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Risk stratification model in predicting mortality among adult cardiac surgery patients and its application in Indonesia: A review

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Abstract

Risk stratification models have become an important tool for predicting mortality among adult cardiac surgery patients. These models provide clinicians with valuable information to guide decision-making and improve patient outcomes. While various models have been developed and validated globally, their application in the Indonesian context has gained attention.

This study aims to examine the use of risk stratification models in predicting mortality among adult cardiac surgery patients in Indonesia. Several validated models, including EuroSCORE II, have shown good calibration and discriminative ability in the Indonesian population. EuroSCORE II, in particular, stands out for its efficient use of variables and the ability to predict mortality across different types of cardiac surgeries.

However, it is essential to consider other risk stratification models that offer specific strengths and applications relevant to the Indonesian setting. The implementation of these models can greatly assist clinicians in assessing surgical risks, making informed decisions, and optimizing patient care.

To further enhance the application of risk stratification models in Indonesia, additional validation studies specific to the Indonesian population are warranted. Furthermore, the establishment of a comprehensive patient database containing cardiac surgery information in Indonesia would facilitate ongoing research and improve the accuracy of model validation.

In conclusion, risk stratification models play a crucial role in predicting mortality among adult cardiac surgery patients. Their application in Indonesia shows promising results, particularly with EuroSCORE II. However, further research, validation, and the development of a comprehensive patient database are needed to maximize the effectiveness and applicability of these models in the Indonesian context.

Keywords: Risk Stratification Model; Cardiac Surgery; Mortality; Indonesia; EuroSCORE

1. Introduction

Cardiovascular disease is one of the leading causes of global mortality, with an estimated 17.9 million deaths in 2019[1]. In Indonesia, approximately 1.5% or around 2,650,340 individuals are believed to suffer from coronary heart disease based on medical diagnoses and/or symptoms[2,3]. Therefore, appropriate management for patients with cardiovascular disease is of utmost importance. One of the treatment modalities employed in the management of cardiovascular disease is cardiac surgery.

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One of the preparations required prior to surgery is determining the ideal operation and management for the patient[4]. A risk stratification model has been developed to assist in assessing risk factors in patients, enabling the prediction of surgical outcomes. The risk stratification model aids in predicting the results of the surgery and improving patient quality. Another underlying factor for the need to utilize a risk stratification model is to make the best decisions for the patients. Risk stratification is also essential in enhancing surgical success, quality analysis, and meaningful outcomes for patients[5].

Risk stratification models have been widely used to assess patients' risk prior to undergoing cardiac surgery. Several risk stratification models have been developed, such as the Parsonnet Score, which was one of the first risk stratification models used in the 1980s. Since then, these models have evolved in line with the advancement of diagnostic technology and interventions in patients[5,6].

The development of risk stratification models has improved the prediction of patient outcomes. Initially, these models focused solely on predicting preoperative patient mortality. However, morbidity occurs more frequently than mortality, and scoring systems that only predict mortality are inadequate in predicting potential morbidity[4]. Therefore, several risk stratification models, such as the STS Score, have been developed to significantly enhance preoperative patient predictions by incorporating various morbidity predictions into the calculations [4,6].

Various patient risk factors related to cardiac surgery are calculated collectively as considerations for risk stratification models to determine the level of risk for patients undergoing surgery. Each risk stratification model incorporates different risk factors to calculate the patient's risk level. Sometimes, simpler models are easier to use but can only predict patient mortality. On the other hand, more complex models are better, but limitations arise due to the complexity, making the calculations less productive [7].

The objective of this article is to provide a review of frequently used risk stratification models in cardiac surgery and offer insights into their utilization in Indonesia.

