Systematic Review / Meta-analysis

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Magnitude and associated factors of postoperative mortality among patients who underwent surgery in Ethiopia: systematic review and meta-analysis

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Background: Postoperative mortality is one of the six surgical indicators identified by the Lancet Commission on Global Surgery for monitoring access to high-quality surgical care. This study aimed to assess the magnitude and associated factors of postoperative mortality among patients who underwent surgery in Ethiopia.

Methods: This systematic review and meta-analysis were conducted based on the Preferred Reporting Items for Systematic Review and Meta-analysis guidelines. Ten studies were included in this Systematic review and meta-analysis. The risk of bias for each study was assessed using the Joanna Briggs Institute quality appraisal scale. Publication bias was checked using a funnel plot and Egger's regression test. Heterogeneity across studies was assessed by I^2 statistics. STATA version 17 software was used for analysis. A random effect model and the DerSimonian–Laird method of estimation was used to estimate the pooled magnitude of postoperative mortality. Odds ratios with 95% CIs were calculated to determine the associations of the identified factors with postoperative mortality.

Results: The results revealed that the pooled magnitude of postoperative mortality among patients who underwent surgery in Ethiopia was 4.53% (95% CI :3.70–5.37). An American Society of Anesthesiologists score greater than or equal to III [adjusted odds ratio (AOR): 2.45, 95% CI: 2.02, 2.96], age older than or equal to 65 years (AOR: 3.03, 95% CI: 2.78, 3.31), and comorbidity (AOR: 3.28, 95% CI: 1.91, 5.63) were significantly associated with postoperative mortality.

Conclusion and recommendations: The pooled magnitude of postoperative mortality among patients who underwent surgery in Ethiopia was high. The presence of comorbidities, age older than 65 years, and ASA physical status greater than III were significantly associated with postoperative mortality. Therefore, the Ministry of Health and other concerned bodies should consider quality improvement processes.

Keywords: Ethiopia, mortality, postoperative, systematic review

Introduction

Surgery is defined as any intervention in a hospital operating theatre that requires incision, excision, manipulation or suturing of tissue occurring and requiring regional or general anaesthesia or profound sedation to control pain[1].

Postoperative mortality has been defined as any death, regardless of cause, occurring within 30 days after surgery in or out of the hospital or after 30 days during the same hospitalization after the operation[2]. The perioperative mortality rate is calculated as the all-cause death rate before discharge in patients who had undergone a surgical procedure in an operating theatre, divided by the total number of procedures. The rate is presented as a percentage and is a credible indicator of the safety and quality of operative care[3]. Nearly 5 billion people do not have access to safe, affordable, or timely surgical care[4].

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

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Over 312.9 million surgical procedures are performed annually worldwide[5]. An estimated 4·2 million people die worldwide within 30 days of surgery each year, and postoperative deaths account for ~8% of all deaths, making it the third leading cause of death after ischaemic heart disease and stroke[6]. In Africa, of 11 193 patients undergoing surgery in 25 African nations, 239 patients died and 225 died within 24 h following the operation; moreover, the risk of postoperative mortality in Africa doubled compared to the global average[7].

Several existing studies revealed that age[8,9], surgical checklist use[10], American Society of Anesthesiologist score[8,9,11], pre-operative oxygen saturation less than 95%[8], emergency surgery[8,9], intensive care unit admission[11], and comorbidities were possible factors contributing to the likelihood of post-operative mortality. Postoperative mortality can be prevented by improving surgical service delivery systems and anaesthesia.

Several studies have reported the magnitude and associated factors of postoperative mortality in Ethiopia; however, there are no systematic reviews or meta-analyses regarding postoperative mortality and its contributing factors. This systematic review and meta-analysis aimed to determine the pooled magnitude and factors associated with postoperative mortality among patients who underwent surgery in Ethiopia.

HIGHLIGHTS

- Postoperative mortality is one of the six surgical indicators identified by the Lancet Commission on Global Surgery for monitoring access to high-quality surgical care.
- The pooled magnitude of postoperative mortality among patients who underwent surgery in Ethiopia was 4.53%.
- An American Society of Anesthesiologists score greater than or equal to III [adjusted odds ratio (AOR): 2.45, 95% CI: 2.02, 2.96], age older than or equal to 65 years (AOR: 3.03, 95% CI: 2.78, 3.31), and comorbidity (AOR: 3.28, 95% CI: 1.91, 5.63) were significantly associated with postoperative mortality.

