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SYSTEMATIC REVIEW **Open Access**

Incidence and predictors of perioperative mortality in Ethiopia: a systematic review and meta-analysis

Tikuneh Yetneberk[1*], Diriba Teshome[1], Abebe Tiruneh[1], Yohannes A. Dersesh[2], Nega Getachew[1], Moges Gelaw[1] and Meseret Firde[1]

Abstract

Introduction The Lancet Commission on Global Surgery highlights perioperative mortality rate (POMR) as a key indicator of a nation's surgical system effectiveness. While POMR is often measured in high-income countries, it is less studied in low- and middle-income countries (LMICs). This study aims to assess the POMR and its predictors in Ethiopia.

Methods We conducted a thorough literature search across PubMed/MEDLINE, Embase, Web of Science, Scopus, and Google Scholar for studies from Ethiopia between 2019 and 2023 reporting POMR for various surgical procedures. Data were extracted in duplicate from eligible studies. We used random-effects meta-analysis to pool estimates of POMR and its predictors.

Results The meta-analysis revealed a POMR of 5.36%. Identified predictors of perioperative mortality in Ethiopia included older age, comorbidities, ICU admission, and an ASA physical status classification of III or higher and emergency surgeries.

Conclusion Ethiopia's perioperative mortality rate is significantly high. Improving surgical care quality and safety, along with expanding access to surgical services, is crucial for bettering surgical outcomes in the country.

Keywords Perioperative mortality, Death, Ethiopia, Surgery, Anesthesia

Introduction

Surgery is a cornerstone of human health, yet access to safe surgical care remains matter of global inequity. Five billion people worldwide, nearly two-thirds of humanity are deprived of this basic right, with 94% of the burden falling on low- and middle-income countries (LMICs) where nine out of ten individuals cannot access even the most essential surgical services [1]. This crisis is not just a statistic; it reflects the lived reality of millions who suffer needlessly from treatable conditions. Surgery is not a luxury, it is fundamental to universal health coverage, tackling nearly a third of the global disease burden, from injuries to cancers [2, 3]. Despite 313 million surgeries performed annually, 4.2 million people die within 30 days post-surgery, representing roughly 7.7% of global deaths [4]. Progress in global health has been uneven, with increased mortality and morbidity from surgical conditions in poorer nations [1, 5]. In LMICs, the promise of safe surgery and anesthesia remains unfulfilled. Decades of underinvestment have left systems stagnant

*Correspondence:
Tikuneh Yetneberk
tikusosi@gmail.com
[1]Department of Anesthesia, Debre Tabor University, Debre Tabor, Ethiopia
[2]School of Medicine, Debre Tabor University, Debre Tabor, Ethiopia

or in decline, with perioperative mortality rates (POMR), deaths during or shortly after surgery, serving as enduring measure of failure [1, 6]. The WHO defines POMR as deaths on the day of surgery or within 30 days post-procedure [7].

The Lancet Commission on Global Surgery emphasizes POMR as a critical measure of a surgical system's strength [1]. However, POMR studies are scarce in resource-limited settings [1]. In developing countries, major surgical procedures often have a fatality rate of 5–10%, with some Sub-Saharan African regions reporting rates as high as one in 150 for general anesthesia [8]. The prevalence of urgent and essential surgical conditions in Sub-Saharan Africa contrasts sharply with developed countries, in contrast, developed nations primarily perform elective surgeries [9]. A multicenter study in Southeast Nigeria reported higher POMR in males, those with delayed presentation, high American Society of Anesthesiologists (ASA) scores, and emergency procedures [9].

A global study highlighted barriers to safe surgery in Africa and proposed measures to enhance surgical quality [10]. Africa's struggle for surgical equity is emblematic. The African Surgical Outcomes Study (ASOS) revealed postoperative mortality rates double the global average, a paradox where fewer complications still lead to more deaths, a reality Ethiopia knows too well [10]. As Africa's second-most populous nation, Ethiopia faces profound healthcare challenges: shortages of skilled workers, sparse infrastructure, and a tiered system strained to serve its people [11]. The Ethiopian healthcare system is structured into three tiers: primary, secondary, and tertiary [12]. This review aimed to assess the perioperative mortality rate (POMR) in Ethiopia and identify its contributing factors.

Methods

We retrieved all available published and unpublished studies on the prevalence and predictors of perioperative mortality in Ethiopia from their respective databases, covering the period up to December 20, 2023. The search strategy was collaboratively developed by two authors (TY and MF) and a research librarian with expertise in systematic reviews. Our systematic search focused on medical literature reporting perioperative mortality or death rates.

We conducted searches across Google Scholar, Web of Science, EMBASE, PubMed/MEDLINE, and Scopus from their inception to December 20, 2023. The search terms used included: perioperative mortality, perioperative death, surgery, associated factors, determinants, predictors, and Ethiopia. Additionally, we reviewed reference lists of selected studies to identify additional relevant research. Search strategies were constructed using MeSH (Medical Subject Headings) terms and Boolean operators. Duplicate entries were removed using EndNote version eight. This systematic review complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [13] and the Joanna Briggs Institute's (JBI) Manual for Evidence Synthesis [14].

