personnel exposed to hazardous ESS in the DHB nor in NZ is known. Okoshi et al. (2015) state that the Occupational Safety and Health Administration (OSHA) estimates more than 500,000 healthcare personnel in the United States of America are annually exposed to surgical smoke. Although the NZ MOH began a campaign in 2011 with a goal towards a smoke-free nation by the year 2025 (MOH, 2021); and despite the distinctive offensive odour and toxicity of ESS with mutagenic potency of cigarette smoke (Vortman et al., 2021), this critical need for a healthier smoke-free work environment to benefit both OT patients and personnel has not received much impetus. Specifically, until now there are no NZ government standards that mandate ESSE (McCamish, 2018). The exposure to hazardous ESS also stands in stark contrast to the large DHB facility that claims to be a "smoke-free" environment (Waitematā DHB, n.d.).

A systematic review by Okoshi et al. (2015) evidenced the potential health risks of ESS to OT patients and personnel. This was further confirmed by several studies that the hazardous nature of ESS can potentially cause dizziness, headache, irritation of eyes, nose and throat, dermatitis, acute and chronic pulmonary conditions, blood disorders such as anaemia and leukaemia, viral disease transmissions such as human papillomavirus (HPV) and infectious disease (Ball & Gilder, 2022; Ilce et al., 2017; Zakka et al., 2020). In fact, ESS is proven to be

potentially mutagenic and carcinogenic (Croke, 2020; Vortman et al., 2021). Lindsey et al. (2015) concur that toxic ESS is a biohazard and could be infectious depending on the type of tissue dissected and the frequency setting of the electrosurgical unit.

Specifically, ESS not only poses a significant health risk to OT personnel but is also a patient safety risk (Ogg, 2021). Schultz (2015) revealed that viable bacteria aerosolised in ESS could contaminate surgical wounds and potentially lead to surgical site infections, increasing patients' cost of hospitalisation. Moreover, in laparoscopies Marsh (2012) demonstrated that ineffective ESSE increases the patient's risk of carbon monoxide toxicity; and a systematic review by Mowbray et al. (2013) identified port-site metastasis in tumour resection laparoscopies. Hepatitis B virus which can survive for up to seven days in dry blood was identified in surgical smoke during laparoscopic and robotic surgeries (Kwak et al., 2016). Hence, it is imperative to utilise ESSE consistently and effectively during both laparoscopic and open procedures, minimising potential health hazards to OT patients and personnel (Okoshi et al., 2015).

More importantly, due to the current COVID-19 pandemic, the evidence warrants cautionary measures to prevent exposure to ESS (Mowbray et al., 2020). A systematic review and meta-analyses on laparoscopies during COVID-19 pandemic revealed that COVID-19 virus (SARS-CoV-2) was detected in abdominal tissue and body fluids, but the evidence was inadequate that SARS-CoV-2 was aerosolised and transmitted through ESS (Cheruiyot et al., 2021). Conversely, Bogani et al. (2021) warn that in asymptomatic COVID-19 positive patients, SARS-CoV-2 particles might be transmitted through ESS and aerosolised peritoneal fluid in laparoscopies. However, barriers exist to establishing consistent ESSE policy and practice in NZ operating theatres (Matthews, 2016), although research has conclusively demonstrated that the only solution to managing hazardous ESS is effective and consistent ESSE (Dobbie et al., 2017; Zakka et al., 2020).

2.8 OT Personnel's Compliance with ESSE

The primary protection against hazardous ESS is diligent utilisation of effective ESSE with LEV as well as OT ventilation with a minimum of 20 air exchanges (Ogg, 2021). More

importantly, the aerodynamic particle size of ESS is less than 0.1 micron, and surgical masks are ineffective as they filter air particles larger than five microns providing no protection from ESS (Ilce et al., 2017; Zakka et al., 2020). Specifically, with infectious cases secondary protection with appropriate PPE utilising respiratory protection such as fit-tested N95 mask should be used against any residual smoke in the OT (Croke, 2020; Ogg, 2021). Despite the evidence of potential health and safety risks of ESS on OT patients and personnel, ESS control measures are inconsistent worldwide including NZ (Giersbergen et al., 2019; McCamish, 2018; Tan & Russell, 2019). Nevertheless, ESSE is currently gaining momentum internationally to promote a safe and healthy OT environment for patients and personnel (Vortman et al., 2021).

1) ESSE compliance in the International Context

Worldwide compliance with ESSE differs, as barriers still exist in implementing consistent and effective ESSE, despite availability of ESSE devices and resources to implement ESSE policy (Giersbergen., 2019; Holmes, 2016). However, promoting a surgical smoke-free OT environment is gaining global momentum (Vortman et al., 2021) with currently five American states passing legislation (AORN, 2021), as well as some Australian states such as New South Wales (New South Wales Government, 2015), and Victoria have implemented legislation to manage ESS exposure in healthcare (WorkSafe Victoria, 2021). Mandatory surgical smoke evacuation policies have been adopted by many countries and jurisdictions such as Denmark, Sweden, Norway, and several states in the United States of America (Watters et al., 2022), with other countries following suit due to the current COVID-19 pandemic (Vortman et al., 2021).

In the United States of America, Ball (2012) identified the key indicators for compliance with ESSE based on Rogers' Diffusion of Innovations Theory (Rogers, 2003) by conducting a web-based survey of 777 nurse members of AORN. The study demonstrates that nurses' innovativeness, perceptions of the innovation attributes and organisational characteristics were three independent constructs that affected compliance with ESSE and importantly the most strongly linked construct was the individual innovativeness characteristic. Ball (2012) recommends the individual nurse to be the focal point of education to change behaviours and practice, to increase compliance with ESSE. Additionally, a succinct and easy to follow ESSE

policy with organisational characteristics such as a large multiple-specialty tertiary hospital, where nurses and surgeons practice in collaboration, were more apt to comply with ESSE. The study pointed out that strong leadership support as a key indicator to compliance with ESSE, where leaders ensure availability of proper ESSE equipment and policy mandate. A limitation of the study was that it included only nurse participants. The researcher recommends further research to pursue the journey of compliance with ESSE (Ball, 2012).

Giersbergen et al. (2019) investigated ESS exposure symptoms and preventative measures in Turkish operating theatres by surveying 672 OT nurses who attended a Turkish Surgical and OT Nurses Association's scientific meeting. Researchers identified that only 8.2% of nurses utilised ESSE despite 73.2% of nurses having experienced ill-effects of exposure to ESS. Inadequate preventative measures were responsible for adverse symptoms among OT nurses caused by ESS. Surgical masks were utilised by 65% of nurses for self-protection from ESS, although surgical masks do not provide protection from ESS (Okoshi et al., 2015). Most surgical masks filter particles larger than five microns and are ineffective for ESS where the particle size can be smaller than 0.1 micron (Rodrigues, 2018). The barriers to ESSE identified by Giersbergen et al. (2019) were lack of knowledge with misconception that standard surgical masks provide protection from ESS, surgeon's concern that the ESSE device may decrease their eye-hand coordination, excessive noise, and the high cost of an ESSE device. Researchers argue that healthcare managers should assess the potential dangers of ESS, educate staff, and encourage ESSE. Although the study provides a snapshot of surgical smoke control practices in Turkey, the researchers indicate much work needs to be done regarding ESSE (Giersbergen et al., 2019).

Holmes (2016) literature review identified the factors influencing compliance with ESSE. Positive factors identified were strong leadership support and OT personnel's education on hazardous nature of ESS, and ESSE. The negative factors were mainly dismissive attitudes towards the risks of ESS, noisy ESSE equipment with bulky design and surgeons' resistance to utilise ESSE. Study limitations were that majority of the studies were cross-sectional surveys with small sample size, conducted either in the United Kingdom or United States of America that mainly focused on OT nurses' perceptions. The researcher recommends future research should

include surgeons with utilisation of other research methods besides surveys to determine compliance with ESSE (Holmes, 2016).

Okoshi et al. (2015) literature review on hazards of surgical smoke and ESS control practices demonstrate concerns about potential risks of ESS, and that surgeons found LEV noisy, bulky and awkward, which influenced their resistance to comply with ESSE. Researchers point out that although the Japanese Association for

Operative Medicine recognises the hazardous nature of ESS and recommends utilisation of ESSE, there are no regulations concerning ESSE, with most OT personnel unaware of ESS hazards. Researchers suggest, surgeons should assess potential dangers of ESS, educate OT personnel, and encourage ESSE (Okoshi et al., 2015).

Tan and Russell (2019) identified the hazards of surgical smoke and concerns around lack of ESSE. Researchers argue that ESS is a controllable occupational hazard and regular exposure to ESS poses a significant health risk. According to Mowbray et al. (2013), the cumulative effect of daily exposure to hazardous ESS is harmful to OT personnel. Hence it is imperative to effectively and consistently evacuate ESS to improve the health of OT patients and personnel, minimising health costs (Tan & Russell, 2019). Barriers to ESSE identified were OT personnel's complacent attitude, unavailability of ESS evacuators and sterile supplies, surgeon's refusal to use ESSE, time constraints, lack of ESSE protocol, noise and high costs of ESSE equipment. Matthews (2016) argues that cost of equipment or supplies should not be an excuse to ensure health and safety of employees as ESS is hazardous. Tan and Russell (2019) suggest, it is possible to overcome the barriers with an easy to follow policy and regular staff education on ESS and effective ESSE.

Schultz (2014) points out that compliance with ESSE requires a more robust approach than a mere discussion of the harmful effects of ESS. In the analysis of surgical smoke capture and evacuation, the researcher identifies the barriers to compliance with ESSE. Barriers identified were dismissive attitude towards ESS and a lack of enthusiasm for ESSE from OT personnel and

administrators, surgeon's refusal, distraction caused by noisy smoke evacuator, surgeon's anxiety and concern to alter their routine, and unavailability of device. Schultz (2014) recommends to create greater awareness through education on hazardous ESS, as it contains the same contaminants as blood or other potentially infectious material in the form of smoke which could potentially transmit viruses or bacteria when inhaled. The researcher warns that ESS could potentially be a source of wound contamination. Therefore, the ESS evacuator should be of high quality, easy to use, cost-effective and should operate quietly without distraction during the procedure for effective ESSE (Schultz, 2014).

2) ESSE Compliance in the NZ Context

A previous QI project on ESSE conducted in the researcher's government-funded public hospital in NZ identified the majority of nurses were non-compliant with ESSE recommendations (Rodrigues, 2018). The study involved a prospective observational clinical audit, a staff survey and a retrospective documentation audit on the use of diathermy and ESSE in the OT. A total of 68% of OT nurses responded to the survey of which a majority, 53% of respondents were non-compliant with ESSE. A further 16% were unaware of the hazards of ESS and 44% did not receive education on ESSE. The clinical audit evidenced 41% did not use ESSE with 27% commenting, "it was due to surgeon's preference" (Rodrigues, 2018). Steege et al. (2016) assert that the decision about utilising ESSE should not be made at the discretion of an individual practitioner when the whole team and the patient is exposed to hazardous ESS. The QI project revealed staff education and policy implementation on ESSE were two key recommendations for compliance with ESSE. Education sessions on ESS and ESSE were conducted for OT nurses following the study, with development, publication and implementation of a succinct, clear and easy to follow ESSE policy for the DHB with the hope of increasing compliance (Rodrigues, 2018). A limitation of the study was its small sample size involving only nurses. The study recommended to extend the education to the physicians to garner support for effective ESSE, with regular audits to monitor clinical practice, evaluate outcome, and initiate corrective action for continuous QI (Rodrigues, 2018). Similarly, an OT survey of 40 nurses at another public hospital in NZ, identified that ESSE policy and staff education is the key to consistent ESSE (Osman, 2016).

Scott et al. (2014) succeeded in achieving full compliance with ESSE by conducting a QI project at one of the private surgical hospitals in NZ. Scott et al. (2014) persevered to overcome barriers to implement ESSE with management support, education, training, and competency verification of OT personnel including surgeons to ensure their hospital was the first private hospital to be free of ESS in NZ. Scott et al. (2014) suggest, raising awareness among OT personnel about ESS and ESSE is the key to smoke-free OT environment with availability of ESSE equipment, supplies, PPE and implementation of ESSE policy. Audit results comparing compliance with ESSE before and after implementation of the QI project confirmed improvement in compliance with ESSE. Scott et al. (2014) recommend mandatory ongoing education and training of OT personnel to increase compliance and further research on ESSE.

Moreover, the PNC of NZ conducted a large web-based survey of 686 perioperative nurses during registration/renewal of PNC membership to explore nurses' knowledge and understanding of surgical smoke and investigate their workplace practices (Manchester, 2018; McCamish, 2018). However, perioperative nurses included not only OT nurses, but also pre-operative, post-operative and radiology nurses who may have not encountered surgical smoke, and to some extent skewing the survey results (Manchester, 2018). Survey revealed that although 57% of respondents believed that surgical smoke inhalation was harmful, 79% of nurses were exposed to surgical smoke and 12% indicated their hospital did not have a smoke evacuation policy (Manchester, 2018; McCamish, 2018). The survey identified that surgeons' refusal to use ESSE and complacent staff attitude were the main barriers to creating a smoke-free OT environment in addition to noisy equipment, lack of consumables and equipment not readily available (Manchester, 2018; McCamish, 2018). The NZNO and PNC endorse the elimination of surgical smoke in NZ (Manchester, 2018); the PNC is a member of the International Council of Surgical Plume Incorporated, that advocates for a safe, smoke-free OT environment for patients and staff (McCamish, 2018). To address ESSE on a national level, the importance of surgical smoke risks had been submitted to WorkSafe NZ, as not all NZ hospitals have policies to guide OT personnel on ESSE (McCamish, 2018). Although the NZ workplace Health and Safety strategy focuses on safe working conditions, currently there are no government mandates on

ESSE. Hence, it is imperative and the duty of all OT personnel to push for the adoption of mandatory ESSE guidelines, to standardise ESSE requirements for a healthy smoke-free environment for the safety of OT patients and personnel in NZ.

2.9 Barriers and Facilitators to Compliance with ESSE

The literature review indicates that ESS control practices among OT personnel was not a priority in the majority of national and international OT settings with numerous barriers. The lack of knowledge and education on hazards of ESS and ESSE is a significant barrier to compliance with ESSE (Ball, 2012; Holmes, 2016; Okoshi et al., 2015; Rodrigues, 2018; Stanley, 2019). Surgeons' preference or refusal to use ESSE was one of the greatest barriers (McCamish, 2018), in addition to equipment problems such as unavailability, noise, bulkiness and high cost of ESSE equipment (Okoshi et al., 2015). Ball (2012) suggests that nurses should take the initiative to educate OT personnel on hazardous ESS and effective ESSE. Conversely, Okoshi et al. (2015) insist that surgeons should assess the potential hazards of ESS and educate OT personnel to minimise potential health hazard to OT patients and personnel. Ball (2012) argues that when nurses receive education on ESS, the compliance with ESSE increases due to positive relationships with surgeons. However, strong organisational support, a succinct and easy to follow policy, and raising awareness among OT personnel on the hazards of ESS were identified as facilitators of ESSE (Scott et al., 2014; Tan & Russell, 2019).

Importantly, the need for more research on OT personnel's attitude towards ESS and their compliance with ESSE is a continuing theme throughout national and international literature (Holmes, 2016; McCamish, 2018; Tan & Russell, 2019). Furthermore, research is lacking on OT personnel's understanding of ESS hazards and effective management of ESSE (Stanley, 2019; Vortman et al., 2021). In fact, very few studies on ESS have been published in the last five years, which represents an opportunity for OT nurses to research and contribute to the body of evidence and advocate for effective ESS control practices (Vortman et al., 2021). Hence, it is imperative to research utilising other methods besides surveys to determine possible causes of inconsistency in compliance with ESSE (Holmes, 2016). Moreover, this literature review indicates that most of the studies include nurses, hence the need for a qualitative study to provide the perspectives of

diverse OT personnel such as surgeons, nurses, anaesthetists and anaesthetic technicians regarding their experience and attitude towards ESS and their compliance with ESSE.

2.10 Summary

The literature review demonstrates that despite the risks of exposure to hazardous ESS, inconsistent ESSE amongst OT personnel continues to be an occupational hazard internationally and nationally. Evidence indicates it is imperative to implement effective and consistent ESSE to mitigate potential harmful effects of ESS on OT patients and personnel. Research-based ESSE recommendations have been publicised by international regulatory organisations such as AORN, and although WorkSafe NZ has been a strong proponent of ESSE, there is no existing national guideline nor legislation on ESSE in NZ. Despite the DHB policy on ESSE, compliance with ESSE appears to be inconsistent among OT personnel with risks of potential health hazard to OT patients and personnel. Although there is a plethora of research on ESS and its potential harmful effects on OT patients and personnel (York & Autry, 2018, Zakka et al., 2020), there is a paucity of research on diverse OT personnel's compliance with ESSE (Bree et al., 2017; Holmes, 2016; Stanley, 2019). Additionally, there is an apparent gap in the NZ-based research on this topic as most of the research on ESS control practices among OT personnel has only been carried out overseas. It is vital to identify this knowledge gap in the context of EDQ research, justifying its use over other methodologies to explore ESS control practices among diverse OT personnel in NZ. The EDQ research process will be explained in the next chapter.