2. Ideal Risk Stratification Model

Several models have been developed to assess the predictive ability of cardiac surgery in patients. The ability of a model in risk stratification can be evaluated based on its calibration and discrimination. The Hosmer-Lemeshow test is one of the most commonly used methods to assess and analyze the discrimination ability of a model by comparing the expected and observed ratios. This test indicates that a model has poor calibration if $P > 0.05$ [5,8]. On the other hand, Receiver Operating Characteristic (ROC) analysis is commonly used to assess sensitivity and specificity based on the Area Under the Curve (AUC) [5,6,9]. A model with a wider AUC indicates better discrimination ability [10].

The ideal risk stratification model is one that can predict future risks, allowing clinicians to provide the best management, accurate triage, and facilitating performance comparisons among surgeons and various surgical centers to ensure good quality control [4–6]. Furthermore, a good risk stratification model should incorporate the latest capabilities and be suitable for advanced surgical techniques while being applicable to the entire population [5,6]. However, the comprehensive coverage of a diverse population with varying characteristics and risk factors poses limitations on the preoperative predictive ability of risk stratification models across the entire population. A good risk stratification model should also possess good predictive capabilities for both mortality and morbidity to be considered ideal [5,11]. It is important for a good risk stratification model to strike a balance between the number of risk factors included in the scoring system to maintain predictive potential. A risk stratification model with a small number of risk factors and high predictive ability is necessary for easy utilization of the scoring system [4,5,11]. In addition, a good risk stratification model is one that can be applied to specific populations, considering economic aspects, facilities, and ease of implementation. If there are multiple models with similar capabilities, the most cost-effective and simple model will be the preferred choice.

In conclusion, the ideal risk stratification model is the simplest and most cost-effective model that can predict both mortality and morbidity accurately in a specific population. Therefore, a good model may vary for each population. This not only applies to the aspect of model validation across different populations (considering that each population has unique characteristics), but also to the aspect of ease and availability of facilities in each population or region.

3. Various Types of Risk Stratification Models in Cardiac Surgery

There are still significant differences in the performance of risk stratification models across populations. For instance, the use of the STS Score is widely accepted in the United States due to its high effectiveness in determining both short-term and long-term mortality risk[12]. On the other hand, EuroSCORE is widely utilized in Europe, North America, and Asia for risk assessment and improving surgical quality[13]. This indicates that there is still no risk stratification model that can be universally applied to diverse populations. Furthermore, the use of risk stratification models is not the sole determining factor for establishing optimal management. Other factors such as physician discussions, interprofessional collaborations, patient conditions, and patient decisions also play a role in predicting and implementing the best possible treatment approach for patients.

Table 1 Summary of Cardiac Surgery Risk-Stratification Models

Risk Stratification Model	Region	Year of Data Collection	Risk Variables	Number of Patients (Center)
ACEF [7]	Italy	2001-2003	3	4.557 (1)
ACEF II [14]	Italy	2010-2016	5	7.011 (1)
Ambler Score [15]	UK	1995-2000	13	16.679 (From Database)
EuroSCORE [16]	Europe (8 Country)	1995	17	13.302 (128)
EuroSCORE II [13]	Europe (43 Country)	2010	17	22.831 (154)
STS Score [17]	USA	2011-2014	65	*Isolated* CABG: 439.092 *valve surgery*: 150.150 *valve +* CABG: 81.588 (From Database)

ACEF = Age, Creatinine, and Ejection Fraction, EuroSCORE = European System for Cardiac Operative Risk Evaluation, STS = Society of Thoracic Surgeons, UK = United Kingdom, USA = United States of America, CABG = Coronary Artery Bypass Graft.

3.1. Risk Stratification Model

3.1.1. ACEF

ACEF (Age, Creatinine, and Ejection Fraction) is one of the risk stratification models in cardiac surgery that has been developed in recent years. It incorporates three risk factors: age, serum creatinine, and patient's ejection fraction [7,18]. The ACEF Score is also included in the guidelines for myocardial revascularization by the European Society of Cardiology and the Association for Cardio-Thoracic Surgery as a risk stratification model for both surgical and percutaneous coronary interventions (PCI) [14]. The ACEF Score is calculated using the formula age (in years) / ejection fraction (%) + 1 if creatinine is greater than 2 mg/dl. Furthermore, the ACEF Score can also be utilized to predict risk in patients undergoing PCI, in addition to elective cardiac surgeries [7,19].