Inclusion criteria

Observational studies that met the 'Participants-Exposure of Interest- Outcomes' (PEO) criteria were included in the review. Eligible studies had to be full-text, observational, and focused on perioperative mortality, with publications in English. Studies that did not provide sufficient outcome data were excluded. The primary outcome of interest was the perioperative mortality rate within 30 days of surgery, which was categorized based on sample size (< 600 vs. ≥600). The secondary outcome was the identification of predictors of perioperative mortality.

Data extraction

Two investigators (TY and DT) independently and in duplicate screened the titles and abstracts to identify relevant articles. Full-text articles of studies considered relevant were also reviewed independently and in duplicate by TY and DT to assess whether they met the inclusion criteria. Any disagreements were resolved by a third author (MF). Data extraction from eligible studies was performed in duplicate by TY and DT using an Excel sheet. Discrepancies in data extraction were addressed through discussion, with unresolved issues adjudicated by MF.

Assessment of study quality

The methodological quality of the included studies was evaluated by two independent reviewers (TY and DT) using the JBI Critical Appraisal Checklist for Prevalence Studies, which assesses nine domains [15]. The studies were categorized based on their methodological quality as good (seven or more 'yes' answers), fair (five or six 'yes' answers), or poor (fewer than five 'yes' answers). Only studies scoring more than 50% (at least five 'yes' answers) were included. Any discrepancies were resolved through discussion, with unresolved issues adjudicated by MF if needed.

Statistical analyses

Descriptive statistics, including numbers and percentages, were used to outline the characteristics and outcomes of the included studies. A random-effects meta- regression model employing the observed log-odds ratio was utilized to examine whether perioperative mortality rates significantly varied with sample size and study design. Analyses were conducted using Stata 17 software, with statistical significance set at $P < 0.05$. Data are presented with 95% confidence intervals (CIs). Perioperative mortality rates were categorized based on sample size (< 600 vs. ≥600). To explore differences in effect sizes across subgroups, a random-effects meta-regression model was employed, and odds ratios (ORs) with 95% CIs were computed using Stata 17. A P value of 0.05 was deemed statistically significant.

Sensitivity analyses

Sensitivity analyses were conducted for the primary outcome to evaluate the impact of each individual study on the overall estimate of perioperative mortality in.

Ethiopia. To assess publication bias and heterogeneity, Egger's test was employed. Statistical heterogeneity was evaluated through visual inspection of forest plots, as well as with the non- parametric Cochran's Q test ($P \leq 0.1$), and the I^2 statistic (with values > 40% indicating substantial heterogeneity) [16].

Results

Our search strategy resulted in 1,067 citations. After removing 412 duplicates, we screened the titles and abstracts, leading to the exclusion of an additional 591 studies that were not relevant. We then obtained 64 potentially relevant full-text articles for further review, of which eleven met the predefined inclusion criteria. The methodological quality of these eleven studies was evaluated, and all met our established quality standards for inclusion (see Table 1). Thus, this review incorporated eleven studies for analysis (see Fig. 1).

Characteristics of the included studies

The characteristics of the included studies are detailed in Table 2. The earliest study was published in 2020, while the most recent was from 2023. The studies were conducted across four regional states in Ethiopia: Amhara, Oromia, South Ethiopia, and Addis Ababa. The review encompassed data from 19,975 patients who underwent surgery and recorded 813 perioperative deaths. Among the studies, four (36.36%) were retrospective and seven (63.64%) were prospective. All studies reported perioperative mortality rates.

Meta-analyses

Perioperative mortality rates (primary study outcome)

Mortality rates from all identified studies and the pooled POMR estimate are shown in Fig. 2. The overall prevalence of perioperative mortality is illustrated in the forest plot (Fig. 2).

The national estimated pooled prevalence of perioperative mortality in Ethiopia was 5.36% (95% CI: 4.73 to 5.99; $P < 0.001$).

Subgroup analysis was carried out due to the observed heterogeneity (Fig. 3). The Cochrane I^2 statistic was 100% ($P < 0.001$), indicating substantial heterogeneity. Consequently, subgroup analysis was performed based on sample size. The findings revealed no statistically significant difference in the pooled prevalence of perioperative mortality between studies with sample sizes greater than 600, which was 4.52% (95% CI: 3.89 to 5.16), and those with sample sizes smaller than 600, which was 6.36% (95% CI: 5.17 to 7.55) (Fig. 4).

We performed a sensitivity analysis for the primary outcome to assess the influence of each study on the pooled estimate of perioperative mortality in Ethiopia. The analysis demonstrated that no individual study significantly affected the overall estimate (Fig. 5).

Factors associated with perioperative mortality in Ethiopia

In this meta-analysis, several factors were found to predict perioperative mortality in Ethiopia. These factors include older age, presence of comorbid conditions, and

Table 1 Critical appraisal of the results of perioperative mortality from included studies using the JBI prevalence critical appraisal checklist