Chapter 3: Methodology

3.1 Introduction

Methodology is the plan of action that links the choice and use of methods to gather and analyse data relevant to the research question and the desired outcomes (Crotty, 2020). This chapter presents an overview of the methodology, validating the use of a qualitative approach with an EDQ research design developed by Hunter et al (2019) to conduct this practice project. This EDQ study that explores ESS control practices among OT personnel in NZ was conducted from June 2021 to May 2022. The method, data analysis, ethical aspects and rigour of the study are addressed to ensure quality and legitimacy of this EDQ study (Hunter et al., 2019). This practice project was guided by JHEBP model (Dang et al., 2021, p.9). The JHEBP model is a problem-solving approach which utilises QI tools such as PICO (acronym for population, intervention, comparison, and outcome) process to identify the problem statement (Dang et al., 2021, p.9).

3.2 Problem Statement

Inconsistent ESSE is a concern among OT personnel in a large DHB in NZ, with OT patients' and personnel's risk of exposure to hazardous ESS, despite an existing DHB policy on ESSE (Waitematā DHB, 2017) and a growing body of evidence on the toxic and harmful effects of ESS (Stanley, 2019; Zakka et al., 2020).

3.3 Aim

The research aims to gain a better understanding of diverse OT personnel's attitudes towards ESS and how it influences their ESS control practices. The purpose is to reveal themes and develop recommendations to be fully compliant with effective ESSE, adhering to the DHB policy (Waitematā DHB, 2017) and best practice guidelines (Ogg, 2021). The goal is to apply the knowledge gained to mitigate OT personnel's and patients' risk of exposure to hazardous ESS and promote a healthy smoke-free OT environment for patients and personnel (Cutler et al., 2021).

3.4 Research Questions

This practice project seeks to answer the following research questions and explore ESS control practices among diverse OT personnel:

1. What is the attitude of OT personnel towards ESS in a large DHB in NZ?
2. How can OT personnel's views and experiences concerning ESS be perceived as facilitators or barriers to effectively evacuate ESS?
3. Why do some OT personnel find it beneficial while others do not, in implementing ESS control practices in NZ hospitals?

3.5 Significance

Currently, there is a lack of qualitative research on ESS control practices among diverse OT personnel such as nurses, anaesthetists, anaesthetic technicians, and surgeons (Ball & Gilder, 2022; Bree et al., 2017; Holmes, 2016). Therefore, this study seeks to identify gaps in safety procedures concerning effective utilisation of ESSE in the OT. It will inform policy and improve clinical practice, addressing OT patients' and personnel's health risk of exposure to hazardous ESS thereby promoting quality and safety in the OT. Additionally, it will improve knowledge and skills to create a healthy smoke-free OT environment. Furthermore, a healthy smoke-free work environment may attract OT nurses, alleviating the current concern of OT nursing shortages (Elley, 2016). The research findings may be used for academic publications and presentations at perioperative conferences. Moreover, the findings may significantly bridge the gap in knowledge and provide a platform for further research on ESSE.

The following is the stepwise progression of the ESSE research project:

3.6 Consultation

Initial formal consultation with the OT Charge Nurse Manager and Acting Operations Manager encouraged discussion on the ESSE practice project which resulted in obtaining the consent and a letter of support to carry out the project at a large DHB in NZ (Appendix C). Additionally, consultation was undertaken with the DHB Māori advisor (Reid et al., 2017). On

approval of the research proposal by Auckland University of Technology, this study was registered by the Research and Knowledge Centre, Waitematā DHB as a QI project and granted relevant approvals, registration number RM15041 with Waitematā DHB Locality Authorisation dated 25th June 2021 (Appendix D). Further consultation was undertaken with the Auckland University of Technology Ethics Committee (AUTEK) advisor (Reid et al., 2017). An application for an appointment with the Mātauranga Māori Committee was made as soon as the ethics approval was received, in an attempt to have a conversation before commencing the research (Reid et al., 2017). However, they were fully booked and were unable to meet, as the earliest appointment date scheduled was too late for the research. As this study explored ESS control practices among diverse OT personnel at the DHB, it was crucial for the researcher to verify the individual consent on the consent form (Appendix E) with the voluntary participants just before commencing the interview. The participants were allowed time to discuss with their whanau, prior to completing the demographic form (Appendix F) at the time of the interviews (Reid et al., 2017).

3.7 Methodology

This research is underpinned by the researcher's constructivist paradigmatic stance that assumes a relativist ontology, meaning there are multiple realities based on subjective epistemology that is typically seen as an approach to qualitative research (Creswell & Creswell, 2018). According to Creswell (2014), qualitative research explores and understands the meaning that individuals or groups ascribe to a social problem. Qualitative studies allow the researcher to explore human behaviour, feelings, perspectives and in-depth experiences in complex situations; the qualitative researcher's judgment is utilised as an indispensable tool for uncovering the complexities to explore the area of interest (Polit & Beck, 2018). In contrast, other methodological approaches such as the randomised controlled trial which is an experimental quantitative approach, and considered the gold standard of evidence is not able to explore the utilisation of ESS control measures, and barriers to compliance with ESSE among OT personnel (Creswell, 2014). Therefore, the randomised control trial does not align with my research, but a qualitative study explores and describes OT personnel's attitudes towards ESS and their compliance with ESSE (Creswell, 2014). According to Crotty (2020), epistemology informs the theoretical

perspectives which lie behind the methodology, which governs the choice of methods to explore a complex phenomenon such as ESS control practices among diverse OT personnel. A clear alignment between the researcher's philosophy, theory, methodology and methods ensured that this research was undertaken with clarity and integrity (Cutler et al., 2021).

This study is based on an EDQ methodological framework developed by Hunter et al. (2019) that entails both exploring as well as an in-depth description of the phenomenon of interest, such as compliance with ESSE which has limited coverage within the literature. Hence, EDQ approach was deemed appropriate as it has the potential to address the specific research aims where the researcher strives to understand and seeks to reveal themes for full compliance with effective ESSE recommendations (Hunter et al., 2019). Although an abundance of research exists on the composition and harmful effects of ESS (Stanley, 2019; Tan & Russell, 2019; Zakka et al., 2020), yet no manuscripts were identified that utilised qualitative research to explore ESS control practices among diverse OT personnel (Ball & Gilder, 2022; Bree et al., 2017; Stanley, 2019), thus strengthening my assertion that EDQ approach was the most appropriate. To justify the use of EDQ research over other methodological approaches Hunter et al. (2019) suggest that it is important to identify this gap in the literature focusing on the topic. Furthermore, EDQ can be utilised to both explore and describe aspects of clinical nursing practice, education, and policy (Hunter et al., 2019). However, EDQ approach should not be utilised to salvage pieces of research that is poorly envisioned or carried out (Sandelowski, 2010). This study aligns with the DHB's smoke-free goal, the researcher's passion for quality and safety as well as the researcher's professional trajectory of contributing towards the qualification of Master of Health Practice.

EDQ research is a hybrid methodology, formally created by Hunter et al. (2019), which is a combination of two methodologies, Stebbins (2001) exploratory research and Sandelowski (2010) descriptive qualitative research which has been underpinned by appropriate theory (Hunter et al., 2019). EDQ research examines the incidents of the phenomenon of interest, as in this study the ESS control practices among diverse OT personnel, while the descriptive element gains insight to inform practice, capturing a detailed understanding of the perspectives of the participants regarding ESS and ESSE compliance. Hunter et al. (2019) suggest that EDQ tends to

answer both, the descriptive as well as exploratory questions. While the descriptive studies uncover the “who, what and where” (Sandelowski, 2010); Stebbins (2001) suggests that the exploratory researcher should attempt to generalise about “who is doing what to whom, when and where.” The EDQ research design (Hunter et al., 2019) has been utilised in prior nursing research by Jacobsen et al. (2020) and Collaço et al. (2022).

3.8 Research Context, Sample and Sampling Procedures

The research context was the government-funded Waitematā DHB’s two hospitals, the Elective Surgical Centre (ESC) and NSH in NZ, which consist of four and twelve operating theatres respectively. All major and minor surgeries are performed in these operating theatres that deal with six surgical sub-specialties such as orthopaedics, obstetrics, gynaecology, urology, ENT, and general surgeries.

An advertising poster (Appendix G) recruitment strategy was utilised with emphasis on the voluntary nature of the study. The poster was displayed on the OT quality board for two weeks with details of the research project, the researcher’s name, and the contact email of the gatekeeper. The gatekeeper was the OT receptionist at NSH who had signed the confidentiality agreement (Appendix H) as the independent third party to assist in the participant recruitment process to prevent researcher’s bias and any other ethical implications (Cooper & Bogossian, 2020, p.353). Once the potential voluntary participants contacted the gatekeeper through an email, the participant information sheet (Appendix I) with the consent form (Appendix E) was sent to them by the gatekeeper. The participant recruitment process strategy required the researcher’s careful planning with a backup strategy of advertising on the DHB intranet if the advertising poster recruitment strategy was unsuccessful.

A purposeful sample of six participants who met the inclusion criteria were recruited for individual semi-structured virtual interviews by the gatekeeper to promote unbiased selection in terms of those who volunteered (Hunter et al., 2019; Cooper & Bogossian, 2020, p.353). The summary of the inclusion and exclusion criteria is shown in table 1.

Table 1: Inclusion and Exclusion criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> OT personnel working for more than six months at the DHB and have encountered ESS during electrosurgical procedures 	<ul style="list-style-type: none"> Senior management such as Charge Nurses
<ul style="list-style-type: none"> Participants from all genders, ethnicities, and various surgical sub-specialties between the ages of 23 to 65 years 	<ul style="list-style-type: none"> Non-clinical OT personnel
<ul style="list-style-type: none"> Participants who voluntarily signed their informed consent 	<ul style="list-style-type: none"> Nurses from NSH
<ul style="list-style-type: none"> Surgeons, Anaesthetists, Anaesthetic Technicians from NSH and Nurses from ESC 	

To avoid conflicts of interest, power differences and any ethical implications, nurses from only ESC could volunteer to participate and the rest of the participants were from NSH as the researcher held the position of an OT Coordinator at NSH. Although the researcher should justify the sample size, EDQ methodology suggests a smaller sample size, provided the selection has a clear rationale and is able to provide quality information to address the study objectives (Braun et al., 2019, p.852; Hunter et al., 2019). Hence the small sample consisted of diverse OT personnel who work across various surgical sub-specialties. Unlike nurses and surgeons, the anaesthetist and anaesthetic technician are not directly involved in ESSE, yet if ESSE is not effectively utilised, they are all exposed to the risks of hazardous ESS. Therefore, the gatekeeper ensured that diverse OT personnel such as two surgeons, one anaesthetist and one anaesthetic technician from NSH, and the two nurse participants from ESC were recruited strictly on a first-come-first-served basis, depending on the date and time they returned their signed consent to the gatekeeper through email to ensure a fair and unbiased selection (Cooper & Bogossian, 2020, p.353).

3.9 Data Collection

ESSE is a complex phenomenon and EDQ research is a pragmatic approach to explore ESS control practices among diverse OT personnel (Hunter et al., 2019). Once the participants were deemed eligible and consented to participate in the interview, the informed consent was verified and the participants were allocated numbers as pseudonyms to maintain confidentiality (Polit & Beck, 2018). Virtual interviews were conducted during non-working hours, at a time

and date convenient to the participants, to reduce the researcher-participant power imbalance (Hunter et al., 2019). The researcher as the key instrument conducted the individual interviews utilising the semi-structured interview protocol (Appendix J) (Polit & Beck, 2018) as shown in table 2.

Table 2: *Semi-structured interview protocol*

No.	Questions began with “please can you tell me”, and were used to probe further
1.	What does the term ESS mean to you?
2.	How has your understanding of ESSE been developed?
3.	If, how and from whom do new OT personnel learn to effectively evacuate ESS?
4.	What are the barriers and enablers of effectively evacuating ESS within the OT?
5.	Why do you think OT personnel do not consistently utilize ESSE?
6.	How do you feel about the current ESSE practice at our hospital?

This protocol was utilised to probe further questions to generate rich findings and reveal new understandings (Polit & Beck, 2018). Specific open-ended questions were asked on participants’ attitude and perceptions about ESS and ESS control practices in the OT to address the research objectives, based on the DHB policy on ESSE (Waitematā DHB, 2017), AORN guidelines for ESSE (Ogg, 2021), and the literature review, following the EDQ methodology (Hunter et al., 2019).

Stebbins (2001) argues that although exploring through observation is useful, it can be more focused with interviews. Moreover, Sandelowski (2010) suggests that semi-structured interviews are normally used in descriptive qualitative studies. The researcher conducted virtual individual interviews due to COVID-19 restrictions and lockdown instructions from the university (Auckland University of Technology, 2021). Interviews were of one-hour duration, that were audio-recorded and notes were taken to enhance the criticality and integrity of the EDQ study as suggested by Hunter et al. (2019).

3.10 Data Transcription

Interviews were manually transcribed verbatim by the researcher within one week of the interview, by noting pauses and tones for subsequent analysis (Creswell, 2014; Tebbs et al., 2021). The researcher ensured the transcripts were accurate by listening to the audiotaped recordings of the interview and reading the transcripts simultaneously several times to reflect the totality of the

interview experience (Polit & Beck, 2018). The audio-taped interviews and transcripts were accessed only by the researcher and project supervisor who checked the accuracy of the verbatim transcriptions. Manual transcriptions were a critical step in preparing and getting familiar with the data for analysis (Braun & Clarke, 2006; Byrne, 2021).

3.11 Data Analysis

Data analysis is a process that involves segmenting the raw data to generate codes and develop them into themes to elicit meaning and better understanding from the data (Creswell, 2014). Hunter et al. (2019) recommend that TA based on the work of Braun and Clarke (2006) as the most appropriate approach for data analysis in EDQ study. TA is a flexible approach to qualitative analysis which enables the researcher to explore and describe the participant's experience in relation to the phenomena under study (Braun & Clarke, 2006). However, TA is an umbrella-term for three broad approaches: coding reliability, codebook, and reflexive TA (Braun et al., 2019; Braun & Clarke, 2021).

Reflexive TA was the chosen data analytic method in this EDQ study (Braun et al., 2019) to explore and describe the participant's experiences in relation to ESS and the compliance with ESSE (Hunter et al., 2019). Reflexive TA is justified in context of the researcher's underlying theoretical and qualitative paradigmatic assumptions of this study; it is best suited to questions related to participant's attitudes and perceptions about ESS, for a better understanding of their ESS control practices (Braun et al., 2019, Braun & Clarke, 2021). In Reflexive TA, the data collection and analysis techniques are underpinned by a qualitative paradigm that emphasises meaning as contextual, with multiple realities and reiterates the researcher's subjectivity as an analytic resource, reflexively engaging with theory, data, and description/interpretation in the process of knowledge production (Braun et al., 2019; Braun & Clarke, 2021).

Although reflexive TA was a slow, time consuming, recursive, and reflexive rather than a linear process, it enabled the researcher to explore and develop a better understanding of the data. Data was open-coded (Appendix K), and the data-based meanings were emphasised to produce themes that were relevant to the research questions (Braun et al., 2019). This iterative

process allowed the researcher a more thorough and unbiased look at the themes that resulted as an analytic output of inductive coding throughout the data. Themes were conceptualised as meaning-based patterns that aimed to provide a coherent and compelling interpretation of the data through the lens of the researcher, yet grounded in the data (Braun et al., 2019). The six-phase reflexive TA process described by Braun and Clarke was utilised as shown in table 3 (Braun & Clarke, 2021, p.331).

Table 3: Six-phase Thematic Analysis process

(Braun & Clarke, 2021, p.331)

Phase	Name of the Phase	Description of the process
Phase One	Data familiarisation and writing familiarisation notes	Transcribing data, reading and re-reading the data and making notes
Phase Two	Systematic data coding	Subjective coding of interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
Phase Three	Generating initial themes from coded and collated data	Codes conceptualised as analytical tools by the researcher to develop potential iterative themes by collating data
Phase Four	Developing and reviewing themes	Checking if the themes work as patterns of shared meaning, united by an idea or a central concept by generating a thematic 'map' of the analysis
Phase Five	Refining, defining, and naming themes	Ongoing analysis to refine the specifics of each theme, generating clear definitions and names for each theme and the overall story of the analysis
Phase Six	Writing the report	Listing of final themes with vivid, compelling data extracts and final analysis of selected extracts relating to the research question, producing a scholarly report of the analysis

3.11.1 Phase One: Data familiarisation and writing familiarisation notes

This most enjoyable phase of the analytic process entailed reading and re-reading the transcripts, becoming intimately familiar and immersed in the data, and making notes about interesting trends in the data (Braun & Clarke, 2006; Braun et al., 2019). Additionally, noticing connections between participants' data shaped by the research questions and being curious yet thoughtful by documenting personal thoughts and feelings gave room for reflexivity (Braun & Clarke, 2021; Braun et al., 2019). An example of preliminary notes written during phase one is shown in table 4.

