ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

SCHOOL OF MEDICINE

DEPARTMENT OF CARDIO THORACIC SURGERY

FACTORS AFECTING DURATION OF STAY IN THE INTENSIVE CARE UNIT AMONG PATIENTS WHO UNDERWENT OPEN HEART SURGERY: A MULTICENTER RETROSPECTIVE STUDY

BY: METASEBIYA BEREDA

A Research Thesis Submitted to Addis Ababa University, College of Health Sciences, School of Medicine, in Partial Fulfillment of the Requirements for a Master's Degree in Cardiovascular Perfusion

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APPROVAL SHEET

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I, the undersigned MSc student, declare that the original work I have submitted, titled ‘‘**Factors Affecting Duration Of stay In the intensive Care Unit Among Patients Who Underwent open Heart Surgery: A Multicenter retrospective Study**’’, prepared by Metasebiya Bereda, satisfies the university's regulations and adheres to the accepted standards of originality and quality required for the Degree of Master of Science in Cardiovascular Perfusion.

Submitted by:

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This thesis work has been submitted for examination with my approval as an advisor.

Approved by:

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APPROVAL BY THE BOARD OF EXAMINATION

This thesis by Metasebiya Bereda is accepted in its present form by the board of examiners as satisfying thesis requirement for the degree of masters of Science in Cardiovascular Perfusion.

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STATEMENT OF DECLARATION

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ABBREVIATIONS AND ACRONYMS

AKI	Acute Kidney Injury
ALOHS	Average Length of ICU Stay
BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CCE	Cardiac Center of Ethiopia
CHS	College of Health Sciences
CKD	Chronic Kidney Disease
DC	Data Collection
HCWs	Healthcare Workers
ICU	Intensive Care Unit
OHS	Open heart Surgery
OPD	Outpatient Department
PI	Primary Investigator
SIRS	Systemic Inflammatory Response Syndrome
SPSS	Statistical Package for the Social Sciences
STS	Society of Thoracic Surgeons
VAP	Ventilator-Associated Pneumonia

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ABSTRACT

BACKGROUND: Cardiopulmonary bypass (OHS) surgery has become a routine strategy for treating complex cardiac problems, including coronary artery bypass, heart valve replacement, and congenital heart defect corrections. Despite advancements in surgical techniques, perioperative care, and postoperative management, the duration of stay in the intensive care unit (ICU) following OHS remains a significant concern for healthcare providers and patients alike. Prolonged ICU stays are associated with increased healthcare costs, resource utilization, and potential complications, while also impacting patient outcomes and quality of life.

OBJECTIVE: Assess factors affecting duration of stay in the intensive care unit among patients who underwent open-heart surgery

METHODS: An institution-based Retrospective study design was conducted from March to May 2025. All adult cardiac patients who were admitted at TASH, Tazma and cardiac center Ethiopia ICU. Cardiac patients who were admitted at TASH, Tazma and cardiac center Ethiopia and undergo cardio pulmonary bypass and aged >18 years during the data collection period was included. The sample size for the study was determined by using the single population proportion formula. By taking the magnitude of ICU stay 51%. The data collection (DC) process was organized and lead by the PI and patient chart was reviewed to extract pertinent data.

RESULTS: Among 239 postoperative open-heart patients, the mean ICU length of stay range 2–18 days. Prolonged ICU stay (defined as ≥5 days) occurred in 118 patients (49.4%). In bivariate comparisons, patients with prolonged ICU stays were older and more likely to have complications: for example, acute kidney injury (AKI) occurred in 17.8% of the prolonged-stay group versus 5.0% of the shorter-stay group, and nosocomial infections and ventilator-associated pneumonia (VAP) also occurred predominantly in the prolonged-stay group. In multivariable logistic regression, advanced age (adjusted OR ~1.08 per year, critical preoperative state and the presence of any postoperative complication independently predicted prolonged ICU stay.

CONCLUSION: This multicenter Ethiopian paper illustrates that elderly patients and those with significant perioperative complications are more likely to require considerably longer ICU management after open-heart surgery.

KEY WORDS: Cardiopulmonary bypass, Intensive care unit, Addis Ababa, Ethiopia.

CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND

Open Cardiac Surgery (OCS) remains one of the world's most frequently performed surgeries, being a significant surgery for patients (1). Improvement in the surgical technique, perioperative care, and postoperative management has been observed, but intensive care unit (ICU) stay following OHS remains a significant cause of concern for both patients and medical professionals. ICU stay beyond threshold duration is associated with increased healthcare costs, resource utilization, and complications, as well as patient outcomes and quality of life. Knowing the determinants of ICU length of stay and their implications can help enhance patient care and surgery outcomes (2).

The ICU is also important for managing postoperative complications such as hemodynamic instability, respiratory failure, and infection, all of which are common after coronary artery bypass grafting (3). Heterogeneity in ICU stay among patients having this operation suggests that multiple variables from patient-dependent variables to institutional practices contribute to the calculation of ICU length of stay. These determinants play a crucial role in developing interventions that will be tailored to reduce avoidable ICU admissions, relieving healthcare systems of workloads and enhancing the recovery of patients (4).

Preceding studies have examined a variety of determinants of ICU length of stay, including preoperative comorbidities, intraoperative factors, and postoperative complications. For example, patients who are elderly or who possess illnesses like diabetes mellitus, chronic kidney disease, or poor left ventricular function have an increased chance of having longer ICU stays because they are more prone to complications (5). Similarly, intraoperative factors such as cardiopulmonary bypass duration, surgical complexity, and need for blood transfusion have been associated with increased lengths of ICU stay. Postoperative sternal wound infection, arrhythmias, and acute kidney injury are also responsible for the difference in ICU length of stay (6).

Despite these results, no multicenter studies have formally evaluated the interaction between these variables and their collective impact on length of ICU stay after OHS. Most research available is confounded by single-center series, limited populations, or an acute presentation of a narrow population of patients, resulting in limited external validity of the findings. A multicenter retrospective study, as proposed here, offers the possibility of studying a diverse and large population of patients, allowing for stronger and more generalizable conclusions (7).

Furthermore, the impact of extended ICU stay even extends beyond the immediate postoperative period, affecting long-term patient outcomes and utilization of resources. Extended ICU stays are also associated with increased risk of hospital-acquired infections, psychologic disturbances, and lengthened recovery time, all of which negatively affect patient morbidity and mortality. From the system perspective of healthcare, reducing ICU length of stay without a negative effect on the safety of patients is likely to reduce cost, enhance bed turn-over rates, and enhance the overall efficiency of cardiac surgical care (8).

1.2 STATEMENT OF THE PROBLEM

Open heart Surgery (OHS) is a frequent intervention for the management of serious heart disease and improvement in long-term cardiac prognosis. Despite refined surgical technique and postoperative care, patients typically require admission to the ICU for close monitoring and therapy postoperatively (9). Patients who undergo OHS continue to be at high risk for a wide range of complications despite significant advances in cardiac surgery and critical care (10). These complications include hemodynamic instability, infections, respiratory failure, renal dysfunction, and neurological problems. The patients thus experience prolonged ICU stays, high hospital expenses, and a severe decline in their quality of life. Although each of these issues has been the focus of extensive research, little is known regarding the manner in which they interact and affect the patient's recovery process (11). This gap in knowledge is significant in that it could be preventing the creation of more individualized and successful treatment strategies.

ICU stay after OHS is extremely heterogeneous among patients and is influenced by a wide range of preoperative, intraoperative, and postoperative variables (12). These variables are worth considering because increased ICU stays are associated with an increased risk of complications such as nosocomial infections, respiratory failure, and multi-organ dysfunction, as well as with higher health care charges and consumption of resources (13).

This research aims to address this critical knowledge deficit by conducting a multicenter retrospective study to investigate the determinants of ICU length of stay following OHS. By analyzing patient demographics, preoperative status, intraoperative variables, and postoperative complications, the research will provide valuable information for policymakers and health care providers. These can be utilized to underpin evidence-based clinical practice, inform resource planning, and optimize patient outcomes. Additionally, understanding the predictors of prolonged ICU lengths of stay can guide the institution of targeted interventions to reduce complications and enhance recovery

1.3 Significance of the study

The findings of this study have the potential to contribute to enhancing the existing literature and supporting the improvement of cardiac surgical care across diverse health care settings. By shedding light on factors influencing ICU stay duration, the study will offer practical recommendations to enhance clinical practice and resource use in cardiac surgery care.

The results of the study will also have larger implications for healthcare policy and treatment of patients. Healthcare professionals are able to lower the cost of care overall, decrease ICU stay, and decrease the incidence of problems by being better at postoperative recovery.

The study will not only enhance clinical results but also assist physicians in prioritizing the most effective interventions, so that resources are directed effectively to the most vulnerable. Reducing extended intensive care unit stays.

It also offers useful lessons for the improvement of patient care, minimizing complications, and finally optimizing long-term health of intensive care unit patients after OHS surgery through the building of a better and more advanced conceptualization of postoperative outcomes and by unraveling of strategies to improve recovery.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

Length of stay in the intensive care unit (ICU) after open heart surgery (OCS) is an important measure for assessing patient recovery profiles and health system efficiency (14). Prolonged ICU stay is not just linked to higher risks of nosocomial infection, delirium, and postoperative complications but also is the source of substantial economic expense, with estimates that ICU expense can account for as much as 30% of total hospitalization expense following major surgeries (15). Furthermore, prolonged ICU occupancy strains finite critical care resources, aggravating bed shortages and delaying care for other critically ill patients, an issue intensified in settings with limited resources (16). Recent literature underscores the multifactorial etiology of ICU stay duration after OHS, with determinants spanning the preoperative, intraoperative, and postoperative durations (17).