Methods

Protocol and registration

This systematic review and Meta-analysis were carried out based on the Preferred Reporting Items for Systematic and meta-analysis (PRISMA) protocols[12], which were conducted according to PRISMA 2020 checklist[13], and registered in Prospero's

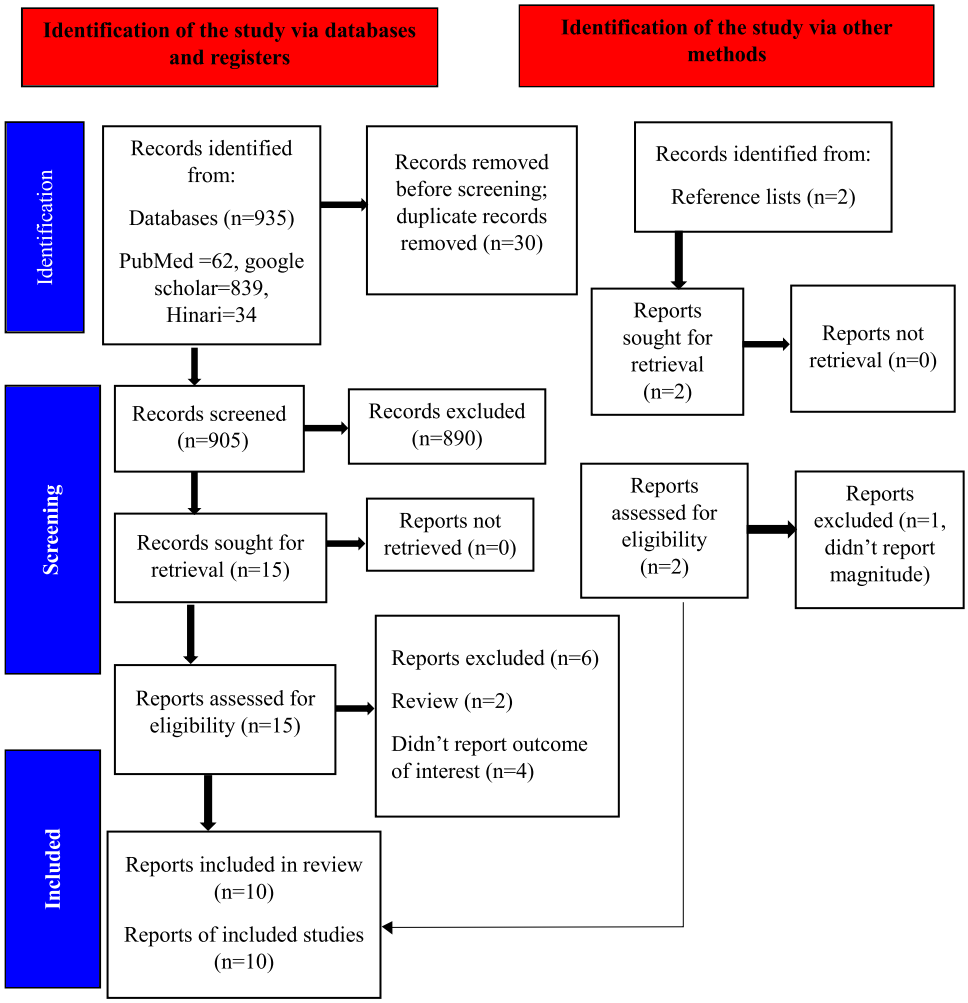

Figure 1. PRISMA flow diagram of screening and selection procedure.

Table 1

Preferred Reporting Items for Systematic and meta-analysis checklist 2020.

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4 and 5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organizations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	5
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6, 7 and 8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	6 and 7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	6 and 7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	18 and 19
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	18 and 19
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	8 and 9
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	9
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	7
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	7
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	5 and 6
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	6 and 8
Study characteristics	17	Cite each included study and present its characteristics.	8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	8, 9 and 10
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	7
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	9
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	8 and 9
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	9
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	7

Table 1

(*Continued*)

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	6
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	10
	23b	Discuss any limitations of the evidence included in the review.	12
	23c	Discuss any limitations of the review processes used.	12
	23d	Discuss implications of the results for practice, policy, and future research.	12
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	5
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	5
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	5
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	13
Competing interests	26	Declare any competing interests of review authors.	12
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	12

international prospective register of systematic reviews CRD42023494726 on 29 December 2023.

Search strategy

This systematic review and meta-analysis were conducted based on the Preferred Reporting Items for Systematic and meta-analysis (PRISMA) protocols[12]. The articles were searched against common databases such as PubMed/MEDLINE and the Cochrane Library, and a gray literature search was conducted on Google Scholars up to 22 December 2023. The key terms used to search for primary studies were (incidence OR prevalence OR magnitude) AND (perioperative OR postoperative) AND (mortality OR death) AND (associated Factors OR risk factors OR determinants) AND patients AND (surgery OR operation) AND Ethiopia. The results obtained from the common databases were imported into Endnote 20 software. First, duplicated studies were removed using EndNote software, and the titles and abstracts of the remaining articles were screened. Studies that were not related to the review question were excluded, after which the full texts of the screened papers were retrieved (Fig. 1).

