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Incidence and predictors of mortality among neonates admitted with birth asphyxia to neonatal intensive care units in Ethiopia: a systematic review and meta-analysis

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Abstract

Background Birth asphyxia is the second leading cause of neonatal mortality worldwide, including in Ethiopia, and remains a significant public health concern. Despite the availability of national data on neonatal mortality in Ethiopia, there remains a gap in understanding the specific incidence and predictors of mortality among asphyxiated neonates. To address this information gap, this meta-analysis was conducted to assess the incidence and predictors of mortality among asphyxiated neonates in Ethiopia.

Methods This systematic review and meta-analysis was conducted in accordance with the PRISMA guidelines. Relevant studies were identified through various databases, including PubMed, CINAHL, Scopus, EMBASE, and Google Scholar. Data analysis of pooled estimates for mortality incidence and its predictors was performed via STATA 17 software with the DerSimonian and Laird model. Heterogeneity was assessed via Cochrane's Q-test and the I^2 statistic. Additionally, publication bias was evaluated through funnel plots, Egger's test, and Doi plots.

Results Out of 68 identified studies, only 10 met the eligibility criteria, including a total of 4,866 participants. The pooled incidence rate of birth asphyxia mortality was 4 per 100 person-days (95% CI: 3–5), which was 35,754 person-days of observation. Furthermore, predictors of birth asphyxia mortality included: pregnancy complications (HR 1.52, 95% CI: 1.41–1.64), labor complications (HR 1.29, 95% CI: 1.15–1.44), severe hypoxic-ischemic encephalopathy (HR 1.67, 95% CI: 1.51–1.85), neonatal seizures (HR 1.23, 95% CI: 1.11–1.38), and comorbidities in neonates (HR 1.31, 95% CI: 1.24–1.39).

Conclusion In the current study, the pooled incidence of birth asphyxia mortality was high, falling short of the Sustainable Development Goals target and highlighting the need for immediate intervention. Additionally, pregnancy and labor complications, severe hypoxic-ischemic encephalopathy, neonatal seizures, and neonatal comorbidities were identified as predictors of birth asphyxia mortality. These findings underscore the urgent need to enhance early

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detection and intervention for pregnancy- and labor-related complications, as well as severe neonatal complications related to asphyxia, in to reduce mortality.

Keywords Incidence, Predictors, Mortality, Birth asphyxia, Neonates, Ethiopia, systemic review, meta- analysis

Introduction

According to the World Health Organization (WHO), birth asphyxia occurs when a baby fails to breathe or does not breathe consistently at birth. It occurs when a baby's blood supply is disrupted, or when the oxygen exchange process is impaired before, during, or after birth [1]. Birth asphyxia can lead to failure of multiple organ systems, severe metabolic acidosis, excessive carbon dioxide in the blood (hypercarbia), worsening oxygen deficiency (hypoxemia), brain damage in newborns (encephalopathy), and even death [2]. The APGAR score, assessed at 1, 5, and 10 min after birth, helps determine the severity of birth asphyxia by evaluating the baby's appearance, heart rate, reflex irritability, muscle tone, and breathing [2, 3].

Globally, approximately 2.4 million newborns die annually, with birth asphyxia estimated to contribute to approximately 23% of these deaths, and over 90% of these cases occur in low- and middle-income countries [1]. The World Health Organization (WHO) reported that birth asphyxia significantly contributes to approximately 900,000 neonatal deaths annually and is responsible for 11% of under-five deaths globally [4]. Birth asphyxia is a significant contributor to 280,000 neonatal deaths in sub-Saharan Africa annually and is responsible for 34% of neonatal deaths in Ethiopia [5, 6].

In addition to its significant contribution to mortality, birth asphyxia is responsible for 25% of permanent neurological disabilities globally [7] and 12.5% of all morbidities, including hypoxic-ischemic organ damage, severe lifelong illnesses, developmental delays, epilepsy, and persistent functional psychotic syndromes [8].

Various studies in Ethiopia have indicated that neonatal mortality due to birth asphyxia is associated with several factors, including neonatal seizures [9], severe hypoxic-ischemic encephalopathy (HIE) [10, 11], and comorbidities such as sepsis and anemia [12–16]. Additionally, labor and delivery complications [17–19], pregnancy-related complications [20, 21], and inadequate maternal health services and accessibility [16, 20–21] are also predictors of neonatal mortality due to birth asphyxia.

Several interventions have been implemented to reduce neonatal mortality due to birth asphyxia, primarily on the basis of Sustainable Development Goals (SDGs). These include skilled delivery, neonatal resuscitation, continuous positive airway pressure (CPAP) therapy, integrated management of neonatal and childhood illnesses (IMNCI), enhancing neonatal intensive care unit (NICU) services at the hospital level, and training qualified care providers [22]. Despite these efforts, neonatal mortality due to birth asphyxia remains a significant public health issue in Ethiopia, with incidence rates ranging from 2.9 to 10.9 per 100 neonates admitted to the NICU [14, 21].

Although primary studies have documented the incidence of birth asphyxia mortality [12–16], the figures remain inconsistent, and there is a lack of pooled time-series data representing the mortality incidence rate due to birth asphyxia, particularly in Ethiopia. This systematic review and meta-analysis aimed to address this gap by providing a comprehensive overview of the incidence and predictors of mortality associated with birth asphyxia. Furthermore, this analysis can assist care providers and health managers in identifying strategies to increase the quality of neonatal care and develop more effective interventions for managing birth asphyxia complications.

Materials and methods

Protocol registrations

To prevent duplicate studies from being included, the researchers conducted a thorough examination and search of registered protocols, systematic reviews, and narrative studies. In the interest of transparency, the protocol was registered in the PROSPERO database (https://www.crd.york.ac.uk/prospero/, **ID = CRD42024579655**). This comprehensive analysis and synthesis of existing research adhered to the PRISMA protocol, ensuring the credibility and reproducibility of the review methodology and its constituent elements (supplementary file 1).