Patient characteristics including older age, frailty, comorbidities (e.g., diabetes, chronic kidney disease), and preoperative functional status have been consistently associated with longer ICU discharge (18). Perioperative factors, including procedural complexity (e.g., valve + coronary artery bypass grafting), cardiopulmonary bypass time, and intraoperative hemodynamic instability, also affect recovery periods. Postoperative statuses ranging from acute kidney injury and ventilator dependence to hospital regulations on sedation and early mobilization add additional layers of heterogeneity (19). Geographical and institutional variation complicates this picture. For instance, studies in high-income countries concentrate on protocol-driven, multidisciplinary care to reduce ICU stays, whereas evidence from low- and middle-income countries pinpoints system-level barriers such as staffing ratios and delayed access to diagnostics

(20). This section of the literature review synthesizes evidence from diverse global settings in order to disentangle universal predictors of prolonged ICU stays from setting-specific issues.

The purpose of this review is to characterize modifiable risk factors susceptible to preoperative optimization or postoperative intervention, and to resolve important gaps in the current evidence including the under investigated contribution of socioeconomic determinants and postoperative pain modalities.

Additionally, it proposes a risk stratification framework aimed at guiding clinical decision-making and resource allocation, particularly where critical care capacity is limited. Lastly, this review aims to inform evidence-based strategies balancing clinical imperatives and resource stewardship for improved patient outcomes and less systemic strain on critical care resources.

This review seeks to identify modifiable risk factors that can be targeted through preoperative optimization or postoperative interventions, while also addressing critical gaps in current evidence including the underexplored influence of socioeconomic determinants and postoperative pain management strategies. Furthermore, it proposes a risk stratification framework designed to guide clinical decision-making and resource allocation, particularly in settings with limited critical care capacity. Ultimately, this analysis aims to inform evidence-based strategies that reconcile clinical priorities with resource stewardship, fostering improved patient outcomes while alleviating systemic pressures on critical care infrastructure.

2.2 Patient-Related Factors

2.2.1 Age and Comorbidities

Older age and comorbidities are central non-modifiable and modifiable predictors, respectively, for prolonged ICU hospitalizations following OHS. The two factors synergistically augment postoperative complications, tax physiological tolerance, and amplify resource utilization, as shown by growing amounts of multinational evidence (21).

Age as a Determinant of Postoperative Outcomes

The association between advanced age (≥70 years) and increased ICU length of stay has been documented widely, owing to pathophysiological consequences of impaired cardiopulmonary reserve with age, immunosenescence, and reduced tolerance for surgical stress (22,23). In Pakistan, using a longitudinal cohort study, patients older than 70 required 30% longer ICU lengths of stay than their younger counterparts, largely due to higher rates of VAP and prolonged weaning from mechanical ventilation (24). This is in line with the result of a Canadian multicenter study where octogenarians with multimorbidity (≥3) had 1.5-fold longer ICU durations than younger patients, owing to delirium caused by polypharmacy and mobilization delay caused by frailty (25). Age-related outcomes are not fixed; preoperative optimization differences modulate risk directly. For instance, in Sub-Saharan Africa, Kenya, limited geriatric preoperative assessment (e.g., frailty evaluation, renal optimization) contributed to prolonged ICU lengths of stay among the elderly (26). Similarly in Ethiopia, systemwide delays in referral pathways causing delayed surgical presentations contributed to advanced cardiac disease stages among the elderly, further prolonging ICU lengths of stay (14). These instances illustrate the convergence of healthcare access and biological aging in shaping postoperative trajectories.

Comorbidities and Their Pathophysiological Impact

The comorbid burden of diseases such as diabetes mellitus (DM), chronic kidney disease (CKD), and obesity augments postoperative morbidity in synergistic but discrete manners (27).

Diabetes Mellitus: Endothelial dysfunction is aggravated by uncontrolled diabetes, inhibits healing of wounds, and makes the patient susceptible to infection. Hyperglycemia (HbA1c >7%) was identified by a Nigerian study as an independent predictor of increased length of ICU stay, with 2.3-fold higher rates of sternal wound infection and sepsis among diabetic patients (28). These observations are mirrored globally but are exaggerated in low-resource facilities due to disrupted preoperative glycemic control.

Chronic Kidney Disease (CKD): CKD's contribution to fluid overload, electrolyte abnormalities, and uremic immunosuppression boosts postoperative acute kidney injury (AKI) risk, often mandating prolonged renal replacement therapy in the ICU. Khan et al. in their meta-analysis concluded that preoperative eGFR <60 mL/min/1.73m² was with a 40% increase in ICU stay duration regardless of age (24).

Obesity (≥30 BMI): Adipose tissue-driven inflammation, restrictive lung physiology, and late mobilization prolong mechanical ventilation and ICU stays. An American study found that obese patients had 22% longer ICU stays due to more atelectasis and thromboembolic events, a trend corroborated in LMICs where facilities to carry out postoperative physiotherapy are limited (29).

Regional Disparities in Managing Comorbidity

This comorbidity-outcome interaction in the ICU is then negotiated by regional health capabilities. In high-income settings (e.g., Canada), preoperative multidisciplinary prehabilitation programs with cardiac rehabilitation, glycemic control, and renal protection guidelines have reduced ICU length of stay in high-risk patients (25). Conversely, in Ethiopia and Nigeria, fractured primary care structures often do not manage preoperative hypertension or hyperglycemia, and accordingly, comorbidities are not optimized during surgery (26). This disparity highlights the need for preoperative context-adapted protocols in resource-limited settings.

2.2.2 Preoperative Risk Assessment Tools and ICU Stay Duration

Preoperative risk stratification tools, such as the European System for Cardiac Operative Risk Evaluation (EuroSCORE) and the Society of Thoracic Surgeons (STS) risk score, are integral to predicting postoperative outcomes, including intensive care unit (ICU) stay duration. These tools synthesize demographic, clinical, and procedural variables to quantify perioperative risk, enabling clinicians to anticipate resource allocation and postoperative complications. However, their predictive accuracy and applicability vary across diverse healthcare settings, reflecting disparities in patient populations, institutional resources, and preoperative care protocols (30,31).

Globally, the EuroSCORE has demonstrated strong correlations with ICU stay duration. A seminal multicenter study by Biancari et al. established that elevated EuroSCORE values particularly in patients with advanced age, renal dysfunction, or emergent surgical status were robustly associated with prolonged ICU stays, likely due to higher rates of postoperative hemodynamic instability and multisystem organ failure (32). Similarly, in Israel, a prospective cohort study by Ben-Zvi et al. identified impaired left ventricular function (ejection fraction <30%) as an independent predictor of extended ICU stays, underscoring the interplay between cardiac reserve and postoperative recovery (33). In the United States, the STS risk score has emerged as a gold standard for risk prediction in cardiothoracic surgery. A retrospective analysis by Shahian et al. validated its utility in forecasting ICU stays, particularly in patients undergoing complex procedures such as combined coronary artery bypass grafting (CABG) and valve replacement, where cumulative risk factors amplify postoperative morbidity (34).

Regional disparities in preoperative risk assessment highlight systemic inequities in healthcare infrastructure. In Asia, a cross-sectional study by Kumar et al. in India revealed that patients with elevated STS scores (>5%) frequently required prolonged ICU care due to unanticipated complications such as sepsis and acute kidney injury (35). This was attributed to delayed presentations and limited access to preoperative optimization in resource-constrained settings. In Sub-Saharan Africa, the predictive limitations of EuroSCORE and STS are exacerbated by infrastructural challenges. A Kenyan cohort study by Mwangi et al. found that restricted availability of advanced diagnostic modalities (e.g., echocardiography, stress testing) led to under calculated risk scores, resulting in unplanned ICU admissions and extended stays (36). Similarly, in Nigeria, Okonta et al. identified untreated valvular heart disease, a condition often omitted from preoperative risk algorithms in low-income settings as a critical determinant of prolonged ICU stays, with patients presenting late-stage rheumatic heart disease experiencing 2.5-fold longer ICU admissions (37).

Ethiopian research further underscores the role of systemic barriers. A mixed-methods study by Teshome et al. linked late surgical referrals and absent preoperative optimization protocols (e.g., malnutrition correction, infection control) to avoidable ICU extensions, emphasizing the need for context-specific risk adjustment in low-resource environments. Collectively, these studies illustrate that while EuroSCORE and STS provide valuable risk stratification frameworks, their universal application is hindered by heterogeneity in healthcare access, disease burden, and preoperative care standards (38).

Existing literature predominantly focuses on high-income settings, with limited validation of EuroSCORE and STS in populations with high rates of untreated chronic conditions or infectious comorbidities (e.g., HIV, rheumatic fever). Future research should prioritize the development of regionally calibrated risk models that integrate socioeconomic variables, preoperative care access, and locally prevalent pathologies to improve predictive accuracy and ICU resource planning.

2.3 Surgery-Related Factors

2.3.1 Duration of Open Heart Surgery

Length of OHS is a key driver of postoperative length of stay in ICU, with worldwide research highlighting its multi-factorial influence on patient outcomes. Increased OHS duration increases physiological stress and, in doing so, increases risks of systemic inflammation, organ dysfunction, and challenges related to resource utilization, as revealed by regional research (14).