Table 4: Preliminary notes written during phase one

“Participants emphasise on the need for education about ESS and ESSE as well as the availability of appropriate ESSE equipment and supplies to facilitate effective and consistent ESSE.”

“Participants speak of ESS in lay terms, indicating some of them were unaware of the definition of ESS and its contents. Additionally, most participants are unknowledgeable of the DHB policy nor best practice guidelines on ESSE.”

“There appears to be a discrepancy among diverse OT personnel in the availability of information regarding ESS. Some participants unaware of potential health risks of ESS to patients and staff as well as effective utilisation of ESSE equipment and sterile supplies for open as well as laparoscopic procedures. This may have implications for the ESS control practices among diverse OT personnel.”

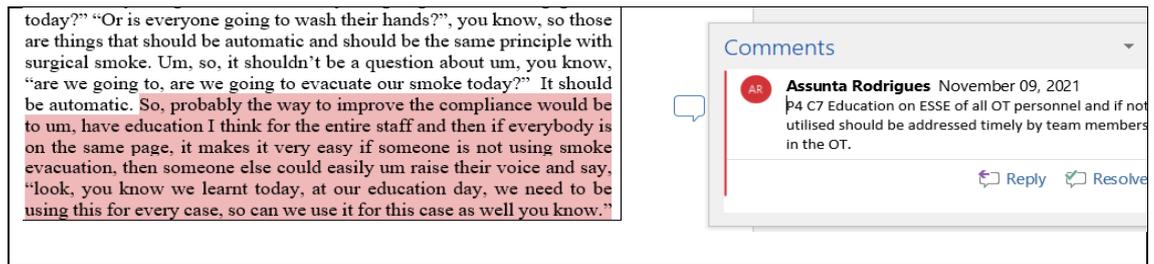
“OT personnel are less clear on the harms/hazards of ESS.”

“Some participants emphasised that OT personnel take precautions with other hazards such as radiation from image intensifiers/x-ray machines and sharps due to greater awareness compared to ESS where OT personnel are less cautious. Hence, prioritising ESS just like other OT hazards, with more education and training around the harms and risks of ESS on OT patients and personnel may improve compliance and effectiveness of ESSE with greater focus on laparoscopic surgeries.”

“Affective disposition communicated by participants seem to be predominantly: enthusiasm in relation to the value of promoting consistent and effective ESSE through education to overcome barriers to ESSE. Frustration at the perceived lack of education and training among diverse OT personnel on ESS, usage of ESSE and availability of ESSE supplies, particularly for laparoscopic surgeries. Resentment at the perceived lack of support for ESSE compared to radiation protection from x-rays and sharps hazard, with efforts regarding the promotion of effective ESSE.”

3.11.2 Phase Two: Systematic data coding

Codes are the fundamental building blocks of themes that created inspirational moments for the researcher producing succinct yet descriptive labels relevant to the research question (Byrne, 2021). Inductive data-driven codes were manually generated by the researcher’s systematic engagement with the data rather than existing concepts or theories (Braun et al., 2019). Codes although brief identified interesting and informative aspects of data in relation to the ESS control practices among OT personnel. Tracking the progression with evolution of codes aided transparency. Semantic data coding at the surface level of the data captured participant’s quotes, allowing the data to speak, trying to better understand the OT personnel’s attitude towards ESS and its influence on their ESS control practices in the OT (Braun & Clarke, 2006; Braun et al., 2019). An extract of a transcript with preliminary iteration of the coding process utilising the ‘comment’ function of the Microsoft Word document is presented in table 5.

Table 5: Preliminary iteration of coding process

3.11.3 Phase Three: Generating initial themes from coded and collated data

Following the coding phase, the researcher utilised a blackboard for collating relevant codes with data extracts, analysing codes, considering combination of various codes into potential themes and sub-themes (Braun et al., 2019). Although codes were used as building blocks, sometimes a code was promoted to a theme as it captured a meaningful pattern across the data set and mind-maps were used to visualise the relationship between codes and themes (Appendix L) to identify the most potential themes (Braun et al., 2019; Byrne, 2021).

3.11.4 Phase Four: Developing and reviewing themes

Fourteen themes and sub-themes were initially identified, and thematic mapping allowed the complexity of the OT personnel's ESS control practice to be explored (Appendix M). Developing, reviewing, and merging themes by values to construct stronger themes that resonate the participants' voices resulted in overarching themes (Braun et al., 2019).

3.11.5 Phase Five: Refining, defining, and naming themes

This phase enabled refining the specifics of each theme by reviewing and further analysing all the compiled coded data, by providing the themes appropriate names and definitions, which is the core to a coherent story about the data in relation to the research question (Braun & Clarke, 2006). Thematic mapping enabled to visualise and develop a clear sense, further exploring potential themes and sub-themes as well as connections between main themes, utilising researcher's subjectivity, and experience, building a coherent, insightful overall story about the data in relation to the research question without overlapping themes (Braun et al., 2019). The three main overarching themes identified from the data analysis are education on ESS and ESSE

across disciplines; attitudes and perceptions about ESS and ESSE; barriers and facilitators to ESSE (Appendix N). These themes will be expanded in the next chapter.

3.11.6 Phase Six: Writing the report

Once the final themes were established, the researcher began the final phase of writing the report. It ensured the themes work well individually and collectively to answer the research questions, exploring ESS control practices amongst diverse OT personnel (Braun et al., 2019). This entailed revisiting the research questions, and all the previous phases of data analysis, making further revisions to aid the flow of the overall analytic story underpinned by a constructivist paradigmatic stance and based on a subjective epistemology (Braun et al., 2019). The findings were effectively summarised with excerpts from the data for a better understanding of the ESS control practices among diverse OT personnel by producing the research report to communicate and share with others including participants (Braun & Clarke, 2006; Braun et al., 2019).

3.12 Ethical Considerations

Ethics are the moral principles that guide the research from inception through completion and beyond publication, according to the Economic and Social Research Council (Rees, 2011). This EDQ study involved human participants attending the semi-structured online/virtual interviews. According to Polit and Beck (2018), any research involving humans or animals must attend to ethical considerations. Hence, the researcher ensured that the EDQ research was undertaken in a manner that placed the safety, security and needs of participants at the forefront (Hunter et al., 2019; Polit & Beck, 2018).

Ethics approval for this study was sought and approved by AUTECH (Appendix A) and the ethics approval for the amendment to the data collection protocol (for online interviews) was also requested and approved (Appendix B). Several ethical issues were considered and integrated into the study design as mentioned in the consultation process. Participants received a \$20/- gift voucher, recognising the value of their contribution to the research.

The three fundamental ethical principles: beneficence, respect for human dignity and justice were incorporated into the study to ensure participants did not encounter any harm or malice (Polit & Beck, 2018). Beneficence involved maximising benefits and protecting the participants from physical and emotional harm. The study's main objective was effective and consistent ESSE in the OT that would not only benefit the participants but also the OT patients, personnel, and the organisation. Respect for human dignity involved the participant's right to self-determination by full disclosure of the research process to make an informed decision before voluntarily consenting to participate in the study. Justice concerns the right to privacy, confidentiality, and fair treatment. To ensure justice, participant pseudonyms were utilised and all participant's interviews, transcripts, data analysis and findings were kept on a password-protected computer. The interviews were transcribed verbatim by the researcher. The research data was stored securely in a locked cupboard and will be destroyed after six years. The participant selection was unbiased in terms of those who volunteered by utilising a gatekeeper (Polit & Beck, 2018).

3.12.1 The Treaty of Waitangi

As this research was undertaken in Aotearoa New Zealand, which is a culturally diverse country, the enhanced set of principles of the Treaty of Waitangi (Te Tiriti o Waitangi) which is "*Self-Determination/Tino Rangatiratanga, Partnership/Pātuitanga, Equity/Mana Taurite, Active Protection/Whakamarumarutia, and Options/Kōwhiringa*" were integrated throughout the research process (Nursing Council of New Zealand, n.d.) and voluntary participation in this project ensured benefits to Māori in an equitable manner (Hudson & Russell, 2009; Reid et al., 2017). The researcher conducted the virtual interviews during non-working hours, at a time and date convenient to the participant to maintain privacy and confidentiality by working in partnership to reduce the researcher-participant power imbalance (Hunter et al., 2019; Reid et al., 2017). In this mainstream approach to research, the participant's ethnicity was unknown, and the participant's role was to share their experience and perceptions about ESS as well as ESS control practices in the OT throughout the interview. The participant's autonomy and free will for voluntary participation were respected which reflects the researcher's integrity (Rees, 2011; Reid

et al., 2017). In this study, although participants signed the informed consent, they could withdraw from the study at any time without repercussions. The researcher and participants were protected from one another by the concept of 'manaakitanga' ensuring the 'mana' of the researcher and the participants were upheld with cultural and social responsibility and respect for each other (Hudson & Russell, 2009; Reid et al., 2017).

3.12.2 Avoidance of Conflicts of Interest

The role of the researcher is that of the OT Coordinator at NSH. To avoid conflicts of interest and minimise power differences, the nurse participants were selected from ESC rather than NSH. Although ESC is part of the same DHB and follows the same DHB policies, it is managed by different management with its own nursing staff who have no connections or line management to the researcher. Moreover, the gatekeeper managed the initial contact with potential participants and the participant recruitment process to prevent coercive influence, power imbalance or selection bias. The study was guided by the NZNO Code of Ethics (New Zealand Nurses Organisation, 2019) and the Nursing Council of NZ Code of Conduct (Nursing Council of New Zealand, 2012).

3.12.3 Rigour

Trustworthiness as a concept of rigour is one way the researcher can convince others that the research findings are worthy of attention (Lincoln & Guba, 1986, Polit & Beck, 2018). As suggested by Hunter et al. (2019), rigour was addressed in this EDQ study by adhering to the framework recommended by Whitemore et al. (2001). It focused on four main validity criteria: credibility, authenticity, criticality, and integrity while also considering reflexivity (Hunter et al., 2019; Polit & Beck, 2018; Whitemore et al., 2001).

Credibility was assured by the researcher's description of the OT experiences and prolonged engagement with audit trails (Polit & Beck, 2018). Credibility was further enhanced by triangulation of different data sources by examining evidence from the perspectives of diverse OT personnel during the interviews that were audio-recorded, with observations and notes taken during the interview to build a coherent justification of themes (Lincoln & Guba, 1986).

Additionally, inductive data analysis was utilised to develop themes, and a rich, thick description with participants' quotes to convey realistic findings. Presenting and discussing themes as well as the discrepant information contradictory to the themes will make this EDQ study more realistic and add credibility (Whittemore et al., 2001).

Authenticity was achieved by ensuring a proper data collection method utilising semi-structured virtual interviews where the participants had the freedom to speak, and their voices were heard. This was followed by verbatim transcriptions that reflected accuracy, and reflexive TA of data with documentation of detailed steps of the research process (Whittemore et al., 2001).

Criticality was ensured by continually comparing study findings with themes and ensuring proper procedures were followed for coding and development of themes (Polit & Beck, 2018). Maintaining detailed notes at every stage throughout the reflexive TA ensured trustworthiness and dependability of the study findings (Whittemore et al., 2001).

Integrity was sought throughout this study by the researcher being self-critical and reflecting on the researcher's assumptions, knowledge background and bias (Whittemore et al., 2001).

Reflexivity: The rigour of this qualitative study was further enhanced utilising reflexivity as a tool throughout the research process to overcome bias. The researcher maintained a personal reflexive diary to ensure assumptions and biases did not override the importance of this EDQ study (Hunter et al., 2019; Polit & Beck, 2018; Whittemore et al., 2001).

Creswell & Creswell (2018) suggest that bias can be caused by various factors including the researcher's preconception, faulty data collection methods, or participant's lack of sincerity. To overcome any bias, the researcher tried to understand the participants' views by asking open-ended questions. Additionally, the researcher was aware of personal background, cultural, and historical experiences to avoid leaning towards certain themes, keeping an open mind. Furthermore, to ensure participants were not tired at the time of data collection and provided accurate information, the interviews were held during non-working hours, at a time and date convenient to the participants (Creswell & Creswell, 2018).

The researcher's perceptions were influenced by personal values and beliefs, as well as OT experiences with ESS over the last 18 years at the hospital. Researcher's experience with ESS is that the hazardous ESS has a strong odour and hinders visualisation of tissues especially during laparoscopies, thereby increasing surgical time. This understanding of the context and the researcher's role as an OT Coordinator enhanced knowledge awareness and sensitivity that assisted the researcher to work with the participants, exploring ESS control practices by utilising a constructivist epistemology. The positioning of constructivism is in the qualitative paradigm, where the researcher seeks to better understand the participants' attitude towards ESS and their compliance with ESSE (Creswell & Creswell, 2018).

In this EDQ study, the researcher's assumption is that there is no single reality on which this inquiry may converge, but multiple realities which are socially constructed by diverse OT personnel and the researcher seeks to understand them, yet strives to be unbiased (Polit & Beck, 2018). Further, the researcher assumes each participant's honest response accurately reflects their professional opinion about ESS and ESS control practices with a sincere interest in this research (Creswell & Creswell, 2018). Therefore, the knowledge arising from this EDQ study will be rich, socially constructed and value-laden (Polit & Beck, 2018).

3.13 Summary

EDQ research design was utilised to explore ESS control practices among diverse OT personnel at a large DHB in NZ. EDQ approach was deemed appropriate as it has the potential to address the specific research aim, which has limited coverage in the literature. A purposeful sample of six diverse OT personnel participated in semi-structured virtual interviews that were analysed utilising reflexive TA. The data analysis revealed three overarching themes with sub-themes. Although other minor themes merged, the focus was on the major themes and the connections between themes to build a coherent, insightful story about the data, exploring ESS control practices amongst diverse OT personnel. The ethical consideration and rigour of the study were discussed. The research findings were effectively summarised by producing a report with excerpts from the data which will be presented in the next chapter.

Chapter 4: Results

4.1 Introduction

This chapter presents the research findings with key themes supported by quoting the raw data. It describes OT personnel's attitudes towards ESS, and the perceived facilitators and barriers associated with their compliance with ESSE.

4.2 Participants' Demographics

Participants' demographics obtained at the start of the interview demonstrate that the small purposeful sample consisted of diverse OT personnel. According to Hunter et al. (2019), participants' demographics may be utilised to support the EDQ study as shown in table 6.

Table 6: Participants' demographics

Participant Number	Profession	Years of Experience	Gender	Age Group (Years)	Prior Training in Surgical Smoke Safety Programme
P1	Nurse	4.5	Female	23-40	No
P2	Anaesthesia Technician	28	Male	50-65	No
P3	Nurse	12	Male	23-40	Yes
P4	Surgeon	10	Male	23-40	No
P5	Surgeon	27	Female	40-50	No
P6	Anaesthetist	11	Male	23-40	No

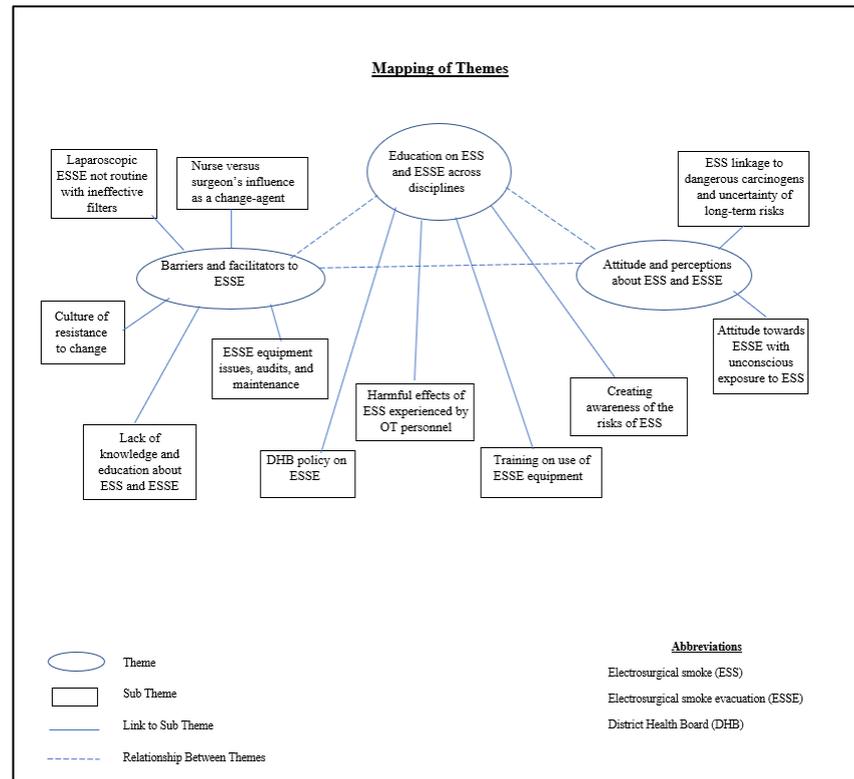
4.3 Emergent Themes

This study revealed inconsistent ESSE among diverse OT personnel. The following three overarching themes were developed from the data analysis:

- 1) Education on ESS and ESSE across disciplines
- 2) Attitude and perceptions about ESS and ESSE
- 3) Barriers and facilitators to ESSE

Subthemes expanded each main theme with a strong relationship between the main themes. The participants' response (quotes) supports more extensive exploration of the identified themes and subthemes. Thematic mapping was utilised as shown in Figure 1.

