ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCE

SCHOOL OF PUBLIC HEALTH

Length of Intensive care unit stay and its associated factors following open cardiac surgery: A retrospective study at the Cardiac Center Ethiopia

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I undersigned agree to accept all responsibilities for the scientific and ethical conduct of this research project and declare that this thesis is my original work in partial fulfillment of the requirement for the Master of Public Health in Epidemiology and Biostatistics.

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As I stand here today with my completed thesis, I recognize that it is a result of collective effort. And I am grateful for all the inputs that shaped this thesis and guided me.

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ACRONYMS AND ABBREVIATIONS

AF Atrial fibrillation

AKI Acute Kidney Injury

AHA American Heart Association

AR Aortic regurgitation

ARF Acute rheumatic fever

BMI Body Mass Index

CBC Complete blood count

CBP Cardiopulmonary bypass

CCE Cardiac Center of Ethiopia

CHD Congenital Heart disease

CHS College of Heath Sciences

CI Confidence Interval

CVDs Cardiovascular diseases

ECG Electrocardiography

EuroSCORE European System for Cardiac Operative Risk Evaluation

HAI Hospital Acquired Infection

HCT Hematocrit

ICU LoS Length of Intensive Care Unit Stay

IRB Institutional Review Board

LMICs Low- and middle-income countries

Hgb Hemoglobin

ICU Intensive Care Unit

LVEF Left ventricular ejection fraction

MRN Medical Record Number

NCDI Non-communicable disease and Injury

OR Odds Ratio

PAH Pulmonary arterial hypertension

PoAF Postoperative atrial fibrillation

RHD Rheumatic Heart Disease

RIPC Remote Ischemic Preconditioning

SD Standard Deviation

VIF Variance Inflation factor

VSD Ventricular Septal Defect

WHO World Health Organization

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ABSTRACT

Background: Prolonged ICU stay after cardiac surgery can lead to higher mortality, increased complications and poorer long-term outcomes. They also strain hospital resources by limiting access to operating rooms—an especially serious issue in countries with limited cardiac surgical services. Identifying risk factors for prolonged stays can support early detection and management of complications. Such findings can also guide improvements in clinical care and aid in resource planning.

Objective: The purpose of this study is to determine the proportion of patients with a prolonged ICU stay following cardiac surgery and what factors are associated with prolongation.

Method: An institution based cross sectional study was carried out on a sample of 580 by using retrospective data. Medical records were selected by using stratified random sampling technique. Data were then collected by using a data abstraction form prepared from extensive literature review. After data were collected it was cleaned and recoded and analysis started from Descriptive statistics followed by bivariable and multivariable logistic regression analysis. P value was set at 0.05 for significance.

Result: Prolonged ICU stay (4 days or more) occurred in 26.6% of patients following cardiac surgery. Five independent variables were found to be associated with prolonged ICU stay including; Preoperative atrial fibrillation (OR=2.41, 95%CI= 1.00-5.80, p=0.04), Duration of cardiopulmonary bypass (OR=1.10, 95%CI=1.00-1.02, p=0.006), Postoperative bleeding (OR=3.04, 95%CI=2.05-6.75, p=0.004), Postoperative AKI (OR= 17.02, 95% CI= 1.52 – 189.87, p=0.02) and other complications (OR=3.73, 95% CI= 1.42-6.48, p=0.0001).

Conclusions: This study examined why some patients stay longer in the ICU after open cardiac surgery. It identified that 26.6% of patients had prolonged ICU stay. Several factors such as Preoperative Atrial fibrillation, Duration of cardiopulmonary bypass, postoperative AKI, Postoperative bleeding and other complications put patients at risk of prolonged stay. These finding can help clinicians identify and manage high-risk patients early and improve perioperative care which could help reduce duration of ICU stay.

Key words: Open cardiac surgery, Retrospective study, Cardiac Center Ethiopia, Intensive Care Unit (ICU), LMICs, Prolonged ICU stay

1. INTRODUCTION

1.1. BACKGROUND

Cardiovascular diseases (CVDs) remain the leading cause of death globally, significantly contributing to the burden of disease and resulting in substantial costs on health systems. (1). CVDs accounted for 20.5 million deaths in 2021, representing approximately one-third of all global deaths. It was estimated that 80% of those deaths occurred in Low and Middle Income countries (LMICs) (2). Although cardiovascular diseases (CVDs) are highly prevalent in developing countries, limited access to reliable data and advanced imaging technologies likely results in an underestimated disease burden. (3).

Open cardiac surgery is a medical specialty dedicated to the surgical management of heart and thoracic aortic disorders. Contemporary open cardiac surgery includes a wide range of surgical procedures, including coronary artery bypass grafting, surgical revascularization for ischemic heart disease, valve repair and replacement for valvulopathies, heart transplantation, and the treatment of congenital heart defects.(4).

The availability of open cardiac surgery is limited in LMICs. For instance, in sub-Saharan Africa, excluding South Africa, there is only 1 open cardiac surgery center per 38 million inhabitants (5). In contrast, North America and Europe have 1 per 120,000 people(6). Studies reveal that, Rheumatic Heart Disease (RHD) and Congenital Heart Disease (CHD) are the leading cardiovascular conditions that typically require surgical intervention in LMICs. (3).

Cardiac Intensive Care Units (ICUs) are specialized facilities designed to manage critically ill patients, particularly those recovering from open cardiac surgery. Following open cardiac surgery, most patients are routinely admitted to the ICU for close monitoring and standard postoperative care. ICU care demands a lot of resources and a dedicated team of healthcare professionals. Because there aren't enough ICU beds to meet the demand, these units often run at or near their maximum capacity. This shortage means that ICUs have become major bottleneck in the healthcare system, slowing down the usage other important services like operation theaters (7).

Length of Intensive Care Unit stay (ICU LoS) is the number of days from the date of admission to the ICU until date of discharge from ICU or death (8). The number of days a patient will stay in a hospital depends on a variety of factors, including but not limited to

patient's diagnosis and characteristics, social circumstances, the hospital's location (i.e. urban/rural), and treatment complexity. This makes it difficult to develop a general unified framework for LoS prediction (9). This has led to various ways of defining prolonged stay in different setups.

The criteria for defining a prolonged ICU length of stay (LOS) differ depending on the type of hospital, ICU, and the type of medical conditions involved (10). It is defined in different ways in different studies. In some studies prolonged length of stay is defined as hospital stay >75th percentile of the overall cohort (11-15). While other studies used the 90th percentile as a cut-off point (16-18). Additionally the median stay is also used as a cut-off point for prolongation in some studies (19), while the average length of stay is used as a cut-off point by others (20).

1.2. STATEMENT OF THE PROBLEM

The Intensive Care Unit (ICU) provides care for patients with severe conditions who need continuous life support. It is staffed by a specialized medical team and equipped with advanced monitoring technology. The duration of a patient's stay in the ICU is often unpredictable, how long it will take for the patient to recover and be discharged from the ICU is often difficult to foresee. Currently, there is no universally agreed-upon definition for what constitutes a prolonged length of stay (LoS) in the ICU(21). And despite there being major advancements in the field of open cardiac surgery reliable predictors of adverse postoperative outcomes such as prolonged ICU LOS remain elusive.

Prolonged ICU stays have been documented in 4% to 11% of patients undergoing open cardiac surgery(22). In Ethiopia, the incidence of extended ICU stays is notably high, despite variations in the cut-off criteria used. According to a research conducted at Addis Ababa (23) and at the Nigist Eleni Mohammed Memorial Hospital in Hosaena (24), almost 50% and 53% of patients had prolonged ICU stays respectively. Furthermore, a study conducted at the Cardiac Center Ethiopia five years back also reported that 49% of patients had prolonged ICU stay following open cardiac surgery (24).

While most patients are routinely admitted to the ICU after heart surgery, staying there for a long time often leads to increased expenses, increased hospital mortality and poor long-term prognosis (25). In Ethiopia, patients had high occurrence of prolonged ICU stays despite utilizing different cut-off points. Despite this, there are limited studies that asses the magnitude of prolonged ICU stay, following open cardiac surgery. Furthermore, most studies conducted in our setup focus on patient outcomes and rely on length of stay as an indicator of mortality, but there is limited research on factors that affect the LoS in ICU (23).

One of the justifications for performing this study is the limited availability of studies in our setup that asses the occurrence of prolonged stay in the ICU and the factors associated with prolonged stay. This is especially true within the context of patients recovering from open cardiac surgery. Only one research was conducted in Ethiopia with regards to this topic and this research was done 5 years back. So the current study is a means to update this outdated research and to assess various additional factors that were not considered in the previous study.

1.3. RATIONALE AND SIGNIFICANCE OF THE STUDY

The ICU LOS is affected by a variety of sociodemographic, pre-operative, intraoperative and post-operative factors. Identification of these factors could help clinicians for early anticipation and management of adverse outcomes (26) and to employ quality improvement measures to shorten ICU stay (27, 28). Hence, predicting the ICU LOS is beneficial from different perspectives. Knowing the expected length of stay in the ICU can also help families prepare for a longer hospital stay and better manage their finances.Furthermore, knowledge of risk factors that prolong ICU LOS would help medical staff avoid its consequence by various ways such as improving perioperative conditions and allowing early anticipation and detection of complications (29, 30). Early anticipation of complications will allow the employment of stringent follow up for the patients that need it most.

Additionally, advancements in predictive modelling have provided important insights into risk stratification before open cardiac surgery by using scoring systems such as European System for Cardiac Operative Risk Evaluation (EuroSCORE) and Society of Thoracic Surgeons (STS) score (31). Therefore, the findings from this research can be used as an input when attempts are made to adapt these scoring systems to our institutions; so that the scoring systems can be tailored to the factors that are found to be significant in our setup.

Although the cardiac center of Ethiopia has been operating by local teams since 2017, The shortage of consumables and small number of cardiac surgeons make mission based delivery of open cardiac surgery an integral part of care provision (32). Prolonged ICU stays occupy beds for longer periods, potentially causing delays or cancellations of other scheduled surgical procedures. Hence, planning the operation schedule based on patients' risk factors and prediction of ICU LoS can help avoid unplanned cancelations of operations(25). This would especially be beneficial when there are international missions at the Cardiac Center addressing the country's open cardiac surgery needs in a very tight schedule.

Furthermore, since prolonged ICU stay is a risk for poor long term outcomes (33-35), knowledge of the predictors for prolongation can aid clinicians in clinical decision making and in early identification of high risk patients. This will allow the employment of stringent long term follow up for patients that need it the most (36).

2. LITERATURE REVIEW

2.1 CARDIAC SURGERY

Around 1.5 million cardiac surgeries are carried out worldwide, but only a small share takes place in low- and middle-income countries (37). It is estimated that low-income countries require between 300 and 400 cardiac surgeries per million people each year (32). Although the need for cardiac interventions is high, access to such care remains limited in sub-Saharan Africa.

In LMICs RHD and CHD are the most common CVDs requiring surgical care. Despite the disproportionate concentration of RHD in these regions, only 11% of patients undergo operation low-income countries. As for patients with CHD , 70% will require medical or surgical treatment in the first year of life (3).

