The effect of gestational age, low birth weight and parity on birth asphyxia among neonates in Sub-Saharan Africa: systematic review and meta-analysis: 2021

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Abstract
Background: Despite simple and proven cost-effective measures were available to prevent birth asphyxia; studies suggested that there has been limited progress in preventing birth asphyxia even in healthy full-term neonates. In Sub-Saharan Africa, inconsistency of magnitude of birth asphyxia and its association gestational age, low birth weight and parity among different studies has been observed through time.

Objective: This study aimed to estimate the pooled magnitude of birth asphyxia and its association with gestational age, low birth weight and parity among neonates in Sub-Saharan Africa.

Method: PubMed, Cochrane library and Google scholar databases were searched for relevant literatures. In addition, reference lists of included studies were retrieved to obtain birth asphyxia related articles. Appropriate search term was established and used to retrieve studies from databases. Searching was limited to cohort, cross-sectional, and case-control studies conducted in Sub-Saharan Africa and published in English language. Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) was used for critical appraisal of studies. Heterogeneity across the included studies was evaluated by using the inconsistency index (I²) test. Funnel plot and the Egger’s regression test were used to test publication bias. A weighted inverse variance random effects model was used to estimate the pooled prevalence of birth asphyxia among neonates in Sub-Saharan Africa. STATA™ version 11 software was used to conduct the meta-analysis.

Result: A total of 40 studies with 176,334 study participants were included in this systematic review and meta-analysis. The overall pooled magnitude of birth asphyxia in Sub-Saharan Africa was 17.28% (95% CI; 15.5, 19.04). Low birth weight and parity among different studies has been observed through time.
Introduction

Birth asphyxia can be defined as the inability to initiate and sustained breathing at birth [1]. Asphyxia is a lack of blood flow or gas exchange which could occur immediately before, during, or after the birth process. Causes of asphyxia include prenatal or immediate post-natal compromise of gas exchange resulting in lack of oxygen to the vital organs with subsequent hypoxemia and hypercapnia. If the hypoxemia is severe enough, vital organs will develop an oxygen debt, anaerobic glycolysis and lactic acidosis.

It is a situation that arises when there is impairment of blood gas exchange, which leads to hypoxemia, hypercapnia, metabolic acidosis, and multi organ failure [2]. According to the International Classification of Diseases, Tenth Revision (ICD-10) of the World Health Organization (WHO), birth asphyxia can be defined and classified by using the APGAR score at 1 and 5 minutes as mild, moderate, and severe [3].

The global incidence of birth asphyxia is estimated at 2 to 10 per 1000 among term newborns [4] and it is higher in developing countries than in developed countries as a result of the reduced availability of skilled care provided during delivery. Globally, birth asphyxia accounts for more than 24% of neonatal mortality [5]. Birth asphyxia is one of the leading causes of neonatal mortality in low and middle-income countries and also the main cause of long-term illnesses including mental retardation, cerebral palsy, and other neurodevelopment disorders [6]. In Africa, birth asphyxia accounts 24.0%, of which two-third of the incidence (15.9%) occurred in East and Central Africa [7].

Causes of birth Asphyxia may be a maternal or fetal condition that happens before birth, during birth, or a combination of these [8–11]. In different studies, many determinant factors of birth asphyxia have been detected, but the reduction of cerebral blood flow by any mechanism is the exact cause of birth asphyxia [12]. Risk factors of birth asphyxia that occur before birth include severe maternal hypotension or hypertensive diseases during pregnancy [12–14], antepartum hemorrhage [15–17], less antenatal care visits, oligohydramnios, young maternal age, advanced maternal age, and low educational status [10, 18–23]. During birth, birth asphyxia can be associated with prolonged home delivery, obstructed labor, oxytocin use, malpresentation, and meconium-stained amniotic fluid [9, 11, 18–21, 24–28]. Fetal risk factors associated with birth asphyxia include low birth weight, multiple gestation, tight nuchal cord, preterm delivery, and fetal distress [9, 11, 18, 19, 21, 25–28].

Birth asphyxia leads to various outcomes in the life of the neonate, such as multi-organ dysfunction, death, severe neurodevelopment delay, motor delay, cerebral delay, and hypoxic ischemic encephalopathy (HIE) [29–31].