Figure 1. Thematic mapping



4.3.1. Education on ESS and ESSE across disciplines

All participants indicate that education on ESS and ESSE across disciplines is the key to consistent and effective ESSE.

“It [education on ESS] wouldn’t hurt, would it, to know something is harmful to you in theatre, to learn about it [ESS].” (P2)

“Number one is education! So, people need to have the knowledge of the harms of ESS. Have education I think for the entire staff and then if everybody is on the same page ... in addition they also need to know what options are available for evacuation. People should feel that they can be open to talking about it [ESSE]. So, for instance if there is a particular surgeon that’s not using the smoke evacuator then a colleague or a nursing staff member should be able to speak up.” (P4)

“First of all, education of everybody involved in theatre. Regular testing of the [ESSE] equipment that we use and education. I think, these are the two key things.” (P5)

(a) Creating awareness of the risks of ESS

Most of the participants perceived that raising awareness among OT personnel through education of the risks of ESS, comparing ESS to other dangerous OT hazard such as x-ray radiation could improve compliance with ESSE in the OT.

“I think, (raising eyebrows) again comparing to radiation. Everybody knows about the harms of radiation and that’s why everyone’s very careful to make sure they have got lead on when we are using x-rays. But surgical smoke, perhaps people are a little bit less clear on the harms it causes. Maybe because we don’t quite know how bad it is for us compared to something like radiation. So probably the way forward, or the way to improve people’s reactions, would be to improve education and do more training around the harms of ESS.” (P4)

“I guess, it is more awareness, maybe some education around that [ESS], then I guess that will increase compliance.” (P6)

However, one of the participants admitted being unaware of the risks of ESS and stressed on the vital role of education to create awareness among OT personnel.

“We haven’t actually had any research taught to me about risks. We really don’t have training on the effects of the smoke. More education about the risks of surgical smoke ... People would be a lot more aware. I think, the main thing is really education!” (P1)

(b) Training on use of ESSE equipment

Participants expressed the need for education and training to set up the ESSE equipment and the options available for ESSE.

“To be honest, there was no in-service, we actually just learnt the machine. I’ve just learnt the machine, actually reading the manual (laughs). I think we just need to educate our team especially our new staff about setting up the [ESSE]equipment. They need to have a formal education about how to setup... and actually the maintenance of our [ESSE] machines.” (P3)

“When students or new staff are being introduced to theatres, as part of theatre safety, learning how to scrub, what PPE and things to wear, that (ESSE) should be included. Perhaps for new surgical registrars, would be the options available for smoke evacuation.” (P4)

(c) DHB policy on ESSE

Despite the existing DHB policy on ESSE in the OT, most participants were either unaware, had limited knowledge or were unfamiliar with the contents of the policy.

“I know that we have got one [ESSE policy] (laughs), but I haven’t really made myself familiar with it unfortunately.” (P1)

“I am aware that there’s a policy and am all aware that it is mandatory for smoke evacuation devices to be used, but I couldn’t tell you much more beyond that. I have read hospital guidelines briefly, but I haven’t read any international guidelines.” (P4)

“No, I wasn’t aware that there’s a policy by the DHB on specific issue [ESSE].” (P6)

(d) Harmful effects of ESS experienced by OT personnel

Creating awareness of the harmful effects of ESS experienced by diverse OT personnel is the final sub-theme within the overarching key theme of education on ESS and ESSE across disciplines. Participants regularly experienced the smell of ESS and some OT personnel experienced other ill-effects such as headaches.

“I think it (ESS) is something that personally would experience the smell of and the presence of smoke every single day in the operating theatre. I don’t think any specific ill-effects other than able to smell it every time we are using diathermy (laughs).” (P4)

“You hear the occasional stories of various colleagues who say, ‘I get a really bad headache’ and some lists which they do, they do a lot of diathermy and smoke just billows up everywhere.” (P6)

One of the participants encountered a worse situation where ESS caused not only headaches, but nauseating sensation with metallic taste in the mouth.

“It [ESS] caused headaches (facial grimaces) and nauseating sensation especially when you smell, when it gets into your system. I had some instances where the diathermy in contact with the metal implants caused nauseous, noxious smell and you can taste it, you can taste the metallic taste in your mouth! Which is quite worrying actually (laughs)!” (P3)

While another participant felt that ESS smell was scary in the middle of a technically challenging surgery.

“It was just that smell which I had experienced. So, it’s actually quite scary you know to smell something, because you are in a patient, and we don’t have the intention of causing any harm to the patient.” (P5)

Education on ESS and ESSE across disciplines could have a strong influence on the OT personnel’s attitude and perceptions about ESS and ESSE which will be explored as the next overarching theme.

4.3.2. Attitudes and Perceptions about ESS and ESSE

Participants viewed ESSE as an important issue. Moreover, participants perceived ESS as harmful and hazardous with linkage to dangerous carcinogens. Some participants reported that

the potential harms of ESS were not highlighted in the OT compared to other OT hazards such as sharps and radiation. Participants spoke about the incautious attitude towards ESSE among OT personnel that caused an unconscious exposure of OT patients and personnel to hazardous ESS with uncertainty of long-term health risks.

“It’s like whenever we are doing any operation, we need to pay attention to the safety of the staff including things like radiation where we always wear radiation shields but for some reasons when it comes to smoke evacuation people are a little bit less cautious. People think that when you are doing laparoscopic surgery, the smoke is often contained and is not so much of an issue.” (P4)

“My perceptions, because it [ESS] is hazardous, I think, we should look at proper elimination of it, so that it is not toxic for the patient, building up can cause problems to the patient and for the surgeons and also all those who are involved with surgeons like the assistant and the scrub nurse.” (P5)

“I think it (ESSE) is a really important issue, I think that one needs to be talked and spoken about more.” (P6)

While another participant who was not aware of the composition of ESS, perceived ESS as bad and nasty with a potential to cause lung damage.

“In theory it [ESS] means a bloody bad smell (sighs). It can be pretty, pretty nasty (facial expressions) if we don’t use the evacuator. I don’t know exactly what it (ESS) contains. The risks might be damage to lungs over periods of time. Some people might have pre-existing conditions, in which it just makes worse.” (P2)

(a) ESS linkage to dangerous carcinogens and uncertainty of long-term risks

Most participants perceived ESS to be harmful with linkage to carcinogens yet unsure of its potential long-term effects. Some compared ESS to cigarette smoke.

“I would put it [ESS] as (tone of voice stresses) harmful and hazardous! Working full time in theatres and you are constantly getting exposure, what sort of issues can you have from that in the future! If you are burning cancerous tissues and that’s being released out into the atmosphere around you and if you are breathing that straight into your lungs, there are risks of having any kind of transmission.” (P1)

“I think it is carcinogenic. I know it’s not good for you. No smoke is good for you that’s for sure! It’s a bit like smoking I suppose. You are taking in all these chemicals over a long period of time, over years ... no one’s really done a study into it I suppose to find out what it actually does! I think being a scrub nurse or a surgeon, the effects may be more.” (P2)

“My perceptions, they [ESS] are harmful based on just strong smell of it and carcinogenic materials, harmful materials.” (P3)

“We usually think of it [ESS] as (sighing) a sort of toxic or noxious stimuli, so something that is harmful to staff in the OT and to patients as well. The risks would be I guess, the theoretical risk of being carcinogenic, similar to cigarette smoke in a way.” (P4)

Referring to the COVID-19 pandemic, one participant expressed the fear of virus transmission risks through ESS.

“With regards to the ESS transmission it is difficult to say, but I’ll just take it that if viruses can be transmitted, I am sure COVID can be transmitted as well.” (P5)

(b) Attitude towards ESSE with unconscious exposure to ESS

Most participants perceived that the lack of knowledge on the potential risks of ESS affected OT personnel’s complacent, incautious, and tolerant attitude towards ESS and their ESS control practices.

“Once you know you’ve smelt it [ESS], then you kind of get brought in that you are inhaling it. Where, unless you can smell it, you are not linking about it (that you are inhaling it). It can still be in the air before you have physically smelt it ... So, if you have got that smoke evacuator really working, and you can still smell it, everyone just gets on with it and doesn’t worry about it.” (P1)

“We all just get on with it (ESS). They are doing a small case or whatever, so we are all very blasé about that (ESS).” (P2)

“I guess it [ESS] is a very common by-product that we encounter every day in surgery, (gesturing with hands) and I think we all know it is harmful, but sometimes it can be difficult to minimise the harms from it.” (P4)

“It (ESS) doesn’t seem to be that dire an issue! I guess there’s a lot of people they don’t see it as a problem. No one really made a fuss over it. There’s always been like this cloud of smoke, and no one seemed just to care about it. In terms of surgical smoke, everyone knows it’s bad, everyone knows it needs to be minimised, but I think it doesn’t go much, much more kind-of past that!” (P6)

Nevertheless, one of the participants highlighted that besides OT personnel, patients too are exposed to the toxic effects of ESS.

“Some of our patients are intubated and they have a closed-circuit airway but if they got spinal anaesthetic, they will be inhaling surgical smoke as well which they might inhale those toxic substances.” (P3)

Although all participants displayed a positive attitude towards ESSE and some perceived ESSE as an important issue, others found it very complex, needing team buy-in and difficult to address.

“I would prefer to use something with smoke evac like all cases, cause even if using a little bit, that is still putting that smoke out that day.” (P1)

“But since they’ve started using the new electrosurgical suction it has been a lot better. When it [ESSE] is used, I think it does reduce a hell-of-a-lot. If you can smell it [ESS], it is in the air Obviously the more we use it (ESSE), keep using it, the more smoke might get into the air, but they’ve made a hell-of-a-difference!” (P2)

“We need to be consistent with using the surgical smoke equipment.” (P3)

“I think it (ESSE) is incredibly important.” (P4)

“But now we have got the suction tubing attached to the diathermy, which helps in evacuation ... not adequately but in some way.” (P5)

“It is a very topical issue and I think one that needs more importance and more kind of team buy-in. Unless surgeons really kind of buy-into it, I don’t see things changing much. It [ESSE] is a delicate issue ... I guess we are exposed to it [ESS], but often we do not have any kind of control over it.” (P6)

4.3.3 Barriers and Facilitators to ESSE

Lack of knowledge and education about ESS and ESSE was identified as the key barrier affecting ESS control practice among OT personnel. Other barriers identified were culture of resistance to change and laparoscopic ESSE not being routine practice with ineffective laparoscopic filters that influenced ESSE. In contrast, the facilitators to ESSE identified were regular audits and maintenance of ESSE equipment, nurses versus surgeons’ influence as change-agents to promote ESSE, with education on ESS and ESSE across disciplines as the key for consistent and effective ESSE.

(a) Lack of knowledge and education about ESS and ESSE

Most participant responses identified that there was a lack of knowledge and education about ESS, its contents, risks, management, and protection, with lack of training on ESSE equipment set-up, functioning and maintenance that negatively influenced their attitude towards ESS as well as their compliance with ESSE. Some participants perceived that the surgical mask protects them from ESS, although surgical masks have proved to be ineffective protection against ESS.

“I think minimal sort of education and training around it (ESSE). We were sort of shown how to use the smoke evac machine, and that’s once you know how to turn it on and that’s kind of all that is done ... I will definitely put on a surgical mask. I haven’t really heard much about the effects ... it’s not really talked about in theatres. Most days I’ve had some

experience of inhaling it [ESS] (laughs) and so it's just figuring out what options there are ... I haven't had much education on the surgical smoke from around it [covid cases]. I haven't worked on these covid patients, and so I haven't experienced inside those theatres yet.” (P1)

“I don't know exactly what it (ESS) contains... There are some people who do not wear masks in theatre.” (P2)

“A lot of my experience is that staff actually don't know how to set up a smoke evacuator so that it can go in sync with (smiling) the diathermy machine and we often see they are plugging it in, but nobody has actually checked the machine is actually working alongside the diathermy machine.” (P3)

“Like even pre-covid, no one was wearing masks, and I would wear a mask for the smoke, and everybody would look at me funny ... There is the sterile barrier as well which offers some protection but just depends upon how much smoke exposure you are talking about.” (P6)

Moreover, two of the participants confirmed that although the principles and the use of electrosurgery was part of their medical training, there was no education on ESS and ESSE training.

“The contents would probably be largely water vapour and there will be presumably some carbon elements and not sure what else actually... I personally haven't undergone any sort of formal training on smoke evacuation or the hazards of it. The majority of it is learnt through from nursing colleagues.” (P4)

“We have training on the principles of electrosurgical, the use of electrosurgery but nothing in terms of evacuation of the smoke. There is absolutely no training!” (P5)

(b) Culture of resistance to change

Some participants stated that implementing ESSE is difficult with some surgeons as well as nurses.

“It's more been the nursing staff, I've found, that's been like, 'Oh, it's only a quick case and we will just use a diathermy that does not have the smoke evac connected'. Surgeon preferences is a hard one as well. Some surgeons, they are used to the equipment that they use, and a change to them, they may not sometimes take on board as easily. Sometimes it's hard to get them to change their lives because they are the old school. The main, where I have seen issues with surgeons using the surgical smoke evac is orthopaedics.” (P1)

“It could depend on the surgeon. I think a lot of the new young surgeons use it all the time I suppose ... but it could be to do with culture like, (laughs) you know, they don't usually use it, so why use it now, kind of thing.” (P2)

“There was some resistance around using them especially on difficult access surgeries, like smaller incision sites. They (ESSE pencils) are bit bulky, so if you have a small incision and have difficult access then it becomes difficult to use smoke evacuators.” (P3)

“People’s resistance to change and changing the tools they were used to, because the smoke evacuation unit is quite a different hand-held, you know it’s quite a bit bigger than the old ones.” (P4)

“Sometimes you haven’t got that [ESSE equipment] available or some surgeons prefer not to use it. I think part of it is, what they have always done. I think it just depends on just the culture about each place. Like if there is more awareness of the problem that might encourage people to take more steps to manage it.” (P6)

(c) Laparoscopic ESSE not routine with ineffective filters

Participants perceived the biggest barrier to ESSE is in laparoscopic surgeries.

“I think ... everybody, every case should be using an evacuator, but they don’t, I know that.... And laparoscopic surgery, all they cause is the abdomen fills up with smoke they evacuate it into the air (frowns). Otherwise, where else will you evacuate? Yeah, you can always smell it!” (P2)

“When we do laparoscopic procedures, we do use filters on our canula ports. Some of the surgeons are actually asking for it (nods head).” (P3)

“I think the main area where this hospital can improve is with regards to laparoscopic smoke evacuation. I think probably the biggest barrier is the fact that it is not a routine set of equipment for every case ... it’s still a bit surgeon dependent. So maybe if it was opened by default for every case then people would think that’s the norm, you know we should be using it, rather than being asked for it to be opened. For laparoscopic I find that the smoke evac, smoke filter thing doesn’t actually work all that well. The smoke evacuators can sometimes impair the pneumoperitoneum and cause you to lose some of the pneumoperitoneum or it can also, if it is not adequately heated it can cause problems with condensation on the camera, and fogging. We know that when smoke builds up inside the abdomen it impairs visibility, and it usually takes a long time for the smoke evacuators to actually work. So, what most people tend to do, is open a port, let out all of the smoke (laughs) into the atmosphere, which is obviously not the ideal way of doing it but is probably very commonly done in practice.” (P4)

(d) ESSE equipment issues, audits, and maintenance

Participants highlighted ESSE equipment issues such as noise of the machine and bulky ESSE pencil that are not long enough for deep cavities. That the failure of equipment could be avoided with regular maintenance and audits as well as filters timely changed and in working order. The availability of appropriate sterile supplies and a spare back-up ESSE machine would facilitate ESSE.

“It’s part of our checks in the morning to make sure it is working. Now we have the boom, and a smoke evac machine for each theatre, so we have got two options. If the machine breaks, then you can’t use it until it’s fixed. To change the filters, can be a barrier; if the people only ordered a few at a time and so if we have got none on the shelf.” (P1)

“It could be time and availability of the evacuator. Some general surgery cases when they are really deep down or some deep anterior resection, where they use long diathermy tip isn’t long enough. So, they use long tongs, and they don’t have an evacuator on them.” (P2)

“There was a procedure where the surgeon’s preference was not to use the surgical smoke because of the difficulty of access. The surgical smoke pencil was too wide making visualization of the surgical site very difficult. We had some issues with smoke evacuators not working properly. One of the things that gets missed out, is some of the filters needs servicing, because those HEPA filters will be replaced in a certain amount of usage, over time. We didn’t have a spare one or a backup just that we can use for smoke evacuation when our machines need maintenance or when they start to fail. We need to make sure that the machines are well maintained, tubing checked for leaks and filters replaced in time.” (P3)

“Working in a narrow space and someone’s using a manual smoke evacuator with a suction device, they might find out that it’s getting in the way. For laparoscopic surgery I find that the smoke filter thing doesn’t work all that well. I think, we can look at more effective methods for laparoscopic surgery. The noise of the machines sometimes it’s quite annoying (laughs).” (P4)

“Regular testing of the ESSE equipment to make sure that it is doing the job and education. I think, these are the two key things.” (P5)

“I guess it just depends on the surgeon and what’s available on the day.” (P6)

(e) Nurses versus surgeons’ influence as a change-agent

Some participants perceived there is lack of surgical buy-in, while others perceived it is not the surgeon but the nurses who influence the use of ESSE with nurses versus surgeons’ influence as a change-agent.