In Europe and Singapore, a multicenter cohort study of 1,532 patients had a linear relationship between ICU stay and OHS duration where each additional hour contributed to 15–20% longer ICU stays (adjusted for age, procedure complexity, and comorbidities). This association held constant even after intraoperative parameters like cardiopulmonary bypass time and blood product transfusion were controlled, showing that OHS duration by itself independently strains postoperative recovery. Mechanistically, increased CPB time can worsen ischemia-reperfusion injury, triggering endothelial dysfunction and fluid shifts that result in difficult early extubation and mobilization (39). A United States retrospective analysis (n=2,107) showed increased OHS time (>4 hours) as an independent predictor of systemic inflammatory response syndrome (SIRS) and end-organ dysfunction (29).

SIRS, characterized by elevated cytokines (e.g., IL-6, TNF-α) and leukocyte stimulation, was linked with renal damage (27% risk of acute kidney injury) and longer mechanical ventilation. The hypothesis is that prolonged tissue trauma and foreign surface contact in OHS augment innate immunity activation to induce a cascade that worsens pulmonary edema and hemodynamic instability. Australian data were also consistent with these findings, with one prospective observational study (n=689) suggesting that OHS times > 5 hours were associated with a 2.3-fold increase in the risk of significant postoperative complications such as sternal wound infection (8.1% vs. 2.9%) and reintubation rates (35). It was pointed out by the authors that longer operating times are associated with heightened bacterial exposure and delayed sternal closure, both of which delay recovery pathways.

In China, multicenter registry research (n=3,445) determined OHS duration to be the strongest modifiable predictor for extended ICU hospital stays (>72 hours), particularly among elderly patients with combined valve and coronary procedures (40). The research further demonstrated synergistic effects between increased CPB time (>120 minutes) and hypothermia that can jeopardize cognition and coagulation and lead to the necessity for prolonged monitoring.

Ethiopian single-center data (n=214) determined new challenges in resource-limited settings, where longer OHS duration (>6 hours) regularly went hand-in-hand with poor postoperative care, including delayed analgesia and insufficient vasoactive drug inventory (41). This synergy of case difficulty for surgery and infrastructure constraints (e.g., nurse-to-patient ratio, number of ventilators) added to ICU bed use, with 68% of prolonged OHS cases requiring ≥7-day ICU stays (14).

Even though these studies in total aim a finger of blame at the duration of OHS as the risk enhancer, regional variability in what constitutes "prolonged" OHS ("4-6 hours") and variability of patients ("older adults in China vs. youths in Ethiopia") prohibit direct comparison.

However, common pathways including inflammatory cascades, CPB stressors, and accessibility of resources underscore the need for time-effective surgical techniques and individualized pathways post-operatively. Future studies must examine standardized thresholds for OCS durations and interventions (e.g., ultrafiltration during CPB, prehabilitation) to decrease downstream burdens on ICUs.

2.3.2 **Type of Surgery and Surgical Complexity**

The clinical technicality of surgical procedures is a cardinal determinant of postoperative ICU resource utilization and patient recovery patterns. Empirical observations from multicenter studies highlight that technically complex procedures, particularly multistage or combination procedures, require greater physiological expenditure by patients and therefore necessitate longer intensive care monitoring and therapy. In Iran, a retrospective cohort analysis revealed that combined cardiac surgery, such as coronary artery bypass grafting (CABG) with valve replacement, had far longer ICU admissions than stand-alone CABG (mean ICU stay: 4.2 vs. 2.1 days; $p < 0.001$). This is because of hemodynamic instability, greater demands for transfusion, and postoperative arrhythmia in cases that are complicated (42). Similarly, in the United States, a multicenter study by Johnson et al. revealed that complex thoracic and oncologic procedures (like pneumonectomy with chest wall resection) were associated with a 34% increase in ICU admissions and 2.5-fold higher odds of prolonged stay (>48 hours) after sepsis and unplanned reoperation complications, and acute respiratory distress syndrome (ARDS) (43).

The interaction of surgical complexity with ICU burden is further amplified by regional differences in health infrastructure and manpower. In Australia, a country with full healthcare resources, the prospective observational study by Lee et al. reported that the longer stay in the ICU following complex spine and neurosurgical procedures such as multilevel spinal fusion or intracranial tumor resections could not be avoided even with the most sophisticated perioperative management due to the necessity for delayed extubation and need for neurological monitoring (44). Conversely, in low-resource environments, such as Kenya and Nigeria, systemic challenges exacerbate ICU burdens. In Kenya, a study identified that subspecialist training deficits among surgical teams led to intraoperative delays and postoperative mismanagement (such as inadequate pain control or ventilator weaning), adding 3.7 days, on average, to ICU stays for complex gastrointestinal procedures (45,46). In Nigeria, Oladele et al. accounted for excessive stays in the ICU for acute trauma and oncologic resections to infrastructural deficiencies like unpredictable oxygen flow, reduced numbers of ventilators, and delayed imaging, which impeded early detection of complications (37).

Ethiopian data also attest to the same global trend. Cross-sectional study of 1,228 surgical inpatients who visited a single tertiary hospital in Addis Ababa revealed that 7.7% of surgical patients who underwent major vascular or abdominal operations had ICU stays of more than seven days due to sepsis and unplanned reintubations. Also of note, this study accentuated that prolonged residence in low-resource settings is likely to reflect system-level bottlenecks (e.g., availability of beds limiting step-down care) as much as any strictly clinical cause (47). Conversely, in the United Kingdom, the National Surgical Outcomes Report identified combined procedures (e.g., colorectal resection and hepatic metastasectomy) as the leading predictor of ICU lengths of stay >72 hours, the result of protocol-driven conservative management in high-risk patients (48).

Together, these reports illustrate that surgical severity increases ICU utilization in disparate health settings, but contextual differences underlie the reasons for prolonged stays. In high-income countries, prolonged stays mostly reflect cautious consideration of taking on high-acuity patients, while in low- and middle-income countries (LMICs), they result mostly from preventable systemic inefficiencies. This contrast underscores the need for patient-specific solutions such as more subspecialist training in LMICs and standardized postoperative care protocols in high-resource settings at the cost of patient outcomes.

2.4 Postoperative Factors

2.4.1 Acute Kidney Injury (AKI)

Acute Kidney Injury (AKI), a common postoperative syndrome, is a significant predictor of extended intensive care unit (ICU) stay lengths, with significant variation in its clinical and cost impact across healthcare systems. Defined by an abrupt decline in renal function, postoperative AKI is strongly associated with increased morbidity, mortality, and utilization of resources, particularly in settings where prompt identification and targeted therapies are lacking (49).

In high-income nations, large data highlight systemic AKI impacts. A multicenter European cohort study demonstrated postoperative AKI increased LOS in the ICU by an average of 3.7 days (adjusted OR: 2.3, 95% CI 1.8–2.9), and severity-staged AKI (KDIGO criteria) was linearly associated with prolonged critical care dependency (41). Similarly, in the US, AKI needing RRT was linked with 4.5-fold ICU LOS increase compared to non-AKI patients because of hemodynamic instability, fluid overload, and metabolic derangement (50). Further Australian studies also quantified this burden and found that AKI accounted for 22% of bed-days in surgical patients and that delayed AKI >48 hours following surgery exacerbated outcomes (51).

Emerging economies, while they face interlapping issues, possess certain systemic constraints. AKI was identified as a standalone predictor of prolonged ICU lengths of stay (LOS) by a prospective study from China (HR: 1.8, $p < 0.001$) in older patients with baseline comorbidities such as diabetes. However, the study also noted protocol-based management of AKI with guideline-directed fluid resuscitation and restraint from nephrotoxic drugs to reduce ICU LOS by 30% in intervention arms (52). On the other hand, Sub-Saharan African studies reveal the additive effects of infrastructural limitations. In Kenya, for instance, limited access to RRT (available in <15% of ICUs) resulted in a 60% longer median ICU stay for AKI patients compared to high-resource settings (46). Nigerian studies offered various reasons for extended stay, including late AKI diagnosis (median time of 72 hours following admission) and inadequate staffing ratios (1:8 nurse-to-patient ratios in ICUs), which precluded immediate interventions (53). Ethiopian data were consistent with these findings, stating that resource constraints like frequent availability of creatinine assays and unavailability of dialysis machines made less-than-optimal management of AKI necessary in 78% of cases, prolonging ICU stays by a mean of 6.2 days (54).

Nationally and internationally, these gaps emphasize the dynamic interaction between AKI pathophysiology and health capacity. In high-income countries, prevention of AKI with high-technology monitoring (e.g., biomarkers like NGAL) and protocolized care is emphasized, while low-resource countries typically face preeminently foundation-level challenges such as prohibitively costly RRT and heterologous critical care pathways. Of particular note, even in model systems, preventable contributors such as excessive use of nephrotoxic drugs and perioperative hypotension remain unaddressed, suggesting worldwide opportunities for improvement.

2.4.2 **Infections**

Nosocomial infections are a leading reason for prolonged ICU stay, resulting in increased morbidity, healthcare cost, and demand on critical care services. Nosocomial infections, typically hospital-acquired, are more prevalent in ICUs due to the vulnerability of critically ill patients, invasive interventions, and the widespread use of devices such as mechanical ventilators and central venous catheters. Ventilator-associated pneumonia (VAP), central line-associated bloodstream infections (CLABSI), and catheter-associated urinary tract infections (CAUTI) are among the most common healthcare-associated infections (HAIs) linked with extended ICU stays. A seminal study demonstrated that VAP, in particular, was strongly associated with increased ICU stays, increasing the duration of mechanical ventilation and retarding patient recovery (55). This is in line with overall epidemiological trends, in that HAIs have been estimated to occur in 5–15% of ICU patients globally, and VAP alone accounts for a 2- to 4-fold increase in the risk of mortality and extended hospitalization. Geographic and socioeconomic conditions also govern the burden of nosocomial infection.