Inclusion and exclusion criteria

The review included all cohort studies conducted on human participants that reported the incidence and predictors of birth asphyxia among neonates admitted to NICUs in Ethiopia. The study population consisted of neonates diagnosed and hospitalized with birth asphyxia, with a follow-up period for time-to-death analysis lasting up to 28 days after birth. The primary outcome was the incidence of mortality due to birth asphyxia, and predictors of birth asphyxia mortality were also considered. Additionally, the meta-analysis was limited to reports in English from the last ten years, including both published and unpublished works, which were evaluated as having a low to moderate risk of bias on the basis of the Joanna Briggs Institute (JBI) criteria.

On the other hand, this review excluded studies conducted outside of Ethiopia, those with undefined follow-up periods, cross-sectional studies, purely qualitative research, case studies, case reports, and randomized trials.

Information source

For a thorough overview, intensive searches were done across multiple databases such as, PubMed, CINAHL, Scopus, EMBASE, and Google Scholar. Additionally, dissertations and reports from governmental and non-governmental organizations were examined. The search encompassed all relevant data published up to August 30, 2024.

Search strategy

We considered all studies involving human participants that were published before our search date. Our search strategy used a comprehensive approach, combining relevant keywords via Boolean operators. This method followed the PICO mnemonic principle. We included studies that met the following criteria: Population – Birth asphyxia neonate admitted to neonatal intensive care units (NICUs) in Ethiopia; Intervention/Exposure – Predictors of mortality; Comparator – not applicable; Outcome – Incidence of birth asphyxia mortality. To select relevant articles, we used a search strategy that combined MeSH terms, keywords, and the Boolean operators 'OR' and 'AND.' Our search strategy comprised of the following steps: ((((((((((((Neonates) OR (Newborns)) OR (Infants)) AND (Birth asphyxia)) OR (Perinatal asphyxia)) AND (Incidence)) AND (predictors)) OR (risk factors)) OR (determinants)) AND (Mortality)) OR (Death)) AND (Neonatal Intensive Care Unit)) OR (NICU)) AND (Ethiopia*). Moreover, we alternatively used the following search strategy: ("Neonates"[MeSH Terms] OR "Newborns" OR "Infants") AND ("Birth asphyxia"[MeSH Terms] OR "Perinatal asphyxia") AND ("Incidence"[MeSH Terms]) AND ("Predictors"[MeSH Terms] OR "Risk factors" OR "Determinants") AND ("Mortality"[MeSH Terms] OR "Death") AND ("Ethiopia"[MeSH Terms] OR "Ethiopia").

In addition to searching databases, we thoroughly examined gray literature via the following search terms: "Incidence and Predictors of Mortality Among Neonates Admitted with Birth Asphyxia to Neonatal Intensive Care Units in Ethiopia." We also conducted a cross-referencing search to uncover any relevant studies that may have been unintentionally overlooked in the primary database search (supplementary file 2).

Study selection process

This meta-analysis included both retrospective and prospective survival studies conducted primarily to examine predictors of mortality among neonates hospitalized with birth asphyxia in Ethiopia. Additionally, four authors (MA, YE, TA, and EB) reviewed the titles, abstracts, and full-text articles to determine their eligibility. Duplicate records were identified and removed via EndNote 20, and any discrepancies were resolved through group discussions (FB, ST, and MAB).

Data extraction

Data extraction was performed and organized in a Microsoft Excel spreadsheet by four authors (MA, YE, TA, and EB), and any discrepancies were resolved through group discussions. The authors of non-open-access articles were contacted via email to request the full text, and articles without full-text availability were excluded. Data extraction included the following main elements: publication year, first author's surname, sample size, event, study region, study setting, study design, hospital level, statistical methods, incidence of birth asphyxia mortality, observational time, and predictors of mortality with 95% confidence intervals.

Outcomes

The incidence of birth asphyxia mortality among hospitalized neonates in Ethiopia was the primary outcome. The pooled estimates of mortality incidence were calculated by dividing events over person-time, along with standard errors (calculated by dividing the square root of events over person-time). Moreover, predictors of birth asphyxia mortality were also a primary outcome and were computed using log hazard ratios as the effect size, along with 95% confidence intervals (CIs) and standard errors.

Study risk of bias assessment

The risk of bias assessment was conducted via the Joanna Briggs Institute (JBI) tool, which includes a total of 8 appraisal elements. Accordingly, studies with scores ≥ 7, 5–6, and ≤ 4 were classified as having a low, medium, and high risk of bias, respectively. Consequently, only studies with a low or medium risk of bias were included in the meta-analysis. Any discrepancies were resolved through group discussions (supplementary file 3).

Data synthesis and analysis

STATA version 17 software, which uses the random-effects DerSimonian–Laird model, was used to analyze the outcomes. Moreover, the Cochrane Q–test and I^2 statistic were used to assess heterogeneity across the included studies. Accordingly, there was substantial evidence of heterogeneity concerning the incidence of birth asphyxia mortality ($I^2 = 96.3\%$, p-value = 0.00). To address the heterogeneity, a subgroup analysis was conducted. The funnel plot, Egger's test, and Doi plot revealed the presence of publication bias. However, the sensitivity analysis suggested that the pooled incidence of mortality due to birth asphyxia is robust and not influenced by any single study.

Results

The systematic review and meta-analysis process began with 68 identified studies. Through various stages of evaluation, studies were progressively eliminated: 38 were excluded before the screening phase, 15 were removed after titles and abstracts were examined, 1 was unavailable for review, and 4 did not meet the eligibility criteria. This rigorous selection process resulted in a final set of ten studies that were deemed suitable for inclusion in the meta- analysis (Fig. 1).