“I have found it is not usually the surgeons dictating which one they want to use, that’s more on the nurses who open. (Laughs) Sometimes they just want to open this little one, its cheaper... So, they are not really thinking of the complications later from it.” (P1)

“To be honest, I think we rely a lot on nursing colleagues for that [ESSE]. So, I think, a good example was when it [ESSE] was being introduced, the smoke evacuator device on the diathermy, I remember working with a lot of surgeons who weren’t keen on change, as a lot of people are, but we were sort of encouraged by nurses that it [ESSE] is what we should be using and then there was a gradual trend towards everyone using it.” (P4)

“It seems to be very much like surgeon-lead, like some surgeons insist that they use it, some surgeons really don’t want to use it all. I think without that kind of surgical buy-in, it’s going to be a very, very uphill battle.” (P6)

Currently a change in organisational culture is being experienced by the OT department where the past hierarchal culture of control is slowly transitioning to a culture of enquiry and interconnectedness. There is greater teamwork in the multidisciplinary team of diverse OT personnel with positive support for QI projects as evident in this project.

“I would be open to having any further information sessions on the products available and what we could utilise in our theatres at this hospital to improve smoke evacuation in laparoscopic surgery.” (P4)

4.4 Summary

The participants emphasised the three themes, education on ESS and ESSE across disciplines as the key to influence OT personnel’s attitude and perceptions about ESS and ESSE to overcome barriers for consistent and effective ESSE. Participants speak of ESS with lack of knowledge about composition of ESS and do not seem to have intimate knowledge of the DHB policy on ESSE or the best practice guidelines. There appears to be a discrepancy in the availability of information regarding ESS, the potential health risks of ESS and effective utilisation of ESSE equipment and sterile supplies for open and laparoscopic procedures between participants. This may have implications for ESS control practices among diverse OT personnel leading to ineffective and inconsistent compliance with ESSE. Participants appear resentful at the perceived lack of organisational support for ESSE compared to protection from other dangerous OT hazards such as radiation from x-rays. Participants seem to be enthusiastic about full compliance with ESSE to mitigate the effects of hazardous ESS on OT patients and personnel.

Chapter 5: Discussion, Recommendations, and Conclusions

5.1 Introduction

This chapter provides the summary of the study, major findings as well as any unanticipated findings are discussed as related to the literature, to develop a better understanding of the diverse OT personnel's views, perceptions, and experiences about ESS control practices. This discussion addresses and answers the research questions. It provides OT professionals the valuable information to develop powerful strategies for effective and consistent ESSE, to mitigate OT patients' and personnel's risk of exposure to hazardous ESS. Conclusions based on findings are offered with the study's strengths and limitations, highlighting the implication for practice and recommendations.

As suggested by Hunter et al. (2019), participants' demographics further support this EDQ study to ensure a small purposeful sample of diverse OT personnel represented the multidisciplinary OT team. Although all participants had encountered ESS during electrosurgical procedures, none except one had prior training in surgical smoke safety. This is of concern, as the lack of training on surgical smoke safety could have influenced participants' ESS control practices.

5.2 Discussion

This study revealed that ESS control practices amongst diverse OT personnel at the DHB were not always effective and consistent. These findings concur with prior national and international literature that OT personnel fail to consistently comply with ESSE (Giersbergen et al., 2019; Holmes, 2016; McCamish, 2018; Steege et al., 2016).

As a result of this study, three major themes emerged from the data analysis. Firstly, education on ESS and ESSE across disciplines. Secondly, attitudes and perceptions about ESS and ESSE. Lastly, barriers and facilitators to ESSE. Although participants perceived ESS as harmful and hazardous with an unpleasant odour and viewed ESSE as an important yet complex issue, they had varied experiences with ESS and ESSE as described in this study. This finding

aligns with Watters et al. (2022) that ESS is hazardous with an unpleasant smell and ESSE is a complex health advocacy issue that requires collaboration and teamwork for successful implementation. This supports the researcher's assumption that ESSE is a complex issue, and that this inquiry is based on multiple realities which are socially constructed by diverse OT personnel in this study (Creswell & Creswell, 2018).

The findings indicate that although all participants displayed a positive attitude towards ESSE and were enthusiastic about full compliance with ESSE recommendations, the reality is different in clinical practice. According to 50% of participants, there were ESSE compliance issues across certain surgical subspecialties such as orthopaedics. Nevertheless, one of the participants acknowledged that ESSE is currently improving in orthopaedics due to the new portable ESSE machines. The new portable ESSE machine causes intermittent automatic ESSE when the diathermy pen is activated, unlike the previous built-in pendant smoke evacuation system, which had raised concerns among some orthopaedic surgeons, about the risk of joint infections due to continuous suctioning of air, pulling in air from outside the sterile field into the wound. However, this finding does not align with Hill et al. (2021) national survey of 157 British orthopaedic trauma units that the utilisation of ESSE increased from 42% to 81%; while the dependency on surgeon's preference decreased from 53% to 19% mainly due to the COVID-19 pandemic.

Despite an existing DHB policy that mandates ESSE for all ESS generating procedures (Waitematā DHB, 2017), only 50% of participants were aware of the DHB policy on ESSE. Those that were aware either had limited knowledge or were unfamiliar with the policy contents. This finding aligns with Stanley (2019), that despite ESSE policies, implementation is criticised due to lack of OT personnel's knowledge about ESS hazards and control measures leading to non-compliance. A previous survey at the researcher's DHB revealed that although 47% of nurses had worked in the OT for more than five years, 53% of nurses were unaware of the DHB policy on ESSE (Rodrigues, 2018).

More importantly, this study revealed an unanticipated finding at the DHB that highlights ESSE is increasingly being used during open surgical procedures, yet in laparoscopies ESSE is

not routine. This finding cannot be generalised due to the small sample size in this study. A few researchers have compared ESS in open versus laparoscopic surgeries, such as the production and composition of ESS (Hsu et al., 2022), exposure to ESS (Kameyama et al., 2022), and the potential risk of COVID-19 transmission through ESS (Mintz et al., 2020). However, the evidence is currently inadequate that aligns with or refutes this study finding, that compares OT personnel's compliance with ESSE in open versus laparoscopic surgery. In this study, 50% of participants indicate that compliance with ESS control practices is poorly upheld in laparoscopies, although ESSE is routine in open surgical procedures. A global study conducted on behalf of the Association of Italian Surgeons in Europe on appendicectomy during the COVID-19 pandemic found that a third of surgeons in the survey switched to open appendicectomy due to inconsistencies in laparoscopic ESSE with only a third having access to commercially available laparoscopic ESSE devices (Ielpo et al., 2020).

The findings indicate, ESSE in laparoscopies is surgeon-dependent with implementation at the discretion of surgeons together with laparoscopic filters not being opened until suggested by the surgeon. A previous survey on ESSE at the researcher's DHB indicated that 41% of OT nurses did not utilise ESSE, with 27% commenting that it was due to surgeon's preference (Rodrigues, 2018). Similarly, a large web-based survey conducted by the PNC of NZ during registration/renewal of the PNC membership with 686 NZ perioperative nurse respondents, identified surgeon's refusal to utilise ESSE was the greatest barrier to being smoke-free in the OT (McCamish, 2018). Conversely, Lotfi et al. (2022) identified the main barrier to ESSE was the lack of ESSE equipment and facilities in the OT, which does not align with this study finding.

In this study 33% of participants indicate that the current laparoscopic ESSE filters at the DHB are ineffective. It was further highlighted by one of the participants that the current laparoscopic filters sometimes impair the pneumoperitoneum when the ESSE is turned on high-suction; however, when ESS builds up inside the abdominal cavity it impairs surgical site visibility and prolongs intraoperative time as the laparoscopic ESSE filters are ineffective and take a long time to work. According to Dobrogowski et al. (2014), when ESS builds up in the abdominal cavity, it could be harmful to the patient due to toxic compounds in ESS being

absorbed into the patient's bloodstream through the peritoneum. Further a third of the participants in this study indicated that it is a common practice at the DHB for the surgeon to intermittently open a laparoscopic portal valve, to let out the intra-abdominal pressurised gas containing ESS into the OT environment, exposing OT personnel to hazardous ESS. This finding concurs with (Choi et al., 2014) that in laparoscopies the concentrated pressurised ESS from the abdominal cavity although suctioned occasionally, is often released by opening a portal valve causing a chimney effect whereby aerosolised abdominal gas jets out exposing the OT personnel to hazardous ESS. Researchers warn that OT personnel should take appropriate measures to minimise ESS exposure due to not only short-term risks but also long-term risks of exposure to ESS (Choi et al., 2014).

The findings pointed out that the inconsistent ESSE in laparoscopies could be due to OT personnel's misconception that ESS is not so much of an issue in laparoscopies as the smoke is contained inside the abdominal cavity. However, Dobrogowski et al. (2015) argue that copious amounts of ESS is confined to the abdominal cavity in laparoscopies for a period of time that may be toxic, mutagenic, carcinogenic and genotoxic. If not effectively evacuated, this dangerous ESS could leak through the trocars into the OT environment during manipulation of laparoscopic instruments with inherent health risks to OT patients and personnel during laparoscopies. Hence, researchers recommend effective ESSE with an active or passive laparoscopic filter to ensure protection from hazardous ESS (Dobrogowski et al., 2015).

Surgical masks were being utilised by 50% of participants in this study with a misconception that the surgical mask protects them from ESS. This finding aligns with Ilce et al. (2017), where 88.9% of doctors and nurses used surgical masks for self-protection from ESS. The findings also concur with Giersbergen et al. (2019), where 65% of nurses used surgical masks to protect themselves from ESS. However, surgical masks are inefficient at providing protection from ESS as they filter particles larger than 5 microns and ESS particle size could be as small as 0.07 microns (Okoshi et al., 2015; Rodrigues, 2018). The best practice guidelines for surgical smoke safety recommend utilising ESSE with LEV in addition to OT ventilation of 20 air exchanges per hour as the primary protection against the hazards of ESS; and fit-tested N95

particulate filtering respirator/mask as secondary protection when indicated for residual ESS (Ogg, 2021). However, the DHB policy states that ESSE should be used when ESS is anticipated and additional control of ESS can be achieved through safe work practices with the use of PPE such as a 0.1micron filtration mask, gloves and eye-shields depending on the surgical procedure (Waitematā DHB, 2017). These study findings together with critical analysis of the DHB policy on ESSE indicate certain aspects of the policy are ambiguous and need updating as they are giving rise to compliance issues (Waitematā DHB, 2017). Lotfi et al. (2022) argue that policies and evidence-based guidelines are vital to deal with occupational hazards such as ESS in the OT to reduce risks and increase safety of OT patients and personnel. Similarly, Ball and Gilder (2022) assert that ESSE policy is the foundation for practice to provide standardisation and consistency, as well as to measure compliance and quality assurance. However, a gap exists between safe practice recommendations and ESS exposure, hence an up-to-date evidence-based policy should support effective and consistent ESSE (Ball & Gilder, 2022).

More importantly, this study revealed that ineffective and inconsistent ESSE in laparoscopies is significant, as it could be the main reason for the unpleasant ESS smell in the OT corridors, exposing OT patients and personnel to hazardous ESS. These findings align with Asdornwised et al. (2018), where 63.7% of nurses reported not using laparoscopic ESSE exposing perioperative nurses to hazardous ESS. Zakka et al. (2020) warn that significant amount of bioaerosol is generated during laparoscopies due to ESS and carbon dioxide insufflation. Hence, port venting with sudden release of pneumoperitoneum should be avoided with effective ESSE and correct utilisation of PPE due to paucity of evidence regarding COVID-19 transmission risks through ESS during laparoscopies (Zakka et al., 2020). Research has evidenced carbon monoxide toxicity in patients during laparoscopies (Marsh, 2012), laparoscopic port-site metastasis in tumour resection (Mowbray et al., 2013) and infectious hepatitis B virus transmission risks to OT personnel during laparoscopies (Kwak et al., 2016), as well as HPV transmission risks through ESS during loop electrosurgical excision procedures (Hu et al., 2021). ESS in laparoscopies is hazardous and carcinogenic with long-term ill-effects on OT personnel (Choi et al., 2014). A large volume of laparoscopies is performed regularly in the OT at the DHB, generating ESS with

potential short and long-term risks to OT patients and personnel. Therefore, this study revealed that a key area for improvement is to ensure more effective methods for laparoscopic ESSE with education and training across disciplines on ESS and ESSE as a priority.

This study revealed that the participants' attitudes and perceptions about ESS and ESSE were influenced by their knowledge about ESS and ESSE. Although participants presented a positive attitude towards ESSE, it was pointed out that education on ESS and ESSE across disciplines is the key to achieving consistent ESSE among OT personnel. Specifically, education of the harmful effects of ESS is vital to raise awareness among OT personnel with effective management of ESSE. In this study, 33% of participants highlight that ESSE is an important issue but is not often spoken about in the OT, despite ESS being regularly generated during electrosurgical procedures. Although all participants perceived ESS as toxic to OT patients and personnel, they were unsure of the composition of ESS and its potential harmful effects, which could lead to inconsistent and ineffective ESSE. This may not necessarily be related to OT personnel's ability to utilise ESSE but is reflective of the OT education and orientation programme to enable OT personnel to safely recognise and manage OT hazards such as ESS. Likewise, other researchers argue that education of all OT personnel is crucial to create greater awareness on the harmful effects of ESS, thereby encouraging ESSE to mitigate risks of ESS (Giersbergen et al., 2019; Holmes, 2016; Tan & Russell, 2019). Giersbergen et al. (2019), point out that OT personnel's refusal to utilise ESSE is usually a reflection of their lack of knowledge about ESS; Holmes (2016) as well as Tan and Russell (2019) literature review revealed that ESS is a controllable occupational hazard in the OT which can be overcome through regular education of OT personnel about ESS and effective ESSE with strong leadership support. Moreover, Merajikhah et al. (2022) argue that the best way to control and prevent surgical smoke complications is to educate all OT personnel across disciplines including students from the time of entry to the OT about the surgical smoke risks and ways to reduce or eliminate it.

All participants stated they regularly smelt ESS in the OT. Similarly, Ilce et al. (2017) survey revealed that 42.2% of nurses and 36.1% of doctors complained that their hair absorbed bad odours of ESS. Moreover, some participants described ESS as a nasty bad smell, with 50%

of participants concerned about carcinogenic risk, while others found ESS scary, and feared long-term health risks from ESS. A recent study of the chemical composition of surgical smoke produced in open versus laparoscopic surgery for cholecystectomy identified 140 organic compounds with numerous toxic, mutagenic and carcinogenic chemicals, besides biological risks including cells, pathogens, viruses, tissue debris and chemical compounds that cause the unpleasant odours in ESS (Hsu et al., 2022). The findings further align with Vortman et al. (2021) who argue that ESSE although available is inconsistent amongst OT personnel, putting OT nurses' health at risk, raising concerns about long-term health effects and nurse retention.

Moreover, 33% of participants perceived ESS as toxic or noxious stimuli, comparing it to cigarette smoke that is harmful to OT patients and personnel. This concurs with a seminal study by Tomita et al. (1981) that proved one gram of electro-surgically ablated tissue is equal to the mutagenicity of smoking six unfiltered cigarettes. Additionally, UK researchers in a plastic surgery OT proved that ESS produced on a daily average was equivalent to 27-30 cigarettes (Hill et al., 2012). It can be strongly argued that all participants in this study discerned that ESS should warrant the same attention as any other OT hazard as part of OT safety. However, two out of six participants identified that there is a perceived lack of organisational support in recognising ESS as a safety hazard when compared to other OT hazards such as x-ray radiations and sharps. These findings concur with Ball (2012) and Steege et al. (2016), who argue that strong leadership support is a key indicator of compliance with ESSE, to ensure ESS is recognised as a hazard, with availability of ESSE equipment and policy mandate to promote compliance with ESSE. Specifically, one of the study participants pointed out that OT personnel are regularly cautious to utilise lead aprons as a precautionary measure with x-rays, yet the same principles of protection are not followed with hazardous ESS. According to Steege et al. (2016), this may be due to managers not being aware of ESS hazards or lack of commitment to control ESS. This study finding was further supported by Scott et al. (2014) who utilised education and management support to overcome barriers and succeeded in achieving full compliance with ESSE in a private surgical hospital in NZ. Researchers further suggest that raising awareness among OT personnel about ESS and ESSE is key to compliance with ESSE.

Ball and Gilder (2022) argue that risk managers and facility administrators should realise the potential for lawsuits as four out of five participants in their study had received monetary compensation after filing a Workers' Compensation claim in the United States of America because of surgical smoke exposure. Currently, in NZ there is no government standard or legislation that mandates ESSE, despite a growing body of evidence on the hazardous nature of ESS (Ball & Gilder, 2022; Özdemir et al., 2020; Vortman et al., 2021; Zakka et al., 2020). Although the goal of NZ MOH is to work towards a smoke-free nation by the year 2025 (MOH, 2021), this critical need for a healthier smoke-free work environment for OT personnel and patients has not yet received any emphasis.