Eligibility criteria

All observational (cross-sectional, cohort, and case-control) studies reporting the magnitude of postoperative mortality and/or its

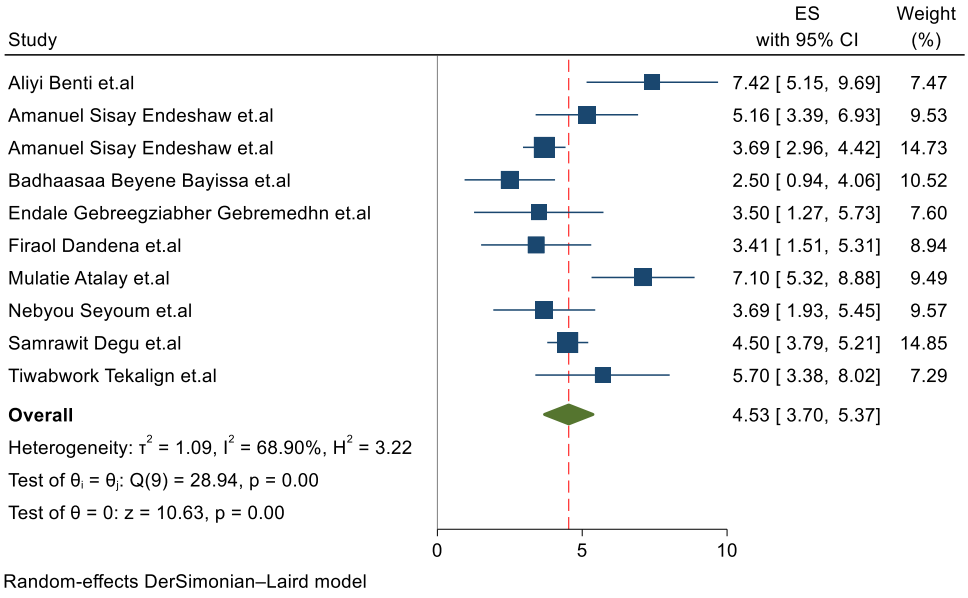

Figure 2. Forest plot for the prevalence of postoperative mortality among patients who underwent surgery in Ethiopia. The midpoint of each line represents the magnitude, the horizontal line represents the 95% CI, and the diamond represents the pooled magnitude.