	Target population	Sampling	Sample size	Description of participants and setting	Coverage of identified sample	Methods to identify outcome	Reliability in outcome measurement	Appropriate statistical analysis	Response rate	Total
Tekalign T et al., 2021[17]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Aliyi B et al.,2022[18]	Y	Y	Y	Y	Y	Y	Y	N	Y	**8/9**
Hailu et al.,2023[19]	Y	Y	Y	Y	Y	Y	Y	N	Y	**8/9**
Degu et al., 2023[20]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Tefera et al.,2020[21]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Endeshaw et al.,2023[22]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Tarekegn F et al.,2021[23]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Tarekegn F et al.,2020[24]	Y	Y	Y	Y	Y	Y	Y	N	Y	**8/9**
Endeshaw et al.,2023[6]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**
Firaol D. et al., 2020[25]	Y	Y	Y	Y	Y	Y	Y	N	Y	**8/9**
K.G. Gelebo et al., 2023[26]	Y	Y	Y	Y	Y	Y	Y	Y	Y	**9/9**

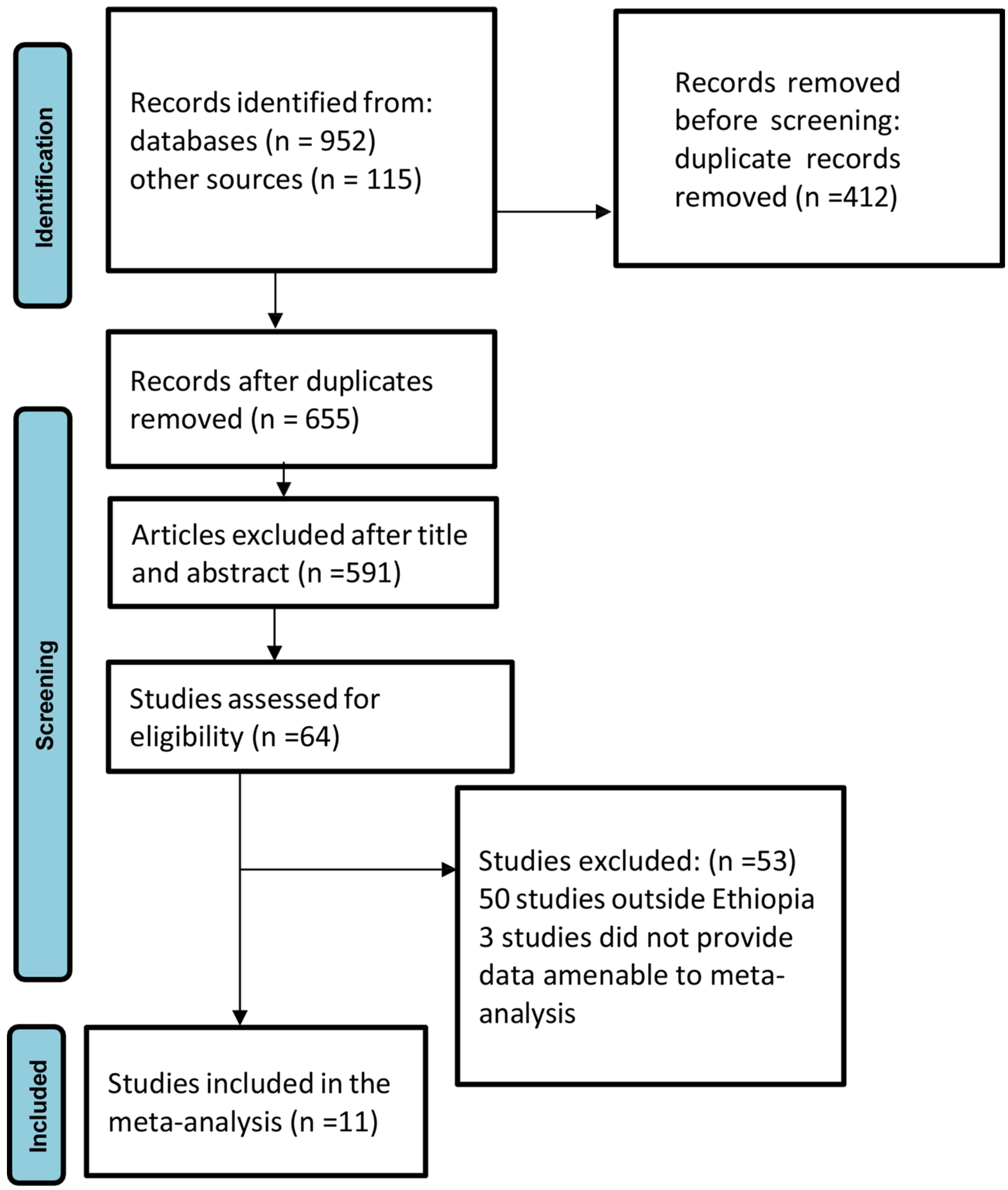

Fig. 1 The PRISMA flow diagram of the research identification, screening, and inclusion process

admission to an intensive care unit, an American Society of Anesthesiologists (ASA) physical status score of III or higher and emergency surgery. **Old Age**: Patients over 65 years old had a 3.9-fold increased risk of perioperative mortality compared to younger patients (AOR = 3.90; 95% CI: 2.13 to 5.67, $P < 0.02$) (Fig. 6). **Intensive Care Unit Admission**: Patients admitted to the intensive care unit after surgery were 6.32 times more likely to experience perioperative mortality than those not admitted (AOR = 6.32; 95% CI: 2.70 to 9.95, $P < 0.001$) (Fig. 7). **ASA Physical Status**: Patients with an ASA score greater than three had a 3.38-fold higher risk of perioperative mortality compared to those with a lower ASA score (AOR = 3.38; 95% CI: 1.70 to 5.06, $P < 0.001$) (Fig. 8). **Emergency Surgery**: The likelihood of perioperative mortality was 2.98 times greater for emergency surgeries compared to elective procedures (AOR = 2.94; 95% CI: 2.09 to 3.79, $P < 0.001$) (Fig. 9). **Comorbid Conditions**: Patients with comorbid conditions had a 5.6-fold increased likelihood of perioperative mortality compared to those without such conditions (AOR = 5.6; 95% CI: 2.22 to 8.99) (Fig. 10).