Participants perceive ESSE as an important topical issue and identified that OT personnel lack training on the use of ESSE equipment such as LEV. Participants stated that some OT personnel are unsure in setting up the LEV, its functioning and maintenance with change of filters as well as the options available for ESSE. These findings concur with Steege et al. (2016), where 44% of respondents had never received any training on ESSE. This study suggests that it is vital for all OT personnel across disciplines to receive orientation, education, and training on ESS and ESSE as part of the theatre safety programme with regular in-service from company representatives for proper setting up and maintenance of the LEV equipment which concurs with (Ogg, 2021). This knowledge would then empower OT personnel to speak up if there is any inconsistency in ESSE among OT personnel. The findings further revealed that the nurses had a positive influence as a change-agent in ESSE at the DHB. One of the participants admitted that the surgeons rely on nursing colleagues; for example, when ESSE was first introduced in open surgeries the surgeons were encouraged by nurses to utilise ESSE and soon ESSE became a routine in open surgical procedures. These findings align with Ball (2012) that compliance to ESSE is strongly linked to nurses' training and education on ESSE, with the individual nurse remaining the focal point of changing behaviours and practice in OT through education. However, Okoshi et al. (2015) argue that surgeons should assess the potential hazards of ESS and educate OT personnel to minimise potential health hazards to OT patients and personnel.

All participants experienced the noxious smell of ESS, a few others experienced ill-effects such as headache, nausea, and one participant experienced metallic taste in the mouth when the diathermy came in direct contact with metallic implants. Concerns were also raised about long-term exposure risks of damage to lungs, transmission of carcinogens from burning cancerous tissue, worsening of any pre-existing conditions and virus transmission risks. Further concerns were about the plausible COVID-19 transmission risks to OT personnel through inhalation of aerosolised ESS in the current COVID-19 pandemic. These findings concur with Ball and Gilder (2022) and Giersbergen et al. (2019). Ball and Gilder (2022) survey identified that exposure to ESS caused headache, lacrimation, nose bleeds, emphysema-like conditions, nasal and/or vocal cord polyps, leukaemia and the most frequent condition being nasal congestion with majority of nurses concerned about COVID-19 transmission risks through aerosolised ESS. Similarly, Giersbergen et al. (2019) reported that OT nurses in Turkey experienced headache, nausea, vomiting, hypoxia, dizziness, conjunctivitis, hepatitis, anaemia, lacrimation, throat irritation, acute and chronic respiratory changes. Merajikhah et al. (2022) identified in their systematic review that ESS which is toxic, carcinogenic, and mutagenic caused ill-effects such as headaches, dizziness, lacrimation, and damage to nasal mucosa in the long-term, as well as could transmit live HPV and hepatitis B virus. However, no studies have proved SARS-CoV-2 transmission through ESS. Although 50% of participants in this study suggested that it was theoretically plausible for the risk of SARS-CoV-2 transmission through ESS. This concurs with Lotfi et al. (2022) that the participants had moderate concerns about acquiring viruses such as HPV, hepatitis B and COVID-19 due to prolonged exposure to ESS. Similarly, Ball and Gilder (2022), argue that concerns have been raised in laparoscopies regarding the ESS in abdominal insufflation gas containing SARS-CoV-2 in COVID-19 positive patients as it can be propelled into OT personnel's breathing zone during laparoscopies. Researchers recommend the use of guidelines for ESSE during laparoscopy published by the Society of American Gastrointestinal and Endoscopic Surgeons in 2020, for the safety of OT patients and personnel (Ball & Gilder, 2022).

In this study 33% of participants stated that some OT personnel display a complacent, blasé attitude towards ESS, although all participants perceived ESS could potentially cause damage to

the lungs. Therefore, it could be argued that OT personnel have developed a tolerant, incautious attitude towards ESS, especially during small cases and laparoscopies as described in this study. This finding concurs with Lindsey et al. (2015) that OT personnel's attitude of tolerance towards ESS appear to be a significant issue that could influence compliance with ESSE. As evidenced by 33% of participants in this study that some OT personnel utilise the regular diathermy rather than utilising the one with incorporated ESSE, as it is cost-effective when they perceive it to be a quick case, for example during small colorectal cases. Conversely, one of the participants suggested utilising ESSE even for a short case as it would reduce the cumulative effects of ESS on OT personnel.

This study indicates that some OT personnel ignored the smell of ESS once the ESSE was connected. As pointed out by one of the participants that it could be due to a lack of knowledge of setting up the LEV equipment for ESSE or a complacent attitude that once the ESSE equipment was plugged in, it was assumed it was functioning and not checked. Hence the study findings concur with Lotfi et al. (2022) that there exists a direct relationship between OT personnel's attitude and practice where knowledge about surgical smoke can raise awareness among OT personnel across disciplines including nursing managers and medical staff. This can lead to change in attitudes and beliefs that are deeply and scientifically structured creating a positive attitude to implement appropriate ESS control practice and improving safety in the OT (Lotfi et al., 2022).

The enablers for effective and consistent ESSE identified in this study were availability of ESSE equipment, maintenance with regular audits, management support in conducting QI initiatives, inter-connectedness between diverse OT personnel, and nurses versus surgeons' influence as a change-agent to promote ESSE. This aligns with Ball (2012) who identified similar facilitators to ESSE. Although this study identified the biggest barrier to ESSE is in laparoscopies as previously discussed, the other barriers identified were OT personnel's lack of knowledge and education about ESS and ESSE, culture of resistance to change including surgeon's preference, noisy ESSE equipment, bulky ESSE pencil which is not long enough for deep cavities and OT personnel's complacent attitude. This concurs with Holmes (2016) who identified barriers to

ESSE were surgeon's preference, refusal, or resistance to utilise ESSE, noisy or bulky ESSE system design and dismissive attitudes towards risks of ESS, while enablers to ESSE were identified as strong leadership support and education of all OT personnel including surgeons.

This study identified that there appears to be a lack of education and training about ESS and ESSE among participants. Specifically, one participant had received minimal education on ESS and ESSE, while another participant had to learn ESSE by reading the ESSE equipment manual. Importantly, two participants confirmed that surgeons received education on the principles of electro-cauterisation, but not on ESS or ESSE, with most of them learning by observing colleagues or from nurses to utilise ESSE. Although the findings cannot be completely generalised across all OT personnel at the DHB as it is limited by the small sample size, these findings are contrary to the recommendations provided in the current DHB policy on ESSE (Waitematā DHB, 2017) and the best practice guidelines (Ogg, 2021). The recommendations state that all OT personnel who use ESSE should receive initial education, training and competency validation on the use of ESSE with regular in-service and updates (Ogg, 2021; Waitematā DHB, 2017). This finding further aligns with Ha et al. (2018), that all surgeons and surgical trainees had a significant knowledge gap in the safe and effective use of the electrosurgical device. Similarly, Özdemir et al. (2020) identified that surgeons, besides understanding the mechanism of action of the electrosurgical unit, lack the knowledge of prevention and management of ESS. Hence this study identified that the knowledge and awareness of the risks of ESS affect diverse OT personnel's attitudes towards ESSE whereby some OT personnel choose to utilise ESSE, while others insist not using it. This concurs with Lotfi et al. (2022), that OT personnel's positive attitude has a direct relationship to consistent and effective ESSE. Moreover, ESSE is influenced by their knowledge through education on ESS hazard prevention, with appropriate ESSE equipment and supportive managers as well as ESSE policies and guidelines (Lotfi et al., 2022).

One of the participants in this study perceived ESSE to be an important but very complex issue that required a team approach and found it difficult to address the issue as it is surgeon-lead, needing surgeon's buy-in. Likewise, Swerdlow (2020) found that OT nurses and anaesthetists often feel powerless to decide on issues related to ESSE as it needs cooperation from surgeons.

Two of the participants in this study explained that it could be difficult to access smaller and deeper incision sites with ESSE pencil, due to its bulkiness compared to diathermy without ESSE. The findings further concur with Swerdlow (2020) that although ESS is a well-established occupational hazard for OT personnel, barriers to ESSE were lack of education on ESS hazards, surgeon's preference with reluctance to use ESSE and decreased visibility due to the bulky, noisy ESSE device. The researcher argues that anaesthetists should strongly advocate for ESSE, just the way they supported and were successful with perioperative smoking cessation (Swerdlow, 2020).

Participants reported that the new young surgeons utilise ESSE all the time, perceiving that it could be the culture, where some surgeons feel that they have never used ESSE before so why use it now? This was further reiterated that some surgeons prefer the diathermy without ESSE, as they are old school and do not want to let go of the familiar to embrace change. Hence, some surgeons' preference cards which is a list that specifies equipment, sterile supplies, patient positioning and OT setup that each surgeon prefers for the surgical procedure were not updated with the ESSE sterile supplies. Schultz (2014) argues that compliance with ESSE requires a more robust approach than a mere discussion of the harmful effects of ESS; besides education of OT personnel on ESS, the high-quality ESS evacuator should be cost-effective, easy to use, effectively evacuate ESS and should operate quietly without distraction. The researcher points out that the barriers to ESSE could be noisy ESSE equipment, dismissive attitude of OT personnel and surgeons' refusal to use equipment (Schultz, 2014). This further aligns with McCamish (2018), where the greatest barrier to ESSE was surgeons refusing to utilise ESSE equipment.

Conversely, one of the participants in this study asserted that it is not always the surgeon's decision but the nurses who do not utilise ESSE for short colorectal cases trying to save on resources and costs. However, Steege et al. (2016) argue that the decision about utilising ESSE should not be made at the discretion of an individual practitioner when the whole team and the patient is exposed to hazardous ESS. Likewise, Tokuda et al. (2020) argue that minimising ESS risks to OT patients and personnel should take priority compared to costs of ESSE systems, and its effectiveness should increase OT personnel's awareness of its benefits over drawbacks.

Furthermore, Matthews (2016) argues that cost cannot be utilised as an excuse for failing to protect OT personnel from ESS.

Overall, these findings suggest that ESS control practices among diverse OT personnel are inconsistent and not always effective at the DHB. However, education about ESS and ESSE across disciplines has a direct effect on raising awareness of the harmful effects of ESS on OT patients and personnel. This knowledge among OT personnel could lead to a positive attitude towards ESSE to overcome barriers with innovative strategies for consistent and effective ESSE. It must be borne in mind that this study was a practice project conducted on a small purposeful sample of diverse OT personnel over a short period of time. Hence further research exploring ESS control practices among OT personnel in other hospitals across NZ with a larger sample size could compare findings before generalised conclusions can be drawn.

5.3 Strengths and Limitations

The strengths of this study are the voluntary participation in this qualitative research, with the EDQ methodology being congruent, consistent and auditable, ensuring that the research conducted was rigorous, where the findings represent the participants' voice. The virtual interviews were conducted at a time suitable to the participants. A major strength of this study is that it involves a purposeful sample of diverse OT personnel representing multidisciplinary professionals such as nurses, surgeons, anaesthetists and anaesthetic technicians from a large DHB in NZ to address a core health and safety issue by exploring ESS control practices in the OT. With regards to limitations, this was a small study carried out for a practice project in partial fulfilment of the requirements for the degree of Master of Health Practice and therefore subject to the time constraint of completing within a year. Besides, there were critical obstacles due to the COVID-19 pandemic such as changing interviews from face-to-face to virtual, causing further time constraints. The advertising poster recruitment strategy utilised, attracted only potential participants who were working during the two weeks when the poster was displayed. A further limitation is that despite the researcher adhering to basic principles of honesty, transparency and accuracy, the data was analysed by only the researcher, thus posing a potential unintentional bias. Furthermore, the findings cannot be generalised due to the small sample size and OT personnel

from all surgical specialties around NZ may not have been represented. Moreover, the limitations of the qualitative paradigm in this EDQ study are that the findings are subjective and context-specific (Polit & Beck, 2018).

5.4 Implications of Findings

The significance of this study is that the findings contribute to the body of knowledge and understanding about the complex issue of compliance with ESSE among diverse OT personnel by discovering barriers to effective and consistent ESSE. The study highlights that the biggest barrier is in laparoscopies, specifically due to laparoscopic ESSE being at the discretion of the surgeon and filters not being opened until suggested by the surgeon. The study revealed OT personnel's lack of education and training on ESS and ESSE resulted in complacent and tolerant attitude towards ESS. Despite the regular smell of ESS in the OT, surgical masks were used for self-protection although they were inefficient protection against ESS. Therefore, education on ESS and ESSE of OT personnel across disciplines with management support is the key to increase knowledge and awareness about potential risks of ESS and appropriate usage of ESS control methods. This could help create a positive attitude towards ESSE among OT personnel to overcome barriers to ESSE and promote compliance with effective ESS control practices. This will mitigate OT personnel's and patients' risk of exposure to hazardous ESS, promoting a healthy smoke-free OT environment. The findings will be utilised to update the DHB policy on ESSE that has come for review (Waitematā DHB, 2017). The senior OT leadership team together with clinical directors of each surgical sub-specialty can work to communicate and discuss with different manufacturers and distributors especially in laparoscopies, to trial and improve ESSE equipment and supplies that are cost-effective, ergonomic and easy to use with minimal noise, that activates automatically when ESS is detected. Furthermore, the knowledge gained will be utilised to develop educational sessions, and OT personnel providing testimonials of ill-effects from ESS could be very powerful to optimise educational programme implementation and promote ESSE. Moreover, for sustainable continued QI, a web-based educational session on ESS and ESSE can be designed to promote awareness with annual competency validation to promote a safe and healthy smoke-free OT environment for patients and staff. More importantly, a healthy

smoke-free OT environment will draw nurses to perioperative practice and promote nurse retention to boost the current OT nursing shortage (Elley, 2016).

5.5 Recommendations

An important step in nursing research is the application of new knowledge and translating the findings by integrating them into practice. By conducting this practice project it was apparent that the study findings provide the basis for significant recommendations within this DHB as follows:

1. Update the DHB policy on ESSE with details on implementing primary controls to reduce ESS exposure. OT ventilation with engineering controls of 20 air exchanges per hour, work practice controls with ESSE systems and administrative controls with policy, education and training. In addition to ESSE, the second level of defence against ESS will be wearing PPE such as gown, gloves, eye protection and fit-tested N95 respirator/mask during any high-risk, aerosol-generating procedure or for procedures on patients with known or suspected aerosol transmissible diseases (Fencl, 2017; Ogg, 2021).
2. Develop and implement an education programme on ESS and ESSE across disciplines with PowerPoint presentations and hands-on training/practice with ESSE company representatives with focus on educating all OT personnel (Chavis et al., 2016).
3. Display posters on the OT quality board to raise awareness on the hazards of ESS. Presenting evidence-based references about the harmful effects of ESS on OT patients and personnel on posters as well as leaving literature on the break-room tables could raise awareness among OT personnel on hazards of ESS (York & Autry, 2018).
4. Update all surgeon's preference cards with appropriate ESSE products. Communicate and collaborate with surgeons and team leaders to discuss surgeon's preference and find solutions to barriers (Chavis et al., 2016).
5. Ensure availability of appropriate ESSE equipment and supplies with material resource centre to streamline ESSE supply inventory (Chavis et al., 2016).
6. An electronic prompt on the intra-operative record for documenting the usage of ESSE as currently there is no documentation of ESSE (Ostapovych & Vortman, 2022).

7. Regular feedback from OT personnel on ESSE equipment and supplies for open and laparoscopic procedures to acquire new products to meet contemporary needs for ESSE. Contact smoke evacuation product representatives from multiple companies to trial samples of smoke evacuating products for open and laparoscopic procedures (York & Autry, 2018).
8. Carry out intraoperative prospective observational audits on effective usage of ESSE and retrospective documentation audit on usage of ESSE annually for quality assurance (Fencel, 2017).
9. Garner management support to ensure ESS is introduced as an occupational hazard on the OT Health and Safety register by monitoring compliance and reporting non-compliance of ESSE (Vollweiler, 2017).
10. Disseminate research findings to participants and the wider perioperative community to influence ESSE by publishing the study in a peer-reviewed local nursing journal.

Importantly, it is vital for all OT personnel, hospitals, and organisations such as the NZNO, the PNC of NZ, and International Council on Surgical Smoke Plume to lobby WorkSafe NZ, who administer the legislation, to include guidelines mandating ESSE in their resources for the safety of OT patients and personnel from hazardous ESS.

Recommendations will be implemented through an action plan and evaluated for continuous QI utilising the Institute for Healthcare Improvement strategy of Plan-Do-Study-Act (PDSA) cycles based on JHEBP model for nurses and healthcare practitioners (Dang et al., 2021, p. 64).

5.6 Future Research

It would be beneficial to continue exploring ESS control practices amongst diverse OT personnel in other hospitals around NZ to compare results with the current findings, since there is a lack of research on ESSE policy implementation and compliance with ESSE. This could cause a ripple effect to promote QI with effective and consistent ESSE in the OT across hospitals in NZ. Research on organisational influence to implement ESSE programmes would be beneficial to

highlight the complexities of implementing evidence-based recommendations. Furthermore, research could prospectively examine the incidence of compliance with ESSE in open versus laparoscopic surgeries in clinical practice. This will enable further systematic steps to be taken to create and sustain a healthy smoke-free environment for OT patients and personnel.