The ACEF Score was initially developed at a hospital center in Italy. A total of 4,557 patients were included in the scoring development phase, covering the period from 2001 to 2003. Subsequently, data were collected from the same hospital center between 2004 and 2007, involving 4,091 patients for validation purposes. The ACEF Score has several limitations, including issues of multicollinearity and the potential for changing definitions of risk factors over time. Additionally, the ACEF Score can only be used for elective surgeries [7]. Therefore, a newer model called ACEF II Risk Score was developed as an improvement upon the ACEF Score. ACEF II utilized data from 7,011 patients for its development at one institution and 1,687 patients for validation at a different institution. ACEF II incorporates five risk factors in determining the patient's risk level, with the formula being age (in years) / ejection fraction (%). Additional points are assigned for specific conditions such as serum creatinine > 2 mg/dl (2 points), emergency status of the surgery (3 points), and anemia (Hematocrit/HCT < 36%, 0.2 points for each HCT point below 36%). Furthermore, ACEF II demonstrates better calibration and discrimination abilities compared to the ACEF Score [14].

The validation of ACEF Score usage in Indonesia has been discussed in several previous studies. These studies have shown that the ACEF Score exhibits poor calibration with an HL test value of $P < 0.001$. Furthermore, the discriminative ability of the ACEF Score is also inadequate, with an AUC value of 0.638 (95% CI: 0.561-0.718) [20]. However, based on other research, the ACEF Score demonstrates good predictive ability for Major Adverse Cardiovascular Events (MACE) such as mortality, acute heart failure, cardiogenic shock, and malignant arrhythmia in patients with ST-elevation

myocardial infarction (STEMI). The AUC value in that study was reported as 0.850 (95% CI: 0.775-0.925) [21]. Another study in Indonesia revealed that the ACEF Score also performs well in predicting MACE in patients with acute coronary syndrome, with an AUC value of 0.8 (95% CI: 0.6-0.98) [22].

3.1.2. Ambler Score

The Ambler Cardiac Risk Score is one of the risk stratification models developed to predict the likelihood of patient mortality, particularly in heart valve surgery [15,23]. The Ambler Score was developed in the United Kingdom in 2005 [15,24]. It utilizes data collected from April 1995 to March 2003. Patient data was obtained from the database of the Society of Cardiothoracic Surgeons of Great Britain and Ireland (SCTS), with the inclusion criteria of patients undergoing aortic and/or mitral valve surgery [10,15]. The data from the first five years (n = 16,679) were used to develop the model, while the subsequent year's data (n = 16,160) were used for model validation [15].

The Ambler Score utilizes several preoperative risk factors as variables to calculate the prediction of patient mortality. These risk factors include age, gender, body mass index, number and position of implanted heart valves, hypertension, diabetes, renal failure, ejection fraction, arrhythmia, operative status, operative sequence, additional CABG surgery, and additional tricuspid valve surgery [15,23].

In Indonesia, there was a study that conducted validation of the Ambler Score. The study utilized data from 416 patients from November 2018 to December 2019. The results of the study indicated that the Ambler Score had good calibration (P = 0.233) and demonstrated good discriminative ability with an AUC value of 0.748 (95% CI: 0.665-0.841) [25].

3.1.3. STS Score

The STS Score is one of the most commonly used risk stratification models. The information needed for its development comes from The Society of Thoracic Surgeons National Cardiac Database (STS NCD), which was established in 1989 and is the largest clinical database of its kind. The objective of developing the STS model is to enhance program quality, improve patient care, and enhance patient outcomes [4,17].

