POST-OPERATIVE INTENSIVE CARE UNIT ADMISSION AND PATIENT OUTCOMES AT MOI TEACHING AND REFERRAL HOSPITAL

BY

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DECLARATION

I, the undersigned, understand that plagiarism is an offense and do declare that this thesis is my original work and has not been presented to any other institution.

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Declaration by supervisors.

The thesis has been submitted for examination with our approval as the college supervisors.

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DEDICATION

This thesis is dedicated to my family, to my wife Lucky Waeni who has stood with me through the strenuous process, my son Samuel who sacrificed our evening walking moments to have me complete the task, and my mom Esther Mwau who sacrificed her luxury to support me through my academic life.

ABSTRACT

Background: Post-operative patients experience surgery and anesthesia-related morbidity of varying degrees which may lead to either planned or unplanned intensive care unit (ICU) admission. There is increased demand for ICU care without reciprocating increase in bed space thus demanding detailed pre-operative planning to ensure the availability of ICU services when needed. Routine post-surgical ICU admission, with debatable outcome benefit, contribute to limited bed space for unplanned admissions who often have adverse outcomes. Moi Teaching and Referral Hospital (MTRH) ICU admission protocol suggest routine admission for major elective surgeries while the facility still experiences a high burden of unplanned admissions.

Objectives: To describe and compare peri-operative adverse events among post-surgical ICU admitted patients, determine risk factors associated with unplanned post-operative ICU admissions and determine post-surgical ICU patient outcomes at MTRH.

Methods: A prospective comparative observational study was carried out in MTRH ICU from October 2021 to September 2022**.** A sample size of 352 participants**,** 176 participants in both planned and unplanned post-operative ICU admission type**,** who underwent surgery at MTRH and were admitted to MTRH ICU post-operatively was recruited through consecutive sampling. Patient treatment records and interviews with the participant or their next of kin were used to collect patient and surgery-related data. Participants were followed up while in ICU and up to 28 days after admission to ICU in case they were discharged from ICU in less than 28 days to determine patient outcome.

Results: The median patient age was 35 (IQR 19.5, 52) years with 205(58.2%) of admissions being male. Majority of admissions were American Society of Anesthesiologist (ASA) class III 176(50.1%) with a 27.3% overall comorbidity incidence. Majority, 193(54.8%), had emergency surgery with neurosurgery as leading admission specialty at 209(59.9%) of admissions. Pulmonary complications were the leading indication for ICU admission, 128(36.4%), and occurred more among unplanned admissions (P=0.001). The single commonest complication leading to ICU admission was poor anesthesia reversal, 58(16.5%). Ear Nose and Throat (ENT), maxillofacial, obstetric and orthopedic specialties (P=0.006), emergency surgery (P=0.008) and post-operative complications (P<0.001) were associated with unplanned admission. The median ICU length of stay was 3(IQR 2,5) days. In-ICU mortality was 23.3% while 28-day mortality was 29.3%. Unplanned admission was associated with mechanical ventilation, in-ICU and 28-day mortality, P<0.001. Advanced age, emergency surgery and low pre-operative Glasgow coma scale (GCS) were predictors of 28-day mortality (aOR>1).

Conclusion: Pulmonary and neurological complications are the commonest complications leading to post-operative ICU admission in MTRH. ENT, maxillofacial, obstetric and orthopedic specialties, type of surgery and time of complication are associated with unplanned admission. Age, type of surgery and preoperative GCS are predictors of 28-day mortality.

Recommendation: Surgeons and anesthesiologists to improve on pre-operative evaluation to reduce incidence of unplanned admissions. Audit cases of poor reversal of anesthesia in MTRH to identify areas of improvement. Use of age, surgery type and pre-operative GCS in ethical dilemma when deciding probability of clinical benefit from ICU admission

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LIST OF ABBREVIATIONS

ASA	American Society of Anesthesiologists
COPD	Chronic Obstructive Pulmonary Disease
CVA	Cerebral Vascular Accident
DM	Diabetes Mellitus
GCS	Glasgow Coma Scale
HDU	high dependence unit
ICU	Intensive Care Unit
IREC	Institutional Research and Ethics Committee
MEq/L	Milli Equivalent per liter
Mg/dl	Milligram per Deciliter
Ml	Milliliter
MmHg	Millimeter of Mercury
Mmol/l	Mill mole per Liter
MO	Medical Officer
MRI	Magnetic Resonance Imaging
MS	Micro-Soft
MTRH	Moi Teaching and Referral Hospital
O2	Oxygen
OR	Odds Ratio
PACU	Post Anesthesia Care Unit
PaO2	Arterial Partial pressure of Oxygen
UK	United Kingdom

OPERATIONAL DEFINITION OF TERMS

Critical care: Specialized patient care in a dedicated intensive care unit (ICU).

Planned post-operative ICU admission: Admission to ICU following confirmed bed booking prior to surgery.

Unplanned post-operative ICU admission: Admission to ICU without confirmed bed booking prior to surgery.

Peri-operative period: The immediate duration before and after surgery; in this study this included the period from patient admission through surgery until discharge from the hospital.

Patient outcome: Measure of patient morbidity and mortality; in this study this included mechanical ventilation hours, length of ICU stay, condition at ICU discharge and 28-day survival

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CHAPTER ONE: INTRODUCTION

1.1 Background Information

Post-surgical patients experience some degree of morbidity as a result of physiological, endocrine, and inflammatory changes associated with tissue injury of surgery and anesthesia-related complications (Rupert, 2011). This puts them at a high risk of complications and adverse events that may require intensive care support. These physiologic changes and associated complications may or may not be anticipated pre-operatively leading to planned or unplanned post-operative admission to intensive care unit (ICU) respectfully. Planned post-operative ICU admission involves having a pre-booked ICU bed prior to surgery while unplanned post-operative ICU admission occurs in an emergency manner where no ICU space had been reserved for the patient prior to surgical procedure (Katori et al., 2022).

In the United Kingdom (UK), Pearse and others found an 8% incidence of post-surgical ICU admission among non-cardiac surgery patients (Pearse et al., 2012). Although the incidence of post-surgical ICU admission in Kenya and MTRH is not known, the burden of post-surgical patients in ICU remains high. In Kijabe, a level 5 mission Hospital in central Kenya, approximately 50% of patients admitted to ICU were post-surgical while in Moi Teaching And Referral Hospital (MTRH), the post-operative ICU admission incidence proportion stands at 23.6% suggesting a high ICU utilization by this patient group (Chao, Patel, Rosenberg, & Riviello, 2015; Lalani et al., 2018).

Patients requiring ICU care may be at risk of rapid deterioration and even death should the service be unavailable or even delayed. However, ICU facilities are expensive to set up and operate with the average cost to a patient admitted in ICU ranging from 52 to 87.5 USD per day, roughly 2 to 3 times the daily reimbursement made by the commonest health insurance program in Kenya the National Hospital Insurance Fund (NHIF) (Chao et al., 2015). As a result of the financial challenge in setting up and running an ICU, the service is not universally available especially in low- and mid-income countries. Covid 19 pandemic led to a significant strain of critical care services across the world leading to increment of critical care beds and health care workers, (Barasa, Ouma, & Okiro, 2020; Kovacevic et al., 2023). However, anecdotal data on the ICU bed occupancy rate post covid 19 in MTRH still remains high suggesting a persistent shortage of this critical resource despite the perceived Covid 19 induced growth. This calls for patient targeted risk stratification with consideration to patients comorbidities, surgical factors, and caregiver factors to anticipate post-surgical ICU requirements and mitigate delays in utilizing the services when needed (Cutuli, Carelli, De Pascale, & Antonelli, 2018).

Peri-operative adverse events refer to unintended events (complications) occurring in the duration surrounding surgery (immediate pre-operative, intra-operative and immediate post-operative) as a result of commission or omission by the medical team during surgery and anesthesia that result in increased potential harm or physical harm to the patient (Jung & Grantcharov, 2019). In a retrospective data review of 9288 abdominal surgeries, Bohnen and others observed an association between intra-operative adverse events and unplanned post-surgical ICU admission, (Bohnen et al., 2017). Age, surgery duration, general anesthesia, surgical specialty, and previous anesthesia complication are easy to assess factors that have been associated with post-operative adverse events and thus may be used to predict post-surgical ICU admission pre-operatively (Protopapa, Simpson, Smith, & Moonesinghe, 2014; Quinn, Gabriel, Dutton, & Urman, 2017; Seglenieks, Painter, & Ludbrook, 2014).

Different methods have been employed to risk stratify patients pre-operatively. The commonest used method in surgery and anesthesia is the American Society of Anesthesiology Physical Status (ASA PS). This scoring system categorizes patients into 6 classes based on presence or absence of comorbidities. ASA I is a generally stable patient without medical comorbidity while ASA VI is a brain dead patient undergoing surgery for organ harvesting, (ASA, 2020). This scoring system has however had mixed results in its usefulness to predict post-surgical ICU admission, (Quinn et al., 2017; Seglenieks et al., 2014).

Post-anesthetic care units (PACU) are specialized care units in theatres that receive patients immediately post-surgical for close monitoring and essentially provide critical care service outside the general critical care unit (Simpson & Moonesinghe, 2013) which is considered standard of care in the immediate post-operative period. Standard post anesthetic care unit is staffed with critical care trained nurses and has a high nursing to patient ratio. The units have capacity to perform continuous electro cardiac monitoring, continuous pulse oximetry, neuromuscular monitoring, mechanical ventilation as well as easy access to ancillary services such as physiotherapy, arterial blood gas analysis and radiology, (Glick, Holt, & Nussmeier, 2021; Simpson & Moonesinghe, 2013). However, the post anesthetic care unit may not be universal with staffing and equipping differences across high-income to low-income countries. During the period of stay in PACU, patients are assessed and triaged by the PACU nurses under the guidance of anesthesiologist or intensivist physician into either general ward, high dependency units (HDU) or intensive care units. When a patient is triaged for HDU or ICU care and the required bed is not immediately available, post-operative critically ill patients may then be managed in PACU for a longer time awaiting bed availability. In MTRH, the PACU is staffed with one nurse per shift and lacks capacity to offer critical care services such as continuous electro cardiac monitoring and mechanical ventilation. As a result, when ICU bed is not immediately available post-surgery, post-surgical patients requiring critical care services in MTRH are managed in the operating rooms for a longer duration awaiting bed availability (Lalani et al., 2018). While the reasons for the post-surgical ICU bed unavailability in MTRH were not singled out, unplanned post-surgical ICU admission requirements could play a major role.

Critically ill patients managed in operating rooms for long duration post-surgery while awaiting ICU bed availability often miss the multi-disciplinary services of critical care units such as early nutritional and physiotherapy care, review by intensivist, critical care nursing, as well as delay in laboratory and radiological investigation services thus delaying or even missing certain interventions. Additionally, most anesthetic machines like the ones available in MTRH theatres, though able to ventilate patients, have limited ventilator modes and thus make them not ideal for prolonged post-operative mechanical ventilation as compared to ICU ventilators. There is however conflicting evidence on the mortality benefit of early post-operative ICU admission with those finding no benefit attributing it to some PACU operations being similar to ICU operations (Bing-Hua, 2014; Zhou, Pan, Huang, Yu, & Zhao, 2015). However, patient delay in PACU and operating rooms as they await ICU bed availability adversely affects hospital operation by increasing operating room holding time, which may lead to cancelation of surgical cases, as well as increasing peak number of patients in PACU with overall reduction in productivity and increase the cost of care (Samad, Khan, Khan, Hamid, & Khan, 2006; Tobi, Osazuwa, & Enyi-Nwafor, 2013). Moreover, MTRH's PACU lacks ventilatory capacity and thus unplanned post-operative ICU admitted patients requiring ventilatory support remain ventilated on anesthetic machines in the operating room until an ICU bed becomes available thus blocking the utilization of the operating room for more surgeries.

This study aimed to determine post-operative intensive care unit admission determinants and compare patient outcomes among planned and unplanned post-operative ICU admitted patients at Moi teaching and referral hospital.

1.2 Problem Statement

There is a markedly growing demand for intensive care services in the last two decades due to increasing elderly population with multiple comorbidities as well as advanced surgical and anesthesia techniques that have resulted in operation of very sick patients that would have otherwise been un operable (Vincent et al., 2014). However, the number and availability of critical care facilities have not reciprocated the increase demand especially in low and middle-income countries (Murthy & Adhikari, 2013). Utilization of this limited resource should therefore be guided on the potentiality for clinical outcome benefit as admission of too sick to benefit or too well to utilize patient groups may lead to futility of care. Routine admission of post-surgical patients to ICU often strains this limited resource without necessarily utilizing the resources (S. De Silva, Pathirana, Gunaratna, & Chandraguptha, 2019) and may result in unavailability of ICU bed space for patients who require critical care services in an unanticipated manner due to emergency surgery or complications intra-operatively or post-operatively.

The debate on the benefit of routine post-surgical ICU admission among high-risk surgical patients remains unsettled. While Jhanji and others found benefit in outcome among elective non-cardiac surgery high-risk patients admitted to ICU post-operatively (Jhanji et al., 2008), Kahan showed that ICU admission offered no survival benefits in elective high-risk surgical patients (Kahan et al., 2017). The MTRH ICU admission protocol, appendix 1, suggests routine post-surgical ICU admission for some major elective procedures which may contribute to the filling of ICU bed capacity with debatable outcome benefit leaving no room for unplanned post-surgical admissions or cancellation or elective cases awaiting availability of ICU space which may lead to deterioration of their surgical condition.

Unplanned post-operative ICU admissions contribute significantly to ICU morbidity and mortality with 37.3% admission and 1.4 times mortality compared to anticipated post-operative admission (Bhat, S, & S, 2006). While the post-operative ICU admitted patients' outcomes at MTRH are undocumented, Lalani and others noted that some post-operative critically ill patients in MTRH are managed in the operating suite suggesting an unanticipated need for ICU care (Lalani et al., 2018) that has been associated with poor outcomes elsewhere.

MTRH's PACU operates as a high dependency unit (HDU) with continuous noninvasive monitoring but lacks ventilatory and invasive monitoring capacity. Unplanned post-operative ICU admitted patients who require ventilatory support, therefore, remain ventilated on an anesthetic machine in the operating room until an ICU bed is available. Patients who remain ventilated post-surgically in the operating rooms in MTRH however lack the services of critical care doctors and nurses and may also experience delay in appropriate laboratory and radiological investigations and review which may adversely affect their outcomes. Although negative outcomes have not been documented among post-surgical patients retained in theatre awaiting ICU bed space availability, due to most PACUs operating as fully pledged ICU, retaining critical post-surgical patients in operating rooms has been associated with an increase in operating room holding time thus reducing theater productivity and increasing cost (Samad et al., 2006; Tobi et al., 2013).

The American Society of Anesthesiologists physical status (ASA) risk stratification scoring is the predominantly applied method worldwide for pre-operative assessment of surgical and anesthetic risk. This scoring system, ASA score, has however had contradicting information on its usefulness in predicting adverse events and the need for intensive care service post-operatively. While Quinn and others found a significant association between high ASA score and post-operative ICU admission, Seglenieks and colleagues found no statistically significant association between ASA score and adverse events in PACU or ICU admission post-operatively (Quinn, Gabriel, et al., 2017; Seglenieks et al., 2014).

1.3 Study Justification

The debate on outcome benefit and resource utilization in routine post-surgical ICU admitted patients remains unsettled while unplanned post-operative ICU admissions contribute the most to ICU morbidity and mortality. The study aimed to describe peri-operative adverse events and determine risk factors associated with unplanned post-surgical ICU admissions in MTRH. Proper understanding of factors associated with peri-operative complications will help augment anesthetists' clinical acumen in peri-operative risk stratification thus reducing the rate of both unplanned and routine post-surgical ICU admissions. Minimizing unplanned and routine post-surgical ICU admissions will improve ICU resources utilization and post-surgical outcomes.

Critical care service provision is resource intensive and therefore universally unattainable with unplanned and routine post-surgical admissions straining the already limited resource. The study aimed to describe post-surgical ICU admissions and patient outcomes. This will guide post-surgical ICU admission policy development and resource allocation by the MTRH hospital management.

Pre-operative risk prediction models help caregivers to anticipate risk and thus presumptively prepare for management. Current pre-operative models are however ineffective in predicting post-operative ICU admission despite the high risk posed by unplanned post-operative ICU admission and underutilization of resources by routine post-operative ICU admissions (Stones & Yates, 2019; Tomlinson & Moonesinghe, 2016). The findings of this study will guide future studies to develop a post-surgical ICU admission prediction model in MTRH which, when applied, will minimize unplanned and routine post-operative ICU requirements.

1.4 Research Questions

1. What are the peri-operative adverse events among post-operative ICU admitted patients at MTRH?
2. What are the risk factors associated with unplanned post-surgical ICU admission at MTRH?
3. What are the outcomes (incidence of mechanical ventilation, mechanical ventilation duration, ICU length of stay, ICU mortality and 28-day mortality) of post-operative ICU admitted patients at MTRH?

1.5 Research Objectives

1.5.1 Broad objective

To describe post-operative intensive care unit admission and patient outcomes at Moi Teaching and referral Hospital.

1.5.2 Specific objective

1. To describe peri-operative adverse events among post-operative ICU admitted patients at MTRH.
2. To determine risk factors associated with unplanned post-surgical ICU admission at MTRH.
3. To compare patient outcomes among planned and unplanned post-operative ICU admitted patients at MTRH.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Surgery, by its nature, involves the disruption of bodily tissues, and the body responds to this trauma with various physiological changes. These changes can include alterations in blood pressure, heart rate, and other vital signs as the body attempts to maintain homeostasis. Surgical stress also triggers the release of stress hormones like cortisol and adrenaline. These hormonal changes can have widespread effects on metabolism, immune function, and other physiological processes. For safe surgery to occur, a patient is normally given a form of anesthetic medication. The anesthesia administered to induce pain relief and hypnosis during surgery can have side effects or complications of its own. These may include post-operative nausea and vomiting, respiratory related complications, and allergic reactions to anesthesia drugs.

In a clinical data review among non-cardiac surgery patients, Rupert and others observed that post-surgical patients experience some degree of morbidity as a result of physiological, endocrine, and inflammatory changes associated with tissue injury of surgery and anesthesia related complications. These complications range from minor consequences such as pain to fatal complications such as pneumonia and myocardial infarction. The survivors of these complications may experience functional limitations and or reduced long term survival. The complications are a result of a complex interplay between surgical and patient factors such as age and comorbidities. He observed that high-risk patients contribute to 80% of surgical mortalities and therefore better pre-operative identification may play a key role in improving peri-operative care. Patient management through this period, therefore, plays a key role in recovery (Rupert, 2011). This observation underscores the importance of comprehensive peri-operative care and the need for healthcare teams to be vigilant in monitoring and managing patients both during and after surgeries to minimize post-surgical morbidity and optimize patient outcomes.