Discussion

In low-income countries with limited access to anesthesia and surgical facilities, perioperative mortality rate serves as a crucial indicator of care quality and the safety of surgical and anesthetic practices [27]. The aim of this study

Table 2 Description of the included studies on perioperative mortality rate in Ethiopia

Investigator and year of publication	Region/State	Study design	Sample size	Prevalence of POMR
Tekalign T et al., 2021[17]	Amhara	Retrospective cross sectional	384	5.7%
Aliyi B et al.,2022[18]	Oromia	Retrospective cross-sectional	512	7.42%
Hailu et al.,2023[19]	South Ethiopia	prospective cohort	191	8.4%
Degu et al., 2023[20]	Addis Ababa	Retrospective	3295	4.5%
Tefera et al.,2020[21]	Oromia	prospective cross sectional	269	4.8%
Endeshaw et al.,2023[22]	Amhara	prospective cohort	601	5.16%
Tarekegn F et al.,2021[23]	Amhara	prospective cross sectional	849	4.59%
Tarekegn F et al.,2020[24]	Amhara	Prospective cross sectional	885	5.78%
Endeshaw et al.,2023[6]	Amhara	Prospective cohort	2530	3.69%
Firaol D. et al., 2020[25]	Addis Ababa	Retrospective	10,259	3.41%
Gelebo et al.,2023[26]	South Ethiopia	prospective cohort	200	5.5%

POMR, Postoperative mortality rate

was to assess perioperative mortality rates and determine the associated risk factors in Ethiopia. A critical limitation in the current literature lies in the widespread absence of procedure-specific reporting for perioperative mortality rates (POMR) in Ethiopia. This gap profoundly undermines the clinical relevance of aggregated data, as mortality risks vary considerably across surgical procedures. Pooling such outcomes without stratifying by procedural risk introduces significant misrepresentations: high-risk surgeries may appear exaggeratedly safer, while low-risk procedures may appear disproportionately hazardous. These inaccuracies reduce pooled estimates misleading for benchmarking or guiding clinical practice, as specialty-specific targets cannot be meaningfully derived. Despite these challenges, we proceeded with calculating pooled POMR estimates in Ethiopia for two reasons. First, the majority of included studies did not report outcomes by procedure type, often aggregating data under vague terms like “major surgery” or omitting granular classifications entirely. Second, while we acknowledge significant heterogeneity across studies. we aimed to establish a provisional baseline for future research. We agree that without procedure-specific stratification, pooled POMR has limited direct clinical utility. However, our analysis serves as a catalyst for methodological reform, illustrating how inconsistent reporting practices hinder meaningful comparisons and advocating for universal adoption of procedure-specific outcome frameworks in surgical research. Our study found a perioperative mortality rate of 5.36% (95% CI: 4.73–5.99). This rate is lower compared to figures from Sub-Saharan Africa, such as 15.2% in Tanzania [28] and 17.2% in Togo [29]. However, it is higher than the rates reported in high- income countries [30–32]. This difference can be attributed to the fact that high-income nations generally have well-equipped and resourced perioperative care units, which include advanced medical technologies and

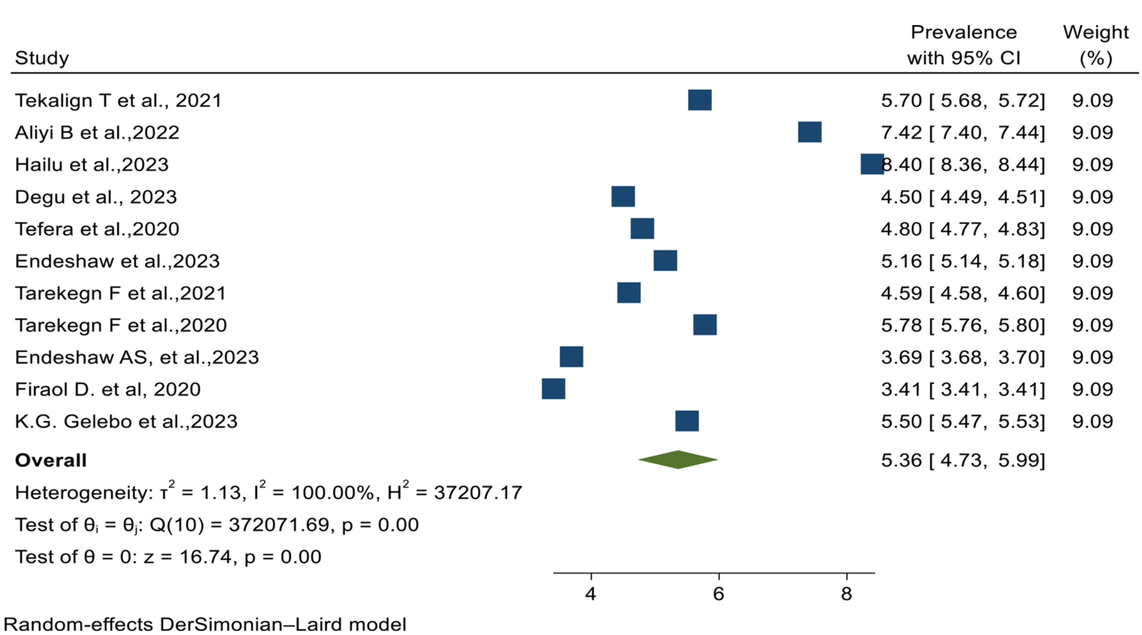

Fig. 2 Pooled analysis of the prevalence and random effects model of perioperative mortality