2.2. MAGNITUDE OF RHEUMATIC HEART DISEASE

RHD remains a significant global public health issue, particularly in LMICs, where it is both a leading cause of cardiovascular morbidity and mortality. Globally, over 40 million people are estimated to suffer from RHD, with 97% occurrence in LMICs. It accounts for 1.6% of all cardiovascular deaths, resulting in 306,000 deaths yearly, mainly in LMICs. Despite a high burden of RHD in these regions it is estimated that only 11% of people have access to open cardiac surgery (3, 38).

The disease typically begins with acute rheumatic fever, a consequence of untreated group A streptococcal infections, which leads to chronic heart valve damage, particularly affecting the mitral and aortic valves (39). Although RHD has declined in developed countries, due to improved socioeconomic conditions and healthcare access, it remains prevalent in resource-limited settings, where repeated ARF episodes lead to progressive and irreversible heart valve damage. In Ethiopia, RHD presents a substantial burden. A systematic review conducted in 2020 reported the pooled prevalence of 3.2%. The Regions bearing the highest burden were Amhara region followed by Oromia and Southern Nation Nationalities and people (SNNP) regions (40). This disease accounts for nearly half of cardiovascular follow-ups and is a leading cause of heart failure and stroke among Ethiopian youth.

A report by the Ethiopian Non-Communicable disease and Injury Commission (NCDI) found an annual RHD mortality rate of approximately 12.5%, highlighting the urgent need for preventive strategies, early intervention, and accessible surgical care (41). Persistent risk factors for RHD include overcrowded living conditions, poor access to healthcare, and limited preventive measures against streptococcal infections, which together contribute to the disproportionate disease burden in low-income settings.

2.3. MAGNITUDE OF CONGENITAL HEART DISEASE

Congenital heart disease (CHD) is the commonest birth defect affecting 1 million babies or 1 in 125 live births per year. Approximately 70% will require medical or surgical treatment in the first year of life (3).It account for 3% of neonatal death and 46% of death from all congenital malformations (42). A meta-analysis reported the prevalence of unrepaired CHD in school children as 3.8 per 1000. This meta-analysis also reported there is an increased prevalence of CHD recognised at birth/infancy or early childhood. In parallel there has been a decrease of first time CHD diagnoses in school-age children. Those together imply an earlier diagnosis of CHD. Despite this, substantial inequalities between higher and lower income countries remain in terms of early diagnosis (43).

Another systematic review reported that Ventricular septal defect (VSD) and Atrial septal defects were the most common CHD in East Africa with a pooled prevalence of 29.92% and 10.36% respectively. It was also found that Ethiopia had relatively higher prevalence of VSD and ASD compared to other east African countries with a pooled prevalence of 36.04% and 13.44% respectively (44).

2.4. MAGNITUDE OF PROLONGED ICU STAY

The definition of prolonged ICU stay varies between different institutions. Based on their specific cut-off points various studies report the occurrence of prolonged ICU stay following cardiac surgery as follows. A prospective study conducted in Athens, Greece reported that 45.5% of patients had prolonged ICU stay (45), which they defined as stay in the ICU for greater than 24 hours. Another study conducted in a referral hospital in Oman reported that 17% experienced prolonged ICU LOS (15), which they defined as a stay in the ICU for 5 days or more. A retrospective study conducted at the Emergency Clinical County Hospital of

Craiova, Romania reported that prolonged ICU stay occurred in 38.5% of patients(22) which was defined as stay in the ICU for 7 days or more.

In Ethiopia, only one previous research has been conducted to identify factors associated with a prolonged ICU stay following cardiac surgery. This study was conducted at the cardiac center Ethiopia and it reported that 49% of patients had prolonged ICU stay following cardiac surgery (46) , which was defined as a stay in the ICU for 5 days or more.

2.4. FACTORS ASSOCIATED WITH LENGTH OF STAY IN THE ICU

2.4.1. Socio-demographic factors

Age and sex are the main socio-demographic factors that affect the ICU LoS. The European system for cardiac operative risk evaluation, which is a risk stratification system to help in the assessment of the quality of cardiac surgical care, identified age greater than 60 and being female as risk factors for poor postoperative outcomes (47, 48). A systematic review also reported that age is the most commonly reported predictor of ICU LoS (7).

2.4.2. Clinical factors

The wide variation in length of stay , is influenced by several clinical and non-clinical factors , as well as by the complexity of heart surgery (7).

2.4.2.1. Preoperative factors that result in Prolonged Length of ICU Stay

Studies have found that patients with comorbidities, such as diabetes, hypertension, chronic respiratory disease and renal disease experienced prolonged ICU stay (45, 49, 50). Another comorbidity present specially in the pediatric population is Downs syndrome (51). It is estimated that 50% of patients with Down syndrome have cardiac disease. A study found that there was no significant difference in ICU LOS in patients with and without Down syndrome. However, the presence concomitant pulmonary hypertension and hypothyroidism in patients with Down syndrome predisposed patients to a prolonged stay in the ICU.

Prior open cardiac surgery, is another factor influencing ICU LoS, however no significant difference has been noted between the effect of one previous operations and multiple previous operations (47). Another preoperative factor found to affect the ICU LoS is Anemia. Iron deficiency both by itself as well as in conjunction with anemia was associated with a 17% increase in ICU LOS (45, 52).

Another preoperative factor, affecting the length of ICU stay is Left ventricular ejection fraction (LVEF). Ejection fraction is considered as an indicator of cardiac function and it was observed that patients with preoperative reduced LVEF (<30-40%) were predisposed to higher complications and adverse events compared to patients with a normal Ejection fraction (53). Additionally, a study also found that patients with Atrial fibrillation (AF) also experience longer stay in the ICU (7).

Furthermore, a study conducted at the cardiac center also assessed the effect of variables such as pulmonary hypertension on the length of ICU stay in patients that underwent open cardiac surgery (54). This factor has been included in the current study.

2.4.2.2. Intraoperative factors that result in Prolonged Length of ICU Stay

The type of surgery, the weight and nature of the intervention are amongst the intraoperative factors that affect the ICU LoS. A study done in Oman found that patients who undergo valve surgeries are more likely to experience a prolongation in their ICU stay(15). Similarly, patients with three or more major cardiac procedures being done have higher risk of prolonged hospital stay and mortality (47).

Another intraoperative factor affecting length of ICU stay is the Aortic cross clamp time. Prolonged aortic cross clamp time is a predictor for the development of low cardiac output syndrome and longer stay in the intensive care unit (55). Similarly, studies have found that a prolonged duration on cardiopulmonary bypass (CPB) is a risk factor for Postoperative Acute Kidney injury, bloodstream infection and prolonged hospital stay (56, 57). The use of inotropes has also been associated with a prolonged ICU stay (26). Particularly the requirement of support by 2 or more inotropic agents was associated with a prolonged ICU stay (58). Additionally, a multicenter study done in Ethiopia revealed that the type of anesthesia, specifically the use of sedatives/hypnotics is linked with a prolonged stay in the ICU (23). In addition to the type of anesthesia , prolonged duration of anesthesia has also been linked to increased odds of complication, venous thromboembolism, increased length of stay, and higher risk of re-operation (59).

2.4.2.3. Postoperative factors that result in Prolonged Length of ICU Stay

Postoperative bleeding occurs in up to 12% of patients following open cardiac surgery and is associated with increased mortality and a prolonged ICU stay.(60). Similarly, postoperative acute kidney injury (AKI) is linked to extended hospital stays and increased healthcare costs.

Patients with multiple comorbidities, a history of previous open cardiac surgery, or a left ventricular ejection fraction (LVEF) of less than 35% are more likely to develop AKI (61, 62). In addition, new-onset postoperative atrial fibrillation (poAF) complicates approximately 20–60% of all cardiac surgeries and is associated with increased perioperative mortality and morbidity, prolonged hospitalization, higher costs, and poorer long-term survival (63).

Furthermore, It was also found that patients who developed Hospital acquired infections (HAI) following open cardiac surgery have a significantly longer ICU stay than those patients who did not acquire HAI (64). Pneumonia was found to be the most common HAI.

2.5. CONCEPTUAL FRAMEWORK

The ICU LoS is influenced by a complex interplay of sociodemographic, preoperative, intraoperative, and postoperative factors. Variables such as age and sex may affect recovery time, while preoperative and intraoperative conditions can lead to complications that prolong ICU admission. This conceptual framework, developed from an extensive literature review, summarizes the interaction of these factors as shown in the figure below.

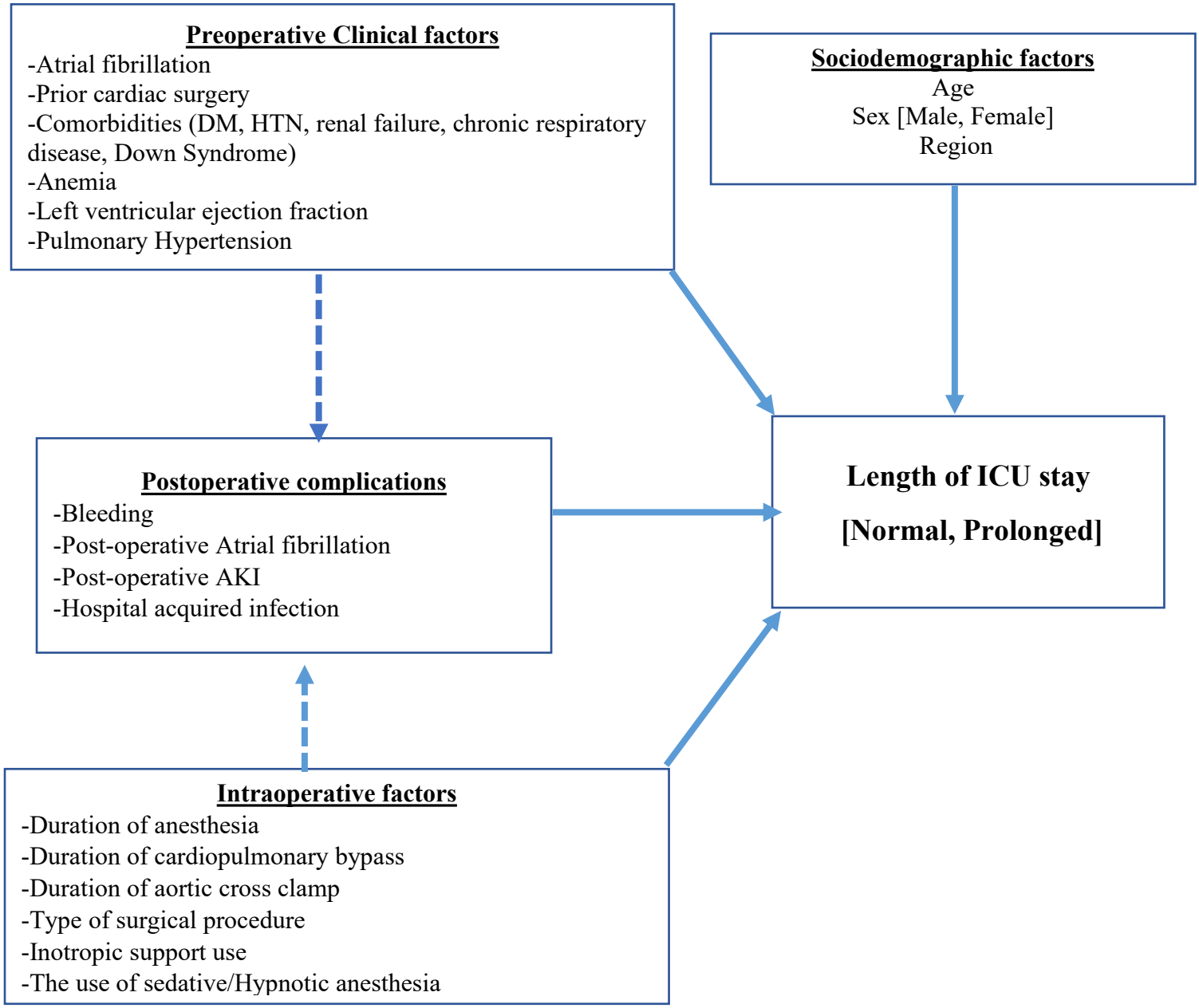


Figure 1: Conceptual framework for Length of ICU stay and its associated factors following open open cardiac surgery: A retrospective study at the Cardiac Center Ethiopia. Source (3, 7, 42, 45, 47, 48, 52, 59, 61, 62)

3. OBJECTIVES

3.1. GENERAL OBJECTIVE

- To assess the length of ICU stay and identify associated factors following open cardiac surgery at the Cardiac Center of Ethiopia.