Characteristics of the included studies

This systematic review and meta-analysis included ten studies, published after 2020, with a total of 4,866 participants and 35,754 person-time observations from various regions in Ethiopia, including Amhara, Oromia, southern Ethiopia, and Addis Ababa. The majority of studies (eight) employed the Cox proportional hazards model, whereas two utilized the Weibull proportional hazards model. Six studies were multicenter studies, and four were single-institution studies. The research designs varied, with eight studies using retrospective follow-up and two using prospective follow-up approaches. The studies

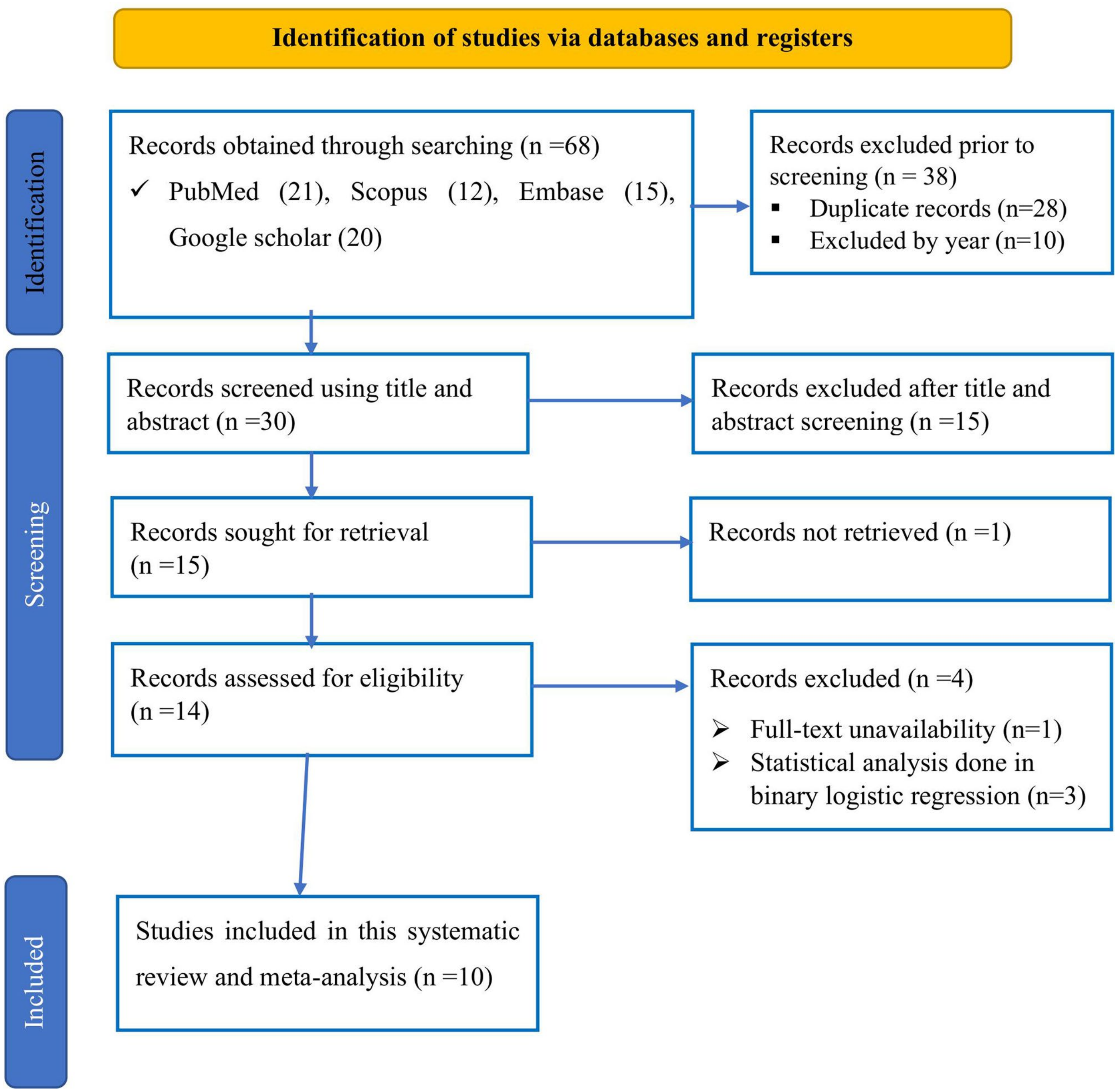

Fig. 1 Study selection for systematic review and meta-analysis of incidence and predictors of mortality among asphyxiated neonates in Ethiopia, 2024

were conducted across different healthcare settings: four at comprehensive specialized hospitals, three at both comprehensive and general hospitals, two at teaching hospitals, and one at a general hospital (Table 1).

Incidence of birth asphyxia mortality

The pooled incidence rate of birth asphyxia mortality was 4 per 100 person-days (95% CI: 3–5, I^2 = 96.3%, $p < 0.00$), which was based on 35,754 person-days of observation. The results indicated that significant variability was found across the studies (Fig. 2).

Subgroup analysis

Sample size, study region, study setting, study design, hospital level, and statistical methods were utilized as factors for subgroup analysis to identify potential sources of heterogeneity. Despite these evaluations, heterogeneity remained (Table 2).

Assessment of publication bias

Funnel plots, Egger's tests, and Doi plots were used to assess publication bias. The funnel plot indicated that more points were on the right side, which could suggest potential publication bias, where studies showing larger or more positive effects are more likely to be published (Fig. 3). However, this could also indicate true underlying differences or heterogeneity in the study results. Further statistical tests, such as Egger's test, were conducted to assess publication bias. The results revealed that the p−value (0.003) was statistically significant, with a bias beta-coefficient of 13, and the confidence interval did not include zero, indicating substantial statistical heterogeneity (Table 3). To account for potential publication bias, the trim-and-fill method was employed. This analysis revealed evidence of publication bias in the original studies. After adjusting for this bias, the overall effect size was smaller than initially reported, suggesting that the true effect might be less significant (Fig. 4).

Certainty of evidence

Moreover, a Doi plot was conducted to identify bias and confirm the certainty of the evidence. The results indicated a Luis Furuya-Kanamori (LFK) index of 2.19, suggesting major asymmetry and the presence of publication bias (Fig. 5).