5.7 Conclusions

ESS is a controllable occupational hazard in the OT and efforts should be made to eliminate or minimise its risks to OT patients and personnel. This study highlights that effective ESS control practices are inconsistently implemented by OT personnel at a large DHB in NZ with an inherent risk of exposure to hazardous ESS for OT patients and personnel. Findings identified that although ESSE is routine in open surgical procedures, it is poorly upheld in laparoscopies. Certain aspects of the DHB policy on ESSE are ambiguous and require updating.

Findings indicate that OT personnel's knowledge and awareness of the risks of ESS have a direct relationship with their attitudes and perceptions towards ESS, which is found to influence their ESS control practice. Participants perceived ESS as harmful and hazardous, and displayed a positive attitude towards ESSE, viewing it as an important but complex issue. However, participants were unaware of the composition and risks of ESS, with only one of the participants having received training on surgical smoke safety. Some participants were under the misconception that surgical masks protect them from ESS. Findings identified that lack of knowledge about risks of ESS creates a tolerant attitude towards ESS and an incautious, complacent attitude towards ESSE. Hence, some OT personnel find implementing ESS control practices beneficial while others do not, thereby causing unconscious exposure of OT patients and personnel to hazardous ESS. However, ESSE should not be at the discretion of individual OT personnel, as the entire OT team is exposed to hazardous ESS. Participants appear resentful at the perceived lack of organisational support for ESSE, when compared to protection from other similar OT hazards such as x-ray radiations and sharps.

Besides the routine smell of ESS in the OT, the participants experienced noxious ESS, nausea, headaches, and on one occasion metallic taste in the mouth, when the diathermy came in

direct contact with metallic implants. Participants were concerned about risks of damage to the lungs, worsening of pre-existing conditions, transmission of carcinogens from electrosurgically dissected cancerous tissue, and plausible COVID-19 transmission risks through aerosolised ESS in the current COVID-19 pandemic. Participants compared ESS to cigarette smoke with linkage to carcinogens and uncertainty of long-term health risks.

Barriers to ESSE identified were lack of knowledge and education on ESS and ESSE, culture of resistance to change, and the biggest barrier was in laparoscopies. Regular audits and maintenance of ESSE equipment, nurses versus surgeons' influence as change-agent to promote ESSE were identified as facilitators to ESSE.

The data analysis revealed that education on ESS and ESSE of OT personnel across disciplines, with strong leadership support is the key to influence positive attitude towards ESSE. This knowledge is vital to overcome barriers for effective and consistent ESSE to mitigate the risks of ESS on OT patients and personnel. Overall, the study findings provide a snapshot of ESS control practices among diverse OT personnel at the large DHB in NZ. This is just the beginning of an achievable goal, in the pursuit of a smoke-free OT environment for the safety of OT patients and personnel. The findings will inform policy and raise awareness among OT personnel by conducting education sessions across disciplines to promote effective ESSE and improve clinical practice at the DHB. It may contribute to the existing literature on compliance with ESSE and provide a platform for further research on ESSE.

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Appendices

Appendix A: Ethics approval from AUTECH



Auckland University of Technology Ethics Committee (AUTECH)

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www.aut.ac.nz/researchethics

20 August 2021

Rhona Winnington
Faculty of Health and Environmental Sciences

Dear Rhona

Re Ethics Application: **21/276 Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTECH).

Your ethics application has been approved for three years until 20 August 2024.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the [Auckland University of Technology Code of Conduct for Research](#) and as approved by AUTECH in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTECH prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTECH Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTECH Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.
8. AUTECH grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any [enquiries](#) please contact ethics@aut.ac.nz. The forms mentioned above are available online through <http://www.aut.ac.nz/research/researchethics>

(This is a computer-generated letter for which no signature is required)

The AUTECH Secretariat
Auckland University of Technology Ethics Committee

Cc: jtj3560@aut.ac.nz

Appendix B: Ethics approval for amendment from AUTECH



TE WĀNANGA ARONUI
 O TĀMAKI MAKAU RAU

Auckland University of Technology Ethics Committee (AUTECH)

Auckland University of Technology
 D-88, Private Bag 92006, Auckland 1142, NZ
 T: +64 9 921 9999 ext. 8316
 E: ethics@aut.ac.nz
 www.aut.ac.nz/researchethics

14 September 2021

Rhona Winnington
 Faculty of Health and Environmental Sciences

Dear Rhona

Re: Ethics Application: **21/276 Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study**

Thank you for your responses to the conditions for the amendment to your ethics application.

The amendment to the data collection protocol (online interviews) has been approved.

Standard Conditions of Approval.

1. The research is to be undertaken in accordance with the [Auckland University of Technology Code of Conduct for Research](#) and as approved by AUTECH in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTECH prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTECH Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTECH Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard.
8. AUTECH grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted. When the research is undertaken outside New Zealand, you need to meet all ethical, legal, and locality obligations or requirements for those jurisdictions.

Please quote the application number and title on all future correspondence related to this project.

For any [enquiries](#) please contact ethics@aut.ac.nz. The forms mentioned above are available online through <http://www.aut.ac.nz/research/researchethics>

(This is a computer-generated letter for which no signature is required)

The AUTECH Secretariat
Auckland University of Technology Ethics Committee

Cc: jj3560@aut.ac.nz

Appendix C: Letter of support

Assunta Rodrigues (WDHB)

From: Stephanie van Zyl (WDHB)
Sent: Thursday, 25 March 2021 16:04
To: Assunta Rodrigues (WDHB)
Subject: RE: Request to please confirm your approval of the electrosurgical smoke evacuation research project

Hi Assunta

I fully support and approve your request to conduct the locality study on Electrosurgical Smoke Evacuation.

I wish you all the best and success with this.

Kind regards

Steph

Stephanie van Zyl | Acting Operations Manager Theatres

NSH | Waitemata DHB

*Shakespeare Road, Private Bag 93 503
mob: 021728405*

E: Stephanie.vanzyl@waitematadhb.govt.nz

www.waitematadhb.govt.nz

Appendix D: Waitematā DHB locality authorisation

6/27/2021

WDHB Locality Authorisation

WDHB Locality Authorisation

Research & Knowledge Centre [research@waitematadhb.govt.nz]

Sent: Friday, June 25, 2021 4:25 PM**To:** Assunta Rodrigues (WDHB)

Dear Assunta

The Research & Knowledge Centre has now received the relevant approvals for the following study:

Title: Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study

Registration #: RM15041

This study now has Waitematā DHB Locality Authorisation. All amendments to your study must be submitted to the Research & Knowledge Centre for review.

Note that all research, audit and related activity must meet ethical standards in relation to the safe storage, retention and disposal of research data.

At the conclusion of this study a copy of any outputs, reports or publications should be forwarded to research@waitematadhb.govt.nz

Good luck with your study.

Regards
Research & Knowledge Centre
Waitematā DHB

research@waitematadhb.govt.nz
ph. (09) 486 8920 ext 42071

Appendix E: Consent form



TE WĀNANGA ARONUI
O TĀMĀKI MAKĀU RAU

Consent Form

For use when interviews are involved

Project title: *Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study*

Project Supervisor: *Rhona Winnington*

Researcher: *Assunta Rodrigues*

I have read and understood the information provided about this research project in the Information Sheet dated --/--/--- dd mm ~~2021~~.

I have had an opportunity to ask questions and to have them answered.

I understand that notes will be taken during the virtual interview and that the interview will also be audio-taped and transcribed.

I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.

I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.

I agree to take part in this research.

I wish to receive a summary of the research findings (please tick one): Yes No

~~Participant's~~ signature :

~~Participant's~~ Name :

~~Participant's~~ Contact Details for the Virtual Interview either ~~e-mail~~ or smartphone number :

Date :

Approved by the Auckland University of Technology Ethics Committee on 14th September 2021, AUTEK Reference number 21/276

Note: The Participant should retain a copy of this form.

Appendix F: Demographic form



The header of the form features a decorative background of overlapping brown and tan squares on the left. On the right, there is a dark grey rectangle containing the 'AUT' logo in white, and below it, a red rectangle with the Māori text 'TE WĀNANGA ARONUI O TĀMAKI MAKĀU RAU' in white.

Demographic Form

Project title: Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study

Project Supervisor: Rhona Winnington

Researcher: Assunta Rodrigues

- Profession: Surgeon/ Nurse /Anaesthetist/ Anaesthesia Technician (Circle one)
- How many years of experience in your profession
- Gender: Female / Male / Other_ (circle one)
- Age group: 23 – 40 yrs./ 40 – 50 yrs. / 50 – 65 yrs. (circle one)
- Worked in the operating theatre at Waitemata DHB for more than six months. Yes/No
- Have had training /participated in a surgical smoke safety program? Yes/No
- Attended surgeries that produced electrosurgical smoke during tissue dissection in the operating theatre: Yes No

Participant's signature :

Participant's name :

Date :

Approved by the Auckland University of Technology Ethics Committee on 14th September 2021 AUTEK Reference number 21/276

Note: The Participant should retain a copy of this form.

Appendix G: Advertising poster



Research Volunteers Wanted

EXPLORING ELECTROSURGICAL SMOKE CONTROL PRACTICES AMONG NEW ZEALAND OPERATING THEATRE PERSONNEL: A QUALITATIVE STUDY



This is an invitation to participate in a research project being conducted by Assunta Rodrigues.

Who:

- Operating theatre personnel such as Nurses, Anaesthesia Technicians, Anaesthetists and Surgeons. (To avoid conflicts of interest as the researcher is an Operating Theatre Coordinator at North Shore Hospital, only nurses from Elective Surgical Centre can volunteer to participate and rest of the participants will be from North Shore Hospital)
- Working for more than six months at Waitemata DHB Operating Theatres

What:

- The goal of this research is to gain a better understanding of the operating theatre personnel's attitudes towards "Electrosurgical Smoke," and the perceived facilitators and barriers associated with their compliance to effectively evacuate electrosurgical smoke.

When:

- This research will take place between September and October 2021.

How:

- Participation will be voluntary, and all information will be confidential
- Participation will involve individual semi-structured 45 to 60 minutes virtual interviews
- A purposeful sample of six participants
- Participants may withdraw from the research study at any time
- Confidentiality will be guaranteed by utilising pseudonyms to maintain privacy of participants in data gathering, analysis and in reporting the findings
- Informed consent will be obtained from the participants before conducting the interviews
- A thank you gift will be given recognising the value of participant's contribution to the research

If you wish to participate in this research, please email for further details
Theatre.Reception@waitematadhb.govt.nz with subject: Electrosurgical smoke evacuation project.

Appendix H: Confidentiality agreement



TE WĀNANGA AROHUI
O TĀMAKI MĀKAU RAU

Confidentiality Agreement

Person assisting the researcher to please tick and sign the appropriate statements, e.g. the transcriber/ Operating Theatre Receptionist at North Shore Hospital.

Project title: *Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study*

Project Supervisor: *Dr Rhona Winnington*

Researcher: *Assunta Rodrigues*

- I understand that all the interviews I will be asked to transcribe is confidential.
- I understand that the contents of the interview recordings can only be discussed with the researcher.
- I will not keep any copies of the transcripts nor allow third parties access to them.
- I understand that all the information regarding participant recruitment is confidential.
- I will not keep any copies of the information nor allow third parties access to them.

~~Transcriber/Receptionist's~~ signature :

~~Transcriber/Receptionist's~~ name :

~~Transcriber/Receptionist's~~ Contact Details (if appropriate):
.....
.....
.....

Date:
Project Supervisor's Contact Details (if appropriate):
Dr Rhona Winnington
rhona.winnington@aut.ac.nz
09 9219999 x 7123

Approved by the Auckland University of Technology Ethics Committee on 14th September 2021 AUTEK Reference number 21/276

Note: The Transcriber/Receptionist should retain a copy of this form

Appendix I: Participant information sheet





TE WĀNANGA ARONUI
O TĀMAKI MĀKAU RAU

Participant Information Sheet

Date Information Sheet Produced:
13/09/2021

Project Title
Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study

An Invitation
Kia Ora,
My name is Assunta Rodrigues. I have been working at North Shore Hospital for more than 17 years and am an Associate Clinical Charge Nurse, Operating Theatre Coordinator for North Shore Hospital. A key focus of my role is to provide clinical leadership, take actions to identify and fix any problems and systems that put the patient and colleagues at risk. It concerns me that if hazardous electrosurgical smoke is not consistently and effectively evacuated at source, it clearly poses a health and safety risk to operating theatre patients and staff.
This is a letter of invitation to participate in a study to explore electrosurgical smoke control practices among New Zealand operating theatre personnel. It is important to understand why this research is being done and what it will involve before you decide to participate in this study. Please take the time to carefully read and understand the "Participant Information Sheet". Please let me know if you have any questions or need more information/clarification. The participants will neither be advantaged nor disadvantaged if they do/do not participate. If you would like to participate in the study, please complete the consent form and return it through email to the Operating Theatre Receptionist at North Shore Hospital at the following email address: Theatre.Reception@waitematahdb.govt.nz with the subject 'Electrosurgical smoke evacuation project'.

About the Researcher
During this research, I am primarily a research student, striving towards gaining a Master of Health Practice in Nursing. My research topic was inspired by my passion for an electrosurgical smoke-free operating theatre with an interest in quality and patient safety. Additionally, this research topic fits the hospital's smoke-free goal and my professional trajectory of improving health and safety in the operating theatre. I have been an operating theatre nurse for the last 27 years of which the last 17 years have been at North Shore Hospital operating theatre. I am concerned when I smell electrosurgical smoke in the corridor outside some operating theatres. This indicates, despite an evidence based Waitemata District Board's policy on electrosurgical smoke evacuation since 2017, exposure to toxic electrosurgical smoke remains a health hazard to operating theatre patients and staff. This is perhaps due to inconsistent or ineffective electrosurgical smoke control practices among operating theatre personnel. There is growing evidence on the hazardous nature of toxic electrosurgical smoke which contains biological and chemical substances including viruses and cellular material that are likely to be mutagenic, infectious, and carcinogenic. A further issue related to the recent coronavirus pandemic is the concern about the virus transmission risk through electrosurgical smoke to operating theatre personnel.

What is the purpose of this research?
The purpose of this qualitative research is to gain an insight and better understanding of some of the experiences and attitudes of the operating theatre personnel towards electrosurgical smoke, and how it influences their electrosurgical smoke control practices. The main reason for undertaking this study is that despite a current evidence-based District Health Board's policy mandating electrosurgical smoke evacuation for all surgeries producing electrosurgical smoke, and international guidelines such as the

Association of periOperative Registered Nurses (AORN) as well as Australian College of Operating Room Nurses' (ACORN) standards for electrosurgical smoke evacuation, it has been observed that there is inconsistency in electrosurgical smoke evacuation in the operating theatres. The significance of the study is to identify gaps in safety procedures, bridge the gap in knowledge, inform policy and improve clinical practice in the operating theatre. It will improve quality and safety by addressing patients and staff health risk issue concerning electrosurgical smoke and will provide a platform for further research on electrosurgical smoke evacuation. Additionally, the findings of this research may be used for academic publications and presentations at the New Zealand perioperative conference.

How was I identified and why am I being invited to participate in this research?

You were identified as you responded to the advertisement poster and indicated an interest in finding out more about the research. You are being invited to participate in this research based on the inclusion and exclusion criteria. Criteria for inclusion is diverse operating theatre personnel such as nurses, surgeons, anaesthetists, and anaesthesia technicians; all genders from various ethnicities between the ages 23-65 years old from Waitemata District Health Board, who have worked for more than six months in the operating theatre and encountered surgeries producing electrosurgical smoke. To avoid conflicts of interest as the researcher is an Operating Theatre Coordinator at North Shore Hospital, only nurses from Elective Surgical Centre can volunteer to participate and rest of the participants will be from North Shore Hospital. The Operating Theatre Receptionist at North Shore Hospital will be involved in the recruitment of first six participants who work across various sub-specialties, with at least one from each profession being recruited who meets the criteria, to promote unbiased selection. Criteria for exclusion is senior management such as charge nurses and non-clinical operating theatre personnel who are not constantly exposed to electrosurgical smoke and nurses from North Shore Hospital to avoid conflicts of interest.

How do I agree to participate in this research?

Your participation in this research is voluntary (it is your choice) and ~~whether or not~~ you choose to participate will neither advantage nor disadvantage you. You ~~are able to~~ withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible. Your participation will contribute towards improving health and safety of patients and staff in the operating theatres at Waitemata District Health Board.

If you agree to participate in this research please complete the consent and return it to the Operating Theatre Receptionist at North Shore Hospital at the following email address:

Theatre.Reception@waitematadhb.govt.nz with the subject 'Electrosurgical smoke evacuation project'.

What will happen in this research?