3.2. SPECIFIC OBJECTIVES

- To determine the magnitude of prolonged ICU stay among patients who underwent open cardiac surgery between 2019 and 2024 at the Cardiac Center of Ethiopia.
- To identify factors associated with prolonged ICU stay following open cardiac surgery at the Cardiac Center of Ethiopia.

4. METHODS

4.1. STUDY SETTING

The study area, Addis Ababa, the Capital City of Ethiopia, is located in East Africa. It has been the Capital since the 19th century. The Cardiac Center of Ethiopia was established in February 2009 in Addis Ababa. It has two operating rooms, two catheterization laboratories, intensive care unit with 10 beds, a medical/surgical ward, and a clinic.

The Mission of the Cardiac Center of Ethiopia is to provide free cardiovascular care to the Ethiopian population. On average, one to two surgical procedures are performed per week. It has partnered with a number of International non-profit organizations that organize medical missions to Addis Ababa. The local team has been operating since 2017. However, there are still more than 6000 patients on the surgery waiting list (32).

4.2. STUDY DESIGN

An institution-based cross-sectional study was conducted at the Cardiac Center in Ethiopia, using data collected retrospectively.

4.3. SOURCE AND STUDY POPULATION

The source population are all patients who underwent open cardiac surgery at the Cardiac Center in Ethiopia between the years 2019-2024.This time frame was selected since it encompasses a total of 700 surgeries, providing a sufficient number of patients to enable the selection of the determined sample size for the study.

The study population are all postoperative patients, who underwent open cardiac surgery for the diagnosis of Rheumatic heart disease and congenital heart disease between the years 2019-2024 at the Cardiac Center of Ethiopia.

4.4. ELIGIBILITY CRITERIA

4.4.1. Inclusion criteria

All post-operative patients who underwent open cardiac surgery for the diagnosis of Rheumatic Heart Disease and Congenital Heart disease between the years 2019-2024 were considered.

4.4.2. Exclusion criteria

Patients who underwent surgery for Coronary artery disease, Myxoma, Constrictive pericarditis, Sternal wire removal, pacemaker debridement and Tracheostomy were excluded. The reason for the exclusion of CABG surgery was because only 6 surgeries were performed between the years 2019 and 2024.

Other exclusion criteria included;

-Medical records that did not document the outcome variable well (i.e. the date of admission and discharge from the ICU)

- Medical records with any missing data with regards to the independent variables.

4.6. SAMPLE SIZE DETERMINATION AND SAMPLING TECHNIQUE

4.6.1. Sample size determination

Sample size determination for magnitude of prolonged length of ICU stay was calculated using the single population proportion formula,

$$n = \frac{(Z\alpha/2)^2.pq}{d^2}$$

The prevalence of prolonged length of ICU stays was found to be 49% from a previous study conducted at the cardiac center, Ethiopia (54). Therefore, n was calculated as:

$$\frac{(1.96)^2(0.49)(0.51)}{(0.05)^2} = 384$$

Where, n is the required initial sample size

$z_{\alpha/2}$ = standard score corresponding to 95% confidence interval

p is prevalence

q= 1-p

d = the margin of error (precision) = 0.05

The sample size for associated factors of prolonged length of ICU stay was calculated by using double population proportion formula for these respective variables on Open Epi version 3.01.

Table 1: Sample size determination for factors that affect ICU length of stay

No	Factors that affect ICU length of stay	Sample size (n)
1	Postoperative bleeding	326
2	Smoking	129

So, the largest sample size of 384 was taken and a design effect of 1.5 was considered making the sample size 576.

Additionally a 5% non-response rate was considered making the total sample size **605**.

4.6.2. Sampling technique and procedure

The sampling frame was taken from the Operation room Logbook. This logbook contains the Medical record number and diagnosis for all patients who underwent surgery at the cardiac center. The Medical record number (MRN) of patients who underwent open cardiac surgery for the diagnosis of CHD and RHD was compiled. Then, stratification was performed, using 'patient diagnosis' as a stratification factor and proportional allocation was performed to ensure proper representation of each disease strata. Then, simple random sampling was employed on each stratum. Then, individual medical records were retrieved from the hospital archive room and data was collected from the Medical records that fulfill the eligibility criteria.

To ensure that the medical records were selected randomly, an online random number generator known as 'Random lists' was utilized.

Between the years of 2019 and 2024 a total of 700 surgeries were performed out of which 682 surgeries were for RHD and CHD. Out of those 682 surgeries 523 surgeries were performed for CHD and 159 surgeries were performed for the diagnosis RHD. Given that information, the proportional allocation was performed using the following formula:

$$ni = \frac{Ni * n}{N}$$

Where "ni" is the sample size for stratum "i", "Ni" is the population size in stratum "i", "N" is the total population size, and "n" is the desired total sample size.

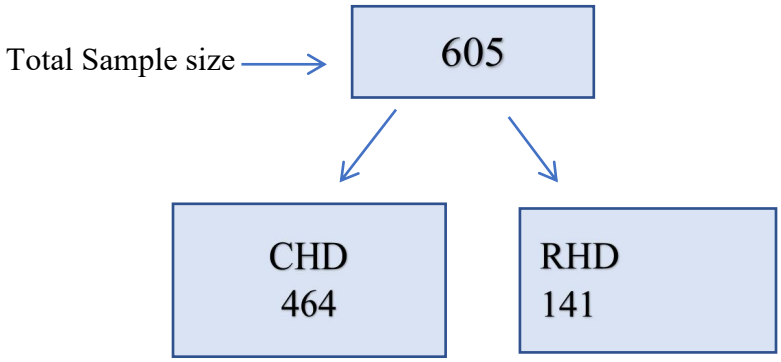
For CHD: Ni = 523, n=605 and N= 682

$$nCHD = \frac{523 * 605}{682} = 463.9 \approx 464$$

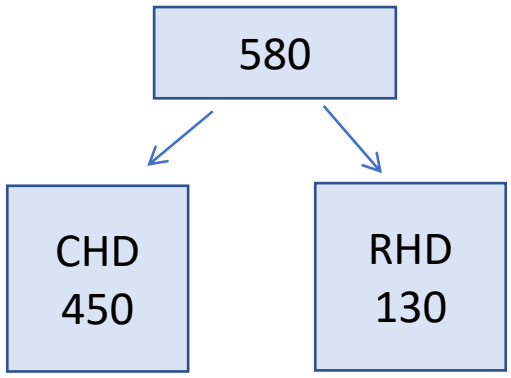
For RHD : Ni= 159 , n= 605, N= 682

$$nRHD = \frac{159 * 605}{682} = 141$$

So for this study 464 and 141 medical records were planned to be reviewed for CHD and RHD respectively.



However, after data collection took place only 580 medical records were complete with regards to the chosen variables of interest. Out of these charts 450 were patients with CHD and 130 were patients with RHD. And these are the datasets that were taken into analysis.



4.7. STUDY VARIABLES

Dependent variable – **Length of ICU stay**

The length of ICU stay is defined as the number of days from the date of admission to the Intensive Care Unit until the date of discharge from the ICU or death (65).

For this study, prolonged ICU stay is defined as a stay exceeding the 75th percentile of the ICU stay distribution, consistent with the methodology used in several previous studies (11-15).

Independent variables- Extensive literature review identified various factors that influence the length of ICU stay in patients following open cardiac surgery. Then factors that have the potential to be available in medical records were included:

- Socio-demographic factors: age, sex, region
- Pre-operative factors: BMI, Atrial fibrillation, Comorbidities (DM, Hypertension, Renal disease, Asthma, COPD and Downs Syndrome) Anemia, Left ventricular ejection fraction, Pulmonary HTN
- Intraoperative factors: Duration of CPB, Duration of Aortic cross clamp, type of surgical procedure, inotropic support, Valves operated on, Duration of surgery and duration of anesthesia
- Postoperative complications: Bleeding, Acute kidney injury, Post-operative Atrial fibrillation, Hospital Acquired Infections

4.8. OPERATIONAL DEFINITIONS

Length of Intensive Care Unit stay (ICU LoS)- is the number of days from the date of admission to the ICU, until date of discharge from ICU or death (8).

For this study, both the dates of admission and discharge date are counted as part of the length of ICU stay. For instance, if a patient is admitted to the ICU on October 9 and discharged on October 11. This patient was considered to have a length of stay of 3 days.

Additionally, a systematic review revealed that most studies in this area dichotomized ICU LoS into two categories: *normal* vs. *prolonged* stay. Consequently, logistic regression models.

However, as mentioned earlier the cut-off points used to define prolonged ICU stay varied across studies and ranged from 24 hours to 7 days(36). Some studies used the mean ICU stay, others used the median, while some used the 75th or 90th percentiles as cut-off points.

Prolonged length of ICU stay – for this study was defined as ICU stay for more than or equal to the 75th percentile of ICU LoS as done in previous studies (11-13, 24).

Normal length of ICU Stay-Patients who stay less than the 75th percentile of ICU LoS.

Nutritional Status- The nutritional status is assessed differently for different age groups by using age and sex specific growth standards.