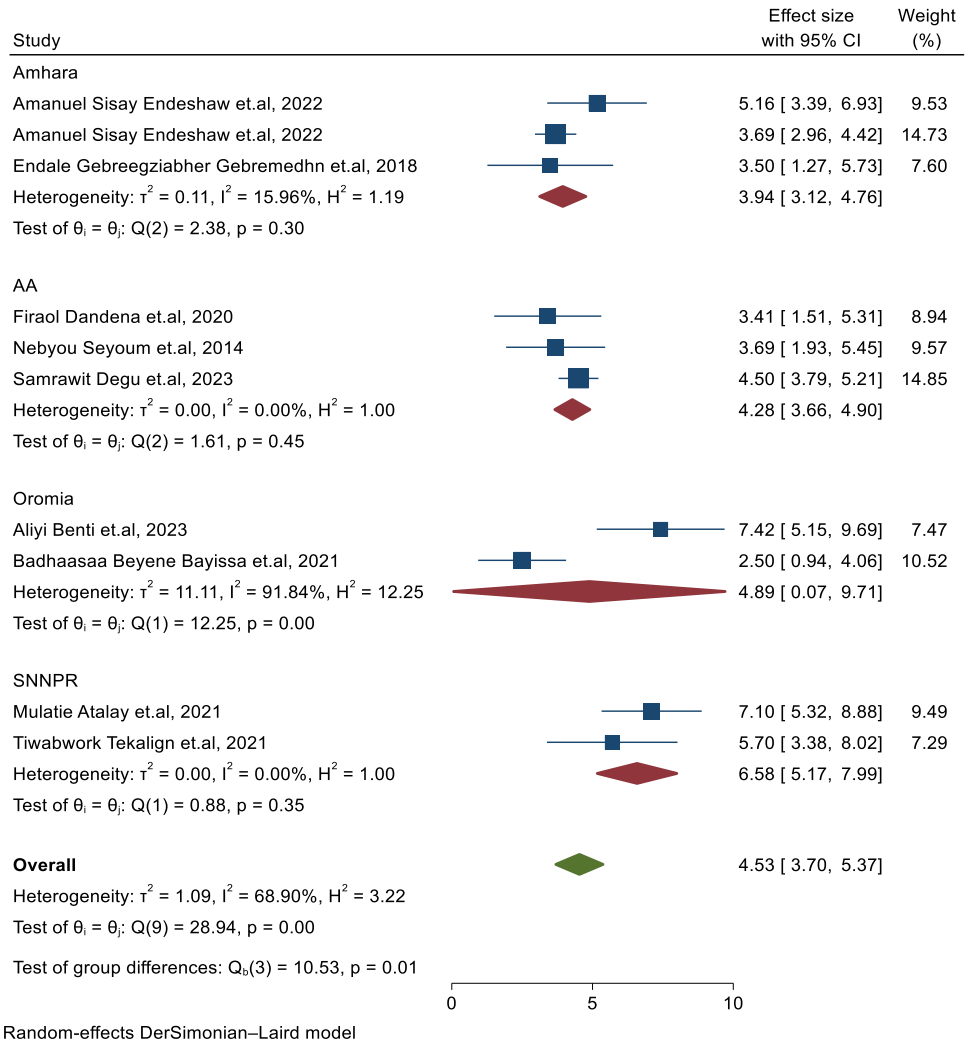

Figure 3. The magnitude of postoperative mortality by region.

determinants among patients who underwent surgery and articles published in English were included, while studies that did not report the magnitude of postoperative mortality, articles that did not report full information for data extraction, and studies that were not fully accessible were excluded.

Outcome measures

The main aim of this systematic review and meta-analysis was to determine the pooled magnitude of postoperative mortality among patients who underwent surgery in Ethiopia. The magnitude was calculated as the number of patients who died within 30 days of surgery divided by the total number of patients who underwent surgical procedures multiplied by 100, represented as a percentage. Factors significantly associated with postoperative mortality were extracted from the included studies using an adjusted odds ratio (OR) with a CI.

Data extraction

The data from each article were extracted by two independent authors (YT and AG) using standardized, prespecified data abstraction criteria. The extraction form included the following information: name of the first author, region of the country where the study was conducted, publication year, sample size included, study design, and magnitude of postoperative mortality. Disagreements between the two authors were resolved through discussion and by the third author. Finally, the data were imported into STATA version 17 for analysis.

Assessment of methodological quality

This SRMA was done based on Assessing the methodological quality of systematic reviews (AMSTAR) Guidelines[14] (Table 1). The Joanna Briggs Institute (JBI) quality appraisal scale was used to assess the risk of bias in each study[15]. Two authors (Y.T. and O.A.) independently assessed the quality of each study identified for retrieval. Disagreements between the two authors regarding the quality of the articles were resolved through discussion and by taking the average score of the two reviewers. The articles were considered low risk if they scored five or more points in all quality assessment items. Therefore, all the included studies were of good quality.

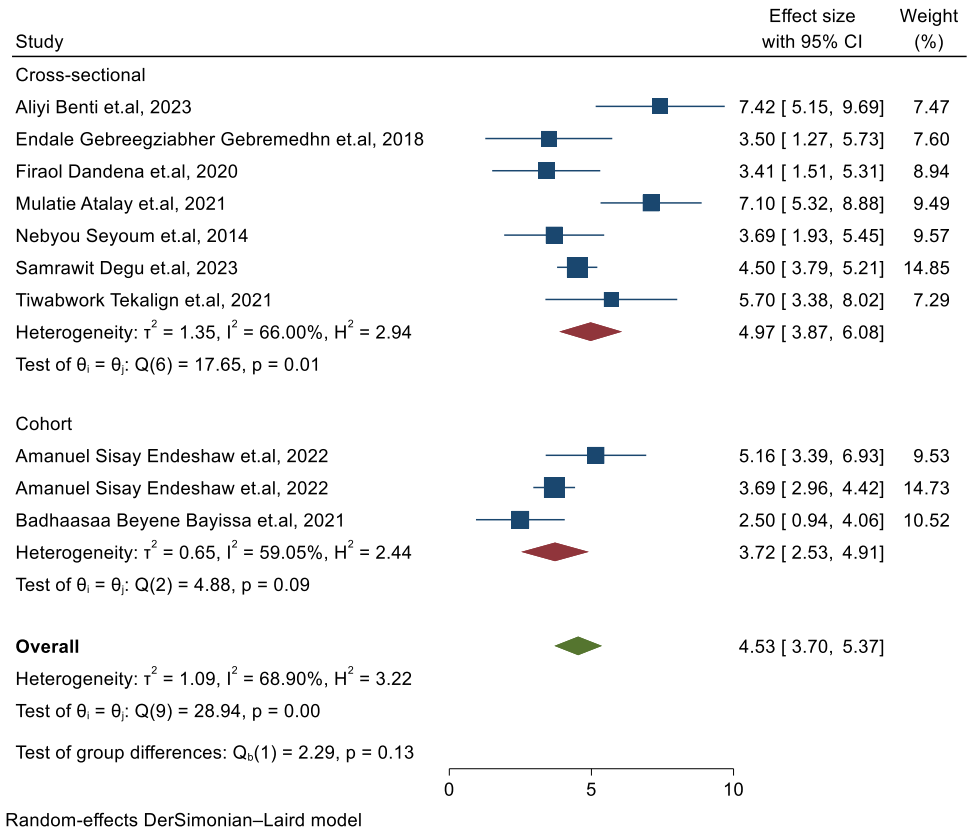

Figure 4. The magnitude of postoperative mortality according to study design.