Sensitivity analysis

The sensitivity analysis revealed that the pooled estimate of birth asphyxia mortality was reliable and not influenced by any single study. This occurred because the effect size remained consistent at approximately 4 per 100 when each study was removed individually, and the confidence intervals were narrow and overlapped with the pooled estimate. Additionally, the consistently

Table 1 Characteristics of individual studies in Ethiopia, 2024($N = 10$)

Authors & publication year	Regions	Study setting	Level of hospital	Study design	Statistical analysis	Sample Size	Event	Person time	Incidence rate per 100 persons	Risk of bias
Yitayew et al.,2022 [12]	Amhara	Single institution	Comprehensive specialized	Retrospective follow-up	Cox PH	378	121	2298	5.3	Low risk
Garuma et al.,2023 [13]	Oromia	Multi-centered	Comprehensive and general hospitals	Retrospective follow-up	Cox PH	519	142	3118	4.5	Low risk
Kajela et al.,2023 [14]	Oromia	Single institution	Teaching hospital	Retrospective follow-up	Cox PH	373	84	2888	2.9	Low risk
ketema et al.,2023 [15]	Amhara	Multi-centered	Comprehensive and general hospitals	Prospective follow-up	Cox PH	480	203	3514	5.8	Moderate risk
Shibabaw et al.,2021 [16]	Amhara	Single institution	Comprehensive specialized	Retrospective follow-up	Weibull PH	402	125	2337	5.35	Moderate risk
Dessu et al.,2021 [17]	Southern Ethiopia	Multi-centered	General hospitals	Prospective follow-up	Cox PH	573	45	3753	1.2	Low risk
Daka et al.,2023 [18]	Oromia	Multi-centered	Teaching hospital	Retrospective follow-up	Weibull PH	616	202	5198	3.9	Low risk
Bekele et al.,2024 [19]	Oromia	Multi-centered	Comprehensive and general hospitals	Retrospective follow-up	Cox PH	760	263	6880	3.8	Moderate risk
Getaneh et al.,2022 [20]	Addis Ababa	Multi-centered	Comprehensive specialized	Retrospective follow-up	Cox PH	435	99	3062	3.23	Moderate risk
Yehouala et al.,2024 [21]	Amhara	Single institution	Comprehensive specialized	Retrospective follow-up	Cox PH	330	60	2706	2.22	Low risk
Total						4,866	1,344	35,754	4 per 100	

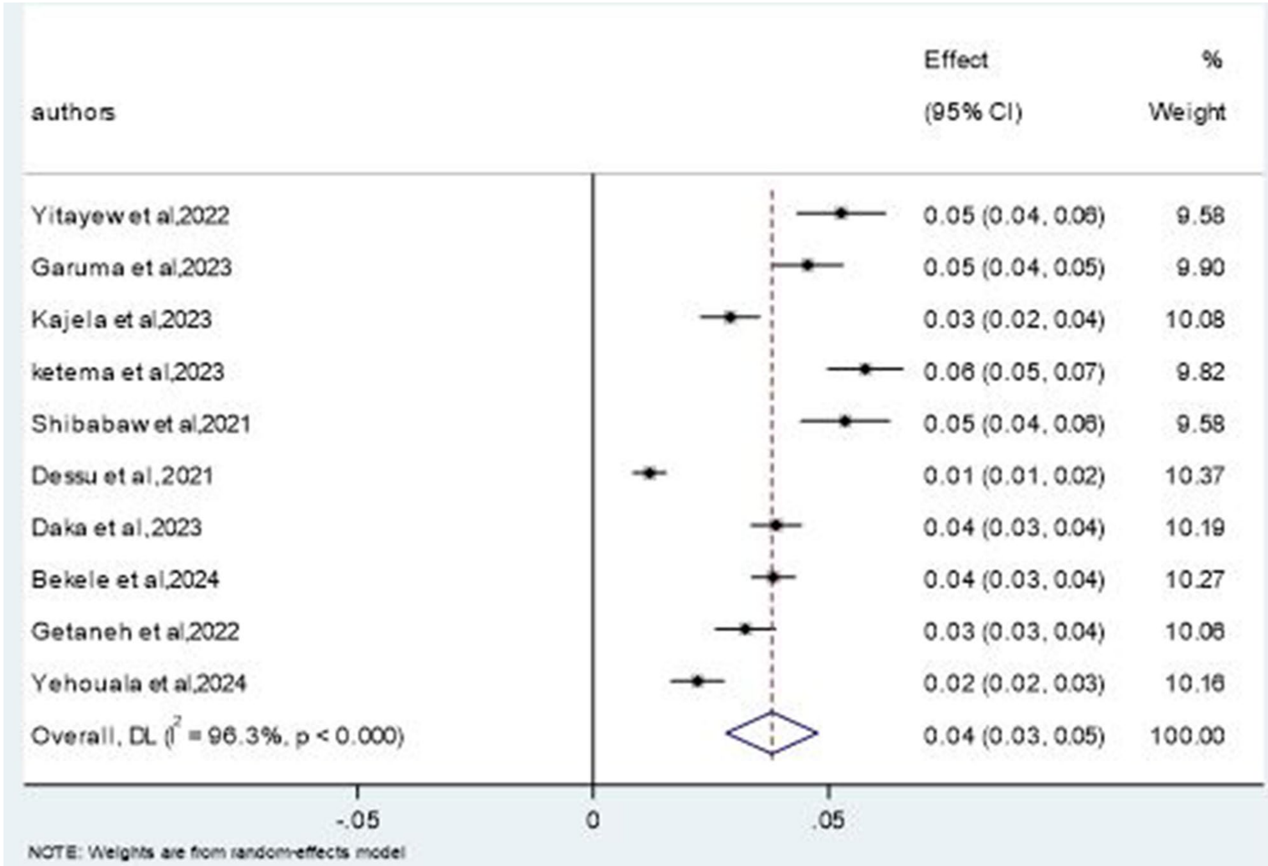

Fig. 2 Pooled estimates of incidence of birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

Table 2 Subgroup analysis of incidence and predictors of mortality among asphyxiated neonate studies in Ethiopia, 2024($N=10$)