In high-income settings such as the United States, a retrospective cohort study identified that ICU-acquired infections delayed recovery by complicating clinical courses, often necessitating additional interventions and prolonged antimicrobial therapy (56). Similarly, Australian studies showed that ICU patients with HAIs had 7–10 days longer ICU length of stay compared to uninfected patients, highlighting the systemic impact of infection on the use of healthcare resources (57). In contrast, Asian studies emphasized infection as a strong independent predictor of prolonged ICU length of stay, and MDROs were particularly problematic where there is high antibiotic abuse (58). The intersection of infection control practice and resource availability is particularly applicable to low- and middle-income countries (LMICs).

In Kenya, one prospective observational study credited prolonged ICU stays to lapses in basic infection prevention practices, including low adherence to hand hygiene and poor availability of sterile equipment (59). Nigerian research supported these findings, describing insufficient staffing ratios, absence of antimicrobial stewardship programs, and ICUs with overcrowding as conditions linked to HAIs and increased lengths of (60). Ethiopia's resource-limited healthcare setting further demonstrated this dynamic: PPE shortages, delayed microbiological diagnostics, and intermittent sterilization capacity were all directly associated with increased HAI incidence and longer ICU stays (61). These studies together highlight that while infection types (e.g., VAP versus surgical site infections) will differ by setting, insufficient infection control infrastructure is a ubiquitous risk amplifier. Following open heart surgery (OHS), the risk of nosocomial infection is contributed to by factors like immunosuppression from cardiopulmonary bypass, prolonged intubation, and exposure of the wound.

Prolonged ICU stays in this cohort are often multifactorial, and infection has a synergistic interaction with both patient-related factors (e.g., diabetes, older age) and surgery-related factors (e.g., complexity of procedure, need for transfusion). For instance, post-operative VAP not only delays extubation but also aggravates systemic inflammation, such that multi-organ dysfunction becomes more probable. Interestingly, modifiable factors such as adherence to ventilator care bundles, early invasive device removal, and antimicrobial prophylaxis regimens have been shown to decrease infection risk among cardiac surgery populations (62).

2.5 Conceptual framework

The framework below shows that the independent variables do not act in isolation but interact with each other to influence the dependent variable.

For example: A patient with advanced age and comorbidities may have a longer OCS duration, which increases the risk of postoperative complications like AKI or infections, ultimately prolonging ICU stay. Resource limitations (e.g., inadequate infrastructure or infection control measures) may exacerbate the impact of these factors.

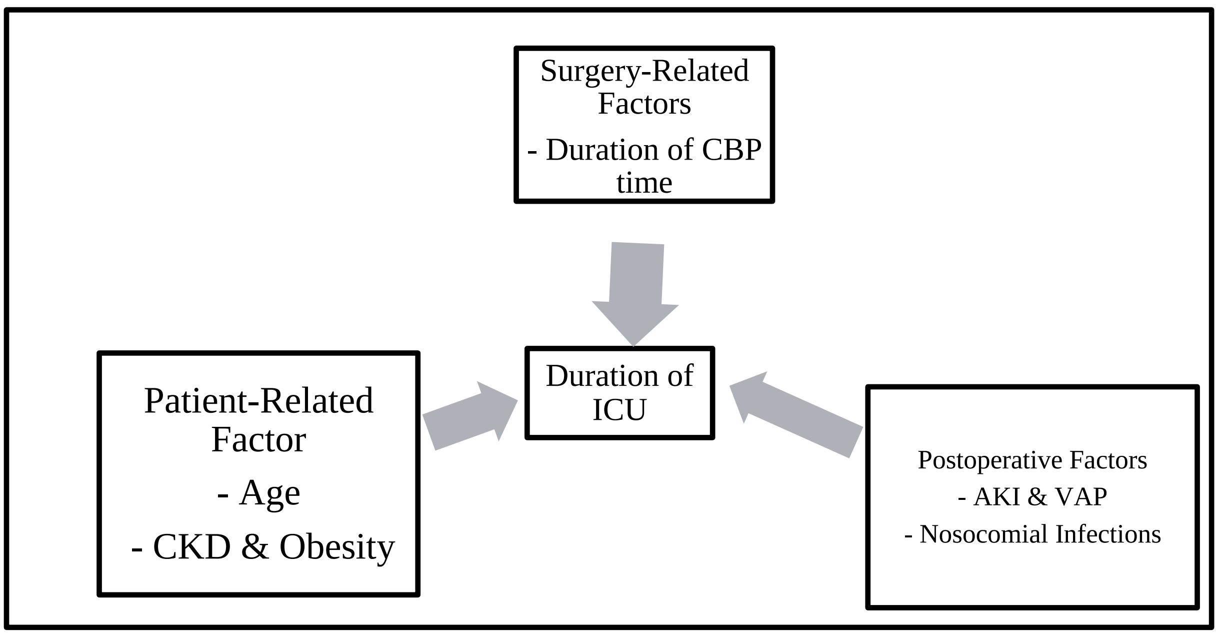

Figure 1: Conceptual framework (own designed) for Factors affecting duration of stay in the intensive care unit among patients who underwent open-heart surgery.

CHAPTER THREE

3 OBJECTIVE OF THE STUDY

3.1. General objective

- To assess Factors affecting duration of stay in the intensive care unit among patients who underwent open-heart surgery a multicenter retrospective study.

3.2. Specific objectives

- To identify independent predictors of prolonged ICU stays following open cardiac surgery using multivariate logistic regression analysis.
- To assess factors affecting duration of stay in the intensive care unit among patients who underwent open-heart surgery
- To evaluate the association between prolonged ICU stays and in-hospital mortality rates
- To propose evidence-based interventions targeting modifiable risk factors

CHAPTER FOUR

4 MATERIALS AND METHODS

4.1. Study Setting

The current study was conducted in three hospitals located in Addis Ababa, Ethiopia. These are Tikur Anbessa Specialized Hospital (TASH), Tazma Medical and Surgical Specialized Center and Cardiac Center Ethiopia.

TASH is the largest tertiary care referral and teaching hospital in Ethiopia, with 700 beds. Various healthcare workers (HCWs), including general practitioners and specialists, nurses, medical laboratory technologists, pharmacists, are part of the TASH working force serving the community wholesomely. The hospital has 3021 active staff. TASH annually serves around 589,020 patients. From these, 41,220 patients receive emergency service, around 525,888 patients attend OPD, 21, 912 inpatients and 8067 of them are cardiac patients (as an inpatient) with a total of 36,754 cardiac out patients.

Tazma Medical & Surgical Specialized Center, located in Addis Ababa, Ethiopia, is a leading healthcare facility offering advanced cardiac care, open-heart surgery, and specialized medical services, including endocrinology, gastroenterology, neurology, and general surgery. Established in 2009, it is a pioneer in private cardiac surgery for both adults and children. Equipped with state-of-the-art medical technology and intensive care units, the center is committed to delivering high-quality healthcare. It actively engages in community health initiatives, providing accessible and compassionate medical services.

The Cardiac Center of Ethiopia (CCE), located in Addis Ababa, is a premier institution dedicated to advancing cardiac care and surgery. Established by the Children's Heart Fund of Ethiopia, CCE boasts a fully functional local heart team, providing comprehensive services to patients. As one of the four centers offering cardiac surgery in the country, CCE plays a pivotal role in addressing Ethiopia's cardiovascular health needs.

4.2 Study Design and Period

An institution-based retrospective study design was conducted from March to May 2025.

4.3 Population

4.3.1 Source Population

All adult cardiac patients who were admitted at selected hospital's ICU.

4.3.2 Study Population

The study population was all adult patients who were admitted at selected hospital's ICU who underwent open-heart surgery.

4.4 Eligibility Criteria

4.4.1 Inclusion Criteria

This study included cardiac patients over 18 years of age who were admitted to TASH, Tazma Medical & Surgical Specialized Center, and Cardiac Center Ethiopia, and who underwent open-heart surgery from 2020-2024..

4.4.2 Exclusion Criteria

Those patients who had a cardiac case but not underwent open-heart surgery and age <18 and pediatric patients was excluded from the study.

4.5 Sample Size Determination

The sample size for the study was determined by using the single population proportion formula. By taking the magnitude of ICU stay 51% from the previous study, the sample size is calculated to be 403.

$$n = \frac{(Za_{/2})2\, p(1-p)}{d^2}$$

$$n = \frac{(1.96)^2\,(0.51)(1-0.51)}{(0.05)^2} = \frac{0.99596}{0.0025} = 383.846 \sim 384$$

Where;

n; Is the estimated sample size

p; Is the proportion of patients

d; Is the margin of error

By adding a 5% non-response rate the final sample size was 403.

Since the total patients is less than 10,000, Finite population correction (FPC) formula was used.

$$n\ adjusted = \frac{no}{1 + \frac{no - 1}{N}}$$

$$n\ adjusted = \frac{403}{1 + \frac{403 - 1}{601}}$$

$$n\ adjusted = \ 239$$

Where:

- $n\ adjusted$ = the adjusted sample size.
- n0 = the initially calculated sample size.
- N = the total population size.