For patients aged less than or equal to 5 years, the WHO Weight for length/height Z score was used. Using the respective curve for each age and sex the patients were classified as Obese, Overweight, Risk of overweight , Normal, Moderately wasted and severely wasted (66). The corresponding Z score for each nutritional status category is shown in table 2 below

Table 2: Nutritional Status Classification Using WHO Weight-for-Length/Height Z-score (for Children ≤ 5 Years)

Nutritional Status	Z-score Range
Obese	> +3
Overweight	> +2 to ≤ +3
Risk of overweight	> +1 to ≤ +2
Normal	≥ -2 to ≤ +1
Moderately wasted	≥ -3 to < -2
Severely wasted	< -3

For patients aged 5 up to 19 years the WHO BMI for age z score was used and patients nutritional status were classified as Obese, Overweight, Normal, Thinness and Severe Thinness. The corresponding Z score for each is shown in Table 3 as follows;

Table 3: Nutritional Status Classification Using WHO BMI-for-Age Z-score (for Children Aged 5–19 Years)

Nutritional Status	Z score range
Obese	>+2 SD
Overweight	Between +2 and +1SD
Normal	Between +1 and – 2 SD
Thinness	Berween – 2 and -3 SD
Severe thinness	<-3 SD

For patients aged 20 and above, the WHO classification of BMI was used and patient's nutritional status were classified as Obesity, Preobesity, Normal weight, Underweight. The BMI corresponding to each nutritional status is shown in Table 4 follows

Table 4: Nutritional Status Classification Using WHO BMI Classification (for Adults Aged ≥ 20 Years)

Nutritional status	BMI
Underweight	Below 18.5
Normal Weight	18.5 - 24.9
Pre-obesity	25.0 – 29.9
Obesity	Above 30

The nutritional status was then summarized as underweight, normal and overweight. For the sake of condensing it for precise depiction on the results section. The nutritional statuses these terms encompass are summarized in the table below

Table 5: Summary Categorization of Nutritional Status for Analysis

Age<18	**Age ≥ 18**
Underweight (Moderately wasted, Severely wasted, Thinness, Severe thinness)	**Underweight** (Moderately wasted, Severely wasted, Thinness, Severe thinness)
Normal	**Normal**
Overweight (Risk of overweight, Overweight, Obese)	**Overweight** (Risk of overweight, Overweight, Pre-obesity, Obesity)

Pulmonary arterial hypertension (PAH) refers to elevated pressure within the pulmonary artery. There are scientifically accepted cut off points to classify PAH gradients as mild, moderate and severe PAH(67).

For this stud, however, the specific measurements were not widely available. Hence, the diagnosis of the class of PAH using echocardiography by treating physician as No PAH, mild PAH, moderate PAH and Severe PAH were used.

Preoperative anemia – The preoperative Hemoglobin (Within a week from date of surgery) was recorded and classified as whether the patient was anaemic or not by using the WHO guidelines for the diagnosis of anemia based on age group (68).

Left ventricular ejection fraction (LVEF) - For this study, the calculated LVEF on echocardiography by the treating physician was used.

Additionally, the American Heart Association (AHA) considers LVEF important in the classification of patients with heart failure because of differing prognosis and response to treatments depending on their LVEF. Hence this study uses 50% as a cut-off point to classify LVEF as reduced EF (<50) and preserved EF (≥50) as seen in this guideline by the AHA (69).

Atrial fibrillation (AF) - For this study, AF was diagnosed by ECG findings and furthermore, whether AF was present before the operation or whether it developed after operation was documented.

Preoperative Hematocrit/Hemoglobin – Is a measure found on Complete blood count (CBC) indices. For this study, these values were obtained from CBC measurements that were reported prior to the operation date. The CBC was measured within a week prior to operation date.

Use of inotropes –For this study, the use of inotrope is defined as the number of Inotropes the patient required support from when leaving the operation theatre.

They were classified into required no inotropes, required 1 inotrope and required 2 or more inotropes depending on whether patients required No, One or two inotropes to maintain hemodynamic stability while leaving the operation theatre.

Type of anesthesia – it is the medication used to induce and maintain anesthesia during the open cardiac surgery. Since the use of sedatives/hypnotics was identified as a factor for prolonged ICU stay. This study focused on these particular group of anesthetics.

For this study the use of sedative/hypnotic anesthesia was defined as the use of benzodiazepines, barbiturates, Etomidate, Ketamine or propofol as an anesthetic during surgery.

Hospital Acquired Infection (HAI) – For this study, a hospital-acquired infection is defined as the diagnosis of pneumonia, surgical site infection, or sepsis made by the treating physician, as these represent the most common HAIs following open cardiac surgery (70). Only patients who developed HAI while they were admitted in the ICU were included in this study.

Postoperative complications – Postoperative complications refer to any adverse clinical conditions occurring after open cardiac surgery during the ICU stay. These include:

1. Postoperative bleeding – defined as bleeding from the incision site, mediastinum or through chest tube that was considered significant enough to be diagnosed as bleeding by the treating physician.

2. Postoperative Acute kidney injury (AKI) - defined as the development of postoperative kidney injury without prior history of renal disease as diagnosed by treating physician.

3. Hypokalemia -Low potassium level requiring supplementation during ICU stay.

4. Other complications- this term includes a variety of complications such as: Chylothorax, Pneumothorax, lung collapse, Left bundle branch block, Supraventricular tachycardia, Ventricular Fibrillation, Delirium, Hypertension, and HAI.

4.9. DATA COLLECTION PROCEDURES

A data extraction tool was prepared from extensive literature review. Then data were collected from medical records that fulfil the inclusion criteria using that data abstraction tool. Data were collected by two trained General Practitioners by using the Kobo Collect application.

Training was given to the data collectors for one day to clarify the content of the data extraction tool, on how to use the Kobo collect application for data collection and to address any concerns the data collectors had. The principal investigator supervised the data collection process three times a week.

The data extraction tool had four sections. It collected socio-demographic, Preclinical, clinical and postoperative factors that affect ICU LOS following open cardiac surgery that are identified from previous literature, including studies done at the same study area. All data were recorded from operation room registry, patients' charts and hospital electronic database.

4.10. Data Management

The data collected by using the Kobo collect application was retrieved from the Kobo Toolbox server in xls format. Then, it was checked for clarity, consistency, and completeness. Data were cleaned by removing incorrectly formatted, duplicate, or incomplete data within a dataset. Then data were exported to Stata version 17 for analysis.

4.11. Data Analysis

After the data were cleaned and recoded, the presence of outliers was thoroughly checked for continuous independent variables by using box-plot. The variables, Duration of anesthesia, Duration of CPB and Duration of aortic cross clamp showed the presence of outliers to a limited degree on box plot. However, upon further evaluation of each dataset. It was observed there was no significant outlier was present. Hence, these outliers were kept for analysis to avoid neutralizing possible significant variables. Then for the primary objective analysis started from descriptive statistics. Frequency and percentage were used to summarize categorical variables. Mean and SD were used for continuous variables. Then, tables were used to present the summaries.

For the second objective multivariable logistics regression was used to examine the relationship between length of ICU stay and the independent variables. Independent variables with a P value less than 0.25 in bivariate analysis, were considered as candidates for multivariate analysis. The level of significance was declared at a P-value less than 0.05, and an adjusted odd ratio (AOR) with a 95% CI of a p-value <0.05 was used to identify the association between length of ICU stay and the independent variables and build a model. For

the case of multivariable analysis the choice of reference category was based on these two strategies i.e. using either the normative category or the largest category.

4.11.1 The issue of missing data

The presence of missing data is a known drawback of using secondary data. Hence several steps were taken even before the initiation of data collection to ensure that the data used for analysis would be as complete as possible. During preliminary stages of the research planning the medical records were reviewed to check which variables in the initial conceptual framework were recorded consistently in the medical records of patients. Then, the data abstraction form was modified in line with the variables that were found to be recorded consistently. Then, data were collected in a three step process to ensure completeness.

Step 1- From the Operation room logbook which contains the diagnosis and MRN of the operated cardiac patients to ensure all the patients were included.

Step 2- From the Medical records. Data were collected from the retrieved medical record of each individual patient. Each page was meticulously examined to extract all the necessary information.

Step 3- Electronic medical records were examined to collect data that were not found in individual medical records,

After data collection took place, 580 medical records were complete with regards to the chosen variables of interest. Out of these charts, 450 were patients with CHD and 130 were patients with RHD. Although this falls short of the initially planned sample size of 605, since it can be covered by the non-response rate, analysis was performed on those 580 charts found to be complete.

4.12. DATA QUALITY ASSURANCE

A data extraction tool was developed after extensively reviewing previous literature. Data were collected by general practitioners to ensure in-depth understanding of the clinical context. Before data collection training was given for the two data collectors on aim of the study, on data extraction tool, and how to use Kobo collect for data collection. Data collection process was supervised by the principal investigator three times a week. Data were cleaned by removing incorrectly formatted, duplicate, or incomplete data within a dataset Furthermore,

the variables were operationalized based on previous literature and the appropriate model for data analysis was utilized.

4.13. Ethical Considerations

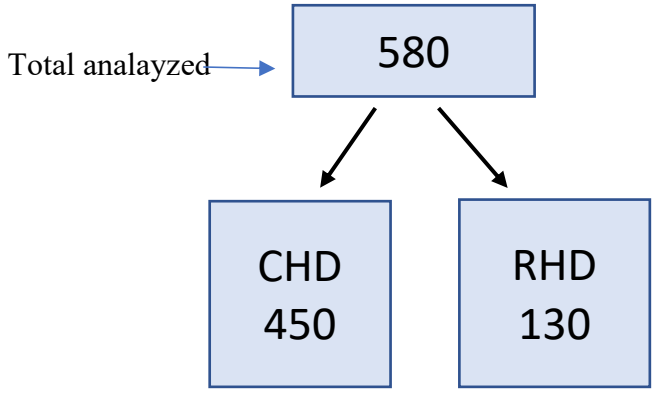
To conduct this study, ethical clearance was obtained from the SPH/REC on the behalf of institutional review board of Addis Ababa University (IRB-AAU/CHS), College of Health Sciences, School of Public Health. Furthermore, the objectives and methods of this study were evaluated by the medical director of the cardiac center and it was found that there was no breech in confidentiality of patients. The secondary data collected from the Medical records were confidential and cannot be used to re-identify patients as personal information was not collected and the medical records are only identified by their medical record number. No racial profiling was present during the data collection process. Transparency was maintained by reporting any conflict of interest. No data manipulation was performed.

4.14. Dissemination of the findings

Hard and soft copies of the results of the study will be submitted to the Addis Ababa University, College of Health Sciences, and School of Public Health. The findings will be submitted to the Cardiac Center Ethiopia. The findings will also be submitted to local and international journals.

5. RESULTS

Analysed population: 580 records were used for analysis out of which 450 were diagnosed with congenital heart disease and 130 were RHD patients.



5.1. BASELINE AND PERIOPERATIVE CHARACTERISTICS

Between 2019 and 2024, 700 patients underwent open cardiac surgery at the Cardiac Center of Ethiopia. Of these, 682 had CHD or RHD. Based on proportional stratified sampling, 605 records were targeted, and 580 complete charts (450 CHD and 130 RHD) were included in the final analysis.

Socio-Demographic Characteristics

The socio-demographic details are presented in Table 7**.** The majority of the patients (78.97%) were younger than 18 years, with a mean age of 11.9 ± 12.1 years. Females comprised 58.28% of the study population. Most patients originated from Addis Ababa, Oromia, and Amhara regions, together accounting for over 87% of all cases.

Regarding nutritional status, among those younger than 18 years, 52.30% had a normal BMI, 28.47% were underweight, and 19.20% were overweight. For patients 18 years and older, 65.20% were within the normal BMI range.