Peri-operative morbidity and mortality can be significantly influenced by the occurrence of adverse events during the peri-operative period. The peri-operative period encompasses the time before, during, and after surgery, and it is a critical phase of a patient's care. Adverse events that occur in this peri-operative window can have a direct impact on patient outcomes. A peri-operative adverse event may be described as any occurrence, either surgical or anesthesia related, that cause or leads to a deviation from the ideal desired surgical course from skin incision to closure. The events rage from patients who develop mild symptoms or no symptoms to peri-operative mortality (Gawria et al., 2022). Surgical adverse events include bleeding, infection, organ damage, or technical errors, and can directly increase morbidity and mortality rates. These complications may necessitate additional surgeries or treatments. Other adverse events may be associated with anesthesia administration, including allergic reactions, medication errors, or complications like respiratory distress, leading to a significant impact on patient safety and outcomes. Some adverse events may be related to the patient's pre-existing health conditions, allergies, medication interactions, or comorbidities. These factors can therefore increase the risk of complications during surgery and the recovery period.

In a multi-center prospective study in Morocco, Meziane and his colleagues underscore the importance of recognizing the link between adverse events during the peri-operative period and post-surgical unplanned admissions to critical care units. This association indeed has significant implications for various aspects of patient care, including morbidity, mortality, and finances. Peri-operative complications contributed to a 10.8% incidence of unplanned post-operative ICU admission. The common surgical related complications were found to be major intra-operative bleeding and post-operative peritonitis at 24% and 13.3% rates respectively. Anesthesia related complications were mainly cardiovascular intra-operatively and respiratory in the recovery period (Meziane et al., 2017).

Unplanned post-operative ICU admission may be defined as any post-surgical ICU admission that had not been anticipated before surgery and therefore no critical care bed had been reserved for the patient prior to commencing the surgery. This often occurs as a result of complications occurring either intra-operatively, in the immediate post-operative period while the patient is in the post anesthetic care units (PACU) or even days post-operatively while in the post-surgical wards. Unplanned post-operative ICU admission is indeed considered a significant quality indicator in the fields of surgery and anesthesia. It is often used as a measure of patient safety, surgical outcomes, and the effectiveness of peri-operative care. The validation of unplanned post-operative ICU admission as a quality indicator reflects its importance in assessing the quality of surgical and anesthesia services. (Katori et al., 2022).

Monitoring and tracking unplanned ICU admissions may thus help healthcare institutions and providers identify potential areas for improvement in patient safety protocols and peri-operative practices. It encourages a proactive approach to preventing complications. The rate of unplanned post-operative ICU admissions can also be used to evaluate surgical outcomes and anesthesia management. A lower rate of unplanned ICU admissions is generally considered a positive indicator of successful peri-operative care. It's important to note that while unplanned post-operative ICU admission is a valuable quality indicator, it should not be viewed in isolation. Other factors, such as patient characteristics, the complexity of surgical procedures, and the presence of comorbidities, can also influence the need for ICU admission. Therefore, a comprehensive assessment of surgical outcomes and patient safety should consider multiple indicators and factors.

Critical care units are resource intensive establishments equipped with advanced medical technology, including ventilators, monitoring devices, and life support equipment. Acquiring and maintaining these resources can be financially challenging for countries with limited healthcare budgets. Critical care units also require highly trained and specialized healthcare professionals, such as intensivists, critical care nurses, and respiratory therapists. A shortage of skilled personnel can hinder the proper functioning of ICUs. Training opportunities have however remained to be unequally distributed in different settings with high income countries having more trained staff per population compared with low- and mid-income countries. While there has been an increase in the capacity for intensive care in recent years, many regions still struggle to adequately implement and sustain these resource-intensive critical care units, resulting in high hospital bed to ICU bed ratios. (Murthy & Adhikari, 2013).

2.2 Surgical and anesthetic risk assessment

Clinical judgement alone may not be adequate in predicting peri-operative adverse outcome. As such, risk assessment and stratification tools before surgery have been widely applied with the aim of determining group or individual risk vs. benefit of the planned surgical intervention. A delicate balance of the risk vs. benefit then informs the role of surgery as well as guiding targeted interventions within the peri-operative period. Those stratified as high risk may benefit from interventions such as pre-operative optimization, post-operative respiratory support and admission to critical care among other interventions. Different risk assessment methods, risk scores and risk prediction models, have been used with different risk predicting capacities. Risk scores use weighted factors identified as independent predictors of surgical outcome such as age, sex, medical history, genetic markers, and other clinical data with sum of the weightings forming a score that allows comparison with other patients. Although most risk scores are simple to use, their main disadvantage is in their inability to provide individualized risk prediction. On the other hand, risk prediction models estimate individuals' probability of risk. They are however complex thus hindering their use in routine clinical practice. However, none of the currently applied risk stratification methods is 100% predictive of adverse events (Stones & Yates, 2019; Tomlinson & Moonesinghe, 2016). Despite this limitation, risk stratification methods are valuable tools for healthcare professionals and other decision-makers to make more informed choices. However, it's essential to use these methods alongside clinical judgment and consider them as probabilistic rather than deterministic predictions.

The American Society of Anesthesiology physical status (ASA-PS) scoring system uses patient comorbidities and perceived functional capacity to stratify anesthesia and surgical risk. It is used to assess a patient's overall health and physical condition before undergoing anesthesia and surgery. The ASA-PS classification system categorizes patients into one of six categories based on their medical status and comorbidities:

- ASA-PS Class I: A normal healthy patient with no systemic diseases or comorbidities. This category represents the lowest risk.
- ASA-PS Class II: A patient with mild systemic disease or a well-controlled comorbidity, such as controlled hypertension, controlled diabetes, or mild asthma. These patients are at a slightly higher risk than Class I.
- ASA-PS Class III: A patient with severe systemic disease or a poorly controlled comorbidity that limits daily activities. Examples include poorly

controlled hypertension, diabetes with end-organ damage, or moderate to severe chronic obstructive pulmonary disease (COPD).

- ASA-PS Class IV: A patient with severe systemic disease that is a constant threat to life. These patients have a high risk of complications. Examples include patients with unstable angina, advanced heart failure, or severe respiratory failure.
- ASA-PS Class V: A moribund patient not expected to survive without surgery. This category is reserved for patients in critical condition who are undergoing surgery as a last resort.
- ASA-PS Class VI: A declared brain-dead patient whose organs are being removed for transplantation.

This scoring system is commonly applied in risk stratification pre-operatively due to its simplicity but as with other risk score systems it has had mixed results in its usefulness in predicting post-surgical ICU admission due to its inability to provide individualized risk. In a retrospective single center study in a University hospital in Minnesota, Lupei and others reported a significant association between ASA score and ICU outcome measures such as length of ICU stay, mechanical ventilation, and the number of end-organ damage (Lupei, Chipman, Beilman, Oancea, & Konia, 2014). The ASA-PS classification system, while valuable for assessing a patient's overall health and guiding anesthesia and surgical decisions, may not be a perfect predictor of an individual's risk of Intensive Care Unit admission post-surgery. The need for ICU admission after surgery may be influenced by a variety of factors, including but not limited to the type of surgery, the patient's specific medical conditions, and potential complications that may arise during or after the procedure.

The ASA-PS score primarily assesses a patient's pre-operative health status but does not take into account all the variables that can influence post-operative outcomes. Factors such as the complexity of the surgery, the patient's age, the presence of specific comorbidities, the surgeon's skill, and the quality of intra-operative care can all contribute to the likelihood of ICU admission post-operatively. In a retrospective analysis of data from national anesthesia clinical outcome registry, Quinn and others found a significant association between high ASA score and unplanned post-operative ICU admission. However, in a prospective observational study, Seglenieks and colleagues found no statistically significant association between ASA score and adverse events in PACU or ICU admission (Quinn, Gabriel, et al., 2017; Seglenieks et al., 2014). While the ASA-PS score provides valuable information about a patient's pre-operative health status, it is only one piece of the puzzle. Anesthesiologists, surgeons, and healthcare teams consider multiple factors when making decisions about post-operative care, including the need for ICU admission. They assess each patient individually and tailor their care plans accordingly.

Surgical outcome risk tool (SORT) was developed on a wide range of surgical patient population to predict 28-day mortality among non-cardiac surgery and non-neurological patients. The SORT risk stratification system takes into account six pre-operative variables:

1. American Society of Anesthesiologists Physical Status (ASA-PS Score): As discussed earlier, this score assesses a patient's overall health status and comorbidities.
2. Urgency of Surgery: The urgency or acuity of the surgical procedure can be an important factor in predicting outcomes. Emergency surgeries may carry a higher risk than elective procedures.

3. Surgical Specialty: The type of surgical specialty or subspecialty can influence the complexity of the procedure and the associated risks. Different specialties have different mortality rates.
4. Severity of Surgery: This variable considers the complexity and extent of the surgical procedure. More extensive surgeries may carry a higher risk.
5. Cancer Diagnosis: Patients with cancer may have different risk profiles due to their underlying disease and the potential for complications related to cancer treatment.
6. Age: Age is an important factor in predicting surgical outcomes, as older individuals may have a higher risk of complications.

SORT uses these pre-operative variables to stratify patients into different risk categories, allowing healthcare providers to better assess the potential risks and benefits of surgery for an individual patient. It can help inform clinical decision-making, guide discussions with patients about their surgical options, and assist in planning for post-operative care.

This model has been associated with high discrimination for 28-day post-surgical mortality with the area under the receiver operating curve of 0.82 and 0.96 for hepatobiliary and head and neck surgery patients respectively (Protopapa et al., 2014). Although the model uses simple easy to obtain pre-operative variables, the inclusion of ASA physical status introduces user variability in the scoring and the exclusion of neurological patients, who form majority of postoperative ICU admitted patients in MTRH, make SORT unpopular in our setting.

Respiratory complications form one of the major reasons for admission to ICU post-surgically. The Assess Respiratory Risk in Surgical Patients in Catalonia (ARISCAT) risk index is the commonest used model to predict respiratory complications post-surgically. It was developed to assess the risk of post-operative pulmonary complications (PPCs) in non-cardiothoracic surgical patients. The ARISCAT risk index includes various pre-operative and intra-operative variables, such as age, pre-operative oxygen saturation (SpO2), surgical procedure type, and respiratory infection, to estimate the risk of developing respiratory complications like pneumonia, atelectasis, and acute respiratory distress syndrome (ARDS) (Canet et al., 2010). However, while the ARISCAT risk index provides valuable information for assessing the likelihood of respiratory complications, its direct applicability to predicting ICU admission after surgery is limited as it has not been specifically validated for predicting post-surgical ICU admission.

A new tool, the score for prediction of post-operative respiratory complication (SPORC-2), to predict the risk of early post-operative re-intubation has been developed. It takes into account pre-operative and intra-operative variables to identify patients who may be at increased risk of requiring re-intubation shortly after surgery. SPORC-2 includes various factors and clinical variables to estimate the risk of respiratory complications that may necessitate re-intubation, such as:

- Pre-operative Factors: These may include patient characteristics like age, comorbidities, and functional status.
- Intra-operative Factors: These factors assess events and conditions during the surgery itself, such as the type and duration of surgery, the use of certain anesthetics, and the occurrence of specific intra-operative events.
- Airway Factors: SPORC-2 considers aspects related to the airway management during and after surgery.

By evaluating these variables, SPORC-2 aims to provide an estimate of the likelihood that a patient may experience early post-operative respiratory complications that could lead to re-intubation and potentially require admission to the ICU for respiratory support. This tool was found to have a good discriminative capacity, the area under receiver curve 0.75 (Lukannek et al., 2019). The tool has however not been externally validated and its use in predicting unplanned ICU admission is limited by the inclusion of intra-operative variables.

The Physiological and Operative Severity Score for the Enumeration of Mortality (POSSUM) and its modified version, the Portsmouth POSSUM (P-POSSUM), are widely used risk prediction tools in surgery. They are designed to predict the 28-day mortality rate following surgery by taking into account various physiological and operative variables. The original POSSUM scoring system includes 12 physiological variables and six operative variables. The P-POSSUM modification of the scoring system was developed to improve the accuracy of risk prediction, especially in the context of elective surgery. P-POSSUM incorporates an additional variable, "time of surgery," which takes into account the time of day when the operation is performed, as it can influence outcomes. Tomlinson and others found P-POSSUM to have a moderate to high discriminative ability in predicting post-surgical mortality. However, it tends to overestimate surgical risk among low-risk patients and its use in the pre-operative risk stratification is limited by its use of surgical variables (Tomlinson & Moonesinghe, 2016). Whilst P-POSSUM is comprehensive and well validated, it doesn’t predict morbidity and the use of surgical parameters limits its use in pre-operative decision making.

The Surgical Apgar Score (SAS) is a simple and quick scoring system used to predict post-operative complications and mortality in surgical patients. It allocates points to patients based on three intra-operative parameters:

- Surgical Blood Loss: The amount of blood loss during surgery is assessed on a scale from 0 to 3 points, with 3 indicating minimal blood loss and 0 indicating severe blood loss.
- Lowest Intra-operative Heart Rate: The lowest recorded heart rate during surgery is evaluated on a scale from 0 to 4 points, with 4 indicating a stable heart rate and 0 indicating a very high heart rate.
- Lowest Intra-operative Mean Arterial Pressure (MAP): The lowest recorded MAP during surgery is scored from 0 to 3 points, with 3 indicating a stable MAP and 0 indicating a very low MAP.

Each parameter is scored independently, and the points are summed to calculate the SAS score, which can range from 0 to 10. A lower SAS score indicates a greater degree of physiological stress and potential complications during surgery, (Gawande, Kwaan, Regenbogen, Lipsitz, & Zinner, 2007). The SAS was developed as a quick and straightforward tool to provide a rough estimate of a patient's risk for post-operative complications and mortality. It is based on the concept that intra-operative factors like blood loss, heart rate, and blood pressure can be indicators of the surgical stress and the patient's physiological response to surgery. The SAS has been associated with outcomes such as post-operative complications, length of hospital stay, and mortality, (Nair, Bharuka, & Rayani, 2018). In a prospective study in Taiwan among all surgical specialties, Lin and others found that a lower SAS was strongly associated with ICU admission post-surgically with adjusted OR, 5.21; 95% CI 2.49–10.88; $P < 0.001$ (Lin, Chen, Yang, & Su, 2021). However, this scoring system is applied intra-operatively and is therefore not be useful in reducing routine and unplanned post-surgical ICU admissions.

Lack of reliable pre-operative risk stratification method has led to unanticipated adverse events in the peri-operative period necessitating changes in the plan of management. Pre-anesthetic risk stratification in MTRH is user dependent with the application of ASA scoring system predominating. However, there is no documented evidence on the impact of the diverse pre-anesthetic risk stratification in MTRH nor the burden of unplanned post-surgical ICU admission. Lalani and colleagues however noted that in some instances, critically sick patients in MTRH end up being managed in the operating suite which may suggest a high burden of unplanned post-surgical ICU admission (Lalani et al., 2018).

The significance of proper pre-operative risk stratification in determining post-surgical care has been amplified by evidence of adverse outcomes among patients who develop intra- and post-operative adverse events with subsequent admission to ICU. A delicate balance is therefore required to minimize both routine and unplanned post-surgical ICU admission to improve patient outcomes and minimize cost.

2.3 Peri-operative adverse events leading to post-surgical ICU admission

2.3.1 Introduction

Peri-operative adverse events refer to unintended events (complications) as a result of commission or omission by the medical team during surgery and anesthesia that result in increased potential harm or physical harm to the patient (Jung & Grantcharov, 2019). In a retrospective data review of 9288 abdominal surgeries, Bohnen and others observed an association between intra-operative adverse events and unplanned post-surgical ICU admission. The occurrence of a surgical adverse event (accidental bowel puncture or laceration) was found to be associated with post-operative complications such as deep surgical site or organ infection (OR = 1.94, 95% CI 1.20– 3.14), P = 0.007), and sepsis (OR = 2.14, 95% CI 1.32–3.47, P = 0.002) with resultant strong link with ventilator dependence odds ratio (OR) of 3.88 95% CI 2.17–6.95, P<0.001, (Bohnen et al., 2017). A similar association between adverse events and unplanned re-intubation and with subsequent ICU admission has been described among neurosurgical patients. In a data base review of 18,642 patients who had underwent craniotomy for brain tumor resection with 2.3% re-intubation rate, Icy and others found a significant association between intra-operative adverse events and unplanned intubation post-surgery. Among patients who underwent unplanned re-intubation, 76.4 % had experienced a peri-operative adverse event compared with 7.6% re-intubation in the control (no peri-operative adverse event) group, P<0.001 (Icy et al., 2020).

The association between adverse event occurrence and unplanned post-operative ICU admission is stronger with major adverse events, those with more significant clinical impact and better reported by surgeons, compared with minor adverse events. In a prospective study of 9292 surgical patients from different specialties in which 181 had confirmed peri-operative adverse event, Kaafarani and colleagues observed that having a major adverse event was associated with ventilator dependence with OR of 3.2 95% CI, 1.2-8.9; P=0.22 (Kaafarani et al., 2014; Peponis et al., 2018). Adverse events may therefore be considered surrogate markers of patient safety during surgery. The relationship between adverse events and patient safety may however vary based on the type of surgery, patient population, and other contextual factors.

Common peri-operative adverse events associated with post-surgical ICU admission range from cardiovascular, respiratory, and neurological complications. These include hypotension, arrhythmia, major blood loss, cardiac arrest, major respiratory compromise from prolonged apnea, laryngospasm pulmonary embolism and failed intubation, and sudden or prolonged reduction in the level of consciousness due to poor reversal of anesthesia, new CVA, or prolonged/repeated seizure (Meziane et al., 2017; Wanderer et al., 2013).

In a teaching hospital in Mumbai, Bhat and others observed that respiratory and cardiac adverse events were the main contributors to unplanned post-surgical ICU admission in adults at 47.4% and 27.6% respectively. Among respiratory adverse events, hypoventilation due to respiratory fatigue was the commonest complication while other causes included airway obstruction, difficulty intubation, and pneumonia. Cardiac adverse events were mainly prolonged hypotension with ionotropic use and arrhythmias (Bhat et al., 2006). The study however excluded patients admitted to ICU more than 48 hours post-surgery, a period during which a complication could still be directly associated with surgery and anesthesia. The exclusion of routine and planned post-surgical ICU admissions in this study left a major group of surgical patients contributing to surgical ICU morbidity and resource burden and therefore calls for a more inclusive study to better understand peri-operative surgical complications and ICU admissions.

Among pediatric population in a university affiliated tertiary institution, Silva and colleagues found a strong association between occurrences of airway abnormality (odds ratio 16.2, 95% confidence interval 2.65–99.6), anesthetic factors (odds ratio 5.8, 95% confidence interval 1.06–32.2), and intraoperative desaturation (odds ratio 7.4, 95% confidence interval 1.21–46.24) with unplanned post-operative ICU admission (P. S. L. Da Silva, De Aguiar, & Machado Fonseca, 2013). However, the study was carried in a highly specialized pediatric hospital where surgeries and anesthesia were carried out by pediatric surgeons and anesthesiologists and therefore the findings may not be generalizable in our setting. The study also excluded patients admitted to ICU 48 hours after surgery, potentially excluding candidates whose reason for ICU admission could be directly linked to surgery and anesthesia. In a similar setting, Bell and colleagues identified emergency surgeries, upper airway complications such as airway obstruction and surgeries involving shared airway and patient comorbidities to be associated with post-surgical ICU admission (Gibson, Limb, & Bell, 2014).