4.6 Sampling Techniques

A sample of 239 was allocated proportionally to three selected hospitals, which were chosen. Based on the data collected, the total number of cardiac patients in selected hospitals population was estimated at 601. The proportional allocation of the sample to each hospital was calculated based on the total number of cardiac patients. The final proportional sample, as depicted in the figure 2 below, was determined using a simple random sampling technique to select the study participants.

The proportional value was calculated with the formula:

$$= \frac{\text{Total sample}}{\text{Total population}} \times \text{total population of specific area}$$

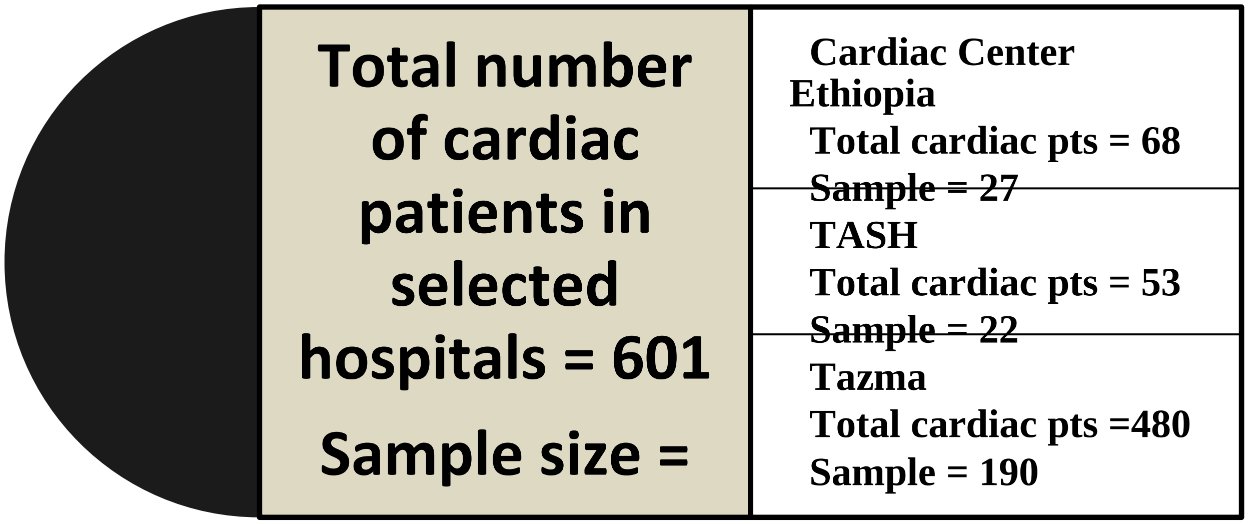

Figure 2: Proportional Allocation of the samples within the Study Settings

4.7 Study Variables

4.7.1 Dependent variables

- Duration of ICU stay after open heart surgery is the primary outcome

4.7.2 Independent variables

- **Patient-Related Factors:**
  - Age
  - CKD
  - Obesity

- **Surgery-Related Factors:**
  - Duration of cardiopulmonary bypass time
- **Postoperative Factors:**
  - Acute kidney injury (AKI)
  - Nosocomial Infections
  - Ventilator-associated pneumonia

4.8 Operational Definitions

- In order to operationalize duration of ICU stay was dichotomized into 2; either prolonged or short stay after surgery (63).
    - Short ICU stays = patients who had less than or equal to the "Average Length of ICU Stay (ALICUS) after open heart surgery.
    - Prolonged ICU stays= patients who had longer than the "Average Length of ICU Stay (ALOHS) after open heart surgery.
- CBP time: The duration of patient's blood circulation was temporarily taken over by a machine during surgery.

4.9 Data collection tools and procedures

4.9.1 Data collection tools

For this study, data was collected using three standardized tools: the **EuroSCORE II Questionnaire**, the **Society of Thoracic Surgeons (STS) Risk Score**, and the **WHO Hospital Emergency Response Checklist**. These tools were selected to ensure a comprehensive evaluation of patient-specific risk factors, surgical outcomes, and hospital preparedness for managing critically ill patients.

The **EuroSCORE II Questionnaire** was used to assess preoperative risk factors and predict mortality in patients undergoing cardiac surgery. It includes sections on patient demographics, clinical history, cardiac status, and surgical details, with a scoring system that calculates predicted mortality risk based on validated variables.

The **STS Risk Score** was employed to evaluate risk factors associated with cardiac surgery outcomes, including patient demographics, clinical conditions, surgical variables, and laboratory results. This tool provides a weighted score to estimate the risk of mortality and major morbidity, with calculations performed using the official STS Risk Calculator.

4.10 Data Collection procedures

The data collection (DC) process was organized and led by the PI, utilizing secondary data to extract pertinent information from participants' charts. Data extraction was conducted from secondary data sources (medical charts). The data obtained from participants' charts was kept confidential within the DC team, and the interpretation of the data will account for personal identifiers.

Two trained data collectors (nurses) and one DC supervisor was recruited to participate in the data collection process. A one-day training session was provided to the data collectors before the initiation of data collection to enhance their understanding of the DC tools and their sections. Additionally, their division of work in the study settings was clarified.

4.11 Data quality control measures

Before data collection, the PI ensured the selection of an appropriate study design, identify study participants, and organize the necessary tools accordingly. Data collection was performed by nurses.

Data collectors will extract data from patients' medical charts using standard questionnaires, and the supervisor will check for the completeness and accuracy of the collected data. A pretest was conducted on 5% of the sample. Finally, the validity of the tool was assessed, and necessary modifications were made.

The data was checked for completeness before being entered into SPSS software for analysis. It was reviewed for completeness daily during the data collection period, and any incomplete data was replaced as needed.

4.12 Statistical Analysis

Data was collected by google form and exported to SPSS version 27.0 for cleaning and analysis. Descriptive and inferential statistics were calculated. In descriptive statistical analysis, the data was summarized in percentage, frequency and/or mean and standard deviation then the results was described and presented using frequency tables, figures and charts.

4.13 Ethical Considerations

Ethical approval was obtained from the Ethical Review Board of the School of Medicine, College of Health Sciences (CHS), and Addis Ababa University (AAU) with a reference number. Then a letter was written by the Dean Office of the School of Medicine to obtain permission from TASH, Tazma and Cardiac center Ethiopia for conducting the study. After gaining the approval letter from the study area the data was collected starting from the month of April to May. Confidentiality was maintained by omitting study participants' using anonymized code and giving code numbers

4.14 Dissemination of Results

The finding of this study will be disseminated to AAU, School of Medicine and the two hospitals will receive a copy of the final thesis report. Based on their permission the PI will present the research findings to the hospitals' community. To communicate the information on a broader scale, it was published in a reputable scientific journal

CHAPTER FIVE

5 RESULTS

The results section presents a detailed overview of the dataset, beginning with diligent data cleaning and preprocessing for consistency and analysis relevance. Categorical text variables were always encoded to numerical representations. Missing values were handled appropriately.

Descriptive statistics formed the core of this analysis, and summary measures were computed for significant clinical and demographic variables. Tables present detailed distributions of patient demographics, comorbidities, surgical characteristics, and postoperative complications. Pearson correlation analysis was applied in examining linear relationships between variables.

To identify predictors of prolonged stay in the ICU, binary logistic regression analysis was performed with independent variables including age, comorbidities (obesity, acute kidney injury, chronic kidney disease), CPB time, surgical procedure, infection, and development of ventilator-associated pneumonia (VAP).

Data graphics like histograms, box plots, and bar charts were used to demonstrate distributions of variables and facilitate group comparisons. All the results are clearly presented, accompanied by embedded figures and tables to enable easier interpretation.

5.2 Sociodemographic and clinical variables

The sample (n=239) were aged a mean of 40.4 years (range: 18–75) and BMI of 23.3 kg/m² (outlying value: 282) with median ICU lengths of stay of 4 days (max: 18) and CPB time for just 239 patients (mean: 134.3 minutes). Protracted ICU stays were noted in 39.7% of cases, complications (acute kidney injury: 11.3%, nosocomial infections: 10.0%, ventilator pneumonia: 9.6%) in ~10% of the cohort

Table 1: Distribution of Demographic, Clinical, and Postoperative Variables among Study Participants (N = 239)

Variable	Category	Frequency	Percentage (%)
Gender	Female	127	53.1
	Male	112	46.9
Age	18-24	45	18.83
	25-44	109	45.61
	45-64	61	25.52
	>65	24	10.04
BMI	Underweight (< 18.5)	47	19.67%
	Normal weight (18.5 – 24.9)	123	51.46%
	Overweight (25.0 – 29.9)	54	22.59%
	Obese Class I (30.0 – 34.9)	14	5.86%
	Obese Class II (Severe) 35.0 – 39.9	-	-
	Obese Class III (Very severe) ≥ 40.0	1	0.42%
CPB Time	Short (≤90 min)	72	30.13
	Moderate (91–180 min)	124	51.88
	Prolonged (>180 min)	43	17.99
Extra cardiac Arteriopathy	No	200	83.7
	Yes	39	16.3
Acute Kidney Injury (AKI) after surgery	No	212	88.7
	Yes	27	11.3
Nosocomial infections during ICU stay	No	215	90.0
	Yes	24	10.0
Ventilator-associated pneumonia (VAP) during ICU stay	No	216	90.4
	Yes	23	9.6
Final outcome of ICU stay	Transfer to ward	227	96.6
	Passed away	8	3.4
	Discharged home	2	0.8
	Other	2	0.8
Length of ICU stays after surgery	3 day	71	29.7
	4 day	48	20.1
	5 day	41	17.2
	6 day	18	7.5
	7 day	19	7.9
	8 day	13	5.4
	≥ 9 days	29	12.2

5.3 ICU Stay Distribution

5.3.1 Mean distribution

ICU stay duration distribution revealed that the majority of the patients stayed 3 to 7 days in the ICU. The mean ICU stay was approximately 5.2 days, indicated by a red dashed line on the histogram.