Table 6: Socio-Demographic Characteristics of Patients Who Underwent Open cardiac surgery at the Cardiac Center Ethiopia (2019–2024)

Variable		Category	Frequency (n)	Percentage (%)
Age		< 18	458	78.97%
		> 18	122	21.03%
Sex		Male	242	41.72%
		Female	338	58.28%
Region		Addis Ababa	245	42.24%
		Oromia	162	27.93%
		Amhara	95	16.38%
		SNNPR	55	9.48%
		Others	23	3.97%
BMI	**Age < 18**	Underweight	129	28.47%
		Normal	237	52.30%
		Overweight	87	19.20%
	Age ≥ 18	Underweight	26	21.30%
		Normal	83	65.20%
		Overweight	13	12.10%

Clinical and Perioperative Characteristics

Table 8 and 9 summarizes clinical, diagnostic, and operation-related variables. CHD was the dominant diagnosis in 77.59% of the patients, while RHD accounted for 22.41%. The vast majority (90.86%) had no comorbidities, with Down syndrome being the most frequent comorbidity (7.93%). Only 1.9% had a history of previous open cardiac surgery, and 98.1% had a preserved left ventricular ejection fraction (EF ≥ 50%). Preoperative anemia was seen in 31.55% of the patients. Severe pulmonary hypertension was present in 38.97% of patients.

Most surgeries addressed one (66.09%) or two lesions (25.61%). The majority (95.17%) received sedative/hypnotic anesthesia. Regarding inotrope use post-surgery: 44.83% required no inotropes, 25.17% required one inotrope, and 30.00% needed two inotropes. Postoperative complications were absent in 56.21% of patients. Among those who experienced complications, hypokalemia (17.59%) and bleeding (8.10%) were the most frequent. Only 0.86% developed postoperative AKI.

Table 7: Clinical and Perioperative Characteristics of open cardiac surgery Patients at the cardiac center(2019-2024)

Variable	Category	Frequency (n)	Percentage (%)
Type of cardiovascular disease	CHD	450	77.59%
	RHD	130	22.41%
Comorbidities	None	527	90.86%
	Down Syndrome	46	7.93%
	Others	7	1.21%
LVEF	Preserved EF(50)	569	98.10%
	Reduced EF (<50%)	11	1.90%
Previous Open cardiac surgery	Yes	11	1.90%
	No	569	98.10%
Atrial Fibrillation	No AF	512	88.28%
	Pre-operative AF	54	9.31%
	Post-operative AF	14	2.41%
Preoperative Anemia	Yes	183	31.55%
	No	397	68.45%
Pulmonary Hypertension	No	289	49.83%
	Mild PAH	23	3.97%
	Moderate PAH	42	7.24%
	Severe PAH	226	38.97%
Number of operated lesions	One	382	66.09%
	Two	148	25.61%
	Three	44	7.61%
	Four or more	4	0.69%
Type of Anesthesia	Sedative/Hypnotics	552	95.17%
	Other Types of anesthesia	26	4.83%
Required Inotropes	None	260	44.83%
	One	146	25.17%
	Two	174	30.00%
Postoperative Complications	None	326	56.21%
	Post-operative bleeding	47	8.10%
	Postoperative AKI	5	0.86%
	Hypokalemia	102	17.59%
	Other	100	17.24%
	Mean	**Standard Deviation**	
Age	11.9	12.1	
Weight	26.26	18.93	
Height	120.48	32.16	
Duration of Anesthesia	227.08	96.77	
Duration of Cardiopulmonary bypass	99.44	53.3	
Duration of Aortic Cross clamp	63.74	42.49	

ICU Stay Characteristics

The length of ICU stay was not normally distributed and hence was summarised as median and Interquartile range (IQR). Figure 2 displays the proportion of patients with normal and prolonged ICU stay. Of the 580 patients, 154 (26.6%) had a prolonged ICU stay (95% CI: 22.9%–30.3%). The median length of ICU stay was 3 days (IQR 2-4 days). The 75th percentile of ICU stay distribution (4 days) was used as the cut-off to define prolonged ICU stay as seen in Table 8**.**

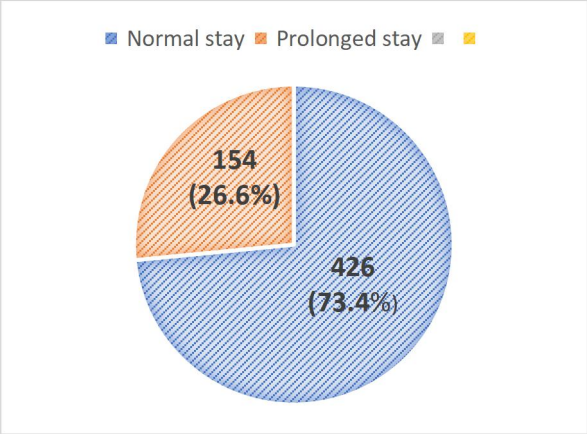


Figure 2: Proportion of Patients with Normal vs. Prolonged ICU Stay following open cardiac surgery at the Cardiac Center Ethiopia (2019–2024)

Table 8: Characteristics of ICU Stay Duration among Patients Who Underwent Open cardiac surgery at the Cardiac Center Ethiopia (2019–2024)

ICU Stay Characteristic	**Value**
Median (IQR)	3 days (2-4 days)
Minimum ICU stay	1 day
Maximum ICU stay	24 days
75th Percentile (cutoff value)	4 days

5.2. FACTORS ASSOCIATED WITH PROLONGED ICU STAY

Factors were analysed first using bivariable logistic regression to identify potential associations, followed by multivariable logistic regression to adjust for confounders and identify independent predictors.

5.2.1. Bivariable Analysis

Bivariable logistic regression was conducted to explore the association between each independent variable and the likelihood of prolonged ICU. Table 9 depicts the results of bivariable analysis.13 variables with a p-value less than 0.25 were identified as candidates for the multivariable model. These factors include Age, Sex, Type of cardiovascular disease, History of previous open cardiac surgery, the number of operated cardiac lesions, Presence of preoperative anemia, Atrial fibrillation, LVEF, Pulmonary hypertension, Duration of anesthesia, Duration of CPB, the use of inotropes and the presence of postoperative complications. Then these significant variables were taken to multivariable analysis.

Table 9: Bivariable Analysis of Factors Associated with Prolonged ICU Stay (Cardiac Center Ethiopia, 2019–2024)

Variable	Category	COR	P-value	Confidence interval
Age	< 18 ≥ 18	Ref 3.92	<0.0001	(2.574 , 5.983)
Sex	Female Male	Ref 1.27	0.19	(0.879 , 1.849)
Type of cardiovascular disease	CHD RHD	Ref 6.71	<0.0001	(4.385 , 10.275)
Comorbidities	None Downs Syndrome Other	Ref 0.40 1.98	 0.038 0.376	 (0.164 , 0.952) (0.437, 8.9362
Prior open cardiac surgery	No Yes	Ref 3.41	 0.045	(1.027 ,11.350) (1.027 , 11.350)
Number of operated lesions	One Two Three Four or more	Ref 3.21 4.70 14.10	 <0.0001 <0.0001 0.023	 (2.104 , 4.883) (2.461 , 8.979) (1.445, 137.686)
Preoperative Anemia	No Yes	Ref 1.83	0.002	(1.249 , 2.694)
Atrial Fibrilation	No AF Preoperative AF Postoperative AF	Ref 6.07 4.76	 <0.0001 0.005	 (3.363 , 10.961) (1.619 , 14.009)
LVEF	≥ 50 <50	Ref 3.41	 0.045	 (1.027 , 11.350)
Pulmonary Hypertension	No PAH Mild PAH Moderate PAH Severe PAH	Ref 1.37 1.25 1.26	 0.507 0.542 0.246	 (0.541 , 3.462) (0.608 , 2.575) (0.852 , 1.873)
Type of Anesthesia	Sedative/Hypnotics Other	Ref 1.57	 0.26	 (0.710, 3.489)
Duration of Aesthesia	-	1.00	0.050	(1.000 , 1.008)
Duration Cardiopulmonary Bypass	-	1.01	0.026	(1.001 , 1.027)
Aortic Cross Clamp time	-	1.00	0.80	(0.988, 1.016)
Inotropic Support	None One Two	Ref 3.84 7.69	 <0.0001 <0.0001	 (2.260 , 6.539) (4.678 ,12.648)
Postoperative complications	None Postoperative AKI Hypokalemia Postoperative bleeding Others	Ref 6.26 1.08 4.36 3.15	0.001 0.047 0.779 <0.0001 <0.0001	(1.085 , 1.364) (1.025 ,38.270) (0.622 , 1.881) (2.309 , 8.216) (1.944 , 5.099)

5.2.2. Multivariable Analysis

Variables with p-values less than 0.25 in the bivariable analysis were included in a multivariable logistic regression model to identify independent predictors of prolonged ICU stay. After adjustment, five variables remained statistically significant.

Table 10 depicts the results of multivariable logistic regression. Patients with preoperative atrial fibrillation (AF) had 2.41 times higher odds of prolonged ICU stay (AOR = 2.41; 95% CI: 1.00–5.78; p = 0.050). Postoperative acute kidney injury (AKI) was associated with a more than sevenfold increase in the odds of prolonged ICU admission (AOR = 7.52; 95% CI: 1.08–52.25; p = 0.040). The odds of prolonged ICU stay were three times higher among patients who experienced postoperative bleeding (AOR = 3.01; 95% CI: 1.41–6.44; p = 0.004). Other postoperative complications were associated with a nearly fourfold increase in the likelihood of prolonged ICU stay (AOR = 3.73; 95% CI: 2.06–6.76; p < 0.0001). For the continuous variable Duration of CPB, each one-minute increase in duration was associated with a 1% increase in the odds of prolonged ICU stay (AOR = 1.01; 95% CI: 1.00–1.02; p = 0.005).