Sub-groups		Number of studies	Effect size (Random, 95% CI)	Heterogeneity (I^2)	*p*-value
Sample size	< 450	5	0.04(0.03, 0.05)	92.17%	0.00
	≥ 450	5	0.04(0.03, 0.05)	97.87%	0.00
	Overall	10	0.04(0.03, 0.05)	96.27%	0.93
Regions	Addis Ababa	1			
	Amhara	4	0.05(0.03, 0.07)	95.89%	0.00
	Oromia	6	0.04(0.03,0.04)	74.57%	0.01
	Southern Ethiopia	1			
	overall	10	0.04(0.03, 0.05)	96.27%	0.00
Study setting	Single institution	4	0.04(0.02, 0.05)	94.12%	0.00
	Multi-center	6	0.04(0.02, 0.05)	97.34%	0.00
	Overall	10	0.04(0.03, 0.05)	96.27%	0.87
Study design	Retrospective follow-up	8	0.04(0.03, 0.05)	88.89%	0.00
	Prospective follow-up	2	0.03(0.01, 0.08)	99.06%	0.00
	Overall	10	0.04(0.03, 0.05)	96.27%	0.87
statistical analysis	Non-parametric model	8	0.04(0.02, 0.05)	96.27%	0.00
	Parametric model	2	0.05(0.03, 0.06)	85.81%	0.01
	Overall	10	0.04(0.03, 0.05)	96.27%	0.00
Levels of hospitals	Teaching Hospital	2	0.03(0.02, 0.04)	81.64%	0.02
	Comprehensive Hospital	4	0.04(0.02, 0.05)	93.89%	0.00
	Comprehensive and general Hospital	3	0.05(0.04, 0.06)	88.68%	0.00
	Overall	10	0.04(0.03, 0.05)	96.27%	0.00

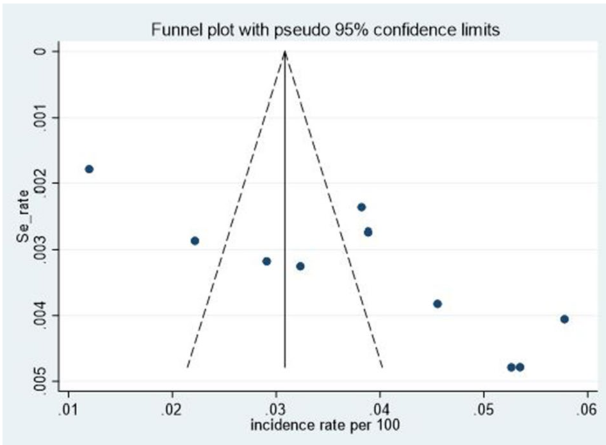

Fig. 3 The funnel plot for analysis of publication bias for incidence of birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

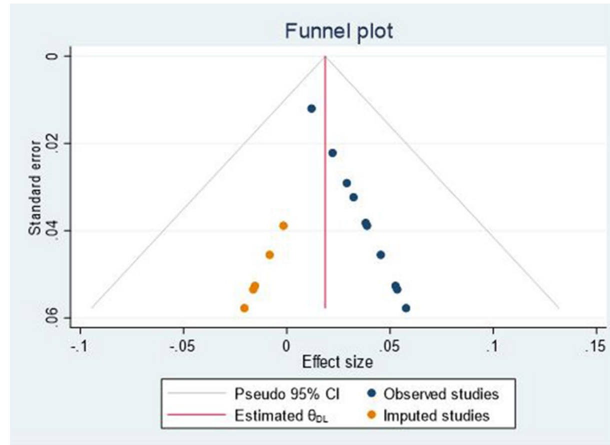

Fig. 4 The trim-and trill analysis of publication bias for incidence of birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

significant p-values (e.g., $p = 0.000$) further supported the reliability of the findings (Fig. 6).

Predictors of birth asphyxia mortality

The meta-regression analysis results indicated that labor complications (cord prolapse, prolonged labor, and premature rupture of membranes), pregnancy-related

Table 3 Egger test result of incidence and predictors of mortality among asphyxiated neonates' studies in Ethiopia, 2024($N = 10$)

Std eff	coefficient	Std. err	t	*p*-value	[95% conf. interval]	
slop	−0.0070166	0.0095789	-0.73	0.485	−0.0291055	0.0150724
Bais	13.51325	3.26161	4.14	0.003	5.991962	21.03454

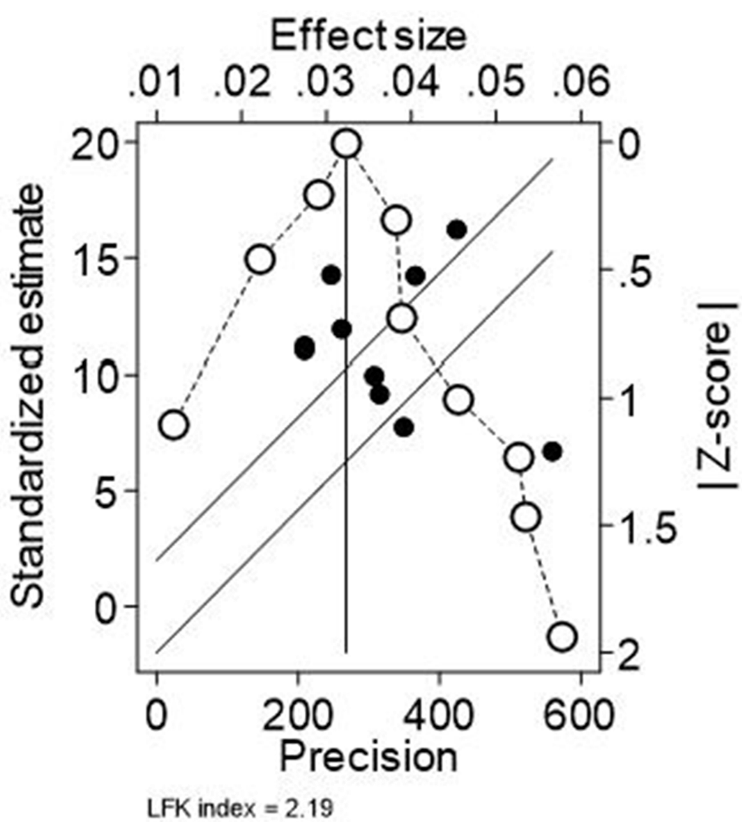

Fig. 5 Doi plot for analysis of publication bias for incidence of birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