2.3.2 Cardiovascular complications

Hypotension refers to decrease in systemic blood pressure below acceptable values leading to insufficient blood flow to vital organs, potentially causing organ dysfunction. While there are no standard accepted values for hypotensive blood pressures, blood pressure <90/60 mmHg has been considered low (Sharma, Hashmi, & Bhattacharya, 2021). In the peri-operative period, hypotension may be caused by a number of factors such as long fasting duration, anesthetic medications, administration of less fluids, excessive blood loss and or infection. Intra-operative exposure to low blood pressures has been linked with adverse post-surgical outcomes. Sessler and colleagues found that intra-operative exposure to mean arterial pressures <65 mmHg was associated with myocardial infarction, renal injury, and death. the extent of intra-operative hypotension (low blood pressure during surgery), the duration of exposure to low blood pressures and the percentage decrease from baseline play significant roles in determining the severity or adversity of intra-operative hypotension. (Sessler & Khanna, 2018). However, the study relied on precisely measured pressure and pressure variations using invasive arterial blood pressure transducers. This accurate way of measuring blood pressure is not routinely used in anesthesia and therefore hypotensive episodes during surgery are often missed. The non-routine investigation for myocardial injury post-operatively may also contribute to failure to document such association in many setups.

In an adult tertiary institution in Australia, Pertersen and others observed a strong relationship between hypotension in the Post Anesthesia Care Unit (PACU) and subsequent patient deterioration in the ward after elective non-cardiac surgery highlighting the potential clinical significance of blood pressure management during the peri-operative period. The study found a 3.08 relative risk of hypotension and patient deterioration and an OR of 21.13(5.17-86.38) $P<0.001$ for unplanned transfer to ICU among patients who developed hypotension (Petersen et al., 2017). However, the study covered elective surgeries only in which patients are well optimized pre-operatively and therefore the association might be higher with inclusion of more unstable emergency surgery patients. In this study, the researcher did not specify the level of blood pressure relative to the baseline patient pressures or the duration of exposure to the low blood pressures making his findings non-replicable.

Among general surgery and orthopedic surgery patients in a metropolitan hospital in Australia, Mohammed and others observed that hypotension was the major contributor to emergency calls post-surgery at 26% of all rapid response team calls. Though the level of hypotension was not specified, the study found no association between the development of hypotension post-surgery and unplanned transfer to ICU in this patient group (Mohammed Iddrisu, Considine, & Hutchinson, 2018). However, the study only focused on the post-operative period leaving out intra-operative period when more catastrophic hypotension is likely to happen.

To address the varying study definitions of hypotension in literature and the level at which hypotension is associated with adverse outcome, Wesselink and colleagues undertook a systematic review of 42 studies showing association of hypotension and adverse events post non-cardiac surgery. In this review, the researchers demonstrated that any exposure to mean arterial pressure of less than 55-50mmHg or exposure to mean arterial pressure of less than 65-60mmHg for more than 5 minutes was significantly associated with end-organ injury and increased morbidity with either OR or RR of between 1.4 to 2.0 (Wesselink et al., 2018). It however remains difficulty to harmonize literature finds due to various methods of monitoring blood pressure intra and post-operatively.

Hypotensive patients in the immediately post-operative period may therefore require intensive care to enable institution of vasopressor support. ICU care in these patients allows close monitoring to help determine the need for intravascular volume expansion by way of intravenous fluid administration as well as early identification of complications that may arise due to hypotension.

Intra-operative major bleeding is a major complication of surgery and is associated with adverse outcomes including death. In a data review of peri-operative adverse events, Irita and colleagues found that massive hemorrhage was responsible for 33% of cardiac arrest and 47% of deaths in the peri-operative period. Although some cases of major bleeding where the indication for the surgery, 1/3 of major hemorrhage was caused by the surgical procedure (Irita, 2011). Despite the significance of hemorrhage in surgery, to date no universally agreed definition of critical hemorrhage exist. While the Korean society of anesthesiology define massive bleeding as loss of blood exceeding circulating blood volume within 24 hours or blood loss exceeding 150 ml per minute, Gonzalez and others define major bleeding as any bleeding that if not properly managed will put the patient at risk (Gonzalez-Rivas et al., 2016). Among obstetrics and gynecology patients, major intra-operative bleeding is defined as blood loss of more than 1000 ml of blood ("Management of hemorrhage in gynecologic surgery - UpToDate," n.d.). This great variance in definition poses a challenge in comparing literature on this topic.

In a defense tertiary institution intensive care unit in India, Singh and others found that intra-operative major bleeding occurred in 24% of patients with unplanned post-operative ICU admission compared to 9% occurrence among the planned post-operative ICU admission group (Singh, Datta, Sasidharan, Tomar, & Babitha, 2019). This study defined major bleed as blood loss more than 1000 ml and excluded pediatric patients in order to minimize bias due to their different physiology. Among patients undergoing elective arthroscopy, Sukhonthaman and colleagues found an association between major bleeding and unplanned ICU admission with an OR of 1.002 (1.001, 1.003) $P<0.001$ (Sukhonthamarn, Grosso, Sherman, Restrepo, & Parvizi, 2020). Intra-operative blood loss is however often a subjective entity with different practitioners using different methods to determine or estimate blood loss. Jaramillo and others found that the different formulae used to estimate blood loss differ substantially with direct measurement of blood loss (Jaramillo et al., 2019) raising the question of whether estimated blood loss reflects the actual intra-operative blood loss.

Patients who experience major bleeding intra-operatively require ICU admission in order to fast track transfusion services. Major intra-operative bleeding may require massive transfusion and this often presents high risk for transfusion related complications such as transfusion reactions and electrolyte disturbances. Monitoring for these complications as well as preparation to manage them in case they occur therefore necessitates the need for intensive care in these patients.

Intra-operative cardiac arrest is a rare but highly catastrophic event in surgery. The European resuscitation council reported an overall incidence of intra-operative cardiac arrest of 4.3 to 34.6 per 10,000 procedures in 2015 with an associated 30% 28-day mortality (Truhlar, Deakin, Soar, & al., 2015). In a database review, Nunnally and others reported 1 cardiac arrest per 1000 procedures with intracranial procedures contributing the highest incidence of cardiac arrest (Nunnally, O'Connor, Kordylewski, Westlake, & Dutton, 2015). Intra-operative cardiac arrest poses an increased risk for unplanned post-operative ICU admission with poor outcome. In a multicenter retrospective study, Quinn and colleagues found an incidence of 21.3 and 66.5 per 10,000 procedures in spine and craniotomy surgeries respectively. Patients who experienced intra-operative cardiac arrest with associated unplanned post-operative ICU admission were was associated with a higher likelihood of failure to wean from ventilators and higher mortality rates (Quinn, Brovman, Aglio, & Urman, 2017). The study however recruited patients up to 30 days post-operatively potentially influencing outcome variables by events occurring post-surgery. Icy and colleagues found similar findings in a prospective study among neurosurgical patients. Intra-operative cardiac arrest occurred in 8.88% of patients who had unplanned ICU admission compared to 0.14% in the planned ICU admission group, $P<0.001$ (Icy et al., 2020).

Due to the events that led to cardiac arrest as well as the possibility of cardiac arrest related complications such as brain hypoxia, myocardial infarction and acute kidney injury among others, post cardiac arrest patients require close monitoring in critical care units. The post-arrest heart often requires some form of ionotropic support that can best be given in cardiac unit or ICU but considering the immediate post-surgical care requirement, such patients are best admitted to critical care units. These patients are also at risk of a recurrence of an arrest and thus benefit from continuous cardiac monitoring.

2.3.3 Peri-operative electrolyte imbalances

Peri-operative electrolytes imbalances play a key role in determining patient outcomes. The imbalances may be a direct result of the primary pathology necessitating surgery or iatrogenic during patient resuscitation prior to or during surgery. In a tertiary care hospital in Thailand among patients with traumatic head injury undergoing emergency craniotomy, Pathomporn and others found an increased likelihood of death in patients with hyperglycemia, acidosis and sodium imbalance. High intra-operative glucose was associated with an odds ratio of death of 1.08 CI (1.01-1.03) $P<0.01$ while sodium imbalance had an odds ratio of dying of 1.23 CI (1.03-1.46) $P<0.01$. There was however no statistically significant association between potassium imbalance and death (Pathomporn, Saringkarinkul, Yodying, Kacha, 2018). This study however focused on emergency surgery only and all participants had severe head injury, an independent predictor of mortality in traumatic head injury.

In tertiary hospital in Atlanta among non-cardiac surgery patients, peri-operative hyperglycemia was found to be associated with hospital length of stay and in-hospital mortality. Significant increase in mortality was found among non-diabetics with hyperglycemia either pre or post-operatively while hyperglycemia peri-operatively did not significantly affect mortality among diabetics (Frisch et al., 2010).

A secondary analysis of the European surgical outcome study, that recruited a heterogeneous population, revealed significant incidence of sodium imbalance among pre-operative non-cardiac surgery patients with 23.8% and 14.9% incidences of hyponatremia and hypernatremia respectively. Patients with pre-operative hyponatremia had a 3-fold increase in likelihood for ICU admission post-operatively while hypernatremia increased the chance for post-operative ICU admission 5-fold. Moderate to severe hypernatremia were independent predictors of in-hospital mortality with odds ratio of 3.4 (95% CI 2.0–6.0), P<0.001(Marshall et al., 2017).

However, among patients undergoing high risk laparotomy for intestinal obstruction or perforated viscous, neither sodium or potassium imbalances were found to be associated with 28-day complications. In this population, electrolyte disorders linked to adverse outcomes included hypochloremia and hyperlactatemia. Hyperlactatemia was found to be associated with increased risk of major complications and death with odds ratio of 4.39 CI 1.42, 15.3, P= 0.013 and odds ratio 2.44 CI 1.24, 4.92, P= 0.010 in intestinal obstruction and perforated viscous respectively. In the subgroup with intestinal obstruction, hypochloremia was associated with major complications and death with odds ratio of 2.87 CI 1.35, 6.23, p= 0.006 (Cihoric, Kehlet, & Højlund, 2017).

Since electrolytes form a key component in physiological homeostasis, severe acute derangements in electrolyte levels require critical care management. Significant imbalances in potassium, magnesium and calcium levels can trigger hemodynamically significant arrythmias and even cardiac arrest. Such patients therefore require continuous electro cardiac monitoring in ICU. Significant sodium imbalances have been associated with mental obtundation due to sodium effect of fluid balance in different fluid compartments in the body. These imbalances thus require well titrated correction with close patient monitoring, an indication for ICU admission. Severe acidosis require intervention in the critical care unit. While the management of severe respiratory acidosis requires assisted ventilation, severe metabolic acidosis require keen evaluation and close monitoring to determine need for alkali administration things that are better managed in ICU set up.

2.3.4 Neurological complications

Peri-operative neurological adverse events have been associated with ICU admissions and adverse post-operative patient outcomes. Patients who undergo surgery under general anesthesia undergo three phases of anesthesia; induction, maintenance and reversal/ emergence from anesthesia. This type of anesthesia (general anesthesia) often includes muscle paralysis intra-operatively to facilitate manipulation of patient airway and providing optimum surgical condition for the surgeon. Emergence from general anesthesia, traditionally thought to be a mirror of induction, is a complex phenomenon involving not only pharmacokinetic characteristics of anesthetics used but also complex distinct neurobiology, (Max kelz, Paul garcia, George mashour, 2019; vijay tarnal, Philips vliseded, 2016). Patient characteristics such as but not limited to genetic composition, physiological and pathological status may thus influence the smoothness and rapidity of the emergence phase of anesthesia. Inadequate reversal of muscle relaxants may also contribute to delayed and poor emergence from anesthesia. Presence of residual neuromuscular blockade may be determined clinically or by use of a nerve stimulator. The use of clinical signs, though having acceptable specificity, has low sensitivity compared to use of nerve stimulator and the latter is therefore considered the gold standard in diagnosis of residual neuromuscular block, (Plaud, Debaene, Donati, & Marty, 2010). Inadequate reversal of the muscle relaxation as well as prolonged non-smooth emergence from general anesthesia, often referred to as poor reversal of anesthesia, may result in patient's inability to control their airway and need thus for prolonged intubation or re-intubation in the post-operative period.

In a tertiary hospital in Boston, Grabitz and others found a 20.5% incidence proportion of inadequate reversal of neuromuscular blockade, as evidenced by residual neuromuscular block. Patients with inadequate reversal of neuromuscular block had a higher likelihood of post-operative ICU admission with odd ratio of 3.03 (95% CI 1.33-6.87) $P<0.01$. However, the study did not find association between poor reversal of anesthesia and length of hospital stay or patient outcomes (Grabitz et al., 2019). Similar residual neuromuscular blockade incidence proportions were found in Spain by Aragon and colleagues. However, their study did not establish association between poor reversal and post-operative ICU admission (Aragón-Benedí et al., 2022). Similarly, high rates of inadequate emergence from anesthesia were reported in post anesthetic care units in Portugal and Iran, 32% and 20.3% respectively. These patients with poor reversal of anesthesia were significantly associated with critical respiratory events though the studies did not follow up to identify the final disposition of the affected patients, (Braga & Abelha, 2022; Makarem et al., 2020).

Regional and neuraxial anesthesia may also present with neurological complications. In this form of anesthesia, patients' specific nerves or groups of nerves are blocked to provide a pain free and conducive environment for surgery. Nerve blocks of the upper limb, especially interscalene nerve block, have been associated with paralysis of the phrenic nerve that is crucial for breathing. Blocking of the phrenic nerve may result in difficulty breathing and subsequent respiratory failure leading to unplanned post operative ICU admission. Other regional anesthesia complications that may result in post-operative ICU admission include local anesthetic systemic toxicity (LAST) which include but not limited to cardiac arrest.

In a case series study, Spitzer and others reported three cases of post-operative ICU admission in one year due to Interscalene nerve block complications with respiratory insufficiency, (Spitzer et al., 2021). Although the cases were few in this study, several case reports have been documented in literature. Use of ultrasound guidance while performing this procedure has also contributed to a reduction in the incidence of such complication.

Central neuraxial anesthetic technique such as spinal block has also been associated with complications that may lead to unplanned post-operative ICU admission. This technique works by blocking the autonomic nervous system at the spinal cord. In some cases, the drugs used have been reported to settle high above the expected level resulting in blockage of the sympathetic arm of the autonomic nervous system that arises in thoracic and lumber levels of the spine. High level of central neuraxial block may then result in either high spinal or total spinal. Though rare complications of spinal anesthesia, high and total spinal, present with severe hemodynamic instability and respiratory failure and catastrophic decline in level of consciousness, (Asfaw & Eshetie, 2020).

Cerebral vascular accidents may occur intra-operatively and in the immediate post-operative period due to the dynamic cardiovascular changes associated with anesthesia and surgery. The occurrence of a cerebral vascular accident in the peri-operative period has been linked to ICU admission as well as adverse patient outcomes. In a retrospective study of cardiac surgery patients in Royal Papworth Hospital (United Kingdom), patients with post-surgical cerebral vascular accident were found to have a longer ICU stay of 8.0 days vs 1.1 days $P<0.001$ and high in-hospital mortality of 17% vs 5.9% $P<0.001$ (Karunanantham, Ali, Evans, Webb, & Large, 2020). In the united states of America, Kashkoush and colleagues found new-onset cerebral vascular accident among patients undergoing cerebral aneurysm clipping to be associated with longer ICU length of stay {average 9.89 ± 2.26 days for patients with new-onset stroke and 6.22 ± 0.72 days for patients without ($p = 0.004$)} (Kashkoush et al., 2017).

Cerebral vascular events are often associated with reduced level of consciousness and the need for advanced airway management to prevent or minimize the risk of aspiration pneumonia. These patients may also require invasive hemodynamic monitoring and thrombolysis in cases of thrombotic vascular event. To help improve the outcomes of such patients, intensive care is therefore inevitable.

Intra-operative convulsion has well been documented in literature. In cases of patients under general anesthesia, the epileptiform movements are often masked by muscle relaxation and thus these events are rarely documented. However, in the presence of intra-operative electro encephalogram (EEG) monitoring, several cases of intra-operative convulsion have been reported with a 1 in 200 cases incidence of seizures in propofol conducted anesthesia reported, (Howe, Lu, Thompson, Peterson, & Losey, 2016). The occurrence of these events alters the brain metabolic rates and oxygen requirements and if not aborted in good time, such patients may require post-operative ICU admission due to reduced level of consciousness post-operatively.

2.3.5 Respiratory system complications

The respiratory system is among body systems most affected by anesthesia. In general anesthesia, once a patient is medically put to sleep, a muscle relaxant is often administered which results in total shut down of the respiratory system. The work of breathing is then taken over by the anesthesiologist either manually or through a ventilator and this requires a lot of airway manipulation including but not limited to tracheal intubation. Due to the anesthetic as well as extensive manipulation of this system, it is thus prone to varied complications both intra- and post-operatively. Respiratory complications are indeed a significant concern following surgery, and they are one of the major reasons for admission to the Intensive Care Unit (ICU) post-surgically. These complications can range from mild to severe and may include:

- Atelectasis: Atelectasis is the collapse or closure of a part of the lung. It can occur after surgery, especially if a patient is not taking deep breaths or coughing effectively due to pain or sedation.
- Pneumonia: Surgical patients may be at an increased risk of developing pneumonia, particularly if they are intubated (placed on a ventilator) during surgery. Ventilator-associated pneumonia is a concern in ICU settings.
- Pulmonary Embolism: Blood clots in the lungs, known as pulmonary embolisms, can be a serious complication of surgery, especially in surgeries with a risk of deep vein thrombosis (DVT). Patients undergoing instrumentation of long bones may also experience embolism of a fat globule into their lungs, fat embolism.
- Respiratory Failure: In some cases, patients may experience respiratory failure, where the lungs cannot provide enough oxygen or remove enough carbon dioxide from the blood. This can be life-threatening and often requires ICU admission and mechanical ventilation.

- Acute Respiratory Distress Syndrome (ARDS): ARDS is a severe form of lung injury that can occur as a complication of surgery, particularly in cases of trauma or major surgeries.

The broad classification of post-operative pulmonary complication has faced varied definitions in literature which may at times lead to under or over diagnosis. Post-operative respiratory complications have high incidence of up to 23% following major surgeries with respiratory failure as the commonest diagnosed respiratory complication post-operatively and have been associated with increased post-surgical morbidity and mortality (Miskovic & Lumb, 2017).

Post-surgical pulmonary complications remain a key determinant of unplanned ICU admission post-operatively. In an academic institution in the United States, Fernandez and colleagues reported a direct association between the number of post-operative pulmonary complications and ICU admission among non-cardiothoracic surgery patients. In this study, the common pulmonary complications post-operatively included, desaturation and atelectasis. Pulmonary complications were more likely to occur among patients with chronic obstructive pulmonary disease (COPD) and those undergoing abdominal pelvic surgery (Fernandez-Bustamante et al., 2017). However, this study did not stratify admission to ICU based on pre-operative bed booking.

Literature concerning unplanned post-surgical ICU admission also places respiratory complications as major indication for ICU admission, (Bhat et al., 2006; Katori et al., 2022). Despite significant difference in the study population in these studies, Katori and colleagues included all specialties while Bhat and friends excluded cardio-thoracic and neuro surgery, abdominal surgeries were commonly associated with respiratory complications while hypoxia remained the commonest respiratory complication.