Table 10: Factors associated with length of ICU stay following open cardiac surgery at the cardiac center(2019-2024)

Variable	Category	ICU stay		COR	AOR	P-value	CI
		Normal	Prolonged				
Age	< 18	**365** (62.9%)	**93** (16.0%)	3.92	Ref		(0.65, 2.53)
	≥18	**61** (10.5%)	**61** (10.5%)		1.28	0.48	
Sex	Female	**255** (43.9%)	**83** (14.3%)	1.28	Ref		
	Male	**171** (29.5%)	**71** (12.2%)		1.28	0.30	(0.80, 2.04)
Type of cardiovascular disease	CHD	**372** (64.1%)	**78** (13.5%)	6.71	Ref		
	RHD	**54** (9.3%)	**76** (13.1%)		1.51	0.26	(0.74, 3.10)
Prior open cardiac surgery	No	**421** (72.6%)	**148** (25.5%)	3.41	Ref		
	Yes	**5** (0.86%)	**6** (1.03%)		1.90	0.44	(0.37, 9.85)
Number of operated lesions	One	**315** (54.5%)	**67** (11.6 %)	2.46	Ref		
	Two	**88** (15.2 %)	**60** (10.38 %)		1.40	0.21	(0.83, 2.36)
	Three	**22** (3.8 %)	**22** (3.8%)		0.85	0.71	(0.36, 2.01)
	Four or more	**1** (0.17 %)	**3** (0.52%)		1.84	0.67	(0.11, 29.69)
Preoperative anemia	No	**307** (52.9%)	**90** (15.5%)	1.83	Ref		
	Yes	**119** (20.5%)	**64** (11.0%)		1.25	0.36	(0.77, 2.04)
AF	No AF	**400** (69%)	**112** (19.31)	3.65	Ref		
	Preop AF	**20** (3.5%)	**34** (5.86 %)		2.41	**0.05***	(1.00, 5.78)
	Postop AF	**6** (1.0%)	**8** (1.4%)		1.59	0.519	(0.39, 6.57)
LVEF	≥ 50	**421**(72.6%)	**148** (25.5%)	3.41	Ref		
	<50	**5** (0.86%)	**6** (1.03%)		1.02	0.99	(0.21, 4.83)
PAH	No PAH	**219** (37.8%)	**70** (12.0%)	1.08	Ref		
	Mild PAH	**16** (2.8 %)	**7** (1.2%)		1.72	0.36	(0.54, 5.48)
	Moderate PAH	**30** (5.1%)	**12** (2.1%)		0.67	0.39	(0.26, 1.63)
	Severe PAH	**161** (27.8%)	**65** (11.2%)		1.00	0.99	(0.58, 1.62)
Postoperative Complications	None	**263** (45.3%)	**63** (10.9%)	1.22	Ref		
	Postop AKI	**2** (0.34%)	**3** (0.52%)		7.52	**0.04***	(1.08, 52.25)
	Hypokalemia	**81** (13.9%)	**21** (3.6%)		1.11	0.77	(0.57, 2.16)
	Postop bleeding	**23** (3.97%)	**24** (4.1%)		3.01	**0.004***	(1.41, 6.44)
	Others	**57** (9.8%)	**43** (7.4%)		3.73	**<0.0001***	(2.06, 6.76)
Inotropic support	None	**233** (40.2%)	**27** (4.7%)	2.70	Ref		
	One	**101** (17.4%)	**45** (7.8%)		1.06	0.86	(0.54, 2.11)
	Two	**92** (15.9%)	**82** (14.1%)		1.61	0.18	(0.81, 3.19)
Duration of anesthesia	-	**197.4 mins**	**288.9 mins**	1.00	1.00	0.31	(1.00, 1.01)
Duration of CPB	-	**75.7 mins**	**132.2 mins**	1.01	1.01	**0.005 ***	(1.00, 1.02)

* - Statistically significant at $p \leq 0.05$

After model building, Correlation between independent variables was checked, using Variance Inflation Factor (VIF) and the goodness-of-fit of the model was checked using Hosmer and Lemeshow test statistics. Additionally, to assess the overall diagnostic performance of the test, the Receiver Operating characteristic (ROC) curve was computed. The results are depicted in the table and figure below:

Table 11: Multicollinearity and Model Goodness-of-Fit Diagnostics

Variance Inflation factor (VIF)	**Result**
	Mean VIF = 1.29
Hosmer lemeshow goodness of fit test	Result
	P-value = 0.903
ROC Curve	Result
	AUC= 0.85

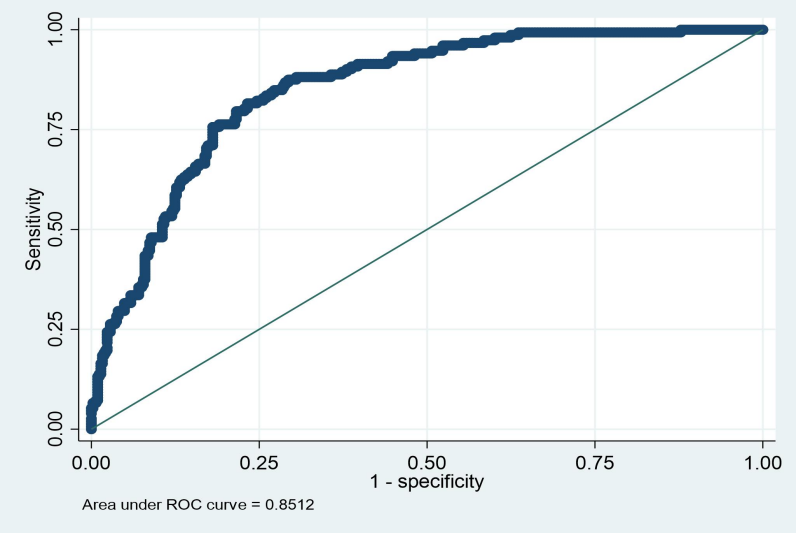


Figure 3 : Receiver Operating Characteristics Curve to asses performance of logistic regression model

6. DISCUSSION

The main purpose of this study was to identify the proportion of patients with prolonged stay in the ICU following open cardiac surgery and to identify what perioperative factors were associated with this prolongation. This study found association of one preoperative factor (Atrial fibrillation), One intraoperative factor (Duration of CPB) and three postoperative factors (Postoperative bleeding, Postoperative AKI and other complications) with prolonged ICU-LOS of open cardiac surgery patients. These findings contribute to the growing evidence identifying perioperative risk factors in open cardiac surgery outcomes.

The occurrence of prolonged ICU stay following open cardiac surgery varies widely across studies, largely due to differences in patient populations, definitions of "prolonged stay," and institutional practices. In the present study, it was observed that 26.6% of patients experienced a prolonged ICU stay which is lower compared to a study done in the same study area which reported that 49% of patients who underwent cardiac surgery between the years 2015 and 2019 had prolonged ICU stay had a prolonged ICU stay following cardiac surgery(46). The decrease in magnitude of prolonged stay over the years could be due to two possible reasons. One reason could be due to a difference in patient population between the current study and the previous one. This study solely focuses on CHD and RHD patients which are the bulk of patients undergoing cardiac surgery at the cardiac center, while the previous study included patients who underwent Coronary Artery Bypass Grafting (CABG). Patients who undergo surgery for CABG are older hence more likely to have a prolonged stay. Since CABG are excluded in this study it could potentially result in underestimation of prolonged ICU stay. Another possible reason is that changes in various institutional factors, surgical techniques or protocol changes are possibly improving patient outcomes resulting in a decreasing trend of prolonged ICU stay over the years. Understanding these factors could contribute to ongoing quality improvement initiatives in cardiac surgical care resulting is further decline in prolonged ICU stay.

Compared to other studies around the world occurrence of prolonged ICU stay in this study was found to be higher to than that reported in Michigan state university, where 14% of open cardiac surgery patients had prolonged ICU stay defined as greater than 7 days(71). However, it is lower than figures reported in other regions such as a study conducted in Iran that report a prolonged stay as high as 64.9%(72).

Preoperative AF is the diagnosis of AF on a patient even before the cardiac surgical procedure takes place while Postoperative AF is the occurrence of new onset AF in a patient following open cardiac surgery. Although there are various literature that identify POAF as being linked with a prolonged ICU stay , such as this meta-analysis of 61 studies (73), it was a non-significant factor in this study.

This study found that patients with preoperative AF were 2.4 times more likely to have a prolonged stay following open cardiac surgery. Similarly, a study conducted in Greece found that patients with preoperative AF were 6 times more likely to have a prolonged ICU stay (74).This can be due to its predisposition of patients to postoperative complications such as delirium and stroke (75). However other studies found that preoperative AF was not a predictor of prolonged stay (22). A Case control study could be beneficial to identify the association of AF with a prolonged stay in the ICU.

Another factor that was associated with a prolonged ICU stay is a prolonged duration of CBP (AOR = 1.01, p = 0.006). A significant p value for a continuous independent variable on logistic regression analysis, such as this one, implies that a unit increase in the independent variable is associated with a multiplicative increase in the occurrence of the outcome variable (76). Meaning the longer the patient stayed on CPB the more likely they are to have a prolonged stay in the ICU postoperatively. Although the OR is numerically small, this factor is still considered clinically relevant due to risk increment with each additional minute. This finding aligns with prior literature that also identify duration of CBP as a significant factor affecting ICU LOS (31) especially when the duration exceeds 227 minutes.

Among the postoperative complications, AKI stood out with a high odds ratio of 7.5 (p=0.04). This is in line with other literature that highlight the link between post-operative AKI and poor postoperative outcomes including prolonged mechanical ventilation, longer intensive care unit stays and increased mortality (77). Hence, emphasis should be given to implementing strategies to prevent post-operative AKI such as using the KIDGO bundle guidelines for prevention of AKI which highlights preventive measures such as optimizing intraoperative hemodynamics and avoiding nephrotoxic drugs(78). Another novel method of preventing postoperative AKI is remote ischemic preconditioning (RIPC)—brief, controlled episodes of ischemia applied to a limb—has shown renal-protective effects through modulation of inflammatory pathways(79).

Postoperative bleeding is another factor associated with prolonged ICU stay in this study. Post-operative bleeding has a prevalence of 2.6% following open cardiac surgery (80). Post-operative bleeding may sometimes require re-exploration to arrest the bleeding. Re-exploration was significantly associated with low ejection fraction, prolonged period of mechanical ventilation and longer intensive care unit stay(81).

In addition to atrial fibrillation, cardiopulmonary bypass duration, postoperative bleeding, and AKI, this study identified a range of other postoperative complications that were significantly associated with prolonged ICU length of stay. These complications, although grouped together due to relatively lower individual incidence, have been widely recognized in the literature as causes of prolonged ICU stay.

Postoperative infections, particularly pneumonia, surgical site infections (SSIs), and sepsis, are well-documented causes of increased ICU length of stay(82). It was observed patients with postoperative infections had a higher incidence of long-term infection and mortality. Neurological Complications such as postoperative delirium which is common in elderly patients and those undergoing prolonged bypass is also a notable complication that can prolong ICU and hospital stays(83).

7. STRENGTHS AND LIMITATIONS

7.1. STRENGTHS

One of the key strengths of this discussion is the fact that it addresses possible preventive mechanisms. Additionally, the strengths of this study include a large sample size, Proper documentation of sampling procedures and proportional allocation of disease which allows reproducibility of the study. And its possible role as supporting evidence specifically for any attempts to create a generalized framework for Length of stay definition worldwide.

7.2. LIMITATIONS

This study is not without its limitations. One limitation is the inability to account for some important confounders due the retrospective nature of the study and the use of secondary data. Variables such as Intraoperative cardioversion, intraoperative blood transfusion, duration of mechanical ventilation Duration of inotropic support and NYHA class were not consistently documented in patient medical records and hence were removed from the analytical

framework. Additionally, since this is a cross sectional study causal inference is not possible. However, it can be a stepping stone for further research.

8. Conclusion and Recommendation

8.1. Conclusion

This study set out to understand how often patients experience prolonged ICU stays after open cardiac surgery in Ethiopia and what factors contribute to that. We found that preoperative atrial fibrillation, longer cardiopulmonary bypass time, and postoperative complications like bleeding and acute kidney injury were key predictors. These findings highlight areas where targeted prevention and better perioperative care could make a meaningful difference

These findings matter because they help identify patients at higher risk early on, allowing for better planning and care. In settings with limited ICU resources, this knowledge can guide clinical decisions, improve outcomes, and make more efficient use of critical care. By better understanding and addressing these risk factors, healthcare teams can improve recovery, ease the strain on ICU resources, and help more patients move through the system safely and efficiently. Encouragingly, the trend at the Cardiac Center of Ethiopia seems to show a decrease in prolonged stays, suggesting that recent improvements in care may already be making a difference.