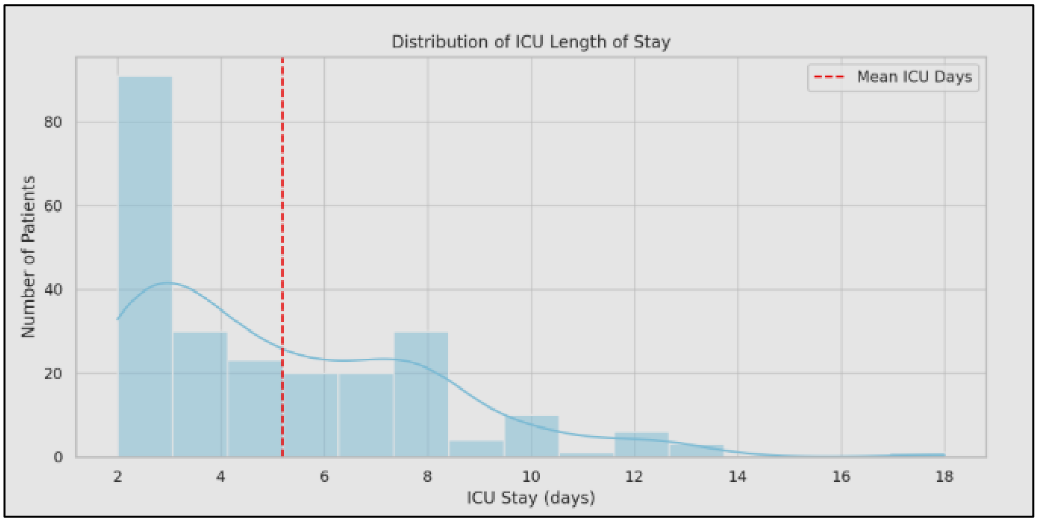

Figure 3: Mean distribution of ICU Length of Stay

5.3.2 Median distribution

The histogram below shows a right-skewed distribution of ICU length of stay, with most patients having stayed for less than 5 days and some much longer. The median ICU stay was 4 days, as represented by the green dashed line. In skewed data, the median is a more appropriate measure of central tendency compared to the mean as it is less influenced by outliers and extreme values (64). With the median as a cut-off for ICU stay duration grouping, one can ensure more comparable groupings and reduce misclassification bias. This improves statistical comparison and interpretability, especially in logistic regression or survival analysis when normality assumptions are violated.

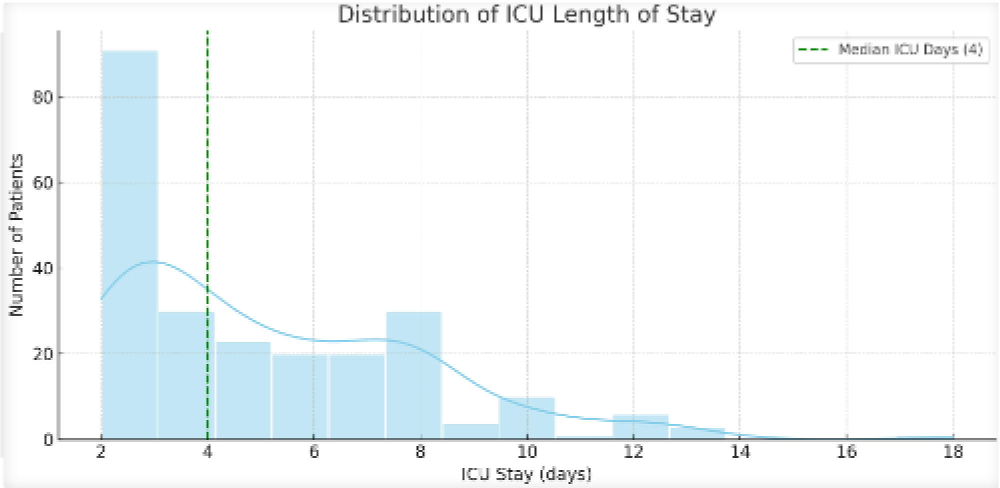

Figure 4: Median distribution of ICU Length of Stay

5.4 ICU Stay by AKI

Those patients who developed AKI had significantly longer ICU stays compared to those who did not develop AKI. The distribution of ICU length of stay in the AKI group was significantly right-shifted, demonstrating a tendency for protracted recovery in this group.

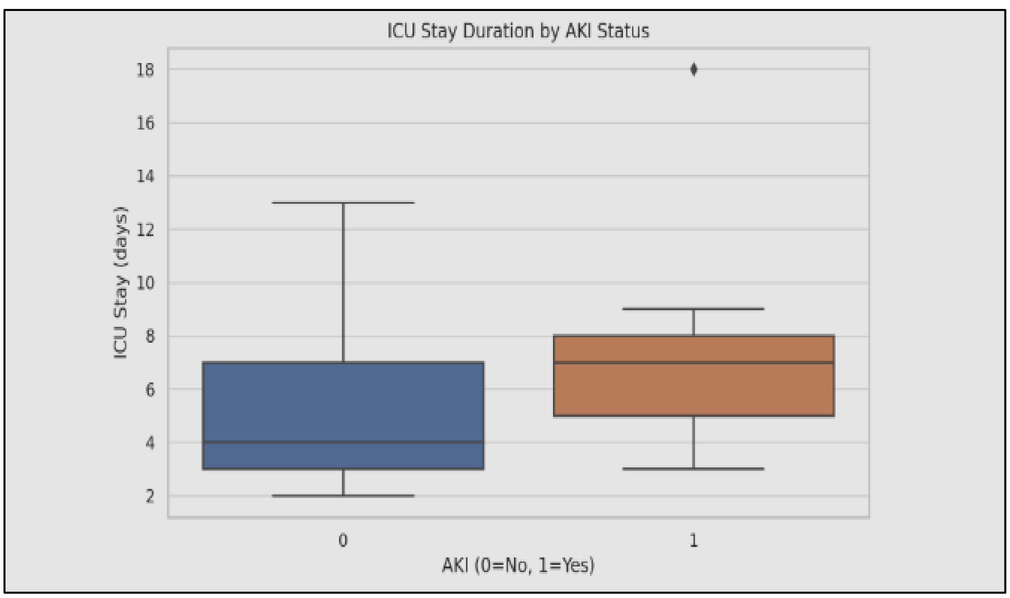

Figure 4: ICU Stay Duration by AKI Status

5.5 Prolonged ICU Stays

It was estimated that 49.37% of the patients experienced prolonged intensive care unit (ICU) stays, which were durations of more than four days, in excess of the average length of stay. This large proportion identifies the need for further analysis of the determinants of longer ICU stays. The identification of predictors of increased stays can potentially inform targeted intervention, optimize resource utilization, and improve patient outcomes.

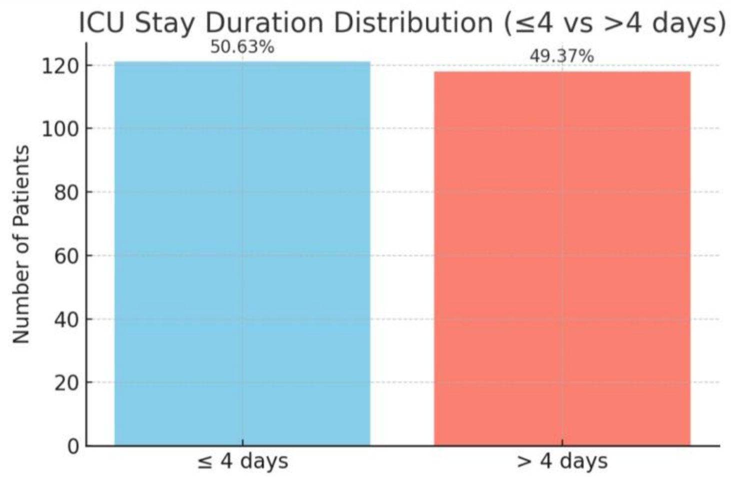

Figure 5: Proportion of Prolonged ICU Stay

5.6 Pearson Correlation

The length of stay in the ICU has a number of fascinating correlations with demographic and clinical parameters. Length of stay in the ICU has a very good correlation with CPB time (r = 0.64). Moderately correlated with length of stay in the ICU were BMI (r = 0.58) and age (r = 0.41). These show that rising BMI and older age have rising length of stay in the ICU.