Patients who develop respiratory complications intra and post-operatively may require a long duration before complete restoration of their physiology and pose a 14 – 30% mortality risk and thus often require some form of respiratory support, (Miskovic & Lumb, 2017). The severe respiratory complications thus require admission to critical care units for assisted ventilation and monitoring in the immediate post-operative period.

2.4 Risk factors associated with unplanned post-operative ICU admissions.

Identification of patients, surgical and anesthetic characteristics associated with unplanned post-surgical ICU admission is critical in improving the planning of patient care and resource allocation. Following the introduction of a multi-disciplinary clinic to risk stratify patients pre-operatively, Coll and others found a statistically significant reduction in post-surgical unplanned ICU admission, 1.3% to 0.4% $P<0.01$, among orthopedic surgery patients (Coll et al., 2011).

Age has been postulated to be a key independent risk factor for unplanned post-operative ICU admission (Quinn, Gabriel, et al., 2017; Wanderer et al., 2013). The extreme of ages, neonates and geriatrics, are generally considered high risk category due to their unique physiologic characteristics that affect their response to stress. However, there is a great variance in the age limit when this factor becomes statistically significant. While Bhat and others found age >60 years to have higher rates of post-operative ICU admission independent of other variables (Bhat et al., 2006), age was shown to be a non-independent factor for post-operative ICU admission following non-cardiac surgery in Spain (Nadal et al, 2018). Among infants, prematurity and age <6moths were significantly associated with unplanned post-surgical intubation, P<0.001 (Lisa Eisler, May Hua, Guohua, Lena Sun, 2019).

The American Society of Anesthesiologists (ASA) Physical Status Classification System is a widely used system to assess a patient's overall health before undergoing surgery or anesthesia. It was developed by the ASA to provide a simple, practical, and standardized way for anesthesiologists to communicate the pre-operative health status of patients. This risk stratification system puts into account the presence or absence of a systemic disease to a patient and classifies patients to ASA class I to VI based on severity of the disease. Generally in literature, patients with ASA classification of >III have been shown to carry a higher risk of ICU admission post-operatively independent of other factors (Kim et al., 2019; Landry et al., 2017; Onwochei, Fabes, Walker, Kumar, & Moonesinghe, 2020). However, ASA class II, who are considered to be otherwise stable predominated among patients with unplanned post-operative ICU admission (Singh et al., 2019; Vijay Singh & Shibu Sasidharan, 2020). Despite its simplicity and ease of use for communication purposes, it is important to note that this classification is subjective and may be influenced by the judgment and experience of the anesthesiologist.(Ferrari et al., 2020; Hurwitz et al., 2017). The stratification method has also been designed to stratify patient population and may therefore not be reliable in individualized risk stratification.

With advancement of surgical techniques and medical technology, different surgical specialties and sub-specialties have emerged. This advancement has led to varied patient and surgical procedure characteristics presenting to the operating room thus presenting a peri-operative care challenge to both the surgeon and the anesthesiologist. The contribution of surgical specialty to unplanned postoperative ICU admission has however remained uncertain in literature. While Quinn and others found that vascular and thoracic surgery formed the majority of unplanned post-surgical ICU admission by surgery type (Quinn, Gabriel, et al., 2017), Bhat found abdominal surgery topping unplanned post-surgical ICU admission by surgery type (Bhat et al., 2006). On the other hand, Vijay found gynecologic and obstetric procedures to lead to unplanned post-surgical ICU admission (Vijay Singh & Shibu Sasidharan, 2020) with Petersen finding no significant association with surgery type and complexity to unplanned post-operative ICU admission (Petersen Tym et al., 2017). These findings should however be interpreted cautiously since the researchers did not match the patient and other surgical characteristics across the different surgical specialties.

General anesthesia, surgery duration, and emergency surgeries have been consistently associated with the risk of unplanned post-operative ICU admission (Landry et al., 2017; Petersen Tym et al., 2017). However, no consensus on the duration cut point for such association with Quinn getting association with duration of >4 hours (Quinn, Gabriel, et al., 2017) while Laundry found an association with surgery duration of >1 hour (Landry et al., 2017).

The composition of surgical and anesthesia teams plays a key role in patient surgical outcome. While individual health provider skill capability may differ among those considered to be of the same level of training and experience, it is generally expected to have better outcomes among the more trained and experienced providers compared to their juniors. However, the debate on the contribution of surgical and anesthesia team composition on unplanned post-surgical ICU admission remains unsettled. Landry and colleagues reported a reduced risk of unplanned post-surgical ICU admission in pediatric surgical procedures done by surgical and anesthesia residents alone compared with those with the attending consultant present with OR of

0.44(0.23-0.83) P=0.012 (Landry et al., 2017). This finding was similar to findings by Wanderer and others that unplanned post-surgical ICU admission was likely to happen with surgeon and anesthetist hands-off OR 2.01(1.59-2.75) P<0.001 and 1.77(1.64-1.90) P<0.001 respectively (Wanderer et al., 2013). However, in Kenyatta National Hospital, Mungai found that surgery carried by surgery and anesthesia registrars in the absence of the respective consultants increased the risk of unplanned post-operative ICU admission (Mungai, 2011). These studies did not factor complexity of the surgical procedures and surgical type (emergency or elective), factors that have been documented to have significant effect of patient outcome.

Medical comorbidities have been associated with intra-operative adverse events and unplanned postoperative ICU admission. Chronic Obstructive Pulmonary Disease (COPD) is a respiratory condition characterized by airflow limitation, and individuals with COPD may have reduced lung function, making them more vulnerable to respiratory complications after surgery. Patients with COPD may therefore present an increased risk of complications following surgery, and unplanned post-operative ICU admission can be one such complication. The increased risk is often related to pre-existing respiratory impairment, increased susceptibility to infections and risk of intra-operative exacerbation among other factors. COPD has been identified as an independent risk factor for unplanned post-operative intubation with an OR of 1.66(1.32,2) P<0.001 following lung resection (Burton, Khoche, A'Court, Schmidt, & Gabriel, 2018) and OR 1.61(1.46,1.78) following vascular and general surgery (Nafiu et al., 2011).

Diabetes mellitus (DM), is an endocrine disorder presenting with abnormalities in glucose utilization due to either insulin deficiency or resistance to insulin. Diabetes can affect various organ systems, and surgical stress can exacerbate these effects, leading to potential complications. Particularly, DM patients may present with non-specific symptoms for cardiovascular diseases including asymptomatic myocardial infarction. These masked disorders may then be exacerbated by surgical stress resulting in peri-operative complications that may require ICU care. DM patients are also at increased risk of delayed wound healing and infections due to immune suppression. While Nafiu and colleagues found no association between diabetic Mellitus and unplanned post-operative intubation, OR 1.07(0.98,1.21), Sukhonthamarn found DM to have a significant association with unplanned post-operative ICU admission, OR 1.01(1.008, 1.014) P<0.001 (Nafiu et al., 2011; Sukhonthamarn et al., 2020). Seglenieks and others found hypertension and heart failure to be associated with peri-operative adverse events (Seglenieks et al., 2014).

2.5 Patient outcomes among post-operative ICU admitted patients

Patient outcomes among post-operative Intensive Care Unit admitted patients can vary widely and depend on a multitude of factors, including but not limited to the type of surgery, the patient's underlying health status, the reason for ICU admission, the quality of post-operative care, and any complications that may arise. Key outcome measures in ICU include duration of mechanical ventilation, the length of ICU stay, survival at ICU discharge and 28-day mortality.

The length of stay (LOS) in the Intensive Care Unit is a significant metric in healthcare that can have various implications and serve as an important measure of patient care and resource utilization. This outcome may be influenced by a number of factors such as severity of disease at admission, quality of care while in ICU and occurrence of complication. The significance of type of ICU admission on duration of ICU stay with unplanned admissions remains debatable. In the international surgical outcome study (ISOS), among low- and middle-income countries, Kahan and others found that unplanned post-surgical ICU admissions had a longer ICU stay with a mean admission duration of 4.2 days (SD 5.3) vs. 2.3 days (SD 3.5) (Kahan et al., 2017). This finding was similar to the finding by Pearse and colleagues that unplanned post-surgical ICU admission had a longer length of stay in ICU, 3 days vs. 1 day (Pearse et al., 2006). Haller and colleagues also found an increased length of stay among unplanned post-surgical ICU admissions compared with planned admissions 16 days vs. 2 days, $P<0.001$ (Guy Haller et al., 2005). However, Kahan and colleagues observed a longer ICU duration of stay among routine post-operative ICU admission compared to complication-induced post-operative ICU admission following elective surgery (Kahan et al., 2017).

Intensive Care Unit admission for observation is a medical practice where certain patients are admitted to the ICU not necessarily because they require immediate intensive interventions or life support but rather for close monitoring and evaluation. Patients with planned post-surgical admission to ICU are more likely to be admitted for observation compared to the unplanned group. Vijay and others reported ICU admission for observation in 58.8% of planned admission compared with 28.3% in the unplanned group. Mechanical ventilation, an ICU specific intervention, was found to be high among the planned admission group compared with the unplanned group 30.3% vs 26.1% $P<0.05$ (Vijay Singh & Shibu Sasidharan, 2020). However, Quin and others reported a great risk of re-intubation and ventilation among unplanned post-surgical ICU admissions compared with planned admissions with OR 282(250-318) among the unplanned group (Quinn, Gabriel, et al., 2017).

The practice of routine post-operative ICU admission has been a topic of discussion and research in the medical community, and its benefits and necessity can vary depending on several factors, including the type of surgery, patient characteristics, and healthcare resources. Research findings on the mortality benefits of routine post-operative ICU admission have been mixed. Routine post-operative ICU admission was found to confer no mortality benefits among patients with pheochromocytoma (Papachristos et al., 2021) while selective post-operative ICU admissions post supra-glotoplasty in the pediatric population reduced ICU utilization from 71% to 26% (P<0.001) with no changes in outcome measures (Cooper, Harris, Mourad, 2017). However, unplanned post-operative ICU admission has been associated with poor patient outcomes with three times mortality among unplanned post-operative admissions compared to planned post-operative admissions (Pearse et al., 2006).

The international surgical outcome study found three times mortality among the unplanned ICU admission compared to planned admissions patient group, 9.7% vs. 2.4%. This finding is similar to the finding by Pearse and others of 28.6% vs. 10.1% mortality among unplanned ICU admission patient group compared with planned ICU admission (Pearse et al., 2016; Pearse et al., 2006). The higher mortality among unplanned admissions was attributed to higher complication rates among this patient group as surgical complications have been linked to high mortality. A multicenter study on post-surgical patient outcomes globally found a 16.8% post-surgical complication rate and 2.8% mortality among those who developed complications (Pearse et al., 2016). In Africa, 18.5% of post-surgical patients developed complications with a 16.3% ICU admission rate and associated 9.5% mortality among those who developed complications post-surgery (Biccard et al., 2018) pointing to a higher mortality rate following surgical complications. However, Wanderer and colleagues reported no difference in both in-hospital and 28-day mortality between unplanned and planned post-surgical ICU admission, 5.6% vs 6% P=0.248 and 7.0%

vs 8% P=0.847 in hospital and 28-day mortalities respectively (Wanderer et al., 2013).

2.6 Conceptual framework

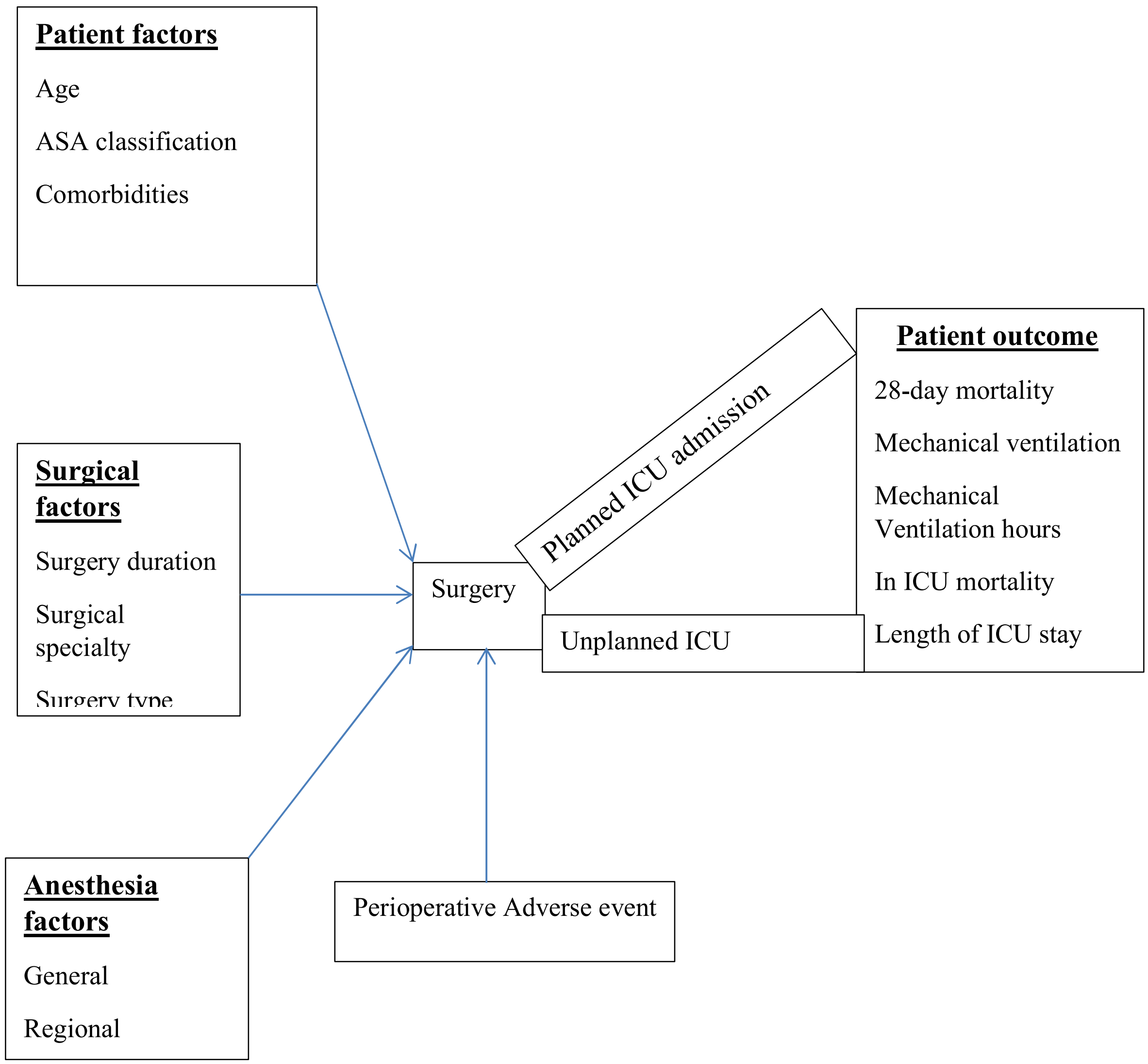

Figure 2.1: Conceptual framework

CHAPTER THREE: METHODOLOGY

3.1 Study setting

The study was carried out in MTRH; the second largest National Teaching and Referral Hospital (level 6 Public Hospital) in Kenya with a general patient bed capacity of 1020, a 17-bed mixed general ICU, and a 6-bed neonatal ICU (NICU). MTRH has a multi-specialty surgical department with specialists in general surgery, pediatric surgery, obstetrics and gynecology, cardio-thoracic, neurosurgery, maxillofacial, Ears Nose and Throat (ENT), orthopedics and spine among other specialties. MTRH operating theatre boasts of 12 operating rooms with four and eight operating rooms dedicated for emergency and elective surgeries respectively during the day Monday to Friday while three operating rooms manage emergencies during the night, weekends and holidays. The hospital serves as the Teaching Hospital for Moi University College of Health Sciences that trains both Undergraduate Medical Students and several masters in Medicine Specialist programs including anesthesiology and several surgical specialties.

MTRH is located along Nandi Road in Eldoret Town and serves residents of the Western Kenya Region (representing at least 22 Counties), parts of Eastern Uganda, and Southern Sudan with a catchment population of approximately 24 million.

3.2 Study design

This was a prospective comparative observational study.

3.3 Target population

The target population for the study were all patients from any surgical specialty undergoing surgical procedures, either elective or emergency, in MTRH.

3.4 Study population

The target population was subjected to study eligibility criteria to determine the study population.

Inclusion criteria;

- Adult and pediatric patients who underwent surgery at MTRH and were admitted to MTRH ICU post-operatively, as per MTRH ICU admission guidelines, within their current hospital admission duration.

Exclusion criteria;

- Post-operative patients operated in MTRH and admitted to MTRH ICU but transferred within their ICU admission to ICU in other facilities to avoid bias on outcomes as a result of the difference in patient care in different facilities.
- Patients who died shortly after decision to admit to ICU had been made, before recruitment into the study, while either in operating room, hospital ward or in ICU to avoid psychological trauma to next of kin in the process of consenting.
- Patients whose pre-operative review and decision to admit to ICU post-operatively was made by the principal investigator to minimize bias as the researcher would influence patient placement in a particular study group.

3.5 Sample size determination

The study aimed at comparing patients' outcomes among planned and unplanned post-operative ICU admissions in MTRH. The researcher compared, among other outcome parameters, the length of hospitalization in ICU as one of the main outcomes. In the multi-center international surgical outcome study (ISOS), the mean length of ICU stay in low and mid-income countries (Brazil, China, Indonesia, Malaysia, Romania, South Africa, Nigeria, and Uganda) was found to be 2.3 ± 8.3 days and 4.2 ± 9.7 days for planned and unplanned post-operative ICU admission respectively (Kahan et al., 2017). Assuming the length of ICU stay follows a normal distribution in the population, the sample size was then determined using the formula for comparison of means as described by Kelsey and colleagues (Jennifer Kelsey, Alice Whittemore, Alfred Evans, 1996).

$$n \geq \left(\frac{r+1}{r}\right)\frac{\sigma^2 (Z_\beta + Z_{\alpha/2})^2}{(d\text{ifference})^2}$$

Where:

n = is the total sample size

r = is the ratio of planned to unplanned ICU admissions (r=1, based on anecdotal findings of MTRH)

σ = is the standard deviation in the population taken as the average of the two standard deviations(σ =9)

$\mathbf{Z_\beta}$ =is the critical value for the desired power (Type II error β = 0.2, $\mathbf{Z_\beta}$ =0.84)

$\mathbf{Z_{\alpha/2}}$**=** is the critical value for standard normal distribution at α-level of significance (Type I error α= 0.05, $\mathbf{Z_{\alpha/2}}$=1.96)

difference = is the expected effect size (the difference in means = 1.9 days)

Substituting for the above figures, the minimum sample size required to detect a mean difference of 1.9 days was 352. Since ration of planned to unplanned admission was taken as one, 176 patients were recruited in each group (planned and unplanned post-operative ICU admissions).

3.6 Sampling technique

A consecutive sampling technique was applied in this study.