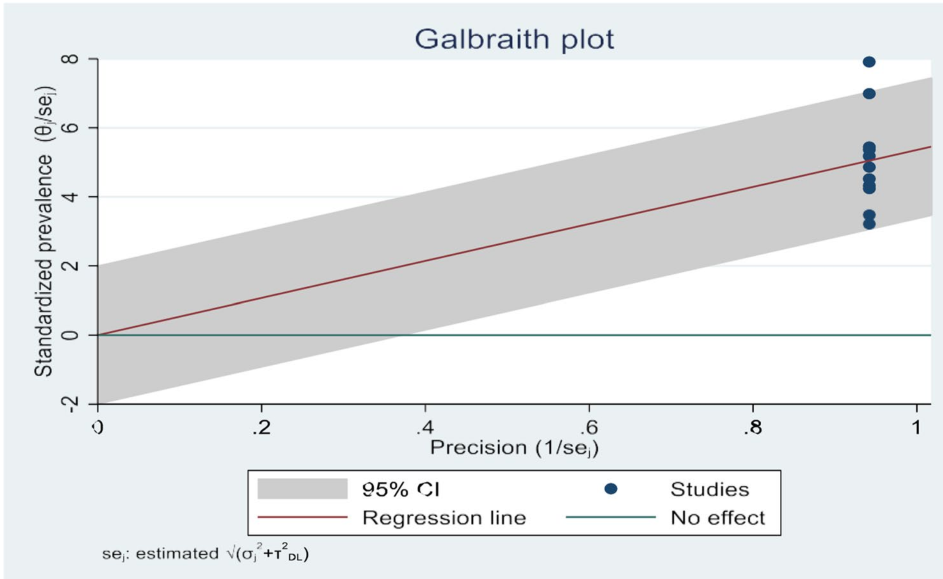

Fig. 3 Analysis of heterogeneity among included studies

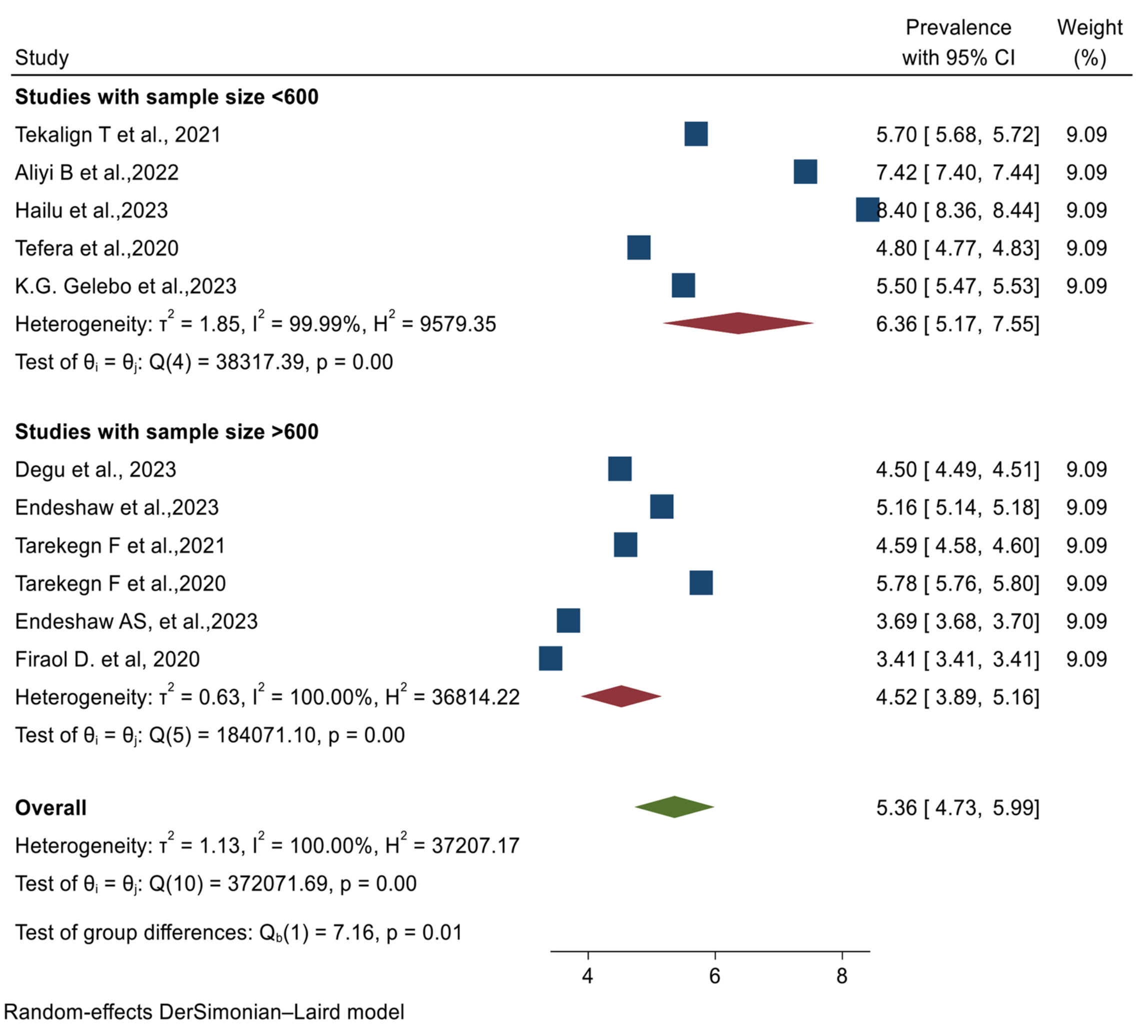

Fig. 4 Pooled analysis of the prevalence and random