The first six participants who work across various sub-specialties, with at least one from each profession who have encountered electrosurgical procedures producing electrosurgical smoke and have complete the consent form will be chosen to attend the semi-structured interview. In this study, the researcher will conduct semi-structured virtual interviews with specific open-ended questions about participant's views and opinions on electrosurgical smoke and electrosurgical smoke control practices in the operating theatre. I am aware that the anaesthetist and the anaesthesia technician are not directly involved in electrosurgical smoke evacuation, yet if electrosurgical smoke evacuation is not effectively utilized, they are all exposed to risks of hazardous electrosurgical smoke. Therefore, at least one anaesthetist, one anaesthesia technician, two nurses and two surgeons who meet the criteria will be selected based on the inclusion criteria. Interviews will be approximately 45 to 60 minutes duration and conducted virtually at a time, and date convenient to the participant during non-working time, to reduce the researcher-participant power imbalance and ensure participant's comfort, confidentiality, and privacy. Interviews will be audio recorded and notes will be taken during the interview. Interviews will be transcribed verbatim for subsequent analysis.

What are the discomforts and risks?

There are no risks, as participant's privacy and confidentiality will be maintained throughout the study. I do not envisage any discomforts. The semi-structured interview participants are all adult operating theatre personnel. In fact, the voluntary participants will be able to voice their views and experiences on electrosurgical smoke and electrosurgical smoke control practices among operating theatre personnel. Participants will not be exposed to any physical, psychological, or emotional harm during the study. However, there is a possibility that some participants may feel emotional when talking about electrosurgical smoke and electrosurgical smoke control practices.

How will these discomforts and risks be alleviated?

As I am an Operating Theatre Coordinator at North Shore Hospital, the nurse participants will be recruited from Elective Surgical Centre to avoid conflicts of interest and power differences. During this study I am a student researcher and will adhere to the primary researcher role. The research will be conducted during non-working time, at a time and date convenient to the participant which will be negotiated with the participants to avoid any issues of power imbalance. Privacy and confidentiality of all participants will be ensured and any information shared will not interfere with their appraisal or performance review. If the participants experience any discomfort or risks, counselling and support services will be available as follows:

AUT Student Counselling and Mental Health is able to offer three free sessions of confidential counselling support for adult participants in an AUT research project. These sessions are only available for issues that have arisen directly as a result of participation in the research and are not for other general counselling needs. To access these services, you will need to:

- drop into our centre at WB203 City Campus, email counselling@aut.ac.nz or call 921 9998.
- let the receptionist know that you are a research participant and provide the title of my research and my name and contact details as given in this Information Sheet.

You can find out more information about AUT counsellors and counselling on <https://www.aut.ac.nz/student-life/student-support/counselling-and-mental-health>

Additionally, participants can contact the Employee Assistance Programme (EAP) at Waitemata District Health Board for three free confidential counselling sessions that are available on a free 24-hour phone support by contacting EAP on 0800 735 343. Study participation is voluntary.

What are the benefits?

The study will benefit operating theatre patients and personnel with findings to suggest recommendations, to create a healthy work environment free of electrosurgical smoke. The interviews will provide an opportunity to participants to voice their perceptions and views on electrosurgical smoke and electrosurgical smoke control practices among diverse operating theatre personnel. It will give the researcher a better understanding on how operating theatre personnel's knowledge and attitude towards electrosurgical smoke can act as facilitators or barriers for effective electrosurgical smoke evacuation. The study may significantly bridge the gap in knowledge, inform policy and improve clinical practice in the operating theatre. It will improve health and safety in the operating theatre by addressing patients and staff health risk issue concerning electrosurgical smoke and will provide a platform for further research on electrosurgical smoke evacuation. The project will improve the researcher's professional knowledge and skills and will enable to attain the qualification of Master of Health Practice in Nursing. Additionally, the findings of this research will be used for academic publications and conference presentations at the New Zealand perioperative conference. The goal is to ensure healthy electrosurgical smoke-free operating theatres in line with the hospital's smoke-free policy as well as the New Zealand government's goal of a smoke-free nation by 2025. Participants will receive a \$20/- gift voucher as a thank you gift recognising the value of their contribution to the research.

How will my privacy be protected?

The participants will sign an informed consent and will be allocated a number from one to six after the consent has been signed by the participant to ensure confidentiality throughout the research process from data collection, data analysis, findings, and publication, although the primary researcher will be able to

identify the participants during the interview. The interviews will be held virtually at a time, and date convenient to the participant during non-working time, to reduce the researcher-participant power imbalance and to protect the participant's identities, respecting privacy, and confidentiality. The nurse participants will be recruited from Elective Surgical Centre rather than North Shore Hospital to avoid conflicts of interest and power difference as the researcher is an Operating Theatre Coordinator at North Shore Hospital. The consent forms will be stored away from the interview data locked in a cupboard in room AA217, the supervisor's room at AUT. All data will be destroyed after six years.

What are the costs of participating in this research?

The cost of participating in this research is only the participant's time of 45 to 60 minutes.

What opportunity do I have to consider this invitation?

After receiving this invitation, you have two weeks to respond to the invitation.

Will I receive feedback on the results of this research?

Yes. If you wish to receive feedback on the results of this research, please indicate this on your consent form with your contact details.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr. Rhona Winnington, email: rhona.winnington@aut.ac.nz, work phone: 09 9219999 x 7123.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEK, ethics@aut.ac.nz, (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Assunta Rodrigues

ACCN, Operating Theatre Coordinator, North Shore Hospital

Assunta.Rodrigues@waitemataadhb.govt.nz

Cell: 0212534881

Project Supervisor Contact Details:

Dr Rhona Winnington

rhona.winnington@aut.ac.nz

09 9219999 x 7123

Please keep this Information Sheet and a copy of the Consent Form for your future reference.

Approved by the Auckland University of Technology Ethics Committee on 14th September 2021, AUTEK Reference number 21/276.

Appendix J: Interview protocol



TE WĀNANGA ARONUI
O TĀMAKI MAKĀU RAU

Interview Protocol

Date: _____ **Time:** _____

Interviewee: _____ **Interviewer:** _____

Kia ora! Thank you once again for volunteering to participate in the interview aspect of my study. My study seeks to explore and gain a better understanding of the diverse operating theatre personnel's attitudes towards electrosurgical smoke and the perceived facilitators and barriers associated with their compliance for effective electrosurgical smoke evacuation.

*Opening statement will be based on the demographic form of the individual participant to elicit conversation and put the participant at ease. *(Establish a rapport, emulate a conversation, listen, be non-judgemental, let the interviewee talk, be attuned to the words and gestures/body language)*

*Consent form for the interview as well as for audio-recording will be checked and the participant informed when the audio-recording will commence as well as that the audio-recording can be paused at any time the participant indicates to do so. However, notes of important points will be taken during the interview.

The semi-structured interview will be guided by a flexible interview protocol. Open-ended questions will probe for information regarding effective electrosurgical smoke evacuation compliance with the Waitemata District Health Board policy based on AORN guidelines for electrosurgical smoke evacuation and themes extracted from the literature review. All questions will begin with "please can you tell me". Semi-structured interview guide is as follows:

No.	Question: All questions will begin with "Please can you tell me"
1.	What does the term electrosurgical smoke mean to you? - probe further
2.	How has your understanding of electrosurgical smoke evacuation been developed?
3.	If, how and from whom do new operating theatre personnel learn to effectively evacuate electrosurgical smoke
4.	What are the barriers and enablers of effectively evacuating electrosurgical smoke within the operating theatre?
5.	Why do you think operating theatre personnel do not consistently utilize electrosurgical smoke evacuation?
6.	How do you feel about the current electrosurgical smoke evacuation practice at our hospital?

A final thank-you statement to the participant with the \$20/- gift card as a thank you gift recognising the value of their contribution to the research will be sent to the participant with their consent to their specified address.

Approved by the Auckland University of Technology Ethics Committee on 14th September 2021 AUTEK Reference number 21/276

Appendix K: Phase two – systematic data coding

Phase Two An Example of Open Coding

Systematic Data Coding 8 th November 2021.	
Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study	
Codes	Verbatim Transcription
C1: Attitude towards ESS	<i>Um, so, so we electrosurgical smoke is the um, plume that's generated as a result of using um, an electrocautery device, so usually diathermy, um, and um, we usually think of it as a (sigh) um, a sort of toxic or noxious stimuli, so something that is um, harmful to staff in the operating theatre and to patients as well.</i>
C2: Knowledge of ESS	<i>Um, the contents would probably be ah, largely water vapor, and there will be um, some um presumably some carbon elements and ah, not sure what else actually... So probably intracell, probably, the results of intracellular break, products broken down from intracellular um, deactivation. Not sure (laughs), sorry.</i>
C3: Perceptions of ESS	<i>What are my perceptions? Um, so I guess it's a very common by-product that we encounter every day in surgery, (gesturing with hands) um and I think we all know it is harmful um, but sometimes it can be difficult to minimize the harm from it.</i>
C4: Participant's experience of ESS	<i>So um, especially thinking about laparoscopic surgery for instance, we know that when smoke builds up inside the abdomen it impairs visibility and um, and it usually takes a long time for the smoke evacuators to actually work so what most people tend to do it, open up a port, let out all of the smoke (laughs), um, into the atmosphere. Ah, which is obviously not the ideal way of doing it but it probably very commonly done in practice.</i>
C3: Perceptions of ESS	<i>Yeh, yeh (laughter) (crosstalk) Yeh, smell barbecue.</i>
C5: Risks of ESS	<i>Um, Um, the risks would be I guess, the theoretical risk of um, of being carcinogenic um, like a similar to cigarette smoke in a way. Um. There is also risk of um, transmitting infectious diseases, um, in theory, um and I guess another theoretical risk of transmitting um, cancer particles or other metastasizing other um materials, I guess.</i>

Assunta Rodrigues  

P4 C1 Attitude towards ESS as toxic, noxious stimuli that is harmful to OT patients and staff

Assunta Rodrigues  

P4 C2 Limited knowledge of the contents of ESS

Assunta Rodrigues  

P4 C3 Perceptions of ESS as harmful by-product encountered regularly in surgery but sometimes difficult to minimise.

Assunta Rodrigues  

P4 C4 Personal experience: ESS impairs surgeon's visibility in laparoscopies and is commonly expelled into the atmosphere due to current ESSE device taking a longer time to

Assunta Rodrigues  

P4 C3 Perception of ESS is compared to barbecue smell

Assunta Rodrigues  

P4 C5 Risks of ESS is that it is carcinogenic and compared to cigarette smoke, which can transmit infectious diseases, cancer particles and metastasizing materials.

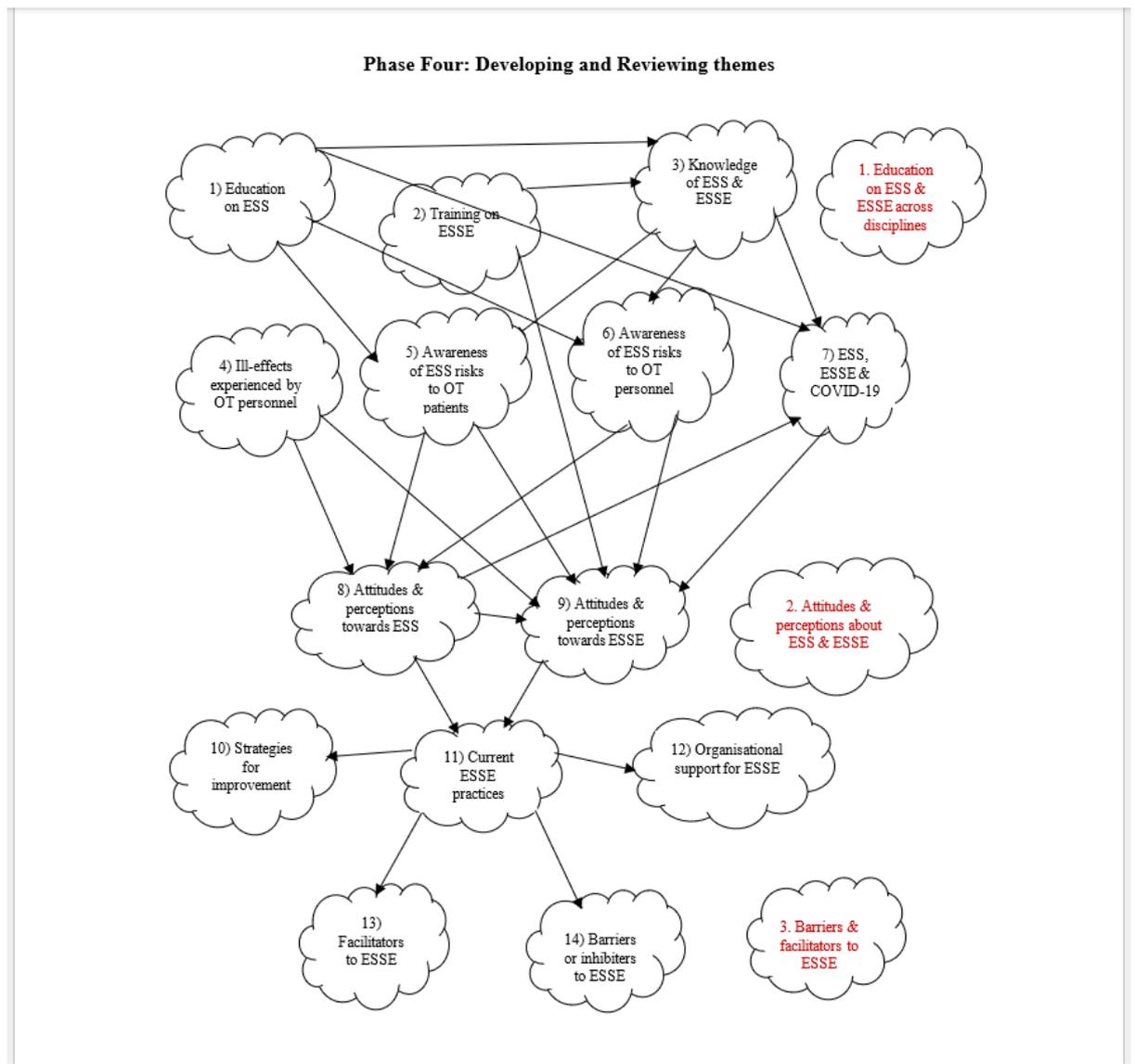
08 November 2021, 9:45 pm

Appendix L: Phase three – generating initial themes from codes

Phase Three: An example of generating Themes from Codes

Phase Three: Generating initial Themes from Codes: 28 th November 2021		
Project Title: Exploring Electrosurgical Smoke Control Practices among New Zealand Operating Theatre Personnel: A Qualitative Study		
Theme	Subtheme	Quotes
<p>Attitude towards electrosurgical smoke (ESS)</p> <p>Incautious attitude towards ESS</p>		<p>"Unless you can smell it (ESS), you are not linking about it. So, if you have got that smoke evacuator really working, and you can still smell it, everyone just gets on with it and doesn't worry about it. Cause like everyone sort of deals with it and doesn't think about it" (P1)</p> <p>"It doesn't seem to be that dire an issue like because whenever it's been raised, they say, "Aw, it's one of those, like issues" but like people have been running smoke for decades and no one seems to be to and far from it. I guess there's a lot of people they don't see it (ESS) as a problem!" (P6)</p> <p>"For a very, very long time there was smoke in the room, and it got cleared out eventually and no one really made a fuss over it" (P6)</p> <p>"I mean, most, most of the time, like in my working career up to now, that I have been in theatre is there's always been like this cloud of smoke, and no one seemed just to care about it" (P6)</p> <p>"In terms of surgical smoke, everyone knows it's bad, everyone knows it needs to be minimised, but aah, you know, I think it doesn't go much, much more kind-of past that" (P6)</p> <p>"But that, kind of as far as the conversation goes, they say "aah, I've had a bad day, lots of smoke, lots of headache" and then everyone just moves on" (P6)</p> <p>"We all just get on with it (ESS). It's one of these things we just, it's another piece of equipment. They are doing a small case, or whatever, so, we are all very blasé about that (ESS)" (P2)</p>
<p>Incautious staff attitude towards ESS despite ill-effects</p>		
<p>Complacent attitude</p>		
<p>Bad and nasty smell</p>		<p>"In theory it (ESS) means a bloody bad smell (sighs). It can be pretty, pretty nasty (facial expressions) ah if we don't use the evacuator" (P2)</p> <p>"I think it (ESS) is a bad thing (Laughing) ... There are the AC vents, and you are meant to have the laminar flow through the theatre, but I mean you can definitely smell it" (P6)</p> <p>"We usually think of it (ESS) as a (sigh) um, a sort of toxic or noxious stimuli, so something that is um, harmful to staff in the operating theatre and to patients as well" (P4)</p> <p>"It (ESS) is the heat energy which is converted to smoke during any surgery whether it is laparoscopic or open" (P3)</p> <p>"Like even say, pre-covid, like you know, no one was wearing masks, and I would wear, put on a mask for the smoke and everybody would look at me funny" (P6)</p>
<p>Toxic, noxious and harmful to operating theatre patients and staff</p>		
<p>Heat energy converted to smoke</p>		
<p>Participant's cautious attitude towards ESS</p>		

Appendix M: Phase four – developing and reviewing themes



Appendix N: Phase five – refining, defining and naming themes