The STS Score is a risk stratification model consisting of up to 30 variables that predict short-term and long-term mortality and morbidity following cardiac surgery based on demographic, structural cardiac, and biochemical characteristics. The STS Score calculator is a tool to determine the risk of death from cardiac surgery in adults. Examples of surgical procedures include Isolated CABG, Isolated MVR, Isolated AVR, AVR+CABG, MVR+CABG, MV repair, and MV repair + CABG [5,26].

The STS Score model is used to predict mortality and morbidity in individuals, such as sternal wound infection, ventilation longer than 24 hours, renal failure, and permanent stroke. This is one of the main advantages of the STS Score. Another advantage of the STS Score is its widespread validation, as data is collected extensively in the United States, and it can predict medium-term and long-term outcomes [5]. Additionally, the latest STS risk model has been developed based on contemporary data available to optimize accuracy [27].

In Indonesia, several validations have been conducted on the STS Score. A study at RSUP Adam Malik Medan showed that the STS Score has good discriminatory ability with a value of 0.852 (95% CI: 0.760-0.9) for mortality and morbidity outcomes [28]. Furthermore, according to another study, the STS Score can effectively predict mortality and has a comparable performance to the EuroSCORE [29].

3.1.4. EuroSCORE

EuroSCORE is one of the risk stratification models used to assess the quality of cardiac surgery. EuroSCORE I was designed in 1999 and was once considered one of the gold standards in risk stratification models [4,16]. EuroSCORE I was developed to establish an assessment system for predicting mortality in cardiac surgery patients in Europe. It was derived from data collected in 8 European countries from September to December 1995, involving 128 centers [4]. The dataset included a total of 13,302 patients in Europe [16].

There are two methods for calculating EuroSCORE prediction outcomes: the Logistic EuroSCORE and the Additive EuroSCORE risk stratification models. The original model, the Additive model, incorporates specific weighted risk factors that, when combined, provide a prediction of mortality following cardiac surgery. On the other hand, the Logistic model was developed due to the potential for underprediction in high-risk patients. The Logistic model is calculated through a complex process and is not easily implemented in the form of a calculator [4,5].

EuroSCORE II is a development and update of EuroSCORE I, aimed at maintaining and optimizing its usefulness in predicting cardiac surgery outcomes. This development and update were conducted due to the issue of overprediction in the previous EuroSCORE model [13,30]. The data for EuroSCORE II were collected from 43 countries and 154 centers, encompassing a total of 22,381 patients who underwent cardiac surgery [13].

EuroSCORE II is considered one of the best and most widely used risk stratification systems [6]. It offers several advantages, including extensive validation, the absence of multiple models such as Logistic and Additive, and validation in aortic surgeries. EuroSCORE is also recognized as superior to other risk stratification models, particularly in terms of its discriminative ability [5,31].

In Indonesia, validation of EuroSCORE II for patient mortality has shown that the model exhibits good calibration (P = 0.065) and excellent discriminative ability with an AUC value of 0.763 (95% CI: 0.660-0.867) [20]. Another study has indicated that EuroSCORE II has poor calibration (P < 0.05) but still demonstrates satisfactory discriminative ability with an AUC of 0.71 (95% CI: 0.65-0.77) [32]. Meanwhile, research conducted in Surabaya has demonstrated that EuroSCORE II exhibits good calibration (P = 0.55) and excellent discriminative ability with an AUC value of 0.85 [33].