effects model of perioperative mortality by sample size

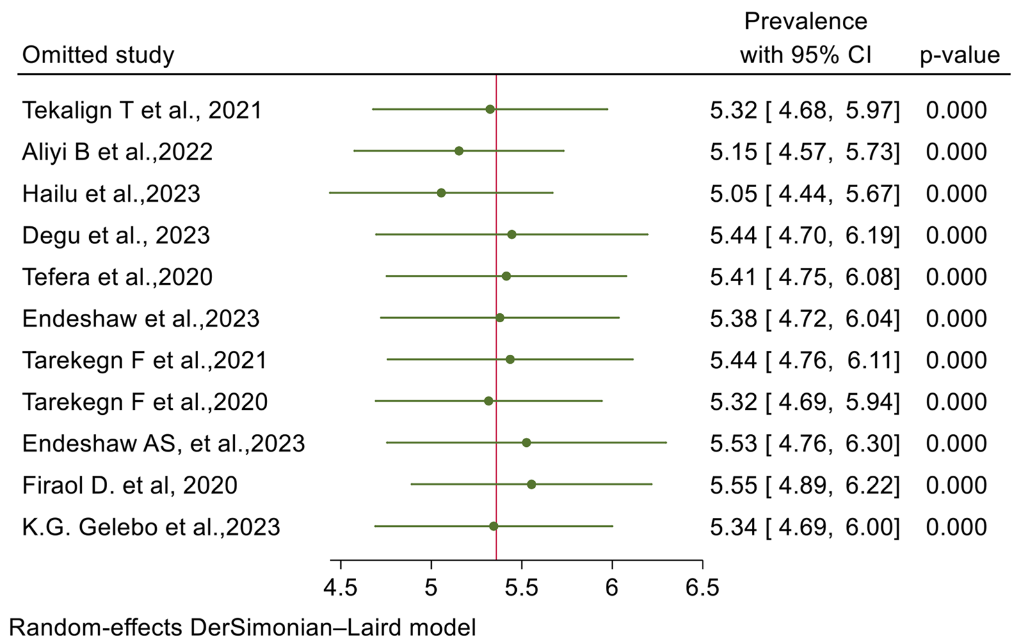

Fig. 5 Sensitivity analysis of the prevalence and random effects model of perioperative mortality