In Sub-Saharan Africa, the burden of birth asphyxia is critical and public health problem that happened as a result of inadequate obstetrics health coverage, inaccessible health facilities, sociocultural norms, poor educational levels, shortage in health workers and supplies and poor health care spending. Likewise, facility deliveries, skilled delivery assistance and adequate antenatal visits was lower in Sub-Saharan Africa regions [21, 29, 32, 33].

Despite simple and proven cost-effective measures were available to prevent birth asphyxia, studies suggested that there has been limited progress in preventing birth asphyxia even in healthy full-term neonates [3].

As far as our search, the pooled prevalence of birth asphyxia was not previously investigated in sub-Saharan Africa. The findings of previous studies on the magnitude of birth asphyxia were inconsistent and ranged from 3.1% [24] to 39.7% [27] across the sub-Saharan African countries. Hence, this systematic review and meta-analysis study was aimed at determining the pooled estimate prevalence of birth asphyxia and its association with gestational age, low birth weight, and parity among neonates in Sub-Saharan Africa.

Method and materials

Searching strategy and eligibility criteria

The Preferred Reporting Items for Systematic Review and Meta-Analysis statement (PRISMA) guideline [34] was used to report the results of this systematic review and
meta-analysis, and it is registered in the Prospero database as (PROSPERO 2021: CRD42021288351).

In order to obtain the significant articles international electronics databases such as PubMed, Google Scholar, and Cochrane library were retrieved. Two independent authors were assigned in order to systematically searching articles.

In addition, other significant articles were retrieved manually from the gray literature by cross-referencing. The core search terms and phrases were “newborn”, “neonate”, “birth asphyxia”, “perinatal asphyxia”, “magnitude of birth asphyxia”, “and associated factors”, “Ethiopia”. The search strategies were developed using different Boolean operators. Particularly, to fit the advanced PubMed