Going forward, more research—especially prospective studies—should explore other factors not captured in this study. Additionally, further research can be done to test how risk stratification tools can be adapted to local contexts. This will help fill important knowledge gaps and strengthen cardiac care in low-resource environments. Additionally, these findings can be used as an input for global efforts made to create a generalized definition of prolonged stay.

8.2. RECOMMENDATIONS

The clinical staff at the Cardiac Center can explore novel methods to reduce the occurrence of complications such as remote ischemic preconditioning (RIPC).

The academic and clinical staff can explore the changes in various institutional factors, surgical techniques or protocol changes over the last 5 years. As the trend of prolonged stay seems to have decreased, further quality improvement methods can be identified.

Researchers should implore all the list of complications that are operationalized under 'other complications' to identify which one has an association with a prolonged ICU stay. This recommendation is suggested because 'other complications' was a significant factor associated with ICU LoS in this study.

Further research can also be done in the lines of validation of risk stratification tools (Such as STS) and also by utilizing a different study design such as case control or cohort study.

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9. ANNEX

9.1. DATA ABSTRACTION FORM

No.	Sociodemographic characteristics	
	Variable	Category
1	MRN	
2	Age	----------
3	Sex	1. Male 2. Female
4	Region	1. Addis Ababa 2.Oromia 3.Amhara 4. SNNP 5. Others mention…….
	2.Pre-operative factors (Baseline Characteristics)	
5	Weight (Kg)	----------
6	Height(cm)	----------
7	BMI	----------
8	History of previous open cardiac surgery	1. Yes 2. No
9	Pulmonary Hypertension	1.Yes 2. No
10.	Atrial Fibrillation	1. Preoperative AF 2.Postoperative AF 3.No AF
11	Left Ventricular Ejection Fraction	_____
12	Preoperative Hemoglobin	_____ _____
13	Comorbidities	1. Diabetes 2. Hypertension 3. Renal disease 4. COPD 5. Down syndrome

	Intraoperative factors	
14	Number of operated lesions	1.One 2. Two 3. Three or more 4. Four or more
15	Duration of Cardiopulmonary bypass	----------
16	Duration of Aortic cross clamp time	----------
17	Inotropic support	1. None 2. One 3. Two
18	Type of anesthesia	1. Sedative/hypnotics 2.Other
	Postoperative factors	
19	Postoperative Bleeding	1. Yes 2.No
20	Postoperative AKI	1. Yes 2.No
21	Hospital acquired infection	1. Yes 2.No
22	Other complications	Mention other complications
23	Length Of ICU stay(days)	----------

9.2. DATA COLLECTOR TRAINING SCHEDULE

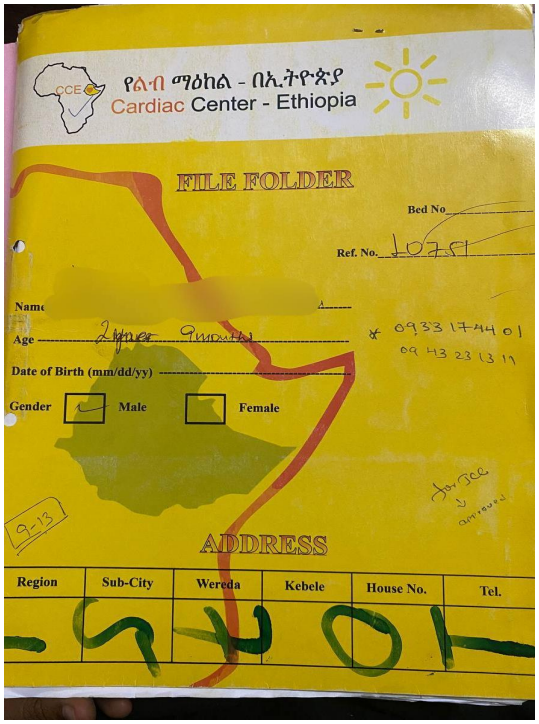
8:30- 10:00	**Welcome, Clarify the training objective and give overview of the study**
10:00-10:15	Break
10:15-12:00	• Research ethics • Role and responsibilities of data collectors
12:00-13:00	Lunch
13:00-15:30	• How to use kobo collect for data collection • Address questions and concerns from data collectors
	Finish

9.3. Sample Pictures of medical records


PLCU FLOWSHEET

Page 3 of 4

Patient's Name:.....


የልብ ማዕከል - በኢትዮጵያ

Cardiac Center - Ethiopia

FILE FOLDER

Bed No.

Ref. No. 10751

Name

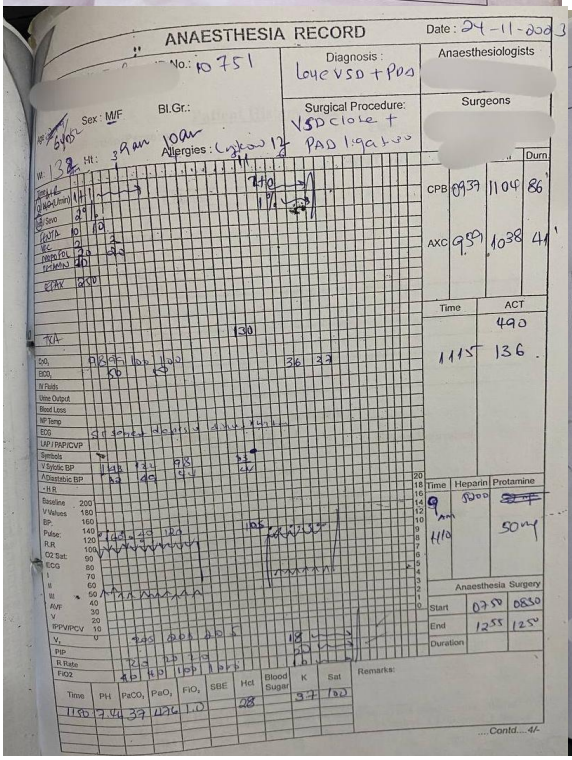
Age 2 Upper 9 month

Date of Birth (mm/dd/yy)

Gender Male Female

ADDRESS

Region	Sub-City	Wereda	Kebele	House No.	Tel.


ANAESTHESIA RECORD

Date : 24-11-2003

No.: 10751

Diagnosis : Large VSD + PDA

Surgical Procedure: VSD close + PDA ligation

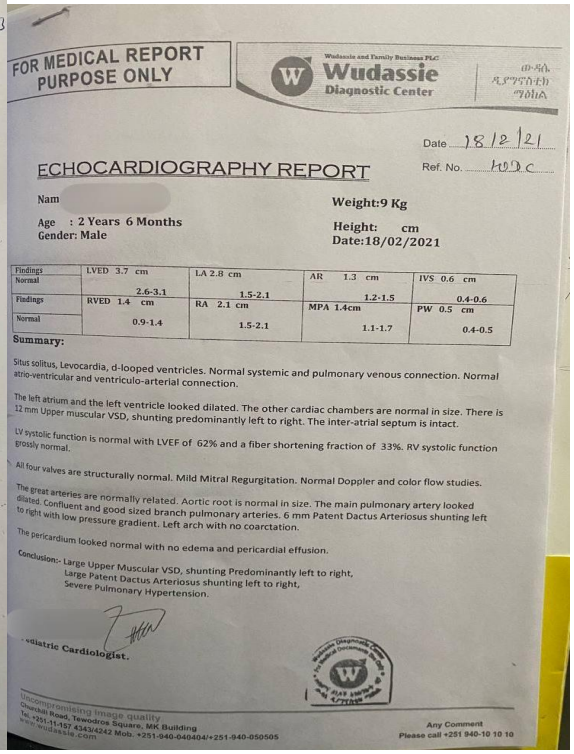
Anaesthesiologists

Surgeons

Sex : M/F

Wt:

Allergies :


FOR MEDICAL REPORT PURPOSE ONLY

Wudassie and Family Business PLC

Wudassie Diagnostic Center

ECHOCARDIOGRAPHY REPORT

Date 18/2/21

Ref. No. 1001C

Nam

Age : 2 Years 6 Months

Gender: Male

Weight:9 Kg

Height: cm

Date:18/02/2021

Findings				
Normal	LVED 3.7 cm 2.6-3.1	LA 2.8 cm 1.5-2.1	AR 1.3 cm 1.2-1.5	IVS 0.6 cm 0.4-0.6
Findings	RVED 1.4 cm	RA 2.1 cm	MPA 1.4cm	PW 0.5 cm
Normal	0.9-1.4	1.5-2.1	1.1-1.7	0.4-0.5

Summary:

Situs solitus, Levocardia, d-looped ventricles. Normal systemic and pulmonary venous connection. Normal atrio-ventricular and ventriculo-arterial connection.

The left atrium and the left ventricle looked dilated. The other cardiac chambers are normal in size. There is 12 mm Upper muscular VSD, shunting predominantly left to right. The inter-atrial septum is intact.

LV systolic function is normal with LVEF of 62% and a fiber shortening fraction of 33%. RV systolic function grossly normal.

All four valves are structurally normal. Mild Mitral Regurgitation. Normal Doppler and color flow studies.

The great arteries are normally related. Aortic root is normal in size. The main pulmonary artery looked dilated. Confluent and good sized branch pulmonary arteries. 6 mm Patent Ductus Arteriosus shunting left to right with low pressure gradient. Left arch with no coarctation.

The pericardium looked normal with no edema and pericardial effusion.

Conclusion:- Large Upper Muscular VSD, shunting Predominantly left to right,
Large Patent Ductus Arteriosus shunting left to right,
Severe Pulmonary Hypertension.

Pediatric Cardiologist.