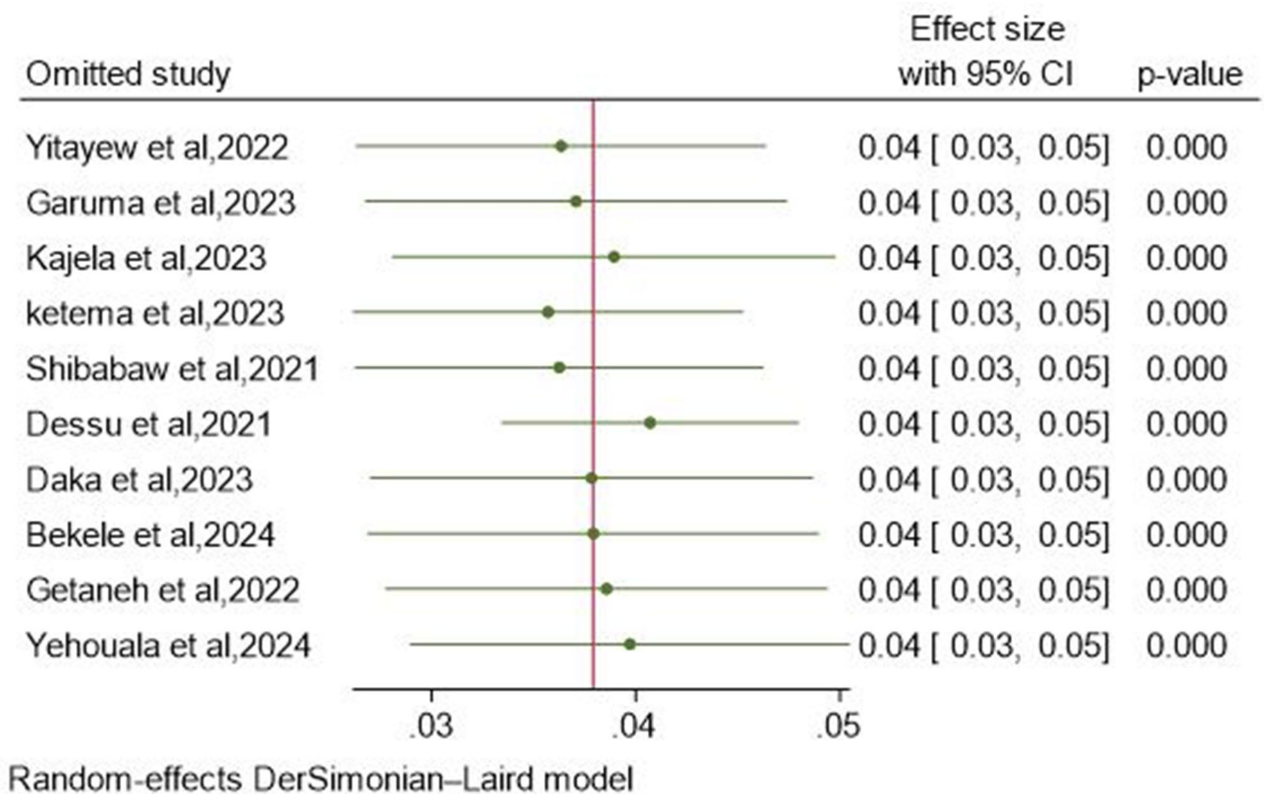

Fig. 6 Sensitivity analysis for incidence of birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

complications (antepartum hemorrhage, pregnancy hypertension, and maternal anemia), severe hypoxic-ischemic encephalopathy, neonatal seizures, and comorbidities (hypoglycemia, sepsis, anemia, and acute kidney injury) were predictors of birth asphyxia mortality.

Five studies [16–19, 21] indicated that asphyxiated neonates delivered by mothers who experienced labor complications had a 1.29-fold higher incidence of mortality due to birth asphyxia than did those delivered by mothers without labor complications (HR 1.29, 95% CI: 1.15–1.44, I^2 = 45.4%) (Fig. 7A). Four studies [13, 16, 17] revealed that asphyxiated neonates delivered by mothers who experienced pregnancy complications had a 1.52-fold higher risk of mortality due to birth asphyxia than did those delivered by mothers without pregnancy complications (HR 1.52, 95% CI: 1.41–1.64, I^2 = 0.00%) (Fig. 7B). Moreover, six studies [12, 14–16, 18, 20] showed that asphyxiated neonates who developed severe hypoxic-ischemic encephalopathy (HIE) complications had a 1.67-fold higher incidence of mortality due to birth asphyxia than did asphyxiated neonates without severe HIE complications (HR 1.67, 95% CI: 1.51–1.85, I^2 = 0.00%) (Fig. 7C). Similarly, three studies [12, 17, 20] reported that asphyxiated neonates who developed neonatal seizure complications had a 1.23-fold higher incidence of mortality due to birth asphyxia than did asphyxiated neonates without neonatal seizure complications (HR 1.23, 95% CI: 1.11–1.38, I^2 = 0.00%) (Fig. 7D). Furthermore, seven studies [12, 14–17, 19, 20] demonstrated that asphyxiated neonates with comorbidities had a 1.31-fold higher incidence of mortality due to birth asphyxia than did asphyxiated neonates without comorbidities (HR 1.31, 95% CI: 1.24–1.39, I^2 = 13.3%) (Fig. 7E).

Discussion

Globally, birth asphyxia is the third leading cause of under-five mortality, following pneumonia and prematurity, and the second leading cause of neonatal mortality, after prematurity [23]. Therefore, assessing survival studies at the national level provides valuable insights into mortality trends, predictors, and interventions for birth asphyxia. Consequently, this systematic review and meta-analysis assessed pooled mortality and identified predictors of birth asphyxia mortality, including pregnancy and labor complications, severe hypoxic-ischemic encephalopathy (HIE), neonatal seizures, and neonatal comorbidities.