Data analysis

The data analysis was carried out using STATA version 17 software. The pooled magnitude of postoperative mortality among patients who underwent surgery was determined using a random effect model with DerSimonian–Laird's method of estimation. The heterogeneity among the included studies was checked with forest plot, I^2 test, and *p* values. Substantial heterogeneity among the included studies was investigated via subgroup analysis, meta-regression, and sensitivity analysis. Publication bias was checked with a funnel plot and Egger's regression test.

Results

Selection of studies

Through a PRISMA flow diagram, a total of 937 studies were identified from different databases and other sources. After the removal of 30 duplicated articles, 907 studies were screened by observing their title and abstract. Seventeen articles were sought for retrieval, and seven studies were excluded. Finally, ten articles[8–11,16–21] were included in this systematic review and meta-analysis (Figure 1).

Description of the included studies

A total of ten studies comprising 9575 participants were included in this systematic review and meta-analysis. Studies assessing the magnitude of postoperative mortality and/or associated factors conducted in Ethiopia were included. The included studies were conducted in Amhara[8,9,18], Addis Abeba[16,19,21], Oromia[11,20], and the SNNPR[10,17]. The majority of the included articles were cross-sectional[10,11,16–19,21], and three studies involved cohort studies[8,9,20]. The magnitude of postoperative mortality in the included studies varied from 2.5 to 7.42% (Table 2).

Prevalence of postoperative mortality

In this systematic review and meta-analysis using a forest plot, the pooled prevalence of postoperative mortality among patients who underwent surgery in Ethiopia estimated by random effect model with DerSimonian–Laird's method of estimation was 4.53% (95% CI: 3.70–5.37) (Fig. 2).

Subgroup analysis

Subgroup analysis by region revealed the highest magnitude of postoperative mortality in the SNNPR (6.58%), followed by Oromia (4.89%) and Addis Ababa (4.28%) (Fig. 3).

Another subgroup analysis using study design revealed that the magnitude of postoperative mortality was high in cross-sectional studies (4.97%) (Fig. 4).

Furthermore, subgroup analysis via sampling technique revealed that the magnitude of postoperative mortality was high in the study with simple random sampling (7.1%) (Fig. 5).