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Diagnostic Center

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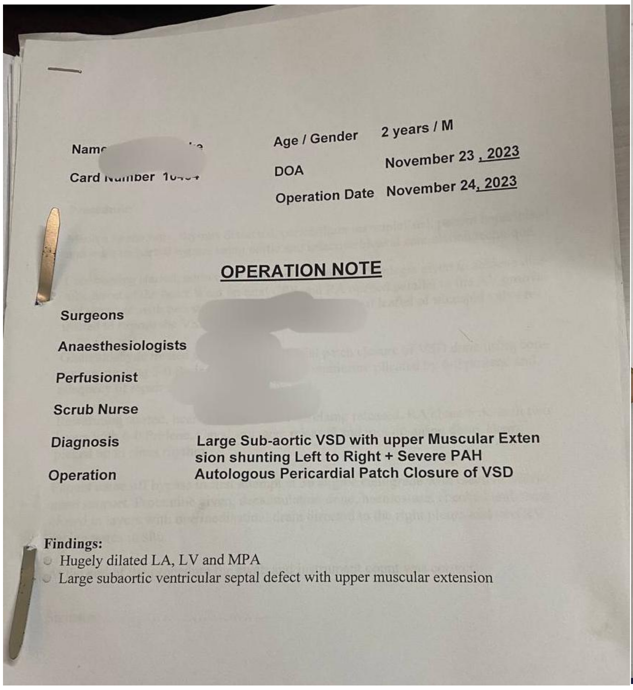
www.wudassie.com

Any Comment
Please call +251 940-10 10 10

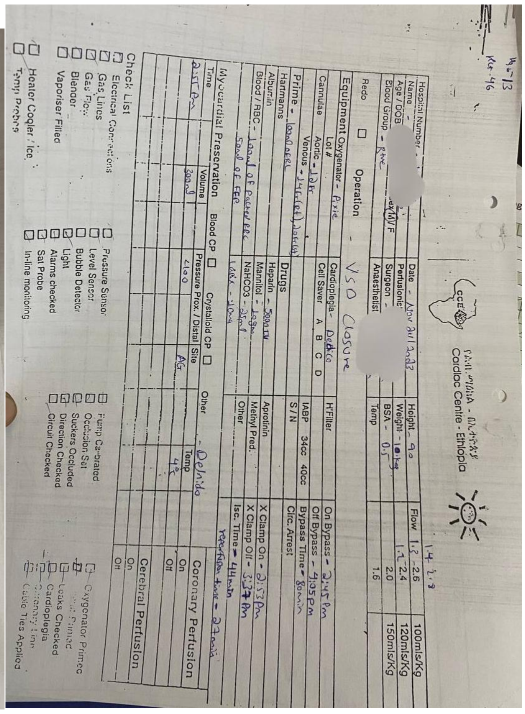


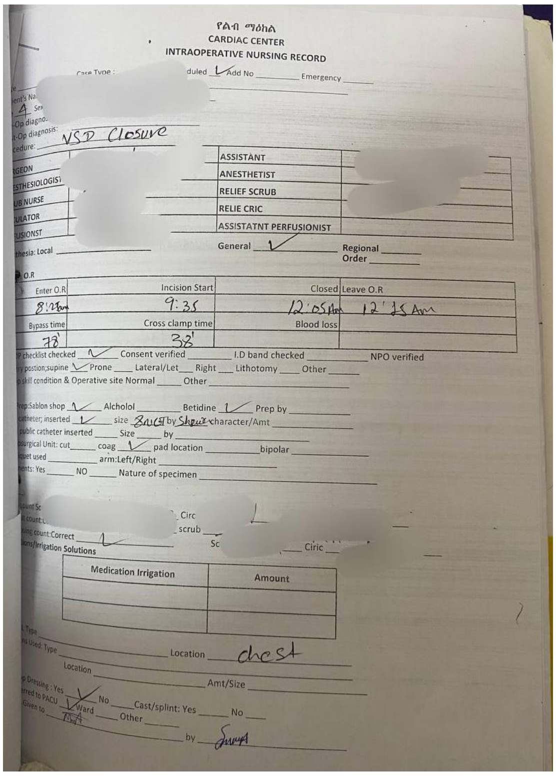
Name [redacted] | Age / Gender 2 years / M
Card Number [redacted] | DOA November 23, 2023
Operation Date November 24, 2023

OPERATION NOTE

Surgeons	[redacted]
Anaesthesiologists	[redacted]
Perfusionist	[redacted]
Scrub Nurse	[redacted]
Diagnosis	Large Sub-aortic VSD with upper Muscular Extension shunting Left to Right + Severe PAH
Operation	Autologous Pericardial Patch Closure of VSD

Findings:
- Hugely dilated LA, LV and MPA
- Large subaortic ventricular septal defect with upper muscular extension





CARDIAC CENTER
INTRAOPERATIVE NURSING RECORD

Case Type: [redacted] Scheduled ✓ Add No ______ Emergency ______

Procedure: VSD Closure

SURGEON	[redacted]	ASSISTANT	[redacted]
ANESTHESIOLOGIST	[redacted]	ANESTHETIST	[redacted]
SCRUB NURSE	[redacted]	RELIEF SCRUB	[redacted]
CIRCULATOR	[redacted]	RELIE CRIC	
PERFUSIONIST	[redacted]	ASSISTATNT PERFUSIONIST	

Anesthesia: Local ______ General ✓ Regional ______ Order ______

Enter O.R	Incision Start	Closed	Leave O.R
8:22 am	9:35	12:05 pm	12:25 Am
Bypass time	Cross clamp time	Blood loss	
78'	38'		

Checklist checked ✓ Consent verified ______ I.D band checked ______ NPO verified
Position: supine ✓ Prone ____ Lateral/Lt ___ Right ___ Lithotomy ____ Other ______
Skin condition & Operative site Normal ______ Other ______

Prep: Sablon shop ✓ Alcholol ______ Betidine ✓ Prep by ______
Catheter: inserted ✓ size 8 ... by ... character/Amt
Suprapublic catheter inserted ______ Size ______ by ______
Electrosurgical Unit: cut ______ coag ✓ pad location ______ bipolar ______
Tourniquet used ______ arm:Left/Right ______
Specimens: Yes ______ NO ______ Nature of specimen ______

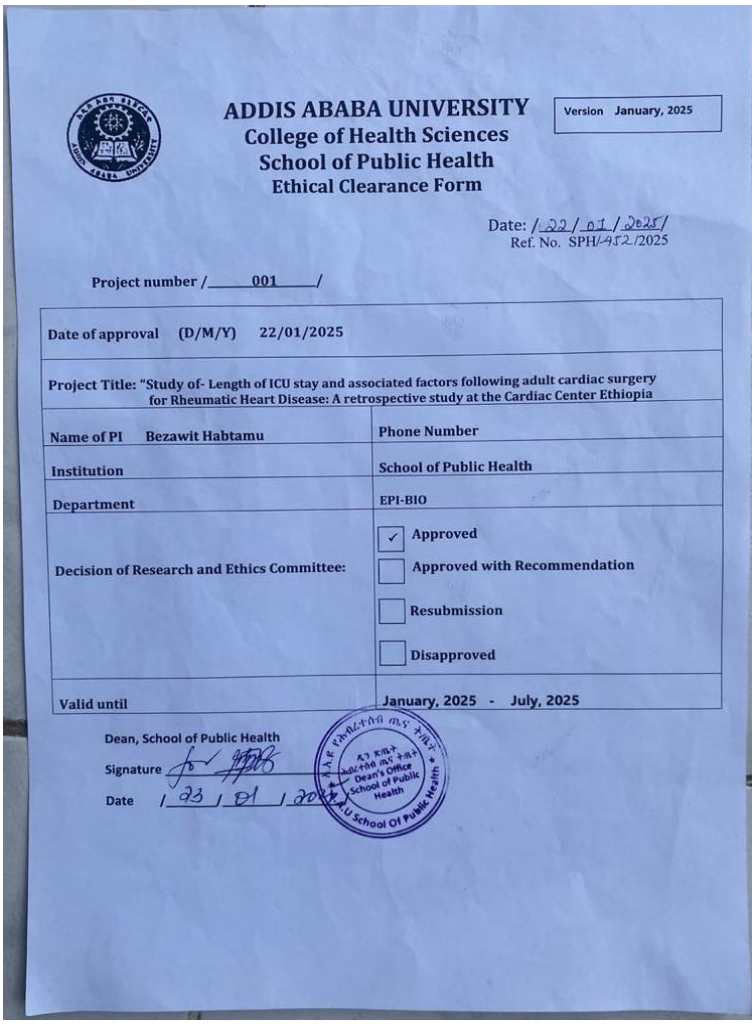
[redacted] Circ [redacted] scrub [redacted] Sc [redacted] Ciric [redacted]

Sponge count: Correct ✓
Solutions/Irrigation Solutions

Medication Irrigation	Amount

Drain Used: Type ______ Location chest
Location ______
Amt/Size ______
Dressing: Yes ✓ No ______ Cast/splint: Yes ______ No ______
Transferred to PACU ✓ Ward ______ Other ______
By ______

9.4. ETHICAL CLEARANCE FORM



ADDIS ABABA UNIVERSITY
College of Health Sciences
School of Public Health
Ethical Clearance Form

Version January, 2025

Date: /22/01/2025/
Ref. No. SPH/452/2025

Project number /001/

Date of approval (D/M/Y) 22/01/2025	
Project Title: "Study of- Length of ICU stay and associated factors following adult cardiac surgery for Rheumatic Heart Disease: A retrospective study at the Cardiac Center Ethiopia	
Name of PI Bezawit Habtamu	Phone Number
Institution	School of Public Health
Department	EPI-BIO
Decision of Research and Ethics Committee:	✓ Approved Approved with Recommendation Resubmission Disapproved
Valid until	January, 2025 - July, 2025

Dean, School of Public Health
Signature
Date /23/01/2025

Dean's Office School of Public Health AAU School Of Public Health

9.5. CURRICULUM VITAE OF PRINCIPAL INVESTIGATOR

Bezawit Habtamu Bekele
Date of birth: 08/10/1996 Nationality: Ethiopian Gender: Female
Phone number: (+251)976359571 (Mobile)
Email address: bezahab10@gmail.com

About me:
I am a junior doctor who is passionate about delivering exemplary patient care. I have excellent communication skills that inspires confidence in patients. I demonstrate aptitude in creating and nurturing patient relationships, and upholding the highest standard of clinical excellence.

DOCTOR OF MEDICINE University of Gondar

Core pre-clinical courses: Anatomy, Physiology, Biochemistry, Microbiology, Pathology, Pharmacology, Epidemiology, Biostatistics, Nutrition, Environmental Health

Core Clinical courses: Internal Medicine; Surgery; Pediatrics; Obstetrics and Gynecology

Skills: Obtained clinical and public health skills through community-based training programs, community- based clinical attachments and team training programs.

Final grade 3.01/4.00

WORK EXPERIENCE

GENERAL PRACTITIONER Delanta Primary Hospital

Duration- 1 year Nov 2022 - Nov 2023

Responsibilities -Evaluation and treatment of outpatient as well as patients admitted in wards. Treated patients with chronic disease as well as tended to patients requiring emergency care in the emergency units.

CERTIFICATIONS

Certificate of Appreciation from EMSA **JULY, 2022**

University of Gonder

Training on the diagnosis, treatment and adverse drug reactions of both drug **MAY, 2022**

Susceptible and drug resistant Tuberculosis

University of Gonder

Certificate of completion on Disaster and Mass Casuality Management **SEPTEMBER, 2021**

University of Gonder

Certificate of Completion of COVID 19 trainingfor healthcare workers **SEPTEMBER, 2020**

Stanford University

Certificate of Appreciation for voluntary activities on Timket Festival **JANUARY, 2020**

University of Gonder

- ADDITIONA INFORMATION

Language- English (Fluent) , Amharic

Skills - Communication, Teamwork, Problem solving, Patience, Adaptability, Attention to detail, Crtical Thinking

RECOMMENDATIONS

Dr. Bewketu Abebe

Assistant Professor of Pathology, Head of Pathology Department University Of Gonder , Ethiopia

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Dr. Mequanent Tiruneh

Assistant Professor of Surgery University Of Gonder , Ethiopia

Email Tassew.mequa143@gmail.com **Phone** (+251) 936743164

Dr. Dawit Kassahun

Assistant Professor of Gynecology and Obstetrics, Gynecologic Oncologist, **Phone** (+251) 936743164