Table 2 Summary of Cardiac Surgery Risk-Stratification Models in Indonesia

Risk Stratification Model	Study	Year of Data Collection	Number of Patients	Region
ACEF	(Widyastuti, 2023)[20]	2006-2011	1883	Data not available (1 center)
	(Fauzan, 2021)[21]	2020	112	Medan (1 center)
	(Ardining, 2021)[22]	2020	71	Kediri (1 center)
Ambler Score	(Asmuni, 2021)[25]	2018-2019	416	Data not available
EuroSCORE II	(Widyastuti, 2023)[20]	2006-2011	1883	Data not available (1 center)
	(Kurniawaty, 2022)[32]	2016-2020	767	Semarang, Samarinda, Yogyakarta (3 centers)
	(Sembiring, 2021)[33]	2016-2018	213	Surabaya (1 center)
	(Asmuni 2021)[25]	2018-2019	416	Data not available
	(Fauzan A, 2021)[34]	2019-2020	75	Medan (1 center)
STS Score	(Dillon, 2021)[28]	2019-2020	75	Medan (1 center)

ACEF = Age, Creatinine, and Ejection Fraction, EuroSCORE = European System for Cardiac Operative Risk Evaluation, STS = Society of Thoracic Surgeons

4. Comparison between Risk Stratification Models

Research related to risk stratification models has been developed in various regions with specific populations. This has resulted in differences in population characteristics among regions, leading to the creation of risk stratification models tailored to the specific characteristics of each area. Consequently, not every risk stratification model may be suitable for use in other regions, and validation is necessary to demonstrate the discriminative power and calibration in new populations. Several studies have conducted validation on various risk stratification models in specific populations, and there are even studies comparing different risk stratification models. These endeavors enrich our knowledge and assist clinicians in utilizing the most appropriate risk stratification model for their respective regions. Risk stratification models play a crucial role in predicting outcomes and assessing the risk associated with various medical procedures. In this context, several risk stratification models have been developed and utilized for different clinical scenarios. This section aims to provide a comparison between some commonly used risk stratification models.

STS Score and EuroSCORE are risk stratification models used to assess the magnitude of risk associated with cardiac surgery procedures. Based on previous studies, STS Score and EuroSCORE are commonly used as risk stratification models [6]. These two models are among the most frequently utilized worldwide. In the United States, STS Score is one of the commonly employed risk stratification models. STS Score is considered one of the best models in America because it is developed using data from The Society of Thoracic Surgeons National Cardiac Database (STS NCD), which aligns

with the American population. Furthermore, the use of STS Score is widely accepted in the United States due to its high effectiveness in determining both short-term and long-term mortality risks [12].

On the other hand, EuroSCORE utilizes data from populations of European countries to develop its risk stratification model, making it particularly suitable for use in Europe. This aligns with several previous studies that have compared the two models. According to a study conducted in America, STS Score outperforms EuroSCORE II in terms of calibration and discriminative ability [35]. According to another study conducted in Turkey, EuroSCORE II and STS Score are equally effective in predicting patient mortality. However, EuroSCORE II slightly outperforms STS Score with respective discriminative values of 0.72 and 0.62 [36]. In contrast, a different study in France found that EuroSCORE II exhibits superior capabilities to STS Score across all age groups [37]. Additionally, a study in the UK concluded that EuroSCORE II is better than STS Score in predicting patient mortality in adult cardiac surgery [38].

Several studies have also compared various risk stratification models in specific populations. A study in Japan compared four risk stratification models, including EuroSCORE II, STS Score, Japan Score, and Ambler Score, in patients undergoing aortic valve replacement for aortic stenosis. The results of the study showed that EuroSCORE II and Japan Score demonstrated good calibration. However, the discriminative abilities of the four risk stratification models were found to be nearly similar [24]. A study conducted in China also compared six risk stratification models, including EuroSCORE II, Ambler Score, NYC risk score, and STS Score, in a population of Chinese patients undergoing cardiac valve surgery. The study showed that EuroSCORE II, VA score, NNE score, and NYC score underpredicted the risks, Ambler score overpredicted the risks, while STS Score demonstrated good calibration. Additionally, among the six models, STS Score exhibited the highest discriminative ability, indicating its superior performance [39]. A multicenter study in China also compared four risk stratification models, namely EuroSCORE II, Ambler score, NYC risk score, and STS score, in patients undergoing heart valve surgery. The results of the study indicated that STS Score and EuroSCORE II provided more accurate predictions compared to Ambler score and NYC score. However, all four risk stratification models were found to be inadequate in predicting patients undergoing multiple valve surgery [10].