Accordingly, the pooled incidence of mortality among neonates with birth asphyxia admitted to the NICU in Ethiopia was 4 per 100 person-days in this meta-analysis. This figure is similar to those reported in Somalia and South Sudan (more than 3.5 per 100 person-days) [24, 25]. However, it is slightly higher than the averages in southern Asia (2.2 per 100) and sub-Saharan Africa

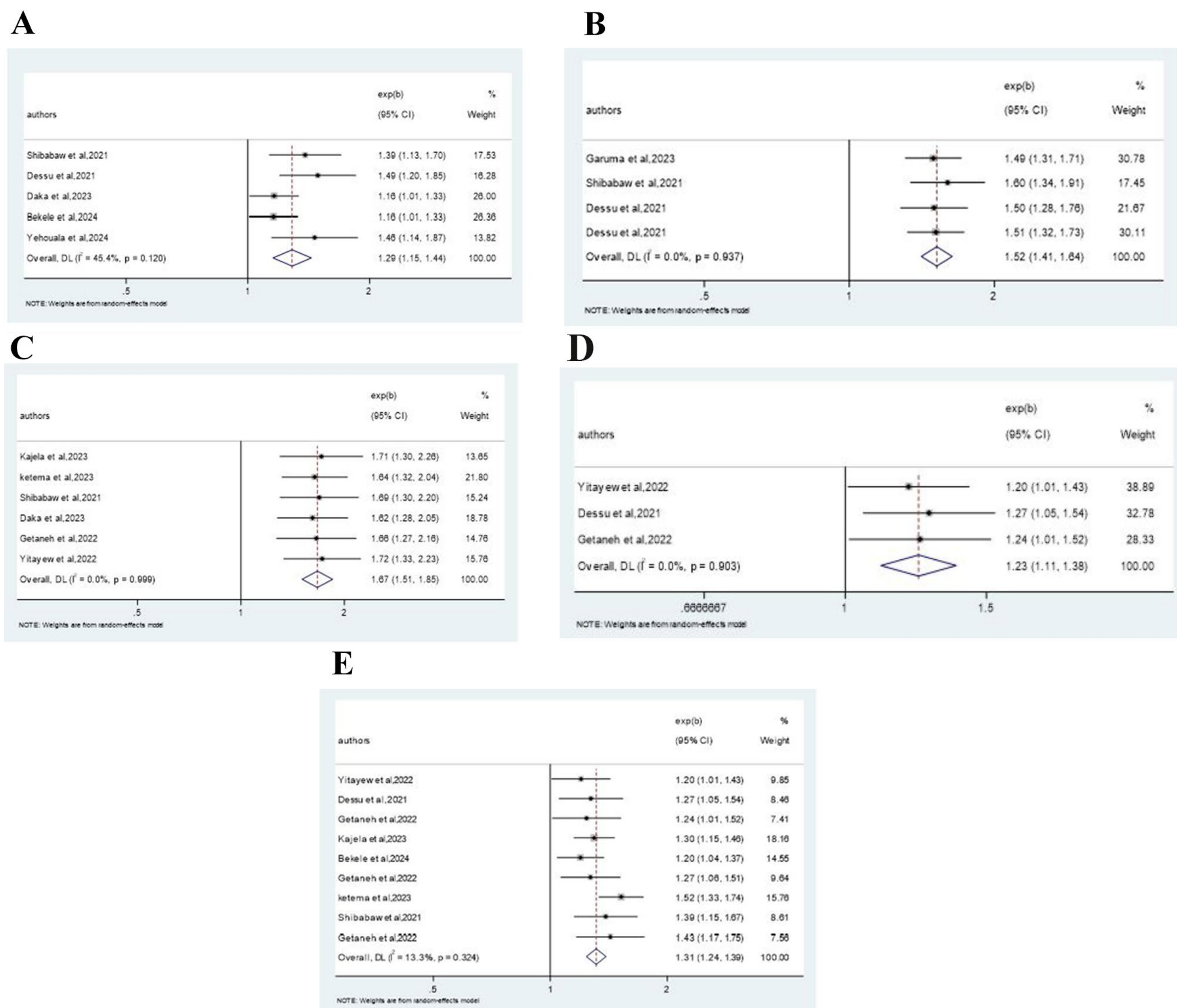

Fig. 7 **A**: The effect of Labor related complications on birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024. **B**: The effect of pregnancy related complications on birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024 **C**: The effect of severe HIE on birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024.**D**: The effect of neonatal seizure on birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024 **E**: The effect of co-morbidities on birth asphyxia mortality among neonates admitted in NICU in Ethiopia, 2024

(2.7 per 100), as well as in most Eastern African countries (Tanzania, Kenya, Eritrea, and Rwanda), where it is less than 2.5 per 100 [25]. Furthermore, the figure is significantly greater than that in North America, Australia (0.2 per 100) and Europe (0.3 per 100). This discrepancy may be due to differences in basic infrastructure, healthcare accessibility, NICU settings, medicinal supply, and the quality of skilled personnel. This implies that birth asphyxia mortality in Ethiopia is more than three times higher than the SDG target of less than 1.2 per 100, making it unlikely for Ethiopia to meet the target by 2030 unless this figure is reduced threefold within the remaining five years [26].

This meta-analysis revealed that neonates with birth asphyxia delivered by mothers who experienced pregnancy complications had a greater risk of mortality than did those with birth asphyxia delivered by mothers without pregnancy complications. This finding is consistent with results from studies conducted in Thailand, Haiti, and Europe [27–29], as well as in Madagascar, South Africa, Ghana, Uganda, and Ethiopia [30–34]. This could be explained by pregnancy-related hypertension, including conditions such as preeclampsia, which can increase the risk of birth asphyxia. Hypertension can reduce blood flow to the placenta, resulting in decreased oxygen and nutrient supply to the fetus, leading to fetal distress and increasing the likelihood of complications such as birth asphyxia during delivery [35]. This implies that the quality of screening and management of pregnancy hypertension during the antenatal period needs to be improved to prevent adverse neonatal outcomes such as birth asphyxia.

In addition, this meta-analysis revealed that Antepartum hemorrhage (APH) and maternal anemia increase the risk of birth asphyxia mortality. This result is consistent with findings from studies conducted in Iran, Tanzania, and Ethiopia, which also revealed that APH increases birth asphyxia mortality [36–39]. Similarly, the results from systematic reviews and meta-analyses in South Asian countries, low- and middle-income countries, and Europe, which showed that maternal anemia increases mortality due to birth asphyxia, align with the current meta-analysis [40–42]. This can be explained by the fact that APH and maternal anemia lead to a reduced oxygen and nutrient supply to the fetus due to compromised placental function or blood loss, resulting in fetal distress and an increased likelihood of birth asphyxia [35]. This implies that prompt management of APH and addressing maternal anemia through proper nutrition and prenatal care can help mitigate these risks and ensure better outcomes for the newborns.