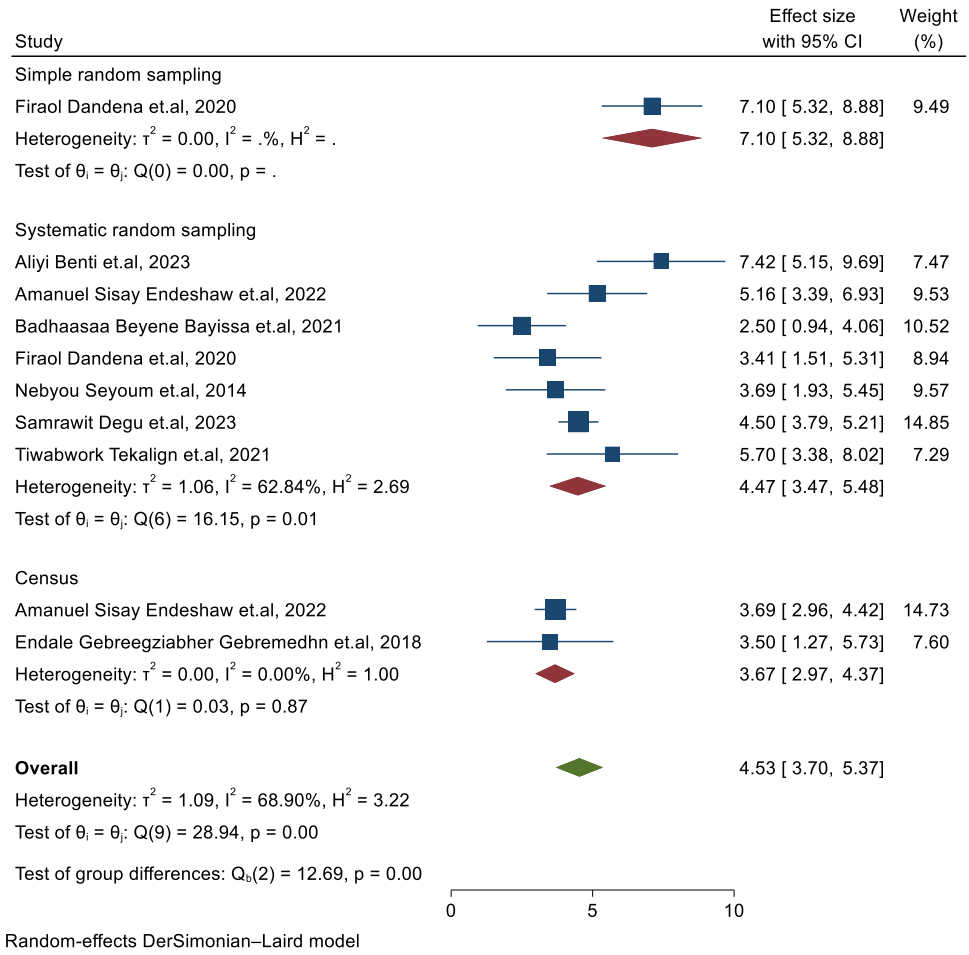

Figure 5. The magnitude of postoperative mortality determined using the sampling technique.

Publication bias evaluation

Publication bias was checked using a funnel plot and Egger's regression test. A symmetrical funnel plot (Fig.6) showed no significant publication bias, and Egger's regression test was not significant ($P > 0.3294$).

Investigation of heterogeneity

A meta-regression analysis of sample size and publication year was performed to observe the possible cause of heterogeneity across studies. However, none of the moderators demonstrated significant heterogeneity (Table 3).

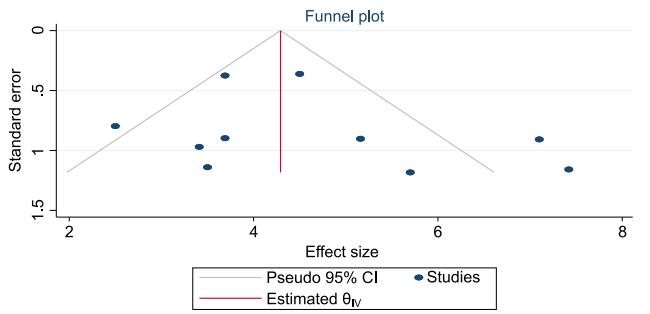

Figure 6. Illustration of the distribution of involved studies using a funnel plot.

Sensitivity analysis

Sensitivity analysis was carried out using a random effect model with DerSimonian–Laird's method of estimation to detect the study that had an impact on the overall effect size. However, there was no study influencing the overall magnitude of postoperative mortality among patients who underwent surgery (Fig. 7).

Factors associated with postoperative mortality

ASA (American Society of Anesthesiologists)

This meta-analysis of the pooled effects of three studies[8,9,11] showed that the odds of postoperative mortality were 2.5 times higher [adjusted odds ratio (AOR): 2.45, 95% CI: 2.02, 2.96] among patients who had an American Society of Anesthesiologists (ASA) status greater than or equal to III than among those whose ASA status was I or II (Fig. 8).

Age

The odds of postoperative mortality among patients aged older than or equal to 65 years were 3.03 times higher (AOR = 3.03,

Table 2

Description of included studies

Author	Publication year	Region	Sampling technique	Sample size	Study design	Prevalence	Quality
Aliyi *et al.*[11]	2023	Oromia	Systematic sampling	512	Cross-sectional	7.42	Low risk
Amanuel *et al.*[9]	2022	Amhara	Systematic sampling	618	Cohort	5.16	Low risk
Amanuel *et al.*[8]	2022	Amhara	Census	2530	Cohort	3.69	Low risk
Badhaasaa *et al.*[20]	2021	Oromia	Systematic sampling	384	Cohort	2.5	Low risk
Endale *et al.*[18]	2018	Amhara	Census	260	Cross-sectional	3.5	Low risk
Firaol *et al.*[16]	2020	Addis Abeba	Systematic sampling	350	Cross-sectional	3.41	Low risk
Mulatie *et al.*[17]	2021	SNNPR	Simple random sampling	801	Cross-sectional	7.1	Low risk
Nebyou *et al.*[19]	2014	Addis Abeba	Systematic sampling	441	Cross-sectional	3.69	Low risk
Samrawit *et al.*[21]	2023	Addis Abeba	Systematic sampling	3295	Cross-sectional	4.5	Low risk
Tiwabwork *et al.*[10]	2021	SNNPR	Systematic sampling	384	Cross-sectional	5.7	Low risk