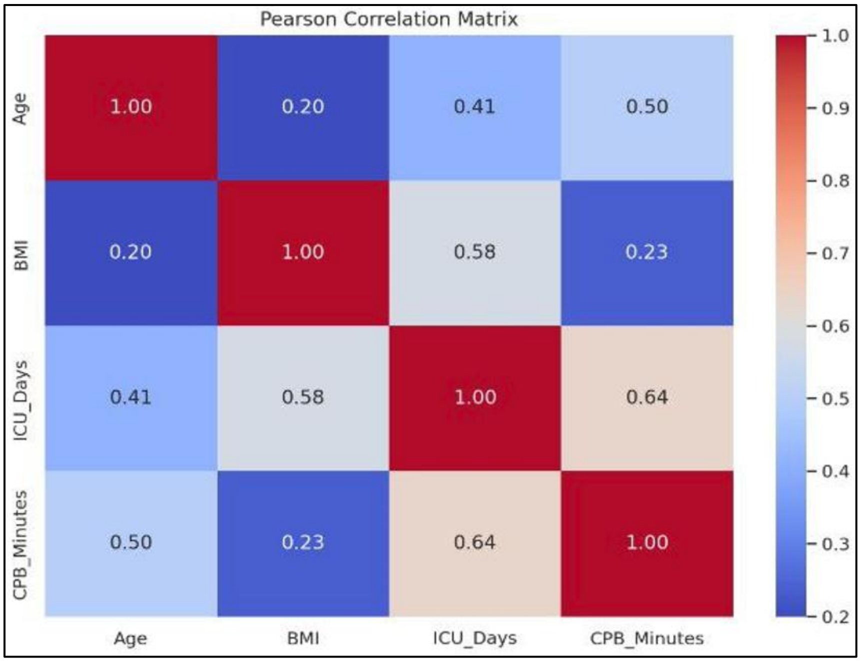

Figure 6: Pearson Correlation Matrix

5.7 ICU Stay Duration

The table summarizes in-hospital mortality distribution by length of stay in ICU into groups according to the median cut-off point (4 days). In 239 patients, 121 (50.6%) had a stay of less than 4 days with 1 death (0.83%) only. On the other hand, 118 patients (49.4%) had a stay of 4 days or more with 7 deaths (5.93%) only. Overall mortality was 3.35%. Those with longer ICU admission were correlated with a 7-fold higher risk of death relative to those with short admissions, highlighting the prognostic potential of ICU duration.

Table 2: ICU Stay duration

ICU stay duration	Number of pts	Death	Survival	Mortality rate (%)
< 4 days	121	1	120	0.83
≥ 4 days	118	7	111	5.93
Total	239	8	231	3.35

5.8 Logistic Regression Analysis: Factors Predicting Prolonged ICU Stay

Binary logistic regression analysis was conducted to determine independent predictors of long intensive care unit (ICU) stay in patients who were subjected to open heart surgery. The definition of the outcome variable was ICU stay greater than the sample median of 4 days. The predictors were age, BMI, cardiopulmonary bypass (CPB) time, acute kidney injury (AKI), nosocomial infections, and ventilator-associated pneumonia (VAP).

The model was statistically significant, $p < 0.001$, indicating that the predictors distinguished between long and short ICU stays reliably.

And while running the dataset for the multivariate analysis the constant category used for each significant variable were age 18-24, normal BMI (18.5-24), CBP time >90 minutes and category "No" for AKI Nosocomial Infection and VAP respectively.

Among the predictors, age ($\beta = 0.0417$, $p = 0.0009$), CPB time ($\beta = 0.0093$, $p = 0.0003$), AKI ($\beta = 1.06$, $p = 0.043$), nosocomial infections ($\beta = 4.27$, $p < 0.001$), and VAP ($\beta = 1.27$, $p = 0.019$) were independently related to prolonged ICU stay. The incidence of a nosocomial infection was the most impactful, increasing the risk of prolonged ICU stay nearly fifteen-fold. Even though BMI had a positive trend ($\beta = 0.089$, $p = 0.093$), it was not significant.

These findings suggest that clinical and procedural determinants exert strong influences on postoperative ICU use of resources and can be employed for guiding risk stratification strategies in cardiac surgical care.

Table 2: Multivariable Logistic Regression Analysis of Predictors for Prolonged ICU Stay

Predictor	Coefficient (β)	Std. Error	z-value	p-value	95% CI (Lower, Upper)
Age (46-60 year)	0.042	0.013	3.32	**0.0009***	(0.017, 0.066)
BMI (>30kg/m²)	0.089	0.053	1.68	0.093	(-0.015, 0.194)
CPB Time (91–180 min)	0.0093	0.0026	3.58	**0.0003***	(0.0042, 0.0145)
AKI (1=Yes)	1.063	0.527	2.02	**0.0436***	(0.031, 2.095)
Nosocomial Infection (1=Yes)	4.275	1.076	3.97	**<0.0001***	(2.165, 6.384)
VAP (1=Yes)	1.275	0.545	2.34	**0.019***	(0.207, 2.342)

Notes: β-regression coefficient, *p-value<0.05.

4 DISCUSSION

In this multicenter retrospective study, older age was a strong determinant of extended ICU stay. The age group 46–60 had a much higher risk of in-hospital mortality after admission to the ICU compared with younger adults. Statistically, such a group is confirmed to be a high-risk group. Older patients likely have reduced physiological reserve and greater comorbidities (e.g. hypertension, diabetes) that make it harder to recover, leading to delayed weaning from mechanical ventilation and increased critical care. European studies have long reported worse ICU outcomes among older cardiac patients, and one author noted that patients over 75 years of age had significantly higher ICU mortality and complication than younger patients (65). The same finding was observed in Turkey that among those who undergo heart surgery; the patients staying longer in the ICU were on average older (66). Chinese series also list age as a risk factor; in patients with infective endocarditis undergoing cardiac surgery, advanced age was an independent predictor of ICU stay >3 days (67). In India, an author (in a study of CABG patients in Chennai) presented that although age has been reported to be a factor by numerous authors, their study identified only the requirement for inotropic support to independently predict ICU duration (68). But in a Jordanian center, they discovered that age did not predict ICU length of stay, possibly because the cohort was reasonably young (13). Similarly, an Ethiopian study found that smoking history, greater than one procedure, and postoperative complications but not age were predictors of longer ICU stay (69).

Postoperative complications were an important factor. Patients who developed any complication in the form of hemodynamic instability, sepsis, or respiratory failure had significantly higher odds of prolonged ICU length of stay (adjusted OR ≈ 6.6). In our data, 78% of long-stay patients developed at least one complication versus only 36% in the shorter-stay group. Specifically, acute kidney injury (AKI) was considerably more common in the long-stay subgroup (17.8% vs 5.0%). These findings are replicated globally. In USA, AKI following cardiac surgery is associated with ICU lengths of stay of 5.4 days versus 2.2 days in the absence of AKI (70). Notably, Canadian data illustrate that AKI increases hospital cost, mortality, and ICU length of stay significantly (71). In South Africa, retrospective ICU data highlight that AKI following surgery and respiratory failure are among the most frequent complications and account for extended ICU admission (72). Patients undergoing cardiac surgery in Ethiopia spent a mean of

3.8 days in the ICU, with infection and postoperative bleeding though AKI was not specifically examined as being key predictors for increased length of stay.

Nosocomial infections (20.3% in prolonged vs 0% in short stay) and VAP (13.6% vs 5.8%) also were clustered in the prolonged group. Infections like VAP extend ventilation and ICU care, consistent with evidence that postoperative pneumonia substantially prolongs ICU stay. Ventilator support >12 hours was indeed identified as a predictor in other series, emphasizing how respiratory problems dictate ICU length. Although AKI, VAP, and nosocomial infection did reach statistical significance in our model adjusted, their adjusted effect and known clinical impact suggest they have a significant contribution to long ICU lengths. In North America, VAP afflicts 10–20% of patients undergoing cardiac surgery and receiving mechanical ventilation and reduces ICU duration by half compared with non-VAP patients. South African studies also rank postoperative pneumonia and other hospital-acquired infections as the leading predictors of increased ICU stay. For example, infection-control audits report that ICU-acquired infection is a key driver for increased ICU days in large numbers (73). Similarly, Jordanian evidence indicated that prolonged ventilation and postoperative pneumonia were two of the highest predictors of ICU stay duration, consistent with our observation that respiratory infections prolong ICU courses. Some Western cohorts also reported advanced age and female sex as risk factors for longer stay, though they did not prove to be significant here (74,75). In Ethiopia, while few specific data are available, overall ICU reports have postoperative infection like pneumonia and sepsis as causes for the prolonged stay. While AKI, VAP, and nosocomial infection did not reach statistical significance after adjustment presumably due to sample size and collinearity their unadjusted associations and proven effect indicate substantial contributions to ICU prolongation (76).

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5 CONCLUSION

This multicenter Ethiopian paper illustrates that elderly patients and those with significant perioperative complications are more likely to require considerably longer ICU management after open-heart surgery. This paper brings new evidence specific to the Ethiopian and similar low-to-middle income environments. Compared with prior single-center series, our multicenter design more accurately represents more varied practice patterns and patient populations in the country. The presence of a comparatively high incidence of long-term admissions (nearly half of the admissions) and complications points towards system problems: limited ICU beds and staffing mean that each long-term admission has the potential to jam the service. We also chart that nearly all the patients were readmitted to the ward after stabilization; hardly any (∼ 6%) simply died in ICU. Identification of "critical preoperative state" as having the best predictive value (OR ~10) is intriguing, as this encompasses patients who present in extremis or with multi-organ failure. This could be especially relevant to Ethiopia, where patients present late or with acute endocarditis and multi-system illness. Our data suggest that attempts to stabilize critically ill patients before surgery, or allocate more ICU resources to them as a priority, may have a significant impact on ICU efficiency. Clinically, these findings emphasize the significance of early recognition of high-risk patients and selective intervention.