Another study also discussed the comparison between ACEF score and several other risk stratification models. A study conducted in 8 cardiac surgery centers in Italy compared ACEF II with EuroSCORE II in cardiac surgery patients. The results showed that EuroSCORE II was found to be more accurate compared to ACEF II. However, ACEF II was easier and simpler to use in patients undergoing coronary artery bypass sraft surgery compared to the results obtained from EuroSCORE II [40].A study in Germany demonstrated that STS Score outperforms ACEF II and EuroSCORE II in predicting mortality in patients undergoing Isolated Conventional or Transcatheter Aortic Valve Replacement surgery [41]. Another study also indicated that EuroSCORE II is superior to ACEF and STS Score in patients undergoing isolated aortic valve surgery [42]. Another study compared the ACEF score and EuroSCORE II in patients undergoing elective and non-elective cardiac surgery. The results of this study showed that EuroSCORE II outperforms the ACEF score in predicting mortality [43]. Furthermore, based on a meta-analysis of previous studies, EuroSCORE II and STS Score have similar abilities in predicting mortality and outperform the ACEF score [44].

Each risk stratification model mentioned above has its strengths and limitations, and their performance may vary depending on the specific patient population and clinical context. Healthcare professionals should carefully consider these factors when selecting an appropriate risk stratification model for accurate risk assessment and informed decision-making.

5. The Implementation of Risk Stratification Models in Indonesia

In Indonesia, the implementation of risk stratification models has gained attention in the field of healthcare. These models are designed to assess the risk associated with various medical procedures, particularly in the context of cardiac surgeries. The use of risk stratification models allows healthcare professionals to evaluate the potential risks and outcomes of surgical interventions on individual patients.

The application of risk stratification models in Indonesia has been driven by the need for more accurate preoperative risk assessment and improved patient outcomes. These models, such as EuroSCORE and STS Score, have been widely recognized and utilized in many countries, including Indonesia. They provide a standardized approach to evaluate the risk factors associated with cardiac surgeries and help in making informed decisions regarding patient management.

Risk stratification models are a crucial component in performing cardiac surgeries in Indonesia. These models serve as a framework to facilitate clinicians in making informed decisions during cardiac surgical procedures. Therefore, an ideal risk stratification model is necessary to be effectively utilized in the Indonesian population.

In Indonesia, there have been several studies comparing different risk stratification models. One study compared EuroSCORE II and ACEF Score, revealing that EuroSCORE II outperforms ACEF Score in terms of discriminative ability, despite both scores demonstrating poor calibration [20]. Another study compared Ambler Score and EuroSCORE II. In this study, both EuroSCORE II and Ambler Score exhibited good calibration and discriminative ability, but EuroSCORE II demonstrated superior discriminative ability compared to Ambler Score [25]. Another validated risk stratification models can be found in Table 3.

Based on validated models in Indonesia, ACEF Score is considered the simplest model to implement. ACEF Score only utilizes 3 variables for prediction, while ACEF II requires only 5 variables. However, ACEF Score has shown poor calibration in some studies, despite its good discriminative ability. Additionally, ACEF II has not been validated in the Indonesian population. Ambler Score is another good risk stratification model in terms of calibration and discriminative ability in the Indonesian population. However, Ambler Score can only predict mortality in patients undergoing valve surgery.

Based on previous studies, STS Score and EuroSCORE are commonly used as risk stratification models [6]. In Indonesia, EuroSCORE II has been validated more extensively compared to STS Score. Both models have shown good calibration and discriminative ability in several studies. However, EuroSCORE II and STS Score have their strengths and limitations in their application. EuroSCORE II has the advantage of requiring fewer variables to predict mortality compared to STS Score. This feature makes EuroSCORE II more effective than STS Score or other risk stratification models. However, EuroSCORE II is primarily useful for predicting mortality, whereas STS Score excels in predicting postoperative patient morbidity.