3.7 Study procedure

PACU records were used to identify patients whose decision to admit to ICU was made following triage in PACU post-surgery. The ICU admission register was used to identify patients whose decision to admit to ICU post-surgery was made pre-operatively or intra-operatively and were therefore admitted to ICU directly from the operating room or those admitted to ICU following a complication while in the post-surgical wards. Eligibility for ICU admission was the sole responsibility of the attending clinician as per MTRH ICU admission criteria, appendix 1, as the researcher observed variables without influencing the type of ICU admission (planned or unplanned). Patient file was used to confirm that surgery was done at MTRH.

Patients admitted to ICU that met the study eligibility criteria were recruited to the study by administering informed consent, appendix 2, to them while admitted in the ICU in cases where the participant was conscious enough to offer informed consent or to their next of kin /guardian in cases where the participant was not conscious enough to offer informed consent or in cases of minors. Following signing of consent by a participant or their next of kin / guardian, patients' records were then be used to extract information on risk factors and peri-operative adverse events (complications) and the type of ICU admission (planned or unplanned) into a data collection form, appendix 3. Missing data from the patient record was reconciled for completeness by interviewing the participant or their next of kin/ guardian.

The study participants were then followed up while in the ICU to determine their duration of ventilation in hours (for those that were mechanically ventilated), length of ICU stay in days and condition at discharge from ICU (either discharged alive or died in ICU). Participants whose length of ICU stay was 28 or more days also had their twenty-eight-day survival determined while in ICU and their follow up terminated at the day of discharge from ICU. However, participants that were discharged from ICU in less than 28 days were followed up via phone calls to them or to their next of kin either while in the general post-surgical wards or at home for a maximum duration of 28 days since the date of ICU admission to determine their twenty-eight-day survival.

3.8 Data management and analysis plan

The data collected in paper form was checked for completeness daily by the researcher. The filled data collection forms remained in the custody of the researcher, in a secured cabinet under lock and key. On a monthly basis, data entry was done by the researcher into an electronic data base, MS Access database. Double data entry was done to ensure accuracy. The data was stripped off the patient identifiers, and the database encrypted to prevent unauthorized access. The decryption key was in the sole possession of the researcher. Backup for the data was done using external data drives to cushion against data loss. These data drives were kept in an off-line CPU to guard against data breach by viruses or hacking.

Data was imported into STATA 16, after the end of data collection and entry of data from the 352 study participants, where coding, management, and analysis was done. Continuous variables such as age, surgery duration, ventilation hours, and length of ICU stay were summarized as means and their corresponding standard deviation if they assumed normal distribution else as medians and their corresponding interquartile range. Categorical variables such as type of anesthesia, surgery type, surgical specialty, ASA classification, comorbidities, type of ICU admission, twenty-eight-day survival, peri-operative adverse event, and condition at discharge from ICU were summarized by percentages and cross-tabulation.

Proportions were calculated to determine the incidence proportion of unplanned post-operative ICU admission and a 95% confidence interval constructed. Peri-operative adverse events contributing to unplanned post-operative ICU admission were summarized as frequencies and corresponding proportions.

Cross-tabulation was done to assess the factors associated with unplanned post-operative ICU admission. Test of association like Chi-square and Fisher's exact test were done at a bivariate level while logistic regression was performed at multivariate level.

Chi squire test or Fisher's exact test was applied to compare the type of ICU admission and 28-day survival and condition at discharge from ICU. T-test or Wilcoxon test was done to compare average ventilation hours and length of ICU stay between types of ICU admission. All statistical analyses were carried out at a 5% level of significance.

After data entry and analysis, the data collection forms were kept in a safe cabinet under a lock and the key kept by the researcher. They will then be destroyed five years after the defence of this thesis by the researcher.

3.9 Ethical considerations

Approval from MTRH/Moi University Institutional Research and Ethics Committee (IREC) was sought before conducting the study, approval number FAN:0004008 and permission to collect data in MTRH was sought from the MTRH CEO and approval given via a letter ref ELD/MRTH/R&P/10/2/V.2/2010, appendix 6 and 7 respectively. Permission for data collection was also sought and granted by the National

Commission for Science, Technology & Innovation (NACOSTI) through license number NACOSTI/P/22/20903, appendix 8. Informed consent was also obtained from the participants or their next of kin/guardians. Data collection forms have been stored in locked cabinets since beginning of data collection and will remain locked until five years after the defence of this thesis by the researcher when they will be destroyed. Participants' identifiable details were de-identified before analysis of the data.

3.10 Study limitations

There are no standard timelines in literature determining when adverse events following surgery can be directly attributable to the surgical procedure and or anesthesia. The study findings may therefore not be precisely comparable with other studies due to variance in recruitment timelines in literature. For this study, patients were recruited if they were admitted to ICU post-surgery within their admission hospital stay duration.

The findings of this study had a risk of being influenced by selection bias as the researcher used consecutive sampling technique. Being a comparative study, the allocation of patients to a specific group would have posed the highest bias. To minimize this bias, the researcher did not influence the decision to admit post-surgical patients to ICU or decision to pre-operatively book ICU bed for surgical patient. When the principal investigator was directly involved in pre-operative decision to post-operatively admit a patient to ICU, the patient was excluded from participating in the study. The rest of the research information was observational and participating in the research did not change standard of care and thus researcher involvement in ICU care of the patient did not influence outcomes.

CHAPTER FOUR: RESULTS

4.1 Introduction

The findings of this study are based on 352 patients who were admitted in MTRH ICU post-operatively between October 2021 and September 2022. The study had an aim of comparing length of hospitalization in ICU as one of the main outcomes, among other outcomes, between planned and unplanned admissions.

4.2 Participants' characteristics

Participants' age ranged from 0.5 year to 97 years with a median age of 35 (IQR 19.5, 52) years. Planned admission had relatively lower median age of 34 (IQR 19, 51) years compared to unplanned admissions 35 (IQR 20.5, 55) though the difference was not statistically significant (p= 0.910). Overall, males were majority 205(58.2%), and significantly, more under the unplanned admission 115(65.3%) compared to females 90(34.7%), p=0.007. About a third 96(27.3%) of the participants had other comorbidities, where 37(21%) of the unplanned admission had comorbidities which is a significantly lower proportion compared to 59(33.5%) among planned admissions, p=0.008. The most common comorbidity was hypertension affecting 59 (16.8%) participants followed by Intracranial space occupying lesion (SOL) 20 (5.7%) and diabetes Mellitus 12 (3.4%) of which planned admission had higher proportion with intracranial SOL 18(10.2%) compared to unplanned admission group 2(1.1%), p<0.001.

ASA III patients formed majority of overall post-operative ICU admissions, 176(50.1%) with no significant difference in ASA score among planned and unplanned group. Most of the admissions 177(56.9%) had a pre-operative GCS of 14 to 15. However, unplanned admission formed majority of admissions with pre-operative GCS of between 3 and 8, (Table 1a).

Table 1a: Bivariate analysis of participants' characteristics by ICU admission type

Variables	ICU admission type		Total (n = 352)	P - value
	Planned (n = 176) n (%)	Unplanned (n = 176) n (%)		
Gender				
Male	90 (51.1)	115 (65.3)	205 (58.2)	0.007[c]
Female	86 (48.9)	61 (34.7)	147 (41.8)	
Comorbidities	59 (33.5)	37 (21)	96 (27.3)	0.008[c]
Cardiovascular comorbidities				
Hypertension	33 (18.7)	26 (14.8)	59 (16.8)	0.318[c]
Arrhythmia	2 (1.1)	1 (0.6)	3 (0.8)	>0.99[f]
Heart failure	4 (2.3)	2 (1.1)	6 (1.7)	0.685[f]
Nervous Disorders				
Seizures	7 (4)	4 (2.3)	11 (3.1)	0.358[c]
Intracranial SOL	18 (10.2)	2 (1.1)	20 (5.7)	<0.001[c]
Endocrine disorders				
Diabetes	6 (3.4)	6 (3.4)	12 (3.4)	>0.99[c]
Hyperthyroidism	0	1 (0.6)	1 (0.3)	>0.99[f]
ASA				
I	12 (6.8)	13 (7.4)	25 (7.1)	0.209[c]
II	43 (24.4)	53 (30.3)	96 (27.3)	
III	98 (55.7)	78 (44.6)	176 (50.1)	
IV	23 (13.1)	31 (17.7)	54 (15.4)	
Pre-operative Oxygen saturation				
Normal (>90%)	148 (85.1)	142 (80.7)	290 (82.9)	0.277[c]
Low (<90%)	26 (14.9)	34 (19.3)	60 (17.1)	
Pre-operative GCS				
14 to 15	106 (66.7)	71 (46.7)	177 (56.9)	<0.001[c]
9 to 13	19 (11.9)	47 (30.9)	66 (21.2)	
3 to 8	34 (21.4)	34 (22.4)	68 (21.9)	

[c] Chi Square test
[f] Fishers Exact test

Overall, emergency surgery formed the majority of participants admitted in ICU at 193(54.8%). Among the participants' ICU admission groups, emergency surgery significantly predominated the unplanned group while elective surgery predominated the planned group at 136(77.3%) and 119(67.6%) respectively. Neurosurgery was the main surgical specialty referring to ICU post-operatively accounting for 209(59.9%) of all admissions followed by pediatric surgery and general surgery at 60(17.2%). Notably, all obstetrics and gynecology patients admitted to ICU post-operatively were unplanned admissions with the specialty accounting for 18(10.4%) of unplanned admissions. A statistical significance was established between general anesthesia and post-operative ICU admission with only 7(2%) of all admissions having received regional and or local anesthesia.

Consultants were more likely to be present during surgery in patients who had planned admission at 82(47.4%) and 123(71.1%) for anesthesiologist and surgeon respectively as compared to those with unplanned admission 14(8.1%) and 49(28.8%) for anesthesiologist and surgeon respectively. Overall, anesthesiologists were present during surgery for 96(27.8%) of participants admitted to ICU while surgeons were present in 172(50.2%) of the participants. Most 201(57.6%) post-operative ICU admissions had anesthesia and surgery duration of more than 3 hours, (Table 1b).

Table 1b: Bivariate analysis of surgical, anesthesia and provider characteristics by ICU admission type

Variables	ICU admission type Planned (n = 176) n (%)	ICU admission type Unplanned (n = 176) n (%)	Total (n = 352)	P - value
Surgery type				
Elective	119 (67.6)	40 (22.7)	159 (45.2)	<0.001[c]
Emergency	57 (32.4)	136 (77.3)	193 (54.8)	
Surgical specialty				
Neuro surgery	117 (66.5)	92 (53.2)	209 (59.9)	0.001[f]
Cardio thoracic	27 (15.3)	7 (4.1)	34 (9.7)	
Maxillofacial/ ENT	1 (0.6)	12 (6.9)	13 (3.7)	
General/ Paediatric surgery	27 (15.3)	33 (19.1)	60 (17.2)	
Orthopaedic surgery	4 (2.3)	11 (6.4)	15 (4.3)	
Obstetric & gynecological	0	18 (10.4)	18 (5.2)	
Anesthesia type				
General	174 (98.9)	171 (97.2)	345 (98)	0.448[f]
Regional/local	2 (1.1)	5 (2.8)	7 (2)	
Presence of consultant				
Anesthesiologist	82 (47.4)	14 (8.1)	96 (27.8)	<0.001[c]
Surgical consultant	123 (71.1)	49 (28.8)	172 (50.2)	<0.001[c]
Surgery duration in hours				
<1	4 (2.3)	12 (6.9)	16 (4.6)	<0.001[c]
1 – 2	14 (8.1)	43 (24.6)	57 (16.3)	
2 – 3	35 (20.1)	40 (22.9)	75 (21.5)	
>3	121 (69.5)	80 (45.7)	201 (57.6)	

[c] Chi Square test

[f] Fishers Exact test

4.3 Peri-operative adverse events among post-operative icu admitted participants

The most common complications that led to ICU admission were pulmonary 128 (36.4%) followed by neurological 116 (32.9%) and cardiovascular 71 (20.2%). Among cardiovascular complications, hemodynamic instability due to hemorrhage was more common, 20(5.7%), and affected unplanned post operative ICU admissions more than planned post operative ICU admissions, p=0.01. Among the pulmonary complications, prolonged apnea requiring ventilator support was the most common affecting 62 (17.6%) of all the participants. Among neurological complications, poor anesthesia reversal with GCS less than 8/15 was most common 58 (16.5%) and more frequent among unplanned than planned post operative ICU admissions, P < 0.001. Notably, prolonged peri-operative convulsions occurred exclusively among unplanned admissions, P < 0.001.

The single common adverse events leading to ICU admission were prolonged apnea and poor reversal of anesthesia at 62(17.6%) and 58(16.5%) respectively. However, poor reversal of anesthesia was significantly higher in unplanned admissions than planned admissions, P<0.001, while no statistically significant difference between planned and unplanned admissions among those with prolonged apnea. (Table 2a).

Table 2a: Bivariate analysis of indications for ICU admission by admission type

Complications	ICU admission type		Total	p-value
	Planned (n = 176) n (%)	Unplanned (n = 176) n (%)	(n = 352)	
Cardiovascular	39 (22.2)	32 (18.2)	71 (20.2)	0.352[c]
Cardiogenic shock	1 (0.6)	0	1 (0.3)	<0.99[f]
Complex arrhythmia	1 (0.6)	1 (0.6)	2 (0.6)	<0.99[f]
Hypertension emergency	2 (1.1)	3 (1.7)	5 (1.4)	>0.99[f]
Status post cardiac arrest	1 (0.6)	6 (3.4)	7 (2)	0.121[f]
Hemodynamic instability	4 (2.3)	16 (9.1)	20 (5.7)	0.010[c]
Pulmonary	49 (27.8)	79 (44.9)	128 (36.4)	0.001[c]
Airway obstruction	1 (0.6)	13 (7.4)	14 (4)	0.002[c]
Prolonged apnea	30 (17.1)	32 (18.2)	62 (17.6)	0.780[c]
Aspiration	0	1 (0.6)	1 (0.3)	>0.99[f]
Neurological	54 (30.7)	62 (35.2)	116 (32.9)	0.427[c]
Acute cerebral vascular accident	9 (5.1)	3 (1.7)	12 (3.4)	0.078[c]
poor anesthesia reversal	15 (8.5)	43 (24.4)	58 (16.5)	<0.001[c]
Peri-operative prolonged convulsion	0	15 (8.5)	15 (4.3)	< 0.001[c]
Deranged laboratory findings	1 (0.6)	5 (2.8)	6 (1.7)	0.215[f]
Serum potassium	2 (1.1)	0	2 (0.6)	0.499[f]
PH	1 (0.6)	5 (2.8)	6 (1.7)	0.215[f]
Surgical factors	0	1 (0.6)	1 (0.3)	> 0.99[f]
When complication started				
Pre-operatively	52 (50.5)	12 (7.1)	64 (23.4)	< 0.001[c]
Intra-operatively	38 (36.9)	50 (29.4)	88 (32.2)	
Post-operatively	13 (12.6)	108 (63.5)	121 (44.3)	

[c] Chi Square test
[f] Fishers Exact test

Surgical specialty was significantly associated with type of adverse events. Cardiovascular events were more likely to occur among cardio-thoracic surgery patients, $P < 0.001$ while pulmonary and neurological events were more likely to occur in neuro-surgical participants. Participants were more likely to be admitted post-operatively to ICU for close monitoring if they had neuro surgery as compared to surgeries in other specialties, (Table 2b).

Table 2b: Bivariate analysis of adverse event by surgical specialty

Complication	Surgical specialty						p-value
	Neuro	Cardio	Maxillo	General/ Peads	Ortho	Obgy	
Cardiovascular	11 (15.5)	25 (35.2)	1 (1.4)	16 (22.5)	8 (11.3)	10 (14.1)	< 0.001[f]
Pulmonary	96 (76.8)	4 (3.2)	7 (5.6)	13 (10.4)	1 (0.8)	4 (3.2)	< 0.001[f]
Neurologic	68 (59.1)	23 (20.6)	2 (1.7)	10 (8.7)	6 (5.2)	6 (5.2)	< 0.001[f]
Deranged Lab	1 (16.7)	1 (16.7)	0	4 (66.7)	0	0	0.064[f]
Close monitoring	68 (68.7)	4 (4.0)	1 (1.0)	22 (22.1)	2 (2.0)	2 (2.0)	0.007[f]

[f] Fisher's Exact test

Presence of either consultant surgeon or anesthesiologist had a significance association with occurrence of some adverse events. Pulmonary and neurologic complications had an occurrence rate of 88(51.5%) and 76(44.4%) respectively in the absence of a surgeon and 110(44%) and 90(36%) respectively in the absence of an anesthesiologist. However, presence of a consultant surgeon was associated with ICU admission for close monitoring, 83% P < 0.001, (Tables 2c and 2d).

Table 2c : Adverse event vs presence of consultant surgeon

Complication	Presence of consultant surgeon		p-value
	Absent (N = 171)	Present (N = 172)	
Cardiovascular	31 (18.1)	39 (33.7)	0.296[c]
Pulmonary	88 (51.5)	36 (20.9)	< 0.001[c]
Neurologic	76 (44.4)	37 (21.5)	< 0.001[c]
Deranged Lab	6 (3.5)	0	0.015[f]
Close monitoring	16 (9.4)	80 (46.5)	< 0.001[c]

[f] Fisher's Exact test

[c] Chi square test

Table 2d: Adverse event vs presence of consultant anesthesiologist

Complication	Presence of consultant anesthesiologist		p-value
	Absent (N = 250)	Present (N = 96)	
Cardiovascular	38 (15.2)	32 (33.3)	< 0.001[c]
Pulmonary	110 (44)	15 (15.6)	< 0.001[c]
Neurologic	90 (36)	25 (26)	0.078[c]
Deranged Lab	4 (1.6)	2 (2.1)	0.671[f]
Close monitoring	50 (20)	46 (47.9)	< 0.001[c]

[f] Fisher's Exact test

[c] Chi square test

4.4 Risk factors associated with unplanned post-surgical icu admission

Several factors were associated with unplanned post-surgical ICU admission on bivariate analysis. However, after adjusting for gender, comorbidities, ASA score, pre-operative GCS, when complication started, type of surgery, surgical specialty, presence of consultant, surgery duration and type of complication, Maxillofacial, ENT, orthopedics and obstetrics and gynecology specialties, emergency surgery and when complication started were the only factors significantly associated with type of ICU admission. Female gender and those who developed pulmonary complications were less likely to be admitted as unplanned admissions with aOR 0.37, 95% CI 0.13-1.03 and 0.38, 95% CI 0.11- 1.26 respectively though the findings were not statistically significant. Those who developed hemodynamic instability due to intra-operative excess blood loss and those who developed airway obstruction post-operatively had a 2.04, 95% CI 0.36-11.59 and 17.56, 95% CI 0.33-947.99 risk of unplanned ICU admission though no statistical significance was found, (Table 3).