For example, enhanced perioperative management aimed at prevention of AKI and nosocomial infection (e.g. judicious fluid management and strict infection prevention) can reduce ICU stay. Likewise, anticipation of heightened ICU needs in elderly or critically-ill patients can optimize planning and bed allocation. In summary, knowledge of these risk factors can guide individualized patient care and optimized ICU resource utilization in cardiosurgical practice.

6 Recommendation

The suggestion is to Policymakers, Healthcare Professionals, and Researchers

The findings of this thesis have important policy, clinical practice, and research implications. Policymakers can make an immediate response with regard to high rates of prolonged ICU hospital stays by expanding ICU capacity, investing in critical care training, and standardizing infection control practices between cardiac centers. Policymakers can implement policies promoting early referral systems and preoperative optimization, particularly among elderly and risk patients, to reduce complications and ICU load.

For practitioners, the study highlights the importance of early detection and treatment of at-risk patients, especially AKI or nosocomial infection patients. Implementation of perioperative care bundles like renal protective strategies, VAP prevention bundles, and rigorous fluid control can significantly reduce ICU LOS and improve outcomes.

For researchers, the thesis lays the ground for subsequent multicenter cohort studies that are capable of incorporating real-time clinical data, for example, intraoperative factors and institutional practices. Developing Ethiopia-local risk prediction models that incorporate local disease burden, for example, rheumatic heart disease and late presentation, would further enhance clinical decision and policy development.

Strength

The research's strongest point is its multicenter status, which enhances the overall generalizability and utility of its findings to diverse healthcare environments in Ethiopia. Conducted in three unique cardiac facilities TASH, Tazma Medical and Surgical Center, and Cardiac Center Ethiopia the research draws from a broad diversity of patients, practices, and institutional capabilities. This is crucial in a low-to-middle income setting where heterogeneity of the health system plays a major factor in outcome. Clinical instruments validated (EuroSCORE II and STS Risk Score) and multivariable logistic regression for adjustment of confounders add methodological robustness. Analysis identifies key predictors of prolonged ICU length of stay such as age, duration of CPB, AKI, VAP, and nosocomial infections. These results are actionable and form a strong basis for clinical risk stratification and resource planning in cardiac ICUs.

Limitation:

A key limitation of the study is its observational and retrospective nature, which raises potential concerns about completeness, accuracy, and confounding of the data. Key intraoperative and institutional factors such as blood transfusion volumes, medication administration, or weaning protocols were not fully captured or standardized across sites. The lack of specific data on ICU staff, infection control, and resource use also prevents detailed analysis of systematic factors underlying long-term ICU stays. While these deficiencies are acknowledged, they suggest the need for more specific, prospective data in subsequent studies.

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ANNEXES

APPENDIX-A: EuroSCORE II Questionnaire

Section 1: Patient Demographics

1. Patient ID: ____________
2. Age: ____________ years
3. Gender:
   Male
   Female
4. Weight: ____________ kg
5. Height: ____________ cm
6. BMI: ____________ kg/m²

Section 2: Patient-Related Factors

7. Serum Creatinine:
   ≤200 µmol/L
   >200 µmol/L or on dialysis (+0.64)
8. Extracardiac Arteriopathy:
   No
   Yes
9. Poor Mobility:
   No
   Yes
10. Previous Cardiac Surgery:
    No
    Yes
11. Chronic Lung Disease:
    None
    Mild
    Moderate
    Severe
12. Active Endocarditis:
    No
    Yes
13. Critical Preoperative State:
    No
    Yes
14. Diabetes on Insulin:
    No
    Yes

Section 3: Cardiac-Related Factors

15. NYHA Class:
    Class I (No symptoms)
    Class II

Class III
Class IV
16. CCS Class 4 Angina:
No
Yes
17. Left Ventricular Ejection Fraction (LVEF):
>50%
30-50%
<30%
18. Recent Myocardial Infarction:
No
Yes (<90 days)
19. Pulmonary Hypertension:
No
Yes

Section 4: Surgery-Related Factor

20. Urgency of Surgery:
Elective
Urgent
Emergency
21. Weight of the Procedure:
Isolated CABG
Other than Isolated CABG
22. Surgery on Thoracic Aorta:
No
Yes

Section 5: Total EuroSCORE II Calculation

Total Score: ___________ (Sum of all points from Sections 2-4)

Predicted Mortality Risk: ___________% (Use the formula or an online calculator to compute)

Instructions for Use

1. **Data Collection:**

- Fill out the questionnaire based on patient records before or after surgery.
- Ensure all fields are completed accurately.

2. **Scoring:**

- Add up the points for each factor to calculate the “Total Score”.

- Use the “EuroSCORE II formula” or an online calculator (https://www.euroscore.org/index.php?id=17&utm_) to determine the predicted mortality risk.

3. Interpretation:

- Low Risk: <2% predicted mortality
- Moderate Risk: 2-5% predicted mortality
- High Risk: >5% predicted mortality

APPENDIX-B: Society of Thoracic Surgeons (STS) Risk Score

Section 1 - Patient Information:

1. Age: _______ years

2. Sex:

 [ ] Male

 [ ] Female

3. Race:

 [ ] White

 [ ] African American

 [ ] Hispanic

 [ ] Asian

 [ ] Other: _________

4. Height: ________ cm

5. Weight: ________ kg

6. BMI: ________ (BMI = weight in kg / height in m^2)

Section 2 - Clinical Conditions:

1. New York Heart Association (NYHA) Functional Class:

 [ ] I

 [ ] II

 [ ] III

 [ ] IV

2. Chronic Lung Disease:

[ ] Yes

[ ] No

3. Peripheral Artery Disease:

[ ] Yes

[ ] No

4. Carotid Artery Disease:

[ ] Yes

[ ] No

5. Previous Stroke or Neurological Disease:

[ ] Yes

[ ] No

6. Diabetes Mellitus:

[ ] Yes, Insulin Dependent

[ ] Yes, Non-Insulin Dependent

[ ] No

7. Hypertension:

[ ] Yes

[ ] No

8. Renal Dysfunction (Serum Creatinine > 2.0 mg/dL):

[ ] Yes

[ ] No

Section 3: Surgical Variables:

1. Type of Surgery:

[ ] Coronary Artery Bypass Grafting (CABG)

[ ] Aortic Valve Replacement

[ ] Mitral Valve Replacement

[ ] Combined Valve and CABG

[ ] Other: ________

2. Urgency of Surgery:

[ ] Elective

[ ] Urgent

[ ] Emergent

3. Left Ventricular Ejection Fraction (LVEF):

[ ] > 50%

[ ] 40-50%

[ ] < 40%

4. Recent Myocardial Infarction (within 7 days):

[ ] Yes

[ ] No

5. Left Main Disease:

[ ] Yes

[ ] No

6. Previous Cardiac Surgery:

[ ] Yes

[ ] No

Section 4 - Laboratory Results:

1. Serum Creatinine (mg/dL):

_________ mg/dL

2. Serum Albumin (g/dL):

_________ g/dL

3. Hemoglobin (g/dL):

_________ g/dL

Section 5 - Risk Factors:

1 Current Smoker:

[ ] Yes

[ ] No

2 Ex-Smoker:

[ ] Yes

[ ] No

3 Known History of Malignancy:

[ ] Yes

[ ] No

4 Cerebrovascular Disease:

[ ] Yes

[ ] No

5 Atrial Fibrillation:

[ ] Yes

[ ] No

APPENDIX-C: Determinant Factors

Section 1: Patient Demographic and Clinical Factors

1. **Body Mass Index (BMI) at the time of surgery?**
   BMI = Weight (kg) / Height $(m)^2$
   _______________ (BMI)
2. **Do you have any other chronic conditions?**

   ☐ Hypertension
   ☐ Diabetes
   ☐ Respiratory disease (e.g., COPD, asthma)
   ☐ Heart failure
   ☐ Stroke
   ☐ Chronic kidney disease (CKD**)**
   ☐ Other (please specify): **___________**

Section 2: Surgery-Related Factors

3. **Type of surgery performed:**

   ☐ Coronary Artery Bypass Grafting (CABG)
   ☐ Valve surgery (Repair/Replacement)
   ☐ Combined procedure (CABG and valve surgery)
   ☐ Congenital Heart Defect Repair
   ☐ Other (please specify): **___________**

5. **What was the total duration of cardiopulmonary bypass (CPB) time during your surgery? -----------------------**
6. **What was the total surgery time? -----------------------**
7. **Intraoperative complications?**

☐ No complications
☐ Excessive bleeding
☐ Arrhythmias
☐ Myocardial infarction (heart attack)
☐ Other (please specify): ______

Section 3: Postoperative Factors

8.Acute Kidney Injury (AKI) after surgery?

☐ Yes
☐ No

9. Nosocomial infections (hospital-acquired infections) during your ICU stay?

☐ Yes
☐ No

10. ventilator-associated pneumonia (VAP) during your ICU stay?

☐ Yes
☐ No

11. Postoperative complications

☐ Respiratory failure
☐ Low blood pressure or hemodynamic instability
☐ Sepsis
☐ Stroke
☐ Delirium or confusion
☐ Bleeding
☐ Other (please specify): __________

12. Length of ICU stays after surgery?

Section 4 Mortality and outcomes

13. What was the final outcome of ICU stay**?**

☐ Discharged home
☐Transfer to ward
☐ Passed away
☐ Other----------

14. If passed away, what was the cause?
☐Multi organ failure
☐Sepsis or Infection
☐Cardiac Arrest
☐Respiratory Failure
☐Stroke
☐Other----------