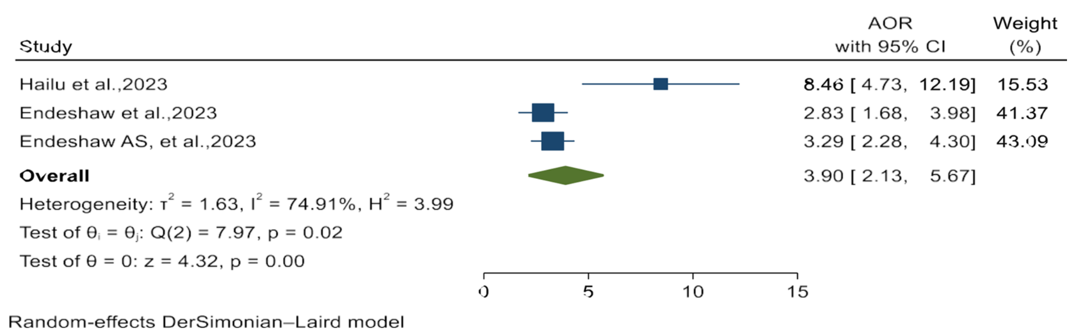

Fig. 6 The pooled effect of age on the perioperative mortality rate

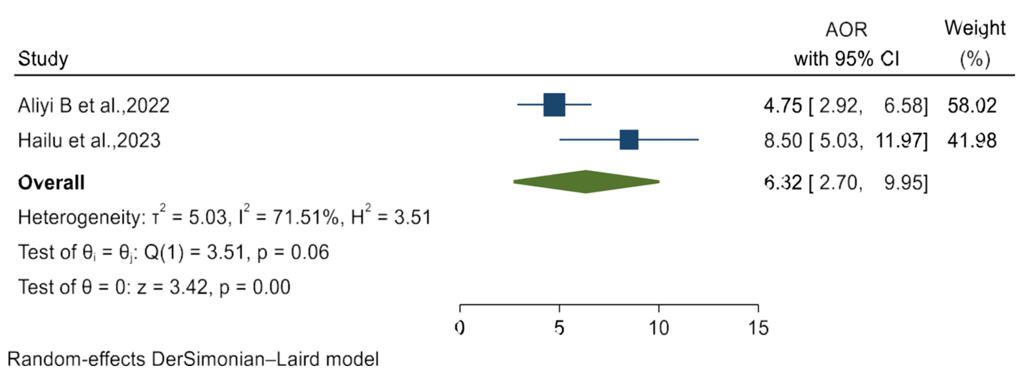

Fig. 7 The pooled effect of intensive care unit admission following surgery on the perioperative mortality rate

infrastructure. Additionally, these countries often benefit from the availability of highly trained specialists, such as anesthesiologists, surgeons, and perioperative care teams, who are skilled in managing complex medical and surgical cases. These factors enable the optimization of patient care through thorough preoperative assessments, effective risk stratification, and timely interventions, all of which significantly contribute to reducing perioperative mortality rate [33, 34]. Studies conducted in resource-limited clinical settings reported postoperative mortality rates of 2.0% and 2.5% following maxillofacial and orthopedic surgeries, respectively [35, 36]. The figures were

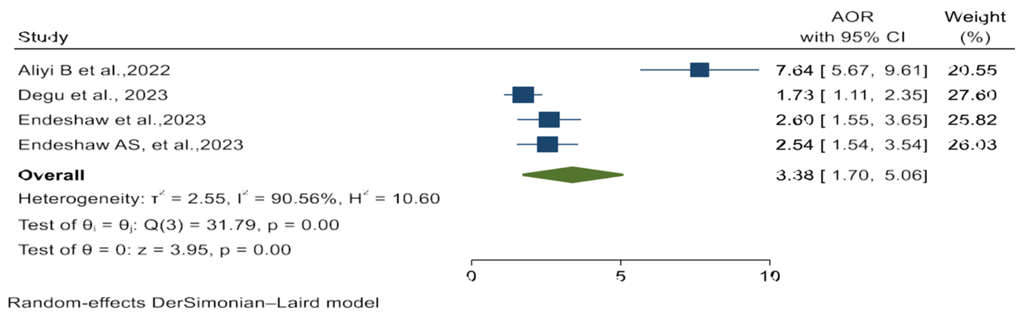

Fig. 8 The pooled effect of ASA physical status on the perioperative mortality rate

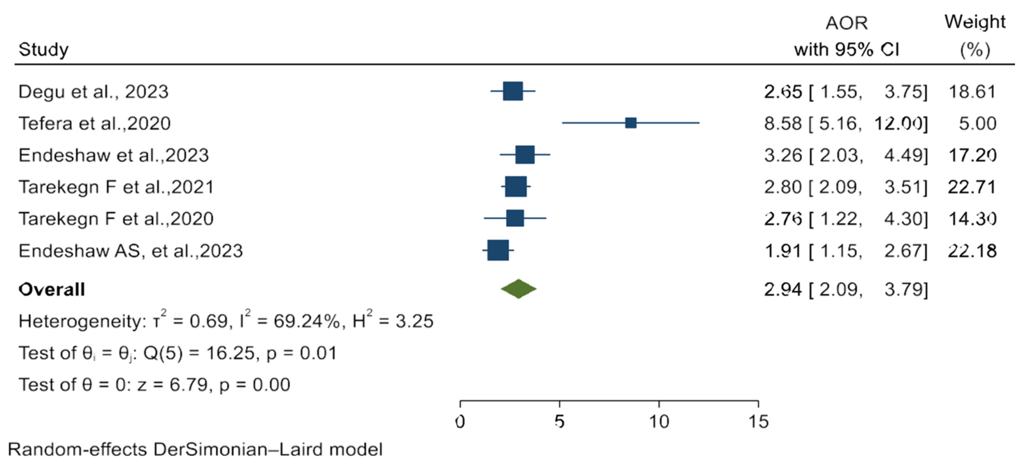

Fig. 9 The pooled effect of emergency surgery on the perioperative mortality rate