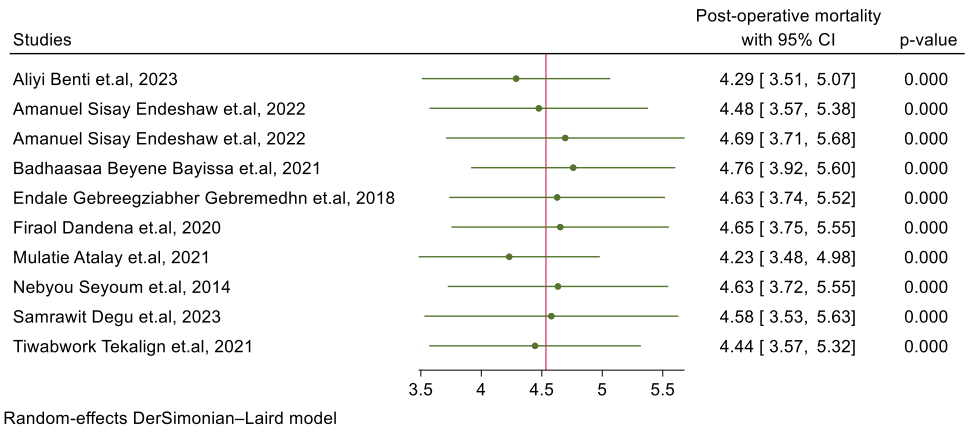

Figure 7. Sensitivity analysis to detect a single study influencing the pooled magnitude of postoperative mortality.

95% CI= 2.78, 3.31) than those among patients aged younger than 65 years (Fig. 9).

Comorbidity

According to three studies[9–11], the odds of postoperative mortality among patients who had comorbidities were 3.3 times higher (AOR = 3.28, 95% CI= 1.91, 5.63) than among patients who did not have comorbidities (Fig. 10).

Discussion

This systematic review and meta-analysis were conducted to estimate the pooled magnitude of postoperative mortality among patients who underwent surgery in Ethiopia, and also to determine possible associated factors, as there has not been a systematic review or meta-analysis performed in Ethiopia regarding postoperative mortality. Subgroup analysis was carried out using region, study design and sampling technique to determine whether the pooled magnitudes found in these subgroups differed significantly from each other.

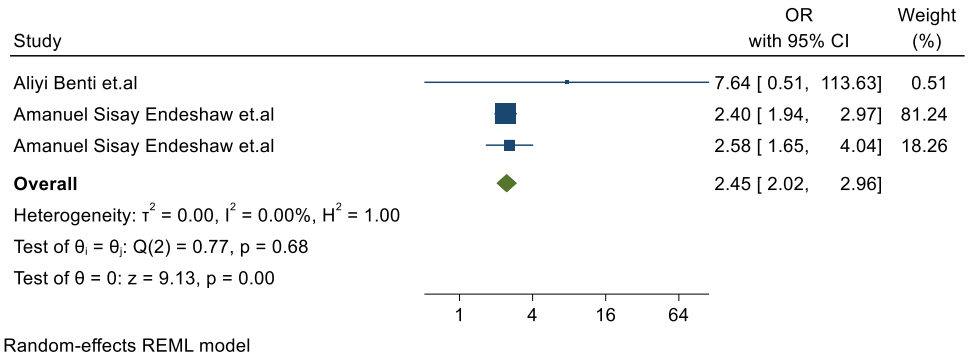

Figure 8. Association between American Society of Anesthesiologists (ASA) score and postoperative mortality. OR, odds ratio.

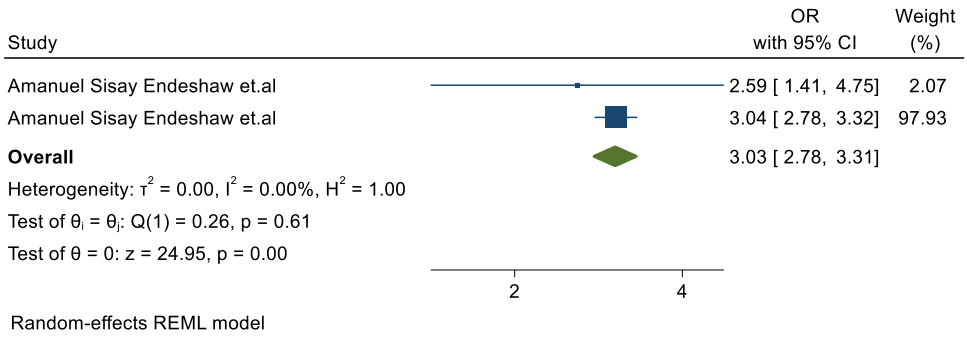

Figure 9. Association between age and postoperative mortality. OR, odds ratio.