Table 3: Factors associated with unplanned ICU admission

Variables	aOR	95% CI	p-value
Being female	0.37	0.13 – 1.03	0.058
Having comorbidities	0.71	0.21 – 2.42	0.586
ASA			
I	Ref		
II	0.87	0.24 – 9.82	0.913
III	1.18	0.12 – 11.75	0.890
IV	0.81	0.06 – 10.39	0.873
GCS			
14 - 15	Ref		
9 – 13	0.74	0.19 – 2.95	0.672
3 – 8	0.99	0.17 – 5.82	0.988
Pulmonary complication	0.38	0.11 – 1.26	0.113
When complication started			
Pre-operatively	Ref		
Intra-operatively	8.77	2.13 – 35.98	0.003
Post-operatively	151.03	31.16 – 732.10	<0.001
Intracranial SOL	1.37	0.12- 15.65	0.801
Emergency Surgery	6.36	1.64- 24.72	0.008
Surgical speciality			
Neuro surgery	Ref		
Cardio thoracic	1.06	0.14- 8.33	0.954
Maxilo/ENT/Ortho/Obgy	18.57	2.33- 148.16	0.006
General/Paeds	1.58	0.33- 7.62	0.566
Presence of consul' surgeon	0.35	0.09- 1.39	0.137
Presence of consult' Anesthesiologist	0.28	0.06- 1.37	0.116
Surgery duration in hours			
1 – 2	0.27	0.01- 5.35	0.390
2 – 3	0.19	0.01- 3.94	0.286
>3	0.27	0.02- 4.71	0.371
Cardiac arrest	1.84	0.07- 47.04	0.713
Hemodynamic instability	2.04	0.36- 11.59	0.421
Airway obstruction	17.56	0.33- 947.99	0.159
Poor anesthesia reversal	0.28	0.07- 1.22	0.090

4.5 Patient outcomes among post-operative icu admitted patients

About two thirds, 231(65.6%), of post-surgical ICU admitted patients were put on mechanical ventilator, of which the proportion of those put on mechanical ventilator was higher 136(77.3%) among those who had unplanned admission compared to planned admissions 95(54%). In addition, mortality rate at ICU discharge was high among unplanned admission 57(32.4%) compared to planned admission group 25(14.2%) and the overall in-ICU mortality was 82(23.3%). The 28-day mortality was also significantly higher among unplanned admissions compared to planned admissions, P< 0.001, (Table 4).

Table 4: Patient outcomes (mechanical ventilation, outcome at discharge and 28-day mortality)

Variables	ICU admission type		Total	p-value
	Planned N (%)	Unplanned N (%)		
Mechanical ventilation				
No	81 (46)	40 (22.7)	121 (34.4)	<0.001[c]
Yes	95 (54)	136 (77.3)	231 (65.6)	
Outcome at discharge				
Died	25 (14.2)	57 (32.4)	82 (23.3)	<0.001[c]
Alive	151 (85.8)	119 (67.6)	270 (76.7)	
Outcome at 28th day				
Died	34 (19.3)	69 (39.2)	103 (29.3)	<0.001[c]
Alive	142 (80.7)	107 (60.8)	249 (70.7)	

[c] Chi Square test

[f] Fishers Exact test

Only ASA IV status, poor reversal of anesthesia, cardiovascular, pulmonary and neurological complications were significantly associated with post-operative mechanical ventilation. Other factors that increased the odds of being mechanically ventilated post-operatively though without statistical significance were type of ICU admission, pre-operative oxygen saturation and pre-operative GCS, (Table 4a).

Table 4a: Factors associated with post-operative mechanical ventilation

	Mechanical ventilation					
Variables	**Absent**	**Present**	**uOR**	**95% CI**	**aOR**	**95% CI**
Comorbidities						
None	81 (31.6)	175 (68.4)	Ref		Ref	
Present	40 (41.7)	56 (58.3)	0.65	0.40- 1.05	0.59	0.36- 1.04
ASA						
I	14 (56)	11 (44)	Ref		Ref	
II	38 (39.6)	58 (60.4)	1.94	0.80- 4.73	1.33	0.22- 8.04
III	63 (35.8)	113 (64.2)	2.28	0.98- 5.33	1.77	0.32- 9.79
IV	6 (11.1)	48 (88.9)	**10.18**	**3.19- 32.45**	9.12	1- 82.88
Oxygen saturation						
Normal	108 (37.2)	182 (62.8)	Ref		Ref	
Abnormal	11 (18.3)	49 (81.7)	2.64	**1.32- 5.30**	1.50	0.39- 5.81
GCS						
Normal	85 (48)	92 (52)	Ref		Ref	
Moderate	7 (10.6)	59 (89.4)	7.79	**3.37- 17.99**	3.05	0.89- 10.44
Severe	4 (5.9)	64 (94.1)	14.78	**5.16- 42.34**	2.33	0.51- 10.67
Cardiovascular complication						
None	107 (38.1)	174 (61.9)	Ref		Ref	
Present	14 (19.7)	57 (80.3)	2.50	**1.33- 4.71**	**6.12**	**2.21- 16.93**
Pulmonary complication						
None	115 (51.3)	109 (48.7)	Ref		Ref	
Present	6 (4.7)	122 (95.3)	21.45	**9.07- 50.72**	52.01	**16.26- 166.33**
Neurological complication						
None	117 (49.6)	119 (50.4)	Ref		Ref	
Present	4 (3.5)	112 (96.6)	27.53	**9.83- 77.07**	37.08	**9.64- 142.70**
Admission type						
Planned	81 (46)	95 (54)	Ref		Ref	
Unplanned	40 (22.7)	136 (77.3)	2.90	**1.83- 4.59**	1.09	0.45- 2.67
Poor anesthesia reversal						
Absent	120 (40.8)	174 (59.2)	Ref		Ref	
Present	1 (1.7)	57 (98.3)	39.31	**5.37- 287.78**	NA	NA

Only age, type of surgery and pre-operative GCS were independently associated with 28-day mortality among patients admitted in ICU post-operatively. The odds of 28-day mortality increased by 2% for patient older by one year. Patients who had emergency surgery were 2.56 times likely to die by 28th day since post-operative ICU admission. Patients with pre-operative GCS of 9-13 and 3-8 were 2.5 and 4.02 times more likely to die by 28th day since admission respectively compared to those with pre-operative GCS of 14-15. Other factors that increased the odds of death at 28 days post-surgery though no statistical significance at multivariate analysis included medical comorbidities, cardiovascular complications, poor anesthesia reversal, being mechanically ventilated post-operatively and ASA IV score. Gender, type of ICU admission, neurological complications, pulmonary complications and absence of a consultant during the surgery were all associated with 28-day mortality on univariate analysis but after adjusting for other factors no statistical significance was established, (Table 4b).

Table 4b: Factors associated with 28th days mortality

	28-day outcome					
Variables	**Alive**	**Died**	**uOR**	**95% CI**	**aOR**	**95% CI**
Gender						
Male	136 (66.3)	69 (33.7)	1.69	**1.04- 2.73**	0.99	0.51- 1.92
Female	113 (76.9)	34 (23.1)	Ref		Ref	
Comorbidities						
None	184 (71.9)	72 (28.1)	Ref		Ref	
Present	65 (67.7)	31 (32.3)	1.22	0.73- 2.02	1.20	0.57- 2.52
ASA						
I	22 (88)	3 (12)	Ref		Ref	
II	73 (76)	23 (24)	2.31	**0.63- 8.43**	0.79	0.16- 3.82
III	131 (74.4)	45 (25.6)	2.52	**0.72- 8.82**	0.76	0.17- 3.44
IV	22 (40.7)	32 (59.3)	10.67	**2.84- 40.04**	2.43	0.48- 12.24
Oxygen saturation						
>90 %	214 (73.8)	76 (26.2)	Ref		Ref	
<90%	34 (56.7)	26 (43.3)	2.15	**1.21- 3.82**	0.92	0.44- 1.94
GCS						
14-15	150 (84.8)	27 (15.2)	Ref		Ref	
9-13	37 (56.1)	29 (43.9)	4.35	**2.31- 8.22**	1.81	0.80- 4.06
3-8	31 (45.6)	37 (54.4)	6.63	**3.53- 12.44**	2.63	**1.03- 6.67**
Cardiovascular complication						
None	202 (71.9)	79 (28.1)	Ref		Ref	
Present	47 (66.2)	24 (33.8)	1.31	0.75- 2.28	1.73	0.73- 4.11
Pulmonary complication						
None	173 (77.2)	51 (22.8)	Ref		Ref	
Present	76 (59.4)	52 (40.6)	2.32	**1.45- 3.72**	0.62	0.28- 1.37
Neurological complication						
None	178 (75.4)	58 (24.6)	Ref		Ref	
Present	71 (61.2)	45 (38.8)	1.95	**1.21- 3.13**	0.64	0.27- 1.50
Deranged lab findings						
None	244 (70.5)	102 (29.5)	Ref		Ref	
Present	5 (83.3)	1 (16.7)	0.48	0.06- 4.15	0.47	0.04- 5.40
When complication started						
Pre-operatively	38 (59.4)	26 (40.6)	Ref		Ref	
Intra-operatively	67 (76.1)	21 (23.9)	0.46	**0.23- 0.92**	0.82	0.29- 2.33
Post-operatively	69 (57)	52 (43)	1.10	0.60- 2.04	1.61	0.55- 4.67
Admission type						
Planned	142 (80.7)	34 (19.3)	Ref		Ref	
Unplanned	107 (60.8)	69 (39.2)	2.69	**1.66- 4.36**	0.95	0.37- 2.44
Age (Median, IQR)	32 (17, 48)	44 (27, 60)	1.02	**1.01- 1.03**	1.02	**1.00- 1.03**
SOL						
Absent	231 (69.6)	101 (30.4)	Ref		Ref	
Present	18 (90)	2 (10)	0.25	0.06- 1.12	0.3	**0.05- 1.12**
Surgery type						
Elective	141 (88.7)	18 (11.3)	Ref		Ref	
Emergency	108 (56)	85 (44)	6.16	**3.5- 10.87**	2.56	**1.05- 6.24**
Consultant presence						
Absent	158 (63.2)	92 (36.8)	5.01	**2.48- 10.12**	0.98	**0.32- 3.04**
Present	86 (89.6)	10 (10.4)	Ref		Ref	
Surgery duration in hours						
<1	9 (56.2)	7 (43.8)	Ref		Ref	
1 -2	29 (50.9)	28 (49.1)	1.24	0.41- 3.79	1.2	**0.4- 3.8**
2 – 3	52 (69.3)	23 (30.7)	0.57	0.19- 1.71	0.58	0.2- 1.72
>3	156 (77.6)	45 (22.4)	0.37	0.13- 1.05	0.37	**0.13- 1.05**
Poor anesthesia reversal						
Absent	222 (75.5)	72 (24.5)	Ref		Ref	
Present	27 (46.6)	31 (53.4)	3.54	**1.98- 6.32**	1.83	0.70- 4.81
Mechanical ventilation						
Absent	110 (90.9)	11 (9.1)	Ref		Ref	
Present	139 (60.2)	92 (39.8)	6.62	**3.37- 12.98**	2.08	0.66- 6.55

On average, those admitted in ICU unplanned had longer duration of mechanical ventilation 53 (IQR 26,105) hours compared to planned admissions 39 (IQR 15, 207) hours and an overall ventilation duration of 49 (18, 117) hours though the difference was not statistically significant. However, median duration of ICU stay was equal (3 days) for both groups, (Table 5).

Table 5: Patient outcomes (ventilation hours and length of ICU stay)

Variables	ICU admission type		Total	p-value
	Planned	Unplanned		
Duration of ventilation in hours				
Median (IQR)	39 (15, 207)	53 (26, 105)	49 (18, 117)	0.327[w]
Range	2 – 1389	2 – 736	2 – 1389	
Duration of ICU stay (in days)				
Median (IQR)	3 (2, 5)	3 (2, 6)	3 (2, 6)	0.370[w]
Range	1 – 58	1 – 35	1 – 58	

[w] Wilcoxon rank-sum test

Overall, patients admitted to ICU post-operatively for close monitoring had shorter length of ICU stay and higher chances of survival at ICU discharge and at 28 days compared to those admitted due to complications, (Table 6).

Table 6: Indication for ICU admission and patient outcome

Variables	ICU Admission reason		
	Complication	Close monitoring	Total
Duration of ICU stay (in days)			
Median (IQR)	4 (3, 7)	2 (1, 3)	3 (2, 6)
Range	1 – 52	1 – 58	1 – 58
Outcome at discharge			
Alive	174 (68.8)	96 (97)	270 (76.7)
Died	79 (31.2)	3 (3)	82 (32.3)
Outcome at 28^{th} day			
Alive	157 (62.1)	92 (92.9)	249 (70.7)
Died	96 (37.9)	7 (7.1)	103 (29.3)

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This chapter presents a discussion of the findings of this study and compares those findings to the findings of other studies that have been conducted to address similar areas.

5.2 Participants', surgical and anesthetic characteristics

5.2.1 Participants' characteristics

The study looked at who ends up in the intensive care unit (ICU) after surgery, whether planned or unplanned. According to the findings, the median age of post-surgical ICU patients was 35 years old, which was similar to surgical ICU patients' age in Nigeria and Ethiopia and the overall (surgical and medical) ICU patient age at the same hospital in 2017 (Lalani et al., 2018; Okafor, 2009; Yetneberk et al., 2022). It however contrast with findings in majority of literature where elderly individuals were more likely than younger patients to be admitted to ICU post-surgically with advanced age found to be a strong predictor of ICU admission in Boston (Thevathasan et al., 2018). This finding can however be explained by the relatively young population in Kenya as well as in most other developing countries as compared to many developed countries. Due to the nationally young population and the likelihood of the young in that population being engaged in activities likely to expose them to trauma, surgical interventions are more likely to be done on young population and thus the relatively young population being admitted to ICU post-operatively.

The majority of the patients were male at 58.2% of admissions, with a stronger gender bias, 65.3%, among the unplanned admissions group. There is no consensus in literature on effect of gender on overall post-surgical ICU admission with some authors finding no gender bias at all, (Cooper, Harris, Mourad, 2017). However, the overall male predominance in this study can be explained by the high number of trauma cases among critically ill surgical patients in Moi teaching and Referral Hospital as males have been found to be more likely to be involved in near fatal accidents than females (Gathecha et al., 2018) while male gender predominance in unplanned admission group is consistent with earlier researches (Kim et al., 2019; Thevathasan et al., 2018).

The most prevalent medical comorbidity among post-surgical ICU admitted patients was hypertension, followed by intracranial space-occupying lesions (SOL) and diabetes mellitus. This finding is consistent with prior researches in Africa, African Surgical Outcome study, which showed hypertension to be the leading medical comorbidity among surgical patients as well as a systematic review by Onwochei and colleagues, (Biccard et al., 2018; Onwochei et al., 2020). In Singapore, however, diabetes mellitus was found to be the most prevalent medical comorbidity among post-surgical ICU patients, (Chiew, Liu, Wong, Sim, & Abdullah, 2020). This variance in literature may be attributable to variations in the study population, study design, and geographical location. Additionally, Chiew and colleagues excluded neurosurgical patients that formed majority of participants in this study and this might have underestimated HTN cases in their study since HTN predispose to Cerebro-Vascular Accidents which require neurosurgical intervention. Planned admissions had a greater proportion of patients with intra-cranial SOL compared with unplanned admissions. The higher incidence of intra-cranial SOL among planned ICU admissions may be attributable to the fact that neurosurgical treatment for intra-cranial SOL is often elective and scheduled, giving time for detailed pre-operative assessment and prior post-operative care planning with a practice of routine ICU booking for elective craniotomies for tumor resection in Moi Teaching and Referral Hospital.

Majority of post-surgical ICU admissions were ASA III in both planned and unplanned admissions. The overall incidence is similar to findings in literature where most post-surgical ICU patients are ASA III. However, unplanned admissions have been reported to be generally of lower ASA classes compared to planned admissions, (Kahan et al., 2017; Katori et al., 2022; Quinn, Gabriel, et al., 2017; Vijay Singh & Shibu Sasidharan, 2020). This finding of unplanned admissions having same ASA score as planned admissions may suggest inadequate evaluation prior to surgery with many emergency surgical patients either not being reviewed or being discussed over the phone by both surgical and anesthesia teams. Such practice is likely to miss key details on patients with higher ASA scores and certain risk factors to predict intra and post-operative complications thus failing to have ICU bed space booked in advance.

Majority of the patients admitted to ICU post-surgery had a pre-operative GCS of more than or equal to 14. This finding is similar to that of Uzman and others in Turkey where post-surgical ICU admissions had preoperative GCS of more than 12 consistently over five year duration, (Uzman et al., 2016). In this study however, 24.4% of unplanned admissions had a preoperative GCS of 3-8. This low GCS, a pre-operative indication for ICU admission, among unplanned admissions may be a pointer to either non-comprehensive assessment and planning pre-operatively and or inadequate ICU capacity where dire emergencies necessitate proceeding with surgery even when no ICU bed was available despite an absolute indication for ICU admission.

5.2.2 Surgical and anesthetic characteristics

Neuro surgery patients formed majority of overall post-operative ICU admissions in MTRH similar to findings in a Nigerian teaching hospital, (Onyekwulu & Anya, 2015), but in contrast to findings in India where GI surgeries formed majority of post-surgical ICU admissions (Vijay Singh & Shibu Sasidharan, 2020). Patients undergoing neuro surgery procedures have been shown to have a higher risk of peri-operative adverse events, which may lead to high rates of post-operative ICU admissions, related to complexity of most neuro surgical procedures, (Gawria et al., 2022). The high incidence of post-operative ICU admitted neuro surgical patients may also be attributable to routine ICU booking for elective craniotomies and the many cases of neuro-trauma cases with low GCS, an independent indication of ICU admission, in MTRH.

Emergency surgeries formed 54.8% of overall post-surgical ICU admissions comparable with findings in Ireland where emergency surgery contributed to 59% of ICU admissions, (A. L. Fowler et al., 2019). The study observed a significant predominance of emergency surgeries, 77.3%, among unplanned admissions similar to findings in Ethiopia where emergency surgery contributed 89.1% of unplanned ICU admissions, (Yetneberk et al., 2022). This might be due to the higher likelihood of inadequate time to fully optimize emergency surgical cases pre-operatively and the inability to reschedule such surgeries in cases where ICU bed space is not readily available prior to surgery.

Overall, consultant surgeon was present during surgery in 50.2% of patients admitted to ICU with majority of the cases, 71.1%, being planned admissions while consultant anesthesiologist was present in 27.8% of the cases admitted to ICU with 47.4% presence among planned admissions. This finding compares with that in Kenyatta

National Hospital (KNH) where consultants were less likely to be intra-operatively present in patients who got unplanned ICU admission as compared to planned admissions, (Mungai, 2011). However, the finding contrasts with those from developed countries where consultants were present in most of unplanned admissions, (Essa, Mogane, Moodley, & Motshabi Chakane, 2022; Landry et al., 2017; Wanderer et al., 2013). The higher incidence of consultant presence in planned admissions may be attributable to pre-operatively perceived surgical complexity and high risk among those patients anticipated to require ICU post-operatively. Unplanned admissions, more common in emergency surgeries, are also more likely to happen during off duty hours when surgical and anesthesia residents' man the surgical list in our setting as well as in KNH and therefore low presence of consultants intra-operatively. The high overall absence of anesthesiologist in cases getting admitted to ICU may be explained by the low number of anesthesia consultants in MTRH with one anesthesiologist covering all operating rooms per day during the period of data collection. The theatre coverage duties result in anesthesia consultants offering guidance to other anesthesia cadres but not being physically present intra-operatively in majority of the surgical cases in MTRH.