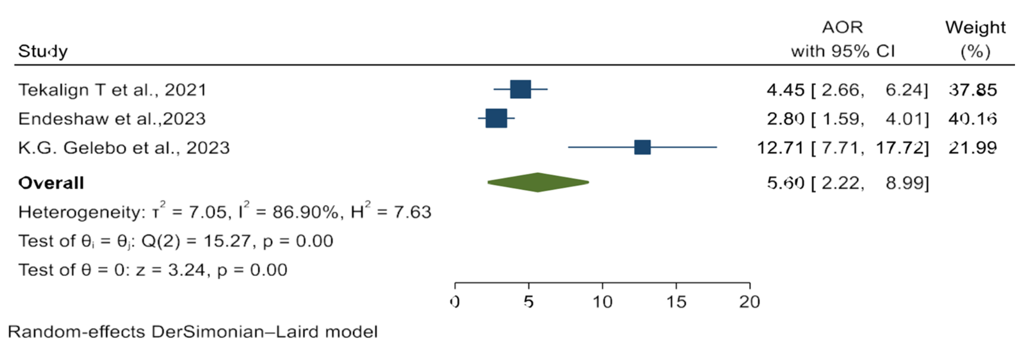

Fig. 10 The pooled effect of comorbidity on the perioperative mortality rate

lower than those observed in our study. This discrepancy may be attributed to variations in postoperative mortality rates, which are highly dependent on procedure-specific risk profiles and patient-related factors. The perioperative mortality rate (POMR) in Ethiopia reflects a significant burden on the healthcare system. When compared to other low- and middle-income countries (LMICs), this rate appears to be relatively high. In LMICs, perioperative mortality rates are often high due to factors such as limited access to healthcare infrastructure, shortages of skilled personnel, inadequate perioperative care, and challenges in managing complex cases [37]. For instance, studies in countries like India and Bangladesh have reported perioperative mortality rates ranging from 2 to 6%, which are similar to Ethiopia's, primarily due to similar resource limitations, including the availability of advanced medical equipment, trained specialists, and access to postoperative care [37].

In comparison, high-income countries (HICs) typically report much lower perioperative mortality rates, often below 1%. This is attributed to the presence of well-established healthcare systems with state-of-the-art perioperative care units, the availability of multidisciplinary teams, and well-equipped intensive care units that facilitate optimal management of patients before, during, and after surgery [38]. Furthermore, HICs benefit from rigorous preoperative screening, advanced surgical techniques, and better access to postoperative care, all of which play a pivotal role in reducing mortality rates.

The findings of this study also reveal that postoperative mortality is significantly higher in individuals over 65 years old. Patients in this age group face a threefold increased risk of mortality (AOR = 3.9, 95% CI: 2.13–5.67) compared to those under 65. This result aligns with research from Denmark and the United Kingdom, which also identified age as a predictor of postoperative death [39, 40]. This increased risk can be attributed to age-related declines in organ function, the presence of multiple comorbidities, reduced functional capacity, frailty, and impaired hemostatic function in older adults [19]. Furthermore, inadequate preoperative screening, undiagnosed symptoms, and limited access to comprehensive healthcare further contribute to higher perioperative mortality among the elderly [41].

Our study identified comorbidity as a significant predictor of perioperative outcomes. Patients with coexisting conditions faced a sixfold increased risk of postoperative complications (AOR = 6.32, 95% CI: 2.7–9.95) compared to those without such conditions. Individuals with comorbidities often experience weakened immune systems, increased fatigue, and reduced physical function, which adversely affect their perioperative prognosis [41]. This finding is consistent with research from the UK, which also reported poorer perioperative outcomes among individuals with comorbidities [42]. Additionally, further studies confirm that a history of comorbid conditions is a strong predictor of perioperative mortality [43].

The study's findings reveal that the postoperative course has a significant impact on mortality risk. Patients who were transferred to the intensive care unit (ICU) faced a threefold higher risk of death compared to those who were sent to the general ward (AOR = 3.38, 95% CI: 1.70– 5.06), underscoring the increased mortality risk associated with ICU admission. Additionally, patients with a higher ASA score (ASA class III or higher) had an elevated risk of perioperative mortality compared to those with lower ASA scores (ASA I or II). This finding is consistent with studies from Tanzania [28], Spain [30], Turkey [44], and Japan [45]. However, the predictive value of the ASA physical status score for postoperative mortality is debated due to its inherent subjectivity [30].

A higher ASA score often reflects reduced physiological reserve, impairing the patient's ability to handle surgical and anesthetic stress. Moreover, patients with higher ASA scores typically have poorer physical status, contributing to increased perioperative mortality [46]. These findings are supported by research by Wolters et al., which showed a significant relationship between higher ASA classifications and mortality risk, likely due to the patients' poor physical condition before surgery [47]. Emergency procedures were also associated with a higher risk of perioperative mortality (AOR = 2.94, 95% CI: 2.09–3.79; $P < 0.001$).

Conclusion

In Ethiopia, the prevalence of perioperative mortality was found to be 5.36%. This finding must be interpreted with caution. Our findings are shaped by the limitations of the original studies. Furthermore, this meta-analysis identified important predictors of perioperative mortality, including advanced age, emergency surgical conditions, admission to the intensive care unit (ICU) following surgery, presence of comorbidities, and an ASA status of III or higher.

Limitation of the study

The limitations of this study include concerns related to the study's design and its ability to establish causality. Additionally, the heterogeneity across the included studies, lack of procedure specific mortality rate, as well as the diversity of the populations studied, may have influenced the generalizability of the findings. These factors present challenges in drawing definitive conclusions. Therefore, we recommend that future research focus on addressing these limitations by utilizing more robust study designs, accounting procedure specific mortality risk, ensuring better homogeneity among study populations, and exploring more homogeneous groups to improve the reliability and applicability of the results.

Abbreviations

POMR	Postoperative Mortality Rate
ASA	American Society of Anesthesiologists
ICU	Intensive Care Unit
WHO	World Health Organization

Author contributions

T.Y., M.F and D.T wrote the study protocol, the main manuscript text, data analysis and and A.T., M.G., N.G., and Y.D prepared figures, revised the manuscript. All authors reviewed the manuscript.

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Data availability

All data generated or analyzed during this study are included in the manuscript.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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