According to the findings of our study, the pooled magnitude of postoperative mortality among patients who underwent surgery was 4.53% (95% CI: 3.70–5.37). This finding is comparable with the finding of a study conducted in the Netherlands in which the pooled in-hospital postoperative mortality was 4%[22]. This finding is higher than the findings of the studies in Spain (2.7%)[23] and Denmark (2%)[24]. However, our findings are lower than those of study in Australia, in which the mean postoperative mortality was 9.15%[25]. This discrepancy might be due to differences in the study population. Our study included all patients who underwent surgery; however, studies in Australia involved participants on chronic dialysis following elective surgery, which may have led to an overestimation of the magnitude of postoperative mortality.

This meta-analysis revealed that ASA status greater than or equal to III, age older than or equal to 65 years, and comorbidities were significantly associated with postoperative mortality. Based on our findings, the odds of postoperative mortality were 2.5 times higher among patients who had an ASA status greater than or equal to III than those patients whose ASA status was I or II. This finding is congruent with a study conducted in the Netherlands[26]. This might be due to the fact that ASA physical status class is a reliable indicator of morbidity and mortality across different surgical specialties and anaesthesia types[27].

In addition, patients aged older than or equal to 65 years had 3.03 times higher odds of postoperative mortality than those who aged younger than 65 years. This result is supported by the findings of studies conducted in the Netherlands[26], China[28], and the USA[29]. This could be explained by the fact that advanced age has traditionally been seen as a surgical risk, and aging is associated with a decline in the functional reserves of organ systems and an increase in the presence of comorbid illnesses[30].

Furthermore, the odds of postoperative mortality were 3.3 times higher among patients who had comorbidities than those patients who did not have comorbidities. This might be explained by the fact that patients with comorbidities are more prone to encounter treatment-related toxicities and have less than ideal outcomes[31]. According to existing studies, the most prevalent comorbidities that increase the likelihood of postoperative death include hypertension, chronic obstructive pulmonary disease, and other malignancies[32]. According to other studies, comorbidities such as cardiovascular disease (24%), respiratory disease (14%), stroke (13%), diabetes mellitus (9%), and malignancy (8%) increase the likelihood of postoperative mortality[33].

Limitations

A small number of studies were included, which reduces the precision of the estimate. Despite considerable heterogeneity being identified across the studies, the source of variation across each study was not well recognized.

Conclusion and recommendations

We found that the pooled magnitude of postoperative mortality among patients who underwent surgery was high. The presence of comorbidities, age older than 65 years, and ASA physical status greater than III were significantly associated with postoperative mortality. Therefore, healthcare providers and other concerned bodies should focus on surgical safety checklists and anaesthesia and optimize the patients' preoperative health status.

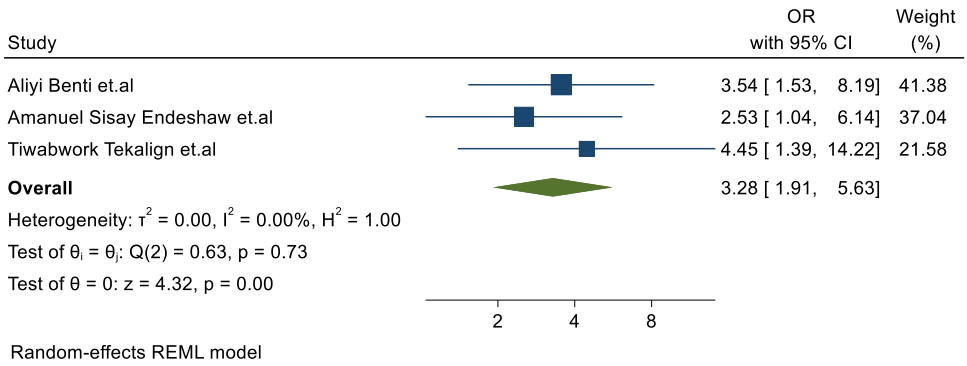

Figure 10. Association between comorbidities and postoperative mortality. OR, odds ratio.

Table 3

Meta-regression of postoperative mortality according to publication year and sample size to determine heterogeneity

Heterogeneity source	Coefficient	Standard error	$P>\|z\|$
Publication year	0.2915592	0.2047135	0.154
Sample size	−0.000427	0.000466	0.359

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Source of funding

Not applicable.

Author contribution

Y.T., S.T. and A.G. were involved in conceptualization, development of the protocol and study design, study selection, data extraction, statistical analysis, and editing of the final draft of the manuscript. Y.T. and O.A. involved in quality assessment and statistical analysis. G.B., G.K., H.B., A.E., A.D., M.A., T.A., W.T. and S.M. study selection and extraction. All the authors read and approved the final draft of the manuscript.

Conflicts of interest disclosure

The author declares no competing interest.

Guarantor

Not applicable.

Availability of data and materials

Data and material can be available where applicable.

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