Compared with those delivered by mothers without labor complications, those delivered by mothers had a greater incidence of mortality due to birth asphyxia. This finding is consistent with studies conducted in China, Bangladesh, Indonesia, Uganda, and Ethiopia [43–48]. This can be explained by the fact that during prolonged labor, the fetus may experience stress and a reduced oxygen supply due to sustained contractions and potential compression of the umbilical cord. PROM can lead to complications such as infections and umbilical cord compression, which may reduce the oxygen supply to the fetus [35, 49]. Moreover, when the umbilical cord slips ahead of the presenting part of the fetus during delivery, it can become compressed [50]. Consequently, all of these risk factors can lead to fetal distress and increased mortality due to birth asphyxia [35, 49, 50]. This implies that early detection and intervention, along with effective monitoring of labor progression, are crucial for reducing these risks.

Asphyxiated neonates who developed severe HIE complications had a greater incidence of mortality due to birth asphyxia than did those without severe HIE complications in the current meta-analysis. This finding is consistent with studies from Germany, Spain, and the Netherlands [51–54], as well as studies from China and Tanzania [55, 56]. A possible explanation might be that severe hypoxic-ischemic encephalopathy (HIE) significantly increases the risk of mortality in cases of birth asphyxia. HIE occurs when there is inadequate oxygen and blood flow to the brain during or after birth. Severe HIE can result in extensive brain injury, affecting vital functions and increasing the likelihood of death [49, 50]. This implies that early interventions, such as therapeutic hypothermia and oxygenation, can help reduce the severity of brain damage and improve outcomes.

Asphyxiated neonates who developed neonatal seizure complications had a greater incidence of mortality due to birth asphyxia than did those without neonatal seizure complications in the current systematic review and meta-analysis. This finding is consistent with results from studies conducted in Europe, Italy, Sweden, and Iraq [57–60]. This can be explained by the fact that neonatal seizures are a common consequence of birth asphyxia and are associated with increased mortality and long-term neurological impairments. Seizures indicate significant brain injury due to inadequate oxygen supply and often result in severe hypoxic–ischemic damage, leading to increased risks of mortality and developmental issues [35, 49, 50]. This implies that early intervention and comprehensive care can help improve outcomes for neonates experiencing neonatal seizures after birth asphyxia.

The current meta-analysis revealed that asphyxiated neonates with comorbidities had a greater incidence of mortality due to birth asphyxia than did asphyxiated neonates without comorbidities. This finding is in line with results from low- and middle-income countries, where sepsis contributes to the mortality of asphyxiated neonates [61]. Additionally, studies from India, Sudan, and Ethiopia have indicated that AKI increased the risk of mortality in asphyxiated neonates [62–66]. A possible explanation might be that neonatal sepsis significantly increases the mortality risk in infants with birth asphyxia. When an infant is already compromised due to asphyxia, the added burden of sepsis can lead to death by further impairing immune function, reducing oxygen delivery, and increasing metabolic demand [49, 50, 61]. Similarly, Acute kidney injury (AKI), which results in multiorgan dysfunction, fluid and electrolyte imbalances, and increased metabolic waste, can significantly increase the risk of mortality in infants with birth asphyxia [50, 66]. Therefore, this implies that early identification and treatment of sepsis and AKI in the context of birth asphyxia are essential for reducing mortality and improving long-term health outcomes.

Strengths and limitations of the study

This systematic review and meta-analysis is the first to estimate of birth asphyxia mortality rates and predictors in Ethiopia, drawing from survival studies. The analysis incorporates a significant number of primary studies, establishing a robust basis for drawing dependable conclusions. However, this study has limitations, such as the inclusion of only English-language articles. Additionally, the primary studies did not identify quality of care or organizational factors as predictors, despite their significant impact on mortality related to birth asphyxia.

Conclusion and recommendations

This meta-analysis revealed that the pooled incidence of birth asphyxia mortality was high and exceeded that of sub-Saharan Africa, falling short of the SDG target and highlighting the need for immediate intervention. Moreover, pregnancy and labor complications, severe hypoxic-ischemic encephalopathy (HIE), neonatal seizures, and neonatal comorbidities were identified as predictors of birth asphyxia mortality. These findings underscore the urgent need to enhance early detection and intervention for pregnancy and labor-related complications to reduce birth asphyxia mortality. Additionally, improving the early identification and treatment of neonatal comorbidities and seizures, and providing comprehensive care—such as therapeutic hypothermia and oxygenation—are essential for preventing severe hypoxic-ischemic encephalopathy and significantly reducing mortality due to asphyxia.

Abbreviations

AHR	Adjusted hazard ratio
APH	Antepartum hemorrhage
AKI	Acute kidney injury
APGAR	Appearance Pulse Grimace Response Activity Respiration
CI	Confident interval
CDC	The centers for disease control and prevention
HIE	Hypoxic-ischemic encephalopathy
NICU	Neonatal intensive care unit
PROM	Premature rupture of membrane
SDG	Sustainable development goals
UNICEFs	United nations international children's emergency fund
WHO	World health organization

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

Muluken Amare Wudu participated in the conception, design, data analysis, and writing of the manuscript. TA was also involved in the conception, design, data analysis, data extraction, and writing of the manuscript. Fekadeselassie Belege, Melaku Ashagrie, Selamyhun Tadesse, Yemane Eshetu, Molla Kassa, and Endalik Birrie contributed to data extraction and reviewed the manuscript. Molla kassa and Yemane Eshetu prepared Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 and the tables. All the authors reviewed and approved the final manuscript for publication.

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Data availability

All the data generated or analyzed during this study are included in this manuscript and its supplementary information files.

Declarations

Ethical approval and consent to participate

The study protocol was registered in a database called PROSPERO (https://www.crd.york.ac.uk/prospero/, ID = CRD42024579655). This study was evaluated and approved by the Wollo University College of Medicine and Health Science Research and Community Service Committee with reference No_(WU/CMHS/20/1027/2024) and ethical clearance was obtained. Moreover, this study was conducted in compliance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure that our review was thorough and reliable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

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