Several risk stratification models have been validated in various regions of Indonesia. Some risk stratification models have shown good calibration and discriminative ability in predicting cardiovascular events and mortality in adult cardiac surgery patients. These risk stratification models can assist in the implementation of cardiac surgery operations and therefore should be applied in Indonesia.

The implementation of these models in Indonesia has faced certain challenges. One of the key challenges is the availability and accessibility of data required for accurate risk assessment. The local adaptation of these models to suit the Indonesian population's characteristics and risk profiles is also important for their effective implementation. Additionally, ensuring proper training and education for healthcare professionals regarding the use of risk stratification models is crucial to their successful implementation. Furthermore, Indonesia does not yet have a validated risk stratification model for the entire Indonesian population. Therefore, Indonesia needs a database of adult cardiac surgery patients in Indonesia.

Table 3 Summary of the Calibration and Discrimination of the Risk Scores

Risk Stratification Model	Study	Discrimination (AUROC)	Calibration (Hosmer-Lemeshow Test)
ACEF	(Widyastuti, 2023)[20]	0.638 (95% CI: 0.561-0.718)	P < 0.001
	(Fauzan, 2021)[21]	0.850 (95% CI: 0.775-0.952)	Data not available
	(Ardining, 2021)[22]	0.8 (95% CI: 0.6-0.98)	Data not available
Ambler Score	(Asmuni, 2021)[25]	0.748 (95% CI: 0.655-0.841)	P = 0.233
EuroSCORE II	(Widyastuti, 2023)[20]	0.774 (95% CI: 0.714-0.834)	P < 0.001
	(Kurniawaty, 2022)[32]	0.71 (95% CI: 0.65-0.77)	P < 0.001
	(Sembiring, 2021)[33]	0.85 (95% CI: 0.77-0.92)	P = 0.55
	(Asmuni 2021)[25]	0.763 (95% CI: 0.660-0.867)	P = 0.065
	(Fauzan A, 2021)[34]	0.976 (95% CI: 0.944-1.00)	Data not available
STS Score	(Dillon, 2021)[28]	0.852 (95% CI: 0.760-0.900)	Data not available

ACEF = Age, Creatinine, and Ejection Fraction, EuroSCORE = European System for Cardiac Operative Risk Evaluation, STS = Society of Thoracic Surgeons.

Despite these challenges, the implementation of risk stratification models in Indonesia holds great potential in improving patient care and surgical outcomes. It enables healthcare providers to identify high-risk patients, tailor treatment plans accordingly, and enhance overall patient safety. Continued research, validation, and refinement of these models based on local data will further enhance their utility in the Indonesian healthcare setting.

6. Conclusion

In conclusion, risk stratification models play a crucial role in predicting mortality among adult cardiac surgery patients. Several risk stratification models have been developed for adult cardiac surgery. Some models have been validated in Indonesia and have shown good predictive ability for mortality or cardiovascular events in adult cardiac surgery patients. However, EuroSCORE II has demonstrated good calibration and discriminative ability in the Indonesian population. Furthermore, EuroSCORE II is highly effective as it only requires 17 variables and can predict mortality for various types of heart surgeries. On the other hand, other risk stratification models can also be used based on their strengths and the specific needs of clinicians. Therefore, risk stratification models need to be implemented in cardiac surgery to assist in the management of adult heart surgeries and provide the best outcomes for doctors and patients, emphasizing the need to apply the best model in Indonesia.

This study only relied on a review of validated models from several locations in Indonesia. Therefore, further validation is necessary for the Indonesian population to determine the most suitable model, and a database of cardiac surgery patients in Indonesia should be established.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no known conflict for this work.

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