Majority of patients admitted to ICU post-operatively had anesthesia and surgery duration of more than 3 hours. The duration of surgery and anesthesia associated with ICU admission still remains undetermined as different studies have found different cut points with some studies having as low as 1 hour cut point for significant association, (Landry et al., 2017). The finding of more than 3-hour surgeries in this study may be attributable to surgery complexity as well as time spend intra-operatively managing complications that necessitated post-operative ICU admissions.

5.3 Peri-operative adverse events among post-operative ICU admitted patient

This study found that pulmonary complications were the most common reason for post-operative ICU admission accounting for 36.5% of all admissions, followed by neurological, 32.9%, and cardiovascular complications, 20.2%. Similar investigations have revealed a higher incidence of post-operative pulmonary complications compared to other body systems among post-surgical ICU admitted patients as do the findings of the current study, (Bhat et al., 2006; Hajnour et al., 2016; Miskovic & Lumb, 2017). Consistent with the literature, (Katori et al., 2022; Meziane et al., 2017), prolonged apnea requiring ventilator support was the most common pulmonary complication in our study accounting for 17.6% of all admissions with no statistically significant difference between planned and unplanned admissions. However, the study found that post-operative airway obstruction was significantly more common among unplanned admissions accounting for 92.8% of all cases of airway obstruction, P 0.002. The high incidence of pulmonary complications in this study could be related to high incidence of poor reversal of anesthesia in MTRH which independently contributed to 16.5% of all post-surgical ICU admissions in this study.

Neurological complications were found to be the second most prevalent contributors to post-operative ICU admission with poor reversal of anesthesia being the most common among them. This result is consistent with earlier reports of poor reversal of anesthesia being the commonest neurological adverse event post-operatively, (Aragón-Benedí et al., 2022; Grabitz et al., 2019). Poor reversal of anesthesia is a complex phenomenon with multifactorial causation such as choice of anesthetic agent, patient factors, incomplete reversal of muscle relaxants, drug interactions and emergence delays (Cascella, Bimonte, & Di Napoli, 2020). The high rates of poor anesthesia reversal in Moi Teaching and referral Hospital may therefore be attributed to relying on clinical methods to assess the wearing off of neuromuscular blocking agents as well as other undefined factors.

Peri-operative prolonged convulsion was the second most common neurological complication similar to findings by Almeida and others (de Almeida et al., 2018). All cases of post-operative ICU admission due to prolonged peri-operative convulsions occurred only among unplanned admissions and contributed to 4.3% of overall ICU admission. This observation may point to either inadequate preparedness or ability to manage unexpected convulsions among anesthetized surgical patients. Lack of neurological monitoring capacity in MTRH theatres may result in missed intra-operative convulsions among general anesthesia patients delaying the interventions to abort the seizure. The intra-operative seizures may then be observed on reversing the patient after a prolonged seizure event thus worsening patient morbidity with subsequent requirement for ICU admission

The study also revealed that cardiovascular complications were the third most common indication for post-operative ICU admission, with hemodynamic instability resulting from hemorrhage being the most prevalent cardiovascular event, accounting for 5.7% of overall ICU admissions. This finding is comparable to that in prior studies that identified intra-operative and post-operative bleeding as a major cause of cardiovascular complications, (Katori et al., 2022; Singh et al., 2019). A study in India however showed hemodynamic instability due to arrythmia and post cardiac arrest state as the most common cardiovascular complication among non-cardiac surgery patients, (Mylavarapu, Joshi, & Kapoor, 2023). This difference may be attributable to low prevalence of cardiac disease among the study population compared to that in the India study as well as the reported low uptake of regional anesthesia technique in MTRH. The complex arrythmias and cardiac arrest reported in

India were associated with regional anesthetic technique. Hemorrhage resulting in hemodynamic instability was more common among unplanned admissions, 80% P 0.001. This may indicate lack of universal preparedness to handle hemorrhage especially among emergency surgeries where patients may proceed for surgery with low hemoglobin and little or no readily available blood for transfusion if required.

The study found that most complications leading to ICU admissions occurred post-operatively, 44.3%, while intra-operative complications contributed to 32.2% of indications for ICU admissions. The findings are consistent with past researches, where post-operative and intra-operative complications contributed to majority of post-operative ICU admissions, (Kim et al., 2019; Vijay Singh & Shibu Sasidharan, 2020; Yetneberk et al., 2022). This finding may be due to inadequate capacity to pre-operatively accurately predict the risk of intra-operative and post-operative complications. MTRH predominantly uses ASA classification to risk stratify patients pre-operatively and while this method is generally acceptable, it is a population based rather than individual based.

The study's findings regarding the prevalence of adverse events based on surgical speciality revealed that various surgical specialties have distinct peri-operative complication risk profiles. Cardio-thoracic surgery patients were more likely to experience cardiovascular complications contributing to 35% of this category of complications. This finding is consistent with previous reports of an increased frequency of cardiovascular complications among cardio-thoracic surgery patients, (Li, Zhang, Xu, & Wu, 2019). The finding may be attributable to high number of open-heart surgeries done during the study period as these surgeries present with complex cardiovascular challenges. The study reported that neurosurgical patients experienced greater pulmonary and neurologic complications at 76.8% and 68% of the respective complication categories. This is contrary to literature were neurological complications contributed to majority of adverse events among neurosurgical patients, (de Almeida et al., 2018; Weber et al., 2022). The higher incidence of pulmonary complications in this study may be due to coexistence of pulmonary event among the commonest observed neurological events, poor reversal of anesthesia and prolonged convulsion, in the study as these events as well as neurosurgery were found to be independent predictors of pulmonary complications, (Karcz & Papadakos, 2013).

The study established that 28.1% of post-operative ICU admissions were for close monitoring with majority of these cases, 75.8%, being planned admissions and 68% from neurosurgery specialty. This finding is similar to that by Vijay and others who found close monitoring as the indication for 58.8% of planned post-surgical ICU admissions and 2.2% of unplanned admissions, (Vijay Singh & Shibu Sasidharan, 2020). The high number of admissions for close monitoring among neurosurgery planned admissions may point to either routine admission in this specialty or extreme application of intra-operative risk mitigation measures with minimal or no review of post-operative ICU admission requirement post-surgery.

5.4 Risk factors associated with unplanned post-surgical ICU admission

The study examined the parameters related with unplanned post-operative ICU admission in surgical patients of different specialties in MTRH. The results demonstrated that surgical specialty was significantly associated with unplanned ICU admission with maxillofacial, ENT, orthopedics and obstetrics and gynecology being independent risk factors for unplanned admission. This finding was similar to that in literature with gastrointestinal, orthopedics, obstetrics and gynecology and ENT found to be specialties associated most with unplanned ICU admissions, (Essa et al., 2022; Katori et al., 2022; Singh et al., 2019). The finding may be explained by the increased risk of post-operative airway obstruction among ENT and maxillofacial surgery patient, hemodynamic instability among obstetrics and orthopedic-trauma patients as well as prolonged intra-operative convulsions obstetric patients with eclampsia. These complications were found to be associated with increased risk of unplanned ICU admission on bivariate analysis, though not statistically significant independent predictors on multivariate analysis.

Emergency surgery was also found to be an independent predictor for unplanned ICU admission. This finding concurs with majority of other studies in literature which associated emergency surgery with unplanned post-surgical ICU admission, (Kim et al., 2019; Wanderer et al., 2013). The finding is attributable to the less optimization done before emergency surgeries making the patient to be highly predisposed to intra and post-operative complications, a factor found to be independent risk factor for unplanned ICU admission in this study. The emergency nature of the surgery also means that operation cannot be postponed in case an ICU bed is not readily available and therefore such patients, though they may be pre-operatively predicted to require ICU care post-operatively, often end up as unplanned ICU admissions.

The time when complications occurred was significantly associated with type of ICU admission. Patients who developed complications intra or post-operatively had a considerably greater probability of unexpected ICU admission than those who had complications before surgery. This finding is in line with findings from previous research that indicate intra-operative and post-operative complications to be associated with a higher chance of unplanned admission to the ICU, (G. Haller, 2017; Katori et al., 2022; Yetneberk et al., 2022). The findings may suggest inability to pre-operatively predict accurately which patient is likely to experience significant intra or post-operatively complications. The poor pre-operative predictive ability for intra and post-operative complications may be as a result of weakness of the risk stratification method used in MTRH, ASA scoring, as this study as well as other studies, (Onwochei et al., 2020; Seglenieks et al., 2014), did not establish an association between ASA score and unplanned ICU admission.

5.5 Patient outcomes among post-operative ICU admitted patients

In this study, the researcher followed up post-surgical ICU admitted patients with aim of determining their outcomes; ventilation requirement, length of ICU stay, condition at ICU discharge and 28-day mortality. The results demonstrated that majority of the post-surgical ICU patients required mechanical ventilation at 65.6% of all admissions. This finding is similar to finding by Meziane and colleagues who found that mechanical ventilation was the most common ICU specific intervention among post-surgical ICU patients, 72%, but differs with those of a study in India which found a 37.5% ventilation rate among post-surgical ICU admitted patients,(Meziane et al., 2017; Vijay Singh & Shibu Sasidharan, 2020). The high ventilation rate may be explained by high number of poor reversal and respiratory failure as indications for ICU admission in this study. On bivariate analysis, type of ICU admission was significantly associated with mechanical ventilation $P<0.001$ similar to findings by Kim and others in Korea, (Kim et al., 2019). However, following adjustment for other factors, only ASA score, pre-operative oxygen desaturation, CVS complications, pulmonary complications and neurological complications were independent predictors for post-operative mechanical ventilation. This finding may be explained by the fact that the specific patient complications, though predisposing a patient to unplanned admission, form the indication for mechanical ventilation. Unplanned admission group patients on mechanical ventilation were also found to have more ventilator hours compared with the planned group, IQR 53 and 39 respectively. This may be explained by the fact that unplanned admissions were more likely to have had lower pre-operative GCS, cardiac arrest intra-operatively, hemodynamic instability and emergency surgery with chances of less optimization prior to surgery therefore requiring longer ventilation duration to allow stabilization prior to extubation.

The average length of ICU stay was found to be 3 days in both planned and unplanned admission groups. This finding defers from literature where unplanned post-surgical admissions have consistently been associated with longer length of ICU stay, (Biccard et al., 2018; Kahan et al., 2017; Wanderer et al., 2013). The deviation from literature may be due to shorter recovery period among those admitted due to poor anesthesia reversal, majority being unplanned admissions. Absence of step down high dependent ward in MTRH may also lead to a number of planned admissions being left for slightly longer duration in ICU than expected for non- ICU specific procedures such as tracheostomy care.

The overall mortality rate at time of discharge from ICU among post-surgical ICU admitted patients in MTRH was found to be 23.3%. This finding is comparable with findings in India with post-surgical ICU mortality rate of 23.5% (Bhat et al., 2006) but higher than 2.8% mortality rate found in the international surgical outcome study (ISOS) (Kahan et al., 2017). The high mortality rate may be related to less advancement in medical and surgical technology among low- and middle-income countries compared to high income countries as well as difference in regional patients' health seeking behavior with majority of patients in our setup likely to present to hospital late in disease process. Compared to planned admissions, the death rate at ICU discharge was higher among unplanned admissions at 32.4% with the former at 14.2%. This finding is comparable to that of a multi-center study in Europe which found that unscheduled ICU admissions were associated with greater rates of morbidity and mortality than planned admissions with a 16.4% mortality among unplanned admissions compared with 4.4% among the planned, (Pearse et al., 2012). The high mortality rates among unplanned admissions may be explained by lack of specialized critical care services in the immediate post-operative period as the patients may stay in operating room awaiting availability of ICU bed. These patients are also likely to be admitted to ICU due to complications, less patients were admitted for observation compared to planned admission group, and the complications leading to ICU admission may independently contribute to mortality.

The overall 28-day mortality was found to be 29.3% with 67% of these mortalities contributed to by unplanned post-operative ICU admissions. The higher mortality rate among unplanned post-operative ICU admissions is consistent with literature, (Jhanji et al., 2008; Wanderer et al., 2013). This finding may be related to the finding that unplanned admission were more likely to be admitted to ICU following a complication with post-surgical complications being a contributor to 28-day post-surgical mortality, (A. J. Fowler et al., 2022). Unplanned post-operative ICU admitted patients were also more likely to be mechanically ventilated and for a longer duration and as Gajic and colleagues demonstrated, ICU patients who needed mechanical ventilation for longer periods of time were more likely to die. (Gajic et al., 2007). However, after adjusting for pre-operative desaturations, ASA class, female gender, low pre-operative GCS, pulmonary complications, neurological complications, unplanned admission and age, only low pre-operative GCS, emergency surgery and old age was significantly associated with 28-day mortality with aOR of 2.47 95% CI 1.13- 5.42 for GCS of 9- 13, 4.02 95% CI 1.58 -10.2 for GCS of 3- 8, 2.56 95% CI 1.05- 6.24 for emergency surgery and 1.02 95% CI 1.00- 1.03 for age.

The association between age, emergency surgery and low GCS with 28-day mortality observed in this study are consistent with literature on contribution of age, emergency operation and GCS to mortality. In Germany, Menzenbach and others found that a patient's age was a strong predictor of death in the post-surgical ICU (Menzenbach et al., 2021). This may be attributable to changes in physiologic capacity to respond to stress and illness in the extremes of ages with reduced physiologic reserves to bear surgical and anesthesia related stress. Among post-surgical patients admitted to ICU in a tertiary hospital in Turkey, a low GCS was found to be an independent predictor of death in the ICU (Uzman et al., 2016). A low pre-operative GCS is a general pointer to depressed neurological status and severe physiologic derangement prior to surgery which when confounded with anesthesia and surgery risk often impairs capacity to recover. In Kenya as well as other parts of the world, emergency surgery significantly contributed to post-surgical mortality, (Kituu, Omundi, & Chokwe, 2022; Mullen et al., 2017; Wanderer et al., 2017). Emergency surgery is often associated with less time to effectively stabilize patients pre-operatively as well as having life threatening diseases that may progress to mortality with or without surgery.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1: Conclusions

Cognizant to the findings of this study, we conclude that:

1. Pulmonary and neurological complications are the commonest reasons for post-operative ICU admission in Moi Teaching and referral Hospital.
2. Maxillofacial, ENT, orthopedics and obstetrics and gynecology specialties, emergency surgery and post-operative complications are associated with unplanned post-operative ICU admission.
3. Age, emergency surgery and low pre-operative Glasgow coma scale score are independent predictors of 28- day mortality among surgical patients in Moi teaching and referral Hospital.

6.2: Recommendations

1. Anesthesiologists to improve pre-operative evaluation for risk of pulmonary, cardiovascular and neurological complication among ASA IV patients, those with low pre-operative GCS, pre-operative oxygen de-saturations and those to undergo maxillofacial, ENT and Obstetric surgery as these factors highly increase patient’s risk for unplanned post-operative ICU admission and mechanical ventilation.
2. Anesthesiologists and other critical care providers to use age, type of surgery and GCS score in ethical dilemmas to determine probability of benefit from ICU admission or lack thereof when deciding which surgical patient to allocate ICU space in case of limited ICU bed capacity.
3. A study to investigate poor reversal of anesthesia in Moi Teaching and Referral operating theatres, the single commonest indication for post operative ICU admission, to identify potential areas for improvement.

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APPENDICES

Appendix 1: MTRH ICU admission protocol

1. Prioritization Model

This system defines those that will benefit most from the ICU (priority 1) to those that will not benefit at all (priority 4) from ICU admission.

Priority 1: These are critically ill, unstable patients in need of intensive treatment and monitoring that cannot be provided outside the ICU. Usually, these treatments include ventilator support, continuous vasoactive drug infusion, etc. priority 1 patient generally have no limits placed on the extent of therapy they are to receive. Examples of these patients may include post-operative or acute respiratory failure patients requiring mechanical ventilatory support and shock or hemodynamically unstable patients receiving invasive monitoring and/or vasoactive drugs.

Priority 2: These patients require intensive monitoring and may potentially need immediate intervention. No therapeutic limits are generally stipulated for these patients. Examples include patients with chronic comorbid conditions who develop acute severe medical or surgical illness.

Priority 3: These unstable patients are critically ill but have a reduced likelihood of recovery because of the underlying disease or nature of their acute illness. Priority 3 patients may receive intensive treatment to relieve acute illness but limits on therapeutic efforts may be set such as no intubation or cardiopulmonary resuscitation. Examples include patients with metastatic malignancy complicated by infection, cardiac tamponade, or airway obstruction.

Priority 4: These are patients that are generally not appropriate for ICU admission. Admission of these patients should be on an individual basis, under unusual circumstances, and at the discretion of the ICU director. These patients may be placed in the following categories:

A. Little or no anticipated benefit from ICU care based on low risk of active intervention that could not be safely administered in a non-ICU setting (too well to benefit from ICU care). Examples include patients with peripheral vascular surgery, hemodynamically stable diabetic ketoacidosis, mild congestive heart failure, conscious drug overdose, etc.

B. Patients with terminal and irreversible illnesses facing imminent death (too sick to benefit from ICU care). For example, severe irreversible brain damage, irreversible multi-organ failure, metastatic cancer unresponsive to chemotherapy and/or radiation therapy (unless a patient is on a specific treatment protocol), patients with decision-making capacity who decline intensive care and or invasive monitoring, and who receive comfort care only, brain dead non-organ donors, patients in a persistent vegetative state, patients who are permanently unconscious, etc.

II. Diagnosis model

This model uses specific conditions or diseases to determine the appropriateness of ICU admission

A. Cardiac system

1. Acute myocardial infarction with complications
2. Cardiogenic shock
3. Complex arrhythmias requiring close monitoring and intervention
4. Acute congestive heart failure with respiratory failure and/or requiring hemodynamic support
5. Hypertensive emergencies
6. Unstable angina, particularly with dysrhythmias, hemodynamic instability, or persistent chest pain.
7. S/P cardiac arrest (status post-cardiac arrest)
8. Cardiac tamponade or constriction with hemodynamic instability
9. Dissecting aortic aneurisms
10. Complete heart blocks

B: Pulmonary system

1. Acute respiratory failure requiring ventilatory support
2. Pulmonary embolism with hemodynamic instability
3. Patients in an intermediate care unit who are demonstrating respiratory deterioration
4. Need for nursing/ respiratory care not available in lesser care areas such as floor or intermediate care units
5. Massive hemoptysis amenable to medico-surgical intervention
6. Respiratory failure with imminent intubation

C: Neurologic disorders

1. Acute stroke with altered mental status and cardiopulmonary instability
2. Coma: metabolic, toxic or anoxic, GCS less than 8/15 with respiratory

compromise after appropriate surgical intervention

3. Intracranial hemorrhage with potential for herniation
4. Acute subarachnoid hemorrhage
5. Meningitis with altered mental status and respiratory compromise
6. Central nervous system and neuromuscular disorders with deteriorating neurologic or pulmonary function
7. Status epilepticus unresponsive to optimal anticonvulsive therapy
8. Braindead or potentially brain dead who are being aggressively managed while determining organ donation status
9. Vasospasm after MRI angiogram
10. Severe head injury patients

D: Drug ingestion and drug overdose

1. Hemodynamically unstable drug ingestion
2. Drug ingestion with significantly altered mental status with inadequate airway protection
3. Seizure following drug ingestion

E: Gastrointestinal disorders

1. Life-threatening gastrointestinal bleeding including hypotension, angina, continued bleeding, or comorbid
2. Severe pancreatitis

F: Endocrine

1. Diabetic ketoacidosis is complicated with hemodynamic instability, altered mental status, respiratory insufficiency, or severe acidosis
2. Thyroid storm or myxedema coma with hemodynamic instability
3. Hyperosmolar state with coma and/or hemodynamic instability
4. Other endocrine problems such as adrenal crises with hemodynamic instability
5. Severe hypercalcemia with altered mental status, requiring hemodynamic monitoring
6. Hypo or hypernatremia with seizures, altered mental status
7. Hypo or hypermagnesaemia with hemodynamic compromise or dysrhythmias
8. Hypo or hyperkalemia with dysrhythmias or muscular weakness
9. Hypophosphatemia with muscular weakness

G: Surgical

1. Postoperative patients requiring hemodynamic monitoring/ ventilatory support

2. Inhalational burns that require intubation to counter airway edema
3. Less than 60% of burns who require ventilatory support

1. H: Miscellaneous

2. Septic shock with hemodynamic instability
3. Hemodynamic monitoring
4. Environmental injuries (lightning, near drowning, hypo/hyperthermia)
5. New/ experimental therapies with potential for complication

III: Objective parameter model

Objective criteria have been requested, expected, and reviewed from individual hospitals as part of the joint commission on accreditation of healthcare organizations' review process of special units in the past. While the review process has jointly been changed, it is understandable that hospitals would continue to incorporate objective parameters as part of the admitting criteria. The criteria listed, while arrived at by consensus, are by necessity arbitrary. They may be modified based on local circumstances. Data demonstrating improved outcomes using specific criteria levels are not available.