| ID | first author      | Year of publication | Country  | Region       | Study design | Sample size | Prevalence% | Quality       |
|----|-------------------|---------------------|----------|--------------|--------------|-------------|-------------|---------------|
| 1  | Uwingabire Fetal  | 2019                | Rwanda   | East Africa  | Cross-sectional | 340         | 39.70       | Low risk      |
| 2  | Abdo et al        | 2019                | Ethiopia | East Africa  | Cross-sectional | 279         | 15.10       | Low risk      |
| 3  | G/her GT et al    | 2020                | Ethiopia | East Africa  | Cross-sectional | 282         | 18.00       | Low risk      |
| 4  | Gebreheat G et al | 2018                | Ethiopia | East Africa  | Cross-sectional | 422         | 22.10       | Low risk      |
| 5  | Berhe YZ et al    | 2020                | Ethiopia | East Africa  | case-control   | 390         | –           | Low risk      |
| 6  | Tesaw H et al     | 2018                | Ethiopia | East Africa  | case-control   | 264         | –           | Low risk      |
| 7  | Gebreslasie K et al | 2020              | Ethiopia | East Africa  | Cross-sectional | 648         | 12.70       | Low risk      |
| 8  | Jamie AH et al    | 2019                | Ethiopia | East Africa  | Cross-sectional | 258         | 31.60       | Low risk      |
| 9  | Ibrahim A et al   | 2017                | Ethiopia | East Africa  | Cross-sectional | 9736        | 3.10        | Low risk      |
| 10 | Wayessa ZJ et al  | 2018                | Ethiopia | East Africa  | Cross-sectional | 371         | 12.50       | Low risk      |
| 11 | Getachew B et al  | 2020                | Ethiopia | East Africa  | Cross-sectional | 352         | 11.50       | Low risk      |
| 12 | Alemu A et al     | 2019                | Ethiopia | East Africa  | Cross-sectional | 262         | 32.8        | Low risk      |
| 13 | Mamo SA et al     | 2020                | Ethiopia | East Africa  | Cross-sectional | 311         | 41.20       | Low risk      |
| 14 | Ayele MW et al    | 2019                | Ethiopia | East Africa  | case-control   | 429         | –           | Low risk      |
| 15 | Gudayu TW et al   | 2017                | Ethiopia | East Africa  | Cross-sectional | 261         | 13.80       | Low risk      |
| 16 | Wosenu L et al    | 2018                | Ethiopia | East Africa  | case-control   | 273         | –           | Low risk      |
| 17 | Woday A et al     | 2019                | Ethiopia | East Africa  | Cross-sectional | 345         | 22.6        | Low risk      |
| 18 | Meshecha ADETal  | 2020                | Ethiopia | East Africa  | case-control   | 386         | –           | Low risk      |
| 19 | Demisse AG et al  | 2017                | Ethiopia | East Africa  | Cross-sectional | 769         | 12.5        | Low risk      |
| 20 | Kibret Y et a    | 2018                | Ethiopia | East Africa  | case-control   | 380         | –           | Low risk      |
| 21 | Mulugeta T et al  | 2020                | Ethiopia | East Africa  | case-control   | 213         | –           | Low risk      |
| 22 | Selamu A et al    | 2019                | Ethiopia | East Africa  | Cross-sectional | 371         | 20          | Low risk      |
| 23 | G/medhin M et al  | 2020                | Ethiopia | East Africa  | case-control   | 662         | –           | Low risk      |
| 24 | Asfere NW et al   | 2018                | Ethiopia | East Africa  | Cross-sectional | 154         | 29.9        | Low risk      |
| 25 | Bayih WA et al    | 2020                | Ethiopia | East Africa  | Cross-sectional | 582         | 28.4        | Low risk      |
| 26 | Lake EA et al     | 2019                | Ethiopia | East Africa  | Cross-sectional | 278         | 25.7        | Low risk      |
| 27 | Gebregziabher GT etal | 2020            | Ethiopia | East Africa  | Cross-sectional | 267         | 18          | Low risk      |
| 28 | Onyriuk et al     | 2006                | Nigeria  | West Africa  | Cross-sectional | 2208        | 8.38        | Low risk      |
| 29 | IgeOO et al       | 2011                | Nigeria  | West Africa  | Cross-sectional | 398         | 12.6        | Low risk      |
| 30 | G. I. McgilUgwu et al | 2012          | Nigeria  | West Africa  | retrospective cohort | 26000       | 3.3         | Low risk      |
| 31 | Halloran DR et al | 2008                | Zambia   | East Africa  | Cross-sectional | 182         | 23          | Low risk      |
| 32 | Sepeku A et al    | 2011                | Tanzania | East Africa  | Cross-sectional | 192         | 21.1        | Low risk      |
| 33 | Kibai K et al     | 2017                | Kenya    | East Africa  | Cross-sectional | 422         | 29.1        | Low risk      |
| 34 | Gichogo M et al   | 2018                | Kenya    | East Africa  | Cross-sectional | 237         | 5.1         | Low risk      |
| 35 | Abbika BM et al   | 2018                | Chad     | Central Africa | Cross-sectional | 7254        | 5.1         | Low risk      |
| 36 | Biselele T et al  | 2013                | DR Congo | Central Africa | Cross-sectional | 902         | 4.4         | Low risk      |
| 37 | Mande et al       | 2018                | DR Congo | Central Africa | Cross-sectional | 612         | 19.4        | Low risk      |
| 38 | Fourmane P et al  | 2013                | Cameroon | West Africa  | case-control   | 117         | –           | Low risk      |
| 39 | K. J. Nathoo et al| 1990                | Zimbabwe | East Africa  | case-control   | 225         | –           | Low risk      |
| 40 | Iran J Child Neuroletal | 2013          | Cameroon | West Africa  | case-control   | 1117        | 8.05        | Low risk      |
database, the following search strategy was applied: [(newborn [MeSH Terms] OR neonate OR newborn baby AND (birth asphyxia [MeSH Terms] OR perinatal asphyxia) AND prevalence [MeSH Terms] OR incidence OR burden OR magnitude OR epidemiology AND (Associated factors) OR predictors OR determinant factors OR risk factors OR predisposing factors OR factors AND (“sub-Saharan Afric.

Studies that reported the prevalence and/or associated factor of birth asphyxia using analytical cross-sectional, cohort, and case-control studies and published in English before October 28, 2021 were included. On the other hand, articles without an abstract and/or full-text, studies that failed to determine the anticipated outcome of interest, and those studies with qualitative study design were excluded.

**Study variables and study selection process**

In this systematic review and meta-analysis, associated factors (primigravida, low birth weight and preterm gestational age) that increase the occurrence of birth asphyxia were considered as exposure variables to estimate their effects on the magnitude of birth asphyxia and the magnitude of birth asphyxia was considered as the outcome variable of this study.

**Study selection process, methods of data extraction and quality assessment**

In order to remove duplicated studies, the retrieved articles were exported to reference manager software, Endnote version 7. Two authors (Masresha Asmare Techane (MAT) and Selam Fisiha Kassa (SFK)) screened and assessed the titles and abstracts of studies, followed by full-text assessments independently and systematically. Disagreements were resolved by consensus and discussion with other authors.

Data were extracted by using the standardized Microsoft Excel data extraction form. Name of the first author, year of publication, country, region, study design, sample size, number of outcomes, prevalence (magnitude), risk estimate (Odds Ratio, RR) with 95% confidence interval (CI) and associated factors were extracted from the included articles. The quality of the included studies was evaluated by using The Joanna Briggs Institute (JBI) quality appraisal checklist [35]. Studies were considered for meta-analysis and categorized as low risk for poor quality when it scored 50% and above of the quality assessment indicators (Table 1).

![Fig. 1 A PRISMA flow diagram of articles screening and process of selection](image)
Data processing and analysis

The data were extracted from Microsoft Excel and analyzed using STATA Version 11. Meta-analysis was performed using statistical software. The funnel plot was used to check for publication bias, and Egger’s regression test was used to check for it more objectively [36]. Heterogeneity of studies was quantified using the I-squared statistic, in which 25, 50, and 75% represented low, moderate, and high heterogeneity, respectively [37, 38]. Given that we found significant heterogeneity among the studies (I² = 98.4%), pooled analysis was conducted by using a weighted inverse variance random-effects model [39]. A sensitivity analysis was employed to see the effect of a single study on the overall estimation. For the second outcome, the odds ratio and relative risk were used to ascertain the association between determinant factors and outcome variables in the included articles.

Operational definition

Meconium-stained amniotic fluid: the presence of meconium in the amniotic fluid which changes the color of the liquor from clear to various shades of green, yellow or brownish color depending on the degree of meconium stained liquor [40].

Result

Searching results, characteristics and quality of the included studies

The search strategy retrieved 449 from Pub Med, 15 from Cochrane library and 12,500 from Google Scholar. 11,500 articles were removed due to duplicates, 657 due
to unmatched title and abstracts, 456 due to study area. Three hundred fifty-one (351) articles were selected for the full text review. After full text reviews, 311 articles didn’t report the outcome of interest and excluded from the analysis. Finally, forty [40] articles were included in this systematic review and meta-analysis to estimate the magnitude of birth asphyxia and its association with parity, low birth weight and preterm gestational age in Sub-Saharan Africa (Fig. 1).

Thirty-two studies were found in East Africa [10, 11, 13, 15−19, 21, 22, 24, 27, 28, 41], Five in west Africa [8, 25, 26, 42, 43] and three in central Africa [44]. Most of the studies were conducted using a cross-sectional study design. In terms of publication year, nine studies were published prior to 2017, and 31 studies were published between January 2017 and December 2021 (Table 1).

The JBI quality appraisal criteria established for cross-sectional, cohort and case-control study design were used to appraise the included studies. The studies included in this systematic review and meta-analysis had no considerable risk. Therefore, all the studies were considered.

**Magnitude of birth asphyxia**

A total of 40 studies with 176,334 participants were analyzed in the meta-analysis to estimate the pooled prevalence of birth asphyxia in Sub-Saharan Africa. Consequently, the overall pooled prevalence of birth asphyxia was 17.28% (95% CI; (15.5, 19.04); $I^2 = 98.4\%$ (Fig. 2).

| Region      | Year of Publication | ES (95% CI) | % Weight |
|-------------|---------------------|-------------|----------|
| East Africa | 2019                | 39.70 (34.50, 44.90) | 2.96 |
|             | 2019                | 15.10 (10.90, 19.30) | 3.24 |
|             | 2020                | 18.00 (13.52, 22.48) | 3.16 |
|             | 2018                | 22.10 (18.14, 26.06) | 3.31 |
|             | 2020                | 12.70 (10.14, 15.26) | 3.67 |
|             | 2019                | 31.60 (25.93, 37.27) | 2.82 |
|             | 2017                | 3.10 (2.76, 3.44) | 3.97 |
|             | 2018                | 12.50 (9.13, 15.87) | 3.47 |
|             | 2020                | 11.50 (8.17, 14.83) | 3.48 |
|             | 2019                | 32.80 (27.12, 38.48) | 2.82 |
|             | 2020                | 41.20 (35.73, 46.67) | 2.88 |
|             | 2017                | 13.80 (9.62, 17.98) | 3.25 |
|             | 2019                | 22.60 (18.19, 27.01) | 3.18 |
|             | 2017                | 12.50 (10.16, 14.84) | 3.71 |
|             | 2019                | 20.00 (15.93, 24.07) | 3.28 |
|             | 2018                | 29.90 (22.67, 37.13) | 2.39 |
|             | 2020                | 28.40 (24.74, 32.06) | 3.39 |
|             | 2019                | 25.70 (20.56, 30.84) | 2.97 |
|             | 2020                | 18.00 (13.39, 22.61) | 3.13 |
|             | 2008                | 23.00 (16.89, 29.11) | 2.69 |
|             | 2011                | 21.10 (15.33, 26.87) | 2.79 |
|             | 2017                | 29.10 (24.77, 33.43) | 3.21 |
|             | 2018                | 5.10 (2.30, 7.90) | 3.61 |
| Subtotal    | (I-squared = 98.5%, $p = 0.000$) | 21.14 (16.12, 26.17) | 73.40 |

| Region      | Year of Publication | ES (95% CI) | % Weight |
|-------------|---------------------|-------------|----------|
| West Africa | 2006                | 8.38 (7.22, 9.54) | 3.91 |
|             | 2011                | 12.60 (9.34, 15.86) | 3.50 |
|             | 2012                | 3.00 (3.08, 3.52) | 3.97 |
|             | 2013                | 8.05 (6.45, 9.65) | 3.85 |
| Subtotal    | (I-squared = 97.7%, $p = 0.000$) | 7.89 (4.08, 11.69) | 15.23 |

| Region      | Year of Publication | ES (95% CI) | % Weight |
|-------------|---------------------|-------------|----------|
| Central Africa | 2018                | 5.10 (4.59, 5.61) | 3.96 |
|             | 2013                | 4.40 (3.06, 5.74) | 3.88 |
| Mando et al  | 2018                | 19.40 (16.27, 22.53) | 3.53 |
| Subtotal    | (I-squared = 97.5%, $p = 0.000$) | 9.25 (4.37, 14.13) | 11.38 |

|             | Overall (I-squared = 98.4%, $p = 0.000$) | 17.28 (15.51, 19.04) | 100.00 |

**NOTE:** Weights are from random effects analysis.
Subgroup analysis, publication bias and sensitivity analysis

We have done subgroup analysis by using region and study design of the included studies. Our subgroup analysis based on regions the study showed that the highest pooled prevalence of birth asphyxia was observed from studies done in East Africa (21.14%; 95% CI: 16.12, 26.17) (Fig. 3). But no any difference in the magnitude of birth asphyxia with study design.
Publication bias was evaluated by a funnel plot and the Egger’s regression test. A funnel plot showed asymmetrical distribution (Fig. 4) subjectively indicates the presence of publication bias. In addition, objectively the Egger’s regression test p-value was 0.000, which indicated the presence of publication bias.

We have conducted a sensitivity analysis to assess the weight of every study on the pooled effect size of the magnitude of birth asphyxia. The sensitivity analysis using the Der Simonian-Laird random-effects model showed that there was no single study that affected the overall magnitude of birth asphyxia in Sub-Saharan Africa (Fig. 5).

**Associated factors of birth asphyxia**

From the included forty studies, twelve [10, 11, 13, 15–19, 24, 27, 28, 33] studies reported the association between parity and birth asphyxia. The pooled adjusted odds ratio from these studies was 1.15 (95% CI: 0.84, 1.46), showing that the odds of birth asphyxia were 1.15 higher in neonates born from primigravida mothers than their counterparts, and it is not statistically significant (Fig. 6).

Out of the included forty studies, the association between low birth weight and birth asphyxia was reported in eight studies [10, 11, 15–17, 19, 27, 44]. The pooled odds ratio was 2.58 (95% CI: 1.36, 4.88), suggesting that the risk of developing birth asphyxia was 2.58 times higher among newborns with low birth weight as compared to newborns with normal birth weight (Fig. 7).

From the included forty studies, the association between meconium stained amniotic fluid and birth asphyxia was reported in nine studies [10, 11, 13, 16, 18, 19, 28, 44]. The pooled odds ratio was 6 (95% CI: 3.69, 9.74), suggesting that the risk of developing birth asphyxia was 6 times higher among newborns with meconium stained amniotic fluid as compared to newborns with clear amniotic fluid (Fig. 8).

Out of the included forty studies, the association between gestational age and birth asphyxia was reported in ten studies [10, 11, 13, 15, 16, 18, 27]. The pooled odds ratio was 0.88 (95% CI: 0.34, 1.43), suggesting that the risk of developing birth asphyxia was 22% among preterm newborns as compared to newborns with term gestational age (Fig. 9).

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**Fig. 6** The pooled effect of parity on birth asphyxia in Sub-Saharan Africa
Discussion

In developing countries, birth asphyxia remains the main cause of neonatal morbidity and mortality [25, 30, 42, 45, 46]. As far as our exhaustive searching, there are no previous systematic reviews and meta-analyses done to estimate the pooled prevalence of birth asphyxia in Sub-Saharan Africa. As findings from various studies showed that the magnitude of birth asphyxia is variable and its association with parity, gestational age, meconium stained amniotic fluid, and low birth weight were reported inconsistently and not well investigated [16, 18, 19, 27, 28]. As a result, this study was aimed to estimate the pooled prevalence of birth asphyxia and its association with Parity, gestational age, meconium-stained amniotic fluid and low birth weight in Sub-Saharan Africa.

In our study, the pooled prevalence of birth asphyxia in Sub-Saharan Africa was found to be 17.28% (95% CI; 15.5, 19.04). This finding is consistent with findings from other systematic review and meta-analysis done in Central and West Africa 15.9% [7]. However, our study finding was higher than studies conducted in South Africa 2.6% [47]. This variation might be due to high level of facility deliveries, skilled delivery assistance, antenatal visits and appropriate implementations of neonatal resuscitation programme in South Africa as compared to in Sub-Saharan Africa [48]. On the other hand, the findings of this study were lower than those found in other systematic reviews and meta-analysis conducted in

| First author | Year of publication | ES (95% CI) | Weight |
|--------------|---------------------|------------|--------|
| Uwungabure F et al | 2019 | 5.91 (0.67, 51.99) | 5.93 |
| Berne YZ et al | 2020 | 0.58 (0.26, 1.30) | 14.51 |
| Tasew H et al | 2018 | 6.90 (3.01, 15.81) | 14.34 |
| Getachew B et al | 2020 | 1.65 (0.94, 2.88) | 16.52 |
| Alemu A et al | 2019 | 3.31 (1.31, 8.37) | 13.51 |
| Wosenu L et al | 2018 | 7.72 (1.88, 31.69) | 9.83 |
| Gebregzabher GT et al | 2020 | 1.86 (0.32, 10.84) | 7.76 |
| Marde et al | 2018 | 3.40 (1.11, 10.40) | 11.97 |
| Fourneau P et al | 2013 | 1.05 (0.11, 10.07) | 5.62 |
| Sepeku A et al | 2011 | (Excluded) | 0.00 |
| Overall (I-squared = 67.2%, p = 0.002) | | 2.38 (1.36, 4.88) | 100.00 |

NOTE: Weights are from random effects analysis

Fig. 7 the pooled effect of low birth weight on birth asphyxia in sub-Saharan Africa
Ethiopia, at 19.3% [49]. The possible explanation for this discrepancy may be due to the variation in study setting, study design, study population, and level of awareness with regard to poor birth outcomes for the general population, in community engagement in Ethiopia’s maternal health issues, and the differences in the implementation of services for mothers and their new-born babies as compared with participants from other Sub-Saharan African countries.

The magnitude of birth asphyxia varied greatly in the included studies, ranging from 3.1% [24] to 39.7% [27]. However, our subgroup analysis based on study location showed that the highest pooled prevalence was observed from studies done in East Africa (41.4%; 95% CI: 33.9, 48.8). A possible explanation for this variation could be the differences in healthcare facilities; With emerging inexpensive technology, the developed nations prevention and treatment of birth asphyxia can more feasibly reach those at risk as compare to resource-limiting settings. Additionally, developed nations may have a better screening strategy of postnatal asphyxia and management of idiopathic etiologies which may help to reach both a near eradication of mortality related with birth asphyxia and reduces in its impairment.

This finding reveals the presence of a strong association between birth asphyxia and low birth weight. The odds of a newborn developing birth asphyxia was 2.58 times higher among newborns with low birth weight than among newborns with normal birth weight. This finding is in line with various studies conducted in Indonesia [50], Pakistan [51], Nigeria [25], Zambia [8], and Ethiopia [49]. This might be due to the fact that a newborn with low birth weight has poor lung surfactant, with immature lungs and weak respiratory muscles and curved ribs, which results in birth asphyxia [52, 53].

This systematic review and meta-analysis also showed that the presence of meconium-stained amniotic fluid increases the occurrence of birth asphyxia. This finding is consistent with studies conducted in India [52], Pakistan [51], Indonesia [50] and Ethiopia [11, 13, 17, 19, 49]. This may be due to the fact that meconium containing amniotic fluid increases the occurrence of meconium aspiration during intrauterine gasping or during the initial breaths taken after birth, which may
cause acute airway obstruction, surfactant dysfunction or inactivation [54, 55].

**Limitation**

This study had its limitations. Primarily, most of the studies included for this analysis had a small sample size, which could have a significant effect on the estimated pooled prevalence of birth asphyxia. Furthermore, majority of studies included in this systematic review and meta-analysis were conducted in East Africa, which may be an underrepresentation for the other region of sub-Saharan Africa. Since it is a first systematic review, lack of enough literature and use odds ratio to estimate the predictor variables may be affected by other confounding variables. Moreover, only articles and reports published in English were considered in this review, which sought to investigate birth asphyxia in the Sub-Saharan Africa. In addition, the majority of studies included in the review were cross-sectional in nature, which limited our ability to assess cause–effect relationships and might have resulted in the outcome variable being affected by other confounding variables.

**Conclusion**

Findings from this study indicated that birth asphyxia in Sub-Saharan was Still the major public health problem. This study also noted that birth asphyxia was significantly associated with low birth weight and meconium-stained amniotic fluid. Hence, it is better to assess all neonates with birth asphyxia for low birth weight and intrapartum meconium-stained amniotic fluid. Moreover, further research is needed to identify other predictors of birth asphyxia in Sub-Saharan Africa.

**Abbreviations**

AOR: Adjusted Odds Ratio; CI: Confidence Interval; HIE: hypoxic ischemic encephalopathy; ICD-10: International Classification of Diseases, Tenth Revision; JBI: Joanna Briggs Institute; OR: Odds Ratio; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; WHO: World Health Organization.
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Authors’ contributions
Conceptualization: MA, NT, KA and CA. Data curation: MA, SFBK, DG.
Methodology: BF, TB, RT, MT, TK, KA, AT, AB. Investigation: MA, TT, AT, GM, AD, TG, AW, MS. Resources: MA, BB, TB, AT, TG, AW. Supervision: GM, CA, NT, KA, BT, MS. Visualization: GM, BT, MT, JT. Writing – original draft: MA, TT, SF. Writing – review & editing: MA and all other authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analyzed during the current systematic review and meta-analysis is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Since this study is systematic review and meta-analysis the issue of ethical approval and consent to participate is not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflict of interest.

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References
1. Organization WH. Guidelines on basic newborn resuscitation. 2012.
2. Antonucci R, Porcella A, Pilloni MD. Perinatal asphyxia in the term newborn. J Pediatr Neonatal Individual Care. 2014;3(2):e030269.
3. Organization WH. The WHO application of ICD-10 to deaths during the perinatal period, 2016. p. ICD-PM.
4. Odd D, Heep A, Luyt K, Draycott T. Hypoxic-ischemic brain injury: planned delivery before intrapartum events. J Neonatal-Perinatal Med. 2017;10(4):347–53.
5. Gibson A, Noguchi L, Kinney MV, Blencowe H, Freedman L, Mofokeng T, et al. Italian Journal of Pediatrics 2013;2013.
6. Wallander JL, McClure E, Biasini F, Goudar SS, Pasha O, Chomba E, et al. BRAIN research to ameliorate impaired neurodevelopment-home-based intervention trial (BRAIN-HIT). BMC Pediatr. 2010;10(1):1–9.
7. Workineh Y, Semachew A, Ayalew E, Animaw W, Tirfe M, Birhanu M. Prevalence of perinatal asphyxia in east and Central Africa: systematic review and meta-analysis. Heliyon. 2020;6(4):e03703.
8. Halloran D, McClure E, Chakraborty H, Chomba E, Wright L, Carlo W. Birth asphyxia survivors in a developing country. J Perinatol. 2009;29(3):243–9.
9. Igboanugo S, Chen A, Mielke JG. Maternal risk factors for birth asphyxia in low-resource communities: A systematic review of the literature. J Obstet Gynaecol. 2020;40(8):1039–55.
10. Tasew H, Zemiaichal M, Teklay G, Mariye T, Ayele E. Risk factors of birth asphyxia among newborns in public hospitals of central zone, Tigray, Ethiopia 2018. BMC Res Notes. 2018;11(1):1–7.
11. Wosenu L, Worku AG, Tesfome DF, Gelagay AA. Determinants of birth asphyxia among live birth newborns in University of Gondar referral hospital, Northwest Ethiopia: a case-control study. PLoS One. 2018;13(9):e0203763.
12. Aslam HM, Saleem S, Afzal R, Iqbal U, Saleem SM, Shaikh MWA, et al. Risk factors of birth asphyxia. Ital J Pediatr. 2014;40(1):1–9.
13. Berhe YZ, Kebedom AG, Gebregziabher L, Aisef A, Berhe LZ, Mohammed SA, et al. Risk factors of birth asphyxia among neonates born in public hospitals of Tigray, northern Ethiopia. Pediatric Health Med Therapeut. 2020;11:13.
14. Desalew A, Sehaghn A, Tesfaye G. Determinants of birth asphyxia among newborns in Ethiopia: a systematic review and meta-analysis. Int J Health Sci. 2020;14(1):35.
15. Fournane P, Niokom G, Mboudou ET, Sanon JD, Nguelfack S, Mofio B. Risk factors of clinical birth asphyxia and subsequent newborn death following nuchal cord in a low-resource setting. Open journal of Obstet Gynecol. 2013;2013.
16. Gebregziabher GT, Hadgu FB, Abebe HT. Prevalence and associated factors of perinatal asphyxia in neonates admitted to ayder comprehensive specialized hospital, northern Ethiopia: a cross-sectional study. Int J Pediatr. 2020;2020.
17. Getachew B, Eftef A, Asefa T, Dereje B. Determinants of low fifth minute Apgar score among newborn delivered in Jimma University medical center, Southwest Ethiopia. Int J Pediatr. 2020;2020.
18. Abdou RA, Halli HW, Kebede BA, Anshebo AA, Gejo NG. Prevalence and contributing factors of birth asphyxia among the neonates delivered at Nigist Eleni Mohammed memorial teaching hospital, southern Ethiopia: a cross-sectional study. BMC Pregnancy Childbirth. 2019;19(1):1–7.
19. Alemu A, Melaku G, Abera GB, Damte A. Prevalence and associated factors of perinatal asphyxia among newborns in Dilla University referral hospital, southern Ethiopia–2017. Pediatr Health Med Therapeut. 2019;10:69.
20. Kene G, Ojira H, Wagiarni N, Zenhun E, Aboma M. Determinants of birth asphyxia among newborns delivered in public hospitals of west Shoa zone, Central Ethiopia: a