Vital signs

Pulse <40 or> 150 beats per minute

Systolic arterial pressure <80 mmHg or 20 mmHg below the patient's usual pressure

Mean arterial pressure <60 mmHg

Diastolic pressure >120mmHg

Respiratory rate >35 breaths/ minute in adults and 50 in babies

Laboratory values (newly discovered)

Serum sodium <110mEq/L or >170mEq/L

Serum potassium <2.0mEq/L or >7.0mEq/L

PaO2 <50 mmHg despite adequate O2 therapy

pH <7.1 or > 7.7

Serum glucose >30mmol/L

Serum calcium >15mg/dl

The toxic level of drug or chemical substance in a hemodynamically or neurologically compromised patient

Radiology/ultrasonography/tomography (newly discovered)

Cerebral vascular hemorrhage, contusion, or subarachnoid hemorrhage with altered mental status or focal neurological signs

Ruptured viscera, bladder, liver, esophageal varices, or uterus with hemodynamic instability after surgical intervention

Dissecting aortic aneurysm

Electrocardiogram

Myocardial infarction with complex arrhythmias, hemodynamic instability, or congestive heart failure

Sustained ventricular tachycardia or ventricular fibrillation

Complete heart block with hemodynamic instability

Physical findings (acute onset)

Unequal pupils in an unconscious patient

Burns covering >10% BSA who need airway protection

Airway obstruction

Coma

Continuous seizures

Cyanosis

Cardiac tamponade

Discharge criteria

The status of patients admitted to an ICU should be reviewed continuously to identify patients who may no longer need ICU care.

A. When a patient's physiologic status has stabilized and the need for ICU monitoring and care is no longer necessary.
B. When a patient's physiological status has deteriorated and active interventions

Discharge criteria from critical care units should be similar to the admitting criteria for the next level of care such as intermediate care where available.

However, not all patients require intermediate care after ICU discharge

Triage

Under ideal conditions, patients would be admitted or discharged strictly on their potential benefit from ICU care. Unfortunately, in many instances, the number of potential ICU patients exceeds the available beds. A method of prioritizing or triaging patients is necessary. Initial triage of patients may follow the guidelines given in the prioritization model for admissions. In the environment where ICU admissions are rigorously screened for benefit and discharge is ongoing and continuous, the need for triage is minimized. When all ICUs and step-down units are filled, the ICU/critical care director should have access to all of these units and have the responsibility and authority to admit/ discharge patients from these units. Triage policies for an institution should be written in advance. Triage decisions should be made explicitly and without bias. Ethnic origin, race, sex, social status, sexual preference, or financial status should never be considered in triage decisions.

Triage decisions may be made without patient or surrogate consent and can be made despite an anticipated untoward outcome. Religious or moral convictions may be the basis for providing treatment 'if the cost is not borne by the general society and the provision of such services does not foreclose the treatment of other patients who would benefit from critical care'. The topic of triage of the critically ill has been recently reviewed by the society of critical care medicine ethics committee. The reader is referred to this document for a more in-depth discussion of this topic.

Performance review

The performance evaluation and review of an ICU should include its admission/ discharge/ triage policy. A multi-professional team should review performance at least annually. To adequately review performance as it relates to admission, outcome, and the decision-making process, a database table to track these and other variables would be extremely useful. Severity-adjusted outcomes should be utilized whenever possible to minimize the effect of severity of illness on raw mortality data, independent of policy or care standards.

As guidelines to limit these types of admissions are instituted, care must be taken to track the patients send to other areas to assure equivalency of outcome, length of stay, etc. a mechanism to review requested admissions that were denied should readmission to the ICU for a similar problem should be monitored closely as they may directly relate to the quality of the discharge process.

The quality and efficiency of an ICU should be continually examined and improved through this process. Studies examining objective criteria for admission and the benefit of admission to ICUs should be encouraged to better define the appropriate utilization of this important and expensive resource.

Overflow

When the ICU is full and a bed is needed, the respective limit and the administration should liaise with the other critical care areas to determine their bed status and the possibility of transfer of the patient.

Emergency admission

Patients from the emergency department or the wards who are considered by the attending doctor to require intensive care will be seen by one of the ICU MO's and or consultant on-call/ private wings will then evaluate and determine their need for admission to the intensive care unit. No patient will gain automatic admission to the ICU, without being assessed in this manner. Those being from other ICU with poor communication and arrangement, early referral to the ICU team are encouraged to allow for better assessment and earlier institution of therapy.

Post-operative admissions

Elective surgery

Certain patients who have major elective procedures benefit from admission to the ICU postoperatively. These patients should have a bed booked in the ICU pre-operatively and their post-operative care discussed, where possible, with the ICU team leader communication should be made 1 day prior. The ICU team must make every effort to prevent the cancellation of such surgical cases.

Emergency surgery

When an ICU bed is required for an emergency case, the ICU should be notified as soon as possible (preferably by the attending anesthetist) or that a bed is available and the patient can be transferred directly from the theater to the ICU. The handover of care by the attending anesthetist to the ICU doctor on duty should occur in the ICU.

Admission from other hospitals

Eligible patients from other hospitals who may benefit from intensive care in MTRH may be admitted directly to the ICU following consultation with the attending doctor from the receiving service. Doubt about suitability for the ICU care should be assessed by the attending doctors/ ICU team in the emergency department and a decision made there about correct placement.

The transfer must occur within 12 hours of acceptance. If there is a delay, the transfer must be reorganized and the status of the patient reassessed and updated before the reacceptance.

Mechanically ventilated patients

Ventilated patient or patients who are hemodynamically unstable may be admitted directly to the ICU but the delays about the patient and caregiving must be available on admission to the ICU so that investigations and therapy can be commenced without delay. Some such patients may benefit from a rapid assessment in the ER before transfer to ICU.

Non-ventilated patients

Patients from other hospitals who are not being ventilated or who are hemodynamically stable will be accepted in consultation with the attending doctor. These patients should be assessed in the emergency department and admitted either to the ICU or a hospital ward depending on their condition. A bed must be available in the ICU before transfer.

Prepared and developed by,

Anesthesia and critical care team

Section Head, ICU

Dr. Kerema Josephat…………………………….. Date:……………………………..

Approved by,

Dr. Wilson K. Aruasa, MBS……………………. Date:………………………………

Chief Executive Officer

Moi Teaching and Referral Hospital

Appendix 2: informed consent

INFORMED CONSENT FORM

Study Title: Post-operative intensive care unit admission and patient outcomes at Moi Teaching and Referral Hospital

Name of the Investigator: Dr. Solomon Mwau, a post-graduate student at Moi University undertaking a master of medicine in anesthesia and critical care.

Informed Consent Form for Post-surgical Intensive Care Unit (ICU) admitted patients

This Informed Consent Form has two parts:

• Part I: Information Sheet [to share information about the study with you]

• Part II: Certificate of Consent [for signatures if you choose to participate]

PART I: INFORMATION SHEET

Introduction:

You are being requested to participate in a research study. This section will inform you about the study. Kindly read it carefully and ask the question(s) that you may have after reading.

Participating in this study is voluntary and non-participation will not affect your rights to health care or any other services. Your treatment will not be affected if you decide not to participate. You may voluntarily withdraw from this study at any time. Information obtained from you will be destroyed in case of withdrawal before data de-identification and aggregation. You will receive a copy of this form after it is signed.

Purpose of the study:

The study aims to identify factors linked to admission to ICU after surgery and compare patient outcomes among patients with prior ICU bed booking and those without.

Study site: Moi Teaching and Referral Hospital

Study population:

Participants of this study are patients that have been admitted to the intensive care unit (ICU) after undergoing surgery in Moi Teaching and Referral Hospital

Study procedures:

A participant joins the study at admission to ICU after surgery where details about the patient, surgery, and anesthesia are filled into the data collecting form. The participant is then followed until discharge from ICU or for twenty eight(28) days from the date of ICU admission whichever is longer. During follow-up, details of participants' conditions are recorded in the data collection form. At the end of the study, data will be analyzed to determine factors that lead to ICU admission after surgery and patient outcomes among those admitted to ICU after surgery.

If you agree to participate in the study, you will do the following:

✓ Sign a consent form to indicate your voluntary participation

✓ Answer to some questions about your health before surgery

✓ Receive calls inquiring about your health if you are discharged from ICU in less than 28 days

Benefits:

There are no direct benefits to you for participating in this study. The findings of the study will however help doctors in the future to determine which patients are most likely to benefit from being admitted to ICU after surgery.

Risks/Discomforts:

There are no directly perceived risks in participating in this study as participants and non-participants will be treated equally.

Payments and Reimbursements:

No payments or reimbursement will be offered for participating in this study.

Confidentiality:

Information obtained during this study will be kept confidential and using such information will follow national privacy guidelines. By signing this study's consent document you are permitting the use of your study information.

We may need to share your protected information with the community advisory board, MTRH//MU-IREC, NACOSTI, or the healthcare team. We will retain your research records for at least six years after the study is completed. At that time, the research information is destroyed by shredding the data collection forms. If you decide to withdraw your permission for use of your data, contact the researcher in writing and let them know your decision. At that time, we will stop further collection of any information about you. However, the health information collected before this withdrawal may continue to be used for reporting and research quality.

Some information obtained from this study will be added to your medical records and kept as per MTRH health records storage and disposal protocols.

Injury compensation:

In the event of psychological trauma resulting from participation in this study, the participant will undergo a session of psychological counseling at the cost of the researcher.

PART II: CONSENT OF PATICIPANT:

I have read or have had someone read to me the description of the research study. The investigator or his representative has answered all the questions I have regarding the study at this time. I have been told of the potential risks and discomfort of the study. I volunteer to take part in this study/ I freely volunteer my next of kin (study participant) to take part in this study.

________________________ __________________ ___________

Name of Participant Signature of participant/Thumbprint Date & Time

________________________ __________________ ___________

Name next of kin Signature of next of kin Date & Time

________________________ __________________ ___________

Name of the person obtaining consent Signature of person the person Date & Time

obtaining consent

Dr. Solomon Mwau __________________ ___________

The investigator Signature of Investigator

Date

Contacts for questions about the study

Questions about the study: You may contact the researcher, Dr. Solomon Mwau, on phone number 0724213731or email Solomon.mwau@gmail.com

Questions about your rights as a participant: You may contact the Institutional Ethics and Research Committee (MTRH//MU-IREC) 0787723677 or email irec@mtrh.go.ke or irecoffice@gmail.com. The MTRH//MU-IREC is a group of people that review studies for safety and to protect the rights of participants.

Appendix 3: Data collection sheet
Demographic characteristics

Patient name ________________________ Contact ______________________

Age _______________________ Gender __________________________

Part 1: Patient characteristics

1. Is patient suffering from medical comorbidities? Yes ______ No _________
If yes to question 1, select the appropriate

- ✓ Hypertension Yes ______________ No _______________
- ✓ Diabetes mellitus Yes______________ No________________
- ✓ Chronic obstructive lung disease Yes___________ No _____________
- ✓ Cardiac Disease Yes _____________ No_____________
- ✓ Other (specify) _______________________________________

2. ASA classification I_______ II __________ III ____________ IV ___________

Part 2: surgical factors

1. Surgery Type: Elective ____________ Emergency _________

2. Surgical specialty: ________________

3. Surgery Duration from initiation to reversal of anesthesia (in minutes): _________

4. Surgical team constitution: Consultant surgeon(s) present Yes _______ No ______

Part 3: anesthesia factors

1. Type of anesthesia: General _____________ Regional/Local ______________

2. Anesthesia team constitution: Consultant Anesthesiologist present Yes ___ No ___

Part 4: Reason(s) for ICU admission

1. Type of ICU admission: Planned ___________ Unplanned ___________________

2. What complication(s) lead to ICU admission?

A. Cardiovascular Yes__________ No _________________

If yes, select the appropriate

- ✓ Acute MI with hemodynamic instability ____________
- ✓ Cardiogenic Shock _____________________
- ✓ Complex arrhythmia with hemodynamic instability or for close monitoring _______

- ✓ Hypertension emergency ________
- ✓ Status Post cardiac arrest __________________
- ✓ Hemodynamic instability due to hemorrhage ___________
- ✓ Other (specify) ______________________

B. Pulmonary Yes ____________ No _______________

If yes, select the appropriate

- ✓ Pulmonary embolism with hemodynamic instability _________
- ✓ Airway obstruction requiring ventilatory support ___________
- ✓ Prolonged apnea requiring ventilatory support or close monitoring_________
- ✓ Aspiration requiring ventilatory support or close monitoring ___________
- ✓ Other (specify) _________________

C. Neurologic Yes ______________ No ________________

If yes, select the appropriate

- ✓ Acute cerebral vascular accident (intra-operative) _______________
- ✓ Failed reversal with GCS <8/15 and respiratory compromise _____________
- ✓ Intraoperative prolonged convulsion or status epilepticus ____________
- ✓ Other (specify) _____________________

D. Deranged laboratory findings Yes ____________ No ______________

If yes, select the appropriate

- ✓ Serum sodium < 110 mEq/L or > 170mEq/L ____________
- ✓ Serum Potassium <2.0mEq/L or >7.0mEq/L ______________
- ✓ Serum Calcium >15mg/dl ____________
- ✓ pH <7.1 or >7.7 _____________
- ✓ Serum Glucose >30mmol/L _____________
- ✓ Other (specify) ____

E. Surgical factors Yes _______ No _______________

If yes, tick the applicable

- ✓ Inhalational burns to protect the airway __________
- ✓ Other (specify) _______________

F. Miscellaneous(specify) ____

3. When did the complication leading to post-operative ICU admission happen?

Pre-operative__________ intra-operative__________ post-operative___________

Part 5: Patient outcome

1. Is the patient mechanically ventilated? Yes ______________ No_____________

If Yes, indicate duration of ventilation (in hours) _______________________

2. Length of stay in ICU (in Days) ______________________

3. Condition at discharge from ICU Dead ________________ Alive ___________

4. 28-day survival Yes ____________ No ________________

Appendix 4: Time plan

Item	Time duration
Study period	2020 to 2023
Proposal development	December 2020 – May 2021
IREC approval	June 2021- August 2021
Data collection	December 2021- December 2022
Data analysis	January 2023- June 2023
Thesis writing, submission, and defense	July 2023- December 2023

Appendix 5: Budget estimate

Category	Estimated quantity	Unit price, KSh.	Sub-total, KSh.
Stationary			
Pens	20	20	400
Printing	600 pages	10	6,000
Photocopy	3500 pages	3	10,500
Binding	6 booklets	500	3,000
Internet and calls			
Airtime			12,000
Internet bundles			15,000
Personnel			
Research assistant	1	15000 per month for 12 moths	180,000
Biostatistician	1		50,000
Approval fee			
IREC			2,000
Sub-total	278,900		
Miscellaneous (10% of sub-total)			27,890
Total cost	306,790		

The whole budget will be self-funded.

Appendix 6: IREC approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2021/129
28th October, 2021

Approval Number: 0004008

Dr. Solomon Mutinda Mwau,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Mwau

POST-OPERATIVE INTENSVE CARE UNIT ADMISSION AND PATIENT OUTCOMES AT MOI TEACHING AND REFERRAL HOSPITAL

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0004008.*** The approval period is **28th October, *2021- 27th October, 2022.*** This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreements (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MTRH/MU-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MOH at the recommendation of NACOSTI*** for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MTRH/ MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances from study sites including a written approval from the CEO-MTRH which is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH) and ~~its satellites sites.~~

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
28 OCT 2021
APPROVED
P. O. Box 4606 - ~~30100 ELDORET~~

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

Appendix 7: MTRH data collection approval

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone :(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

1st November, 2021

Dr. Solomon Mutinda Mwau,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET -KENYA.

POST-OPERATIVE INTENSVE CARE UNIT ADMISSION AND PATIENT OUTCOMES AT MOI TEACHING AND REFERRAL HOSPITAL

You have been authorised to conduct research within the jurisdiction of Moi Teaching and Referral Hospital (MTRH) and its satellites sites. You are required to strictly adhere to the regulations stated below in order to safeguard the safety and well-being of staff, patients and study participants seen at MTRH.

1 The study shall be under Moi Teaching and Referral Hospital regulation.
2 A copy of MTRH/MU-IREC approval shall be a prerequisite to conducting the study.
3 Studies intending to export human bio-specimens must provide a permit from MOH at the recommendation of NACOSTI for each shipment.
4 No data collection will be allowed without an approved consent form(s) to participants unless waiver of written consent has been granted by MTRH/MU-IREC.
5 Take note that data collected must be treated with due confidentiality and anonymity.

The continued permission to conduct research shall only be sustained subject to fulfilling all the requirements stated above.

01/11/2021

DR. WILSON K. ARUASA, *MBS, EBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

MOI TEACHING AND REFERRAL HOSPITAL
CEO
APPROVED
11 NOV 2021
SIGN
P. O. Box 3-30100, ELDORET

c.c. - Senior Director, Clinical Services
- Director of Nursing Services
- HOD, HRISM

All correspondence should be addressed to the Chief Executive Officer
Visit our Website: www.mtrh.go.ke

Appendix 8: NACOSTI license

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 599552

Date of Issue: 19/October/2022

RESEARCH LICENSE

This is to Certify that Dr.. solomon mutinda mwau of Moi University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Uasin-Gishu on the topic: POST-OPERATIVE INTENSIVE CARE UNIT ADMISSION AND PATIENT OUTCOMES AT MOI TEACHING AND REFERRAL HOSPITAL for the period ending : 19/October/2023.

License No: NACOSTI/P/22/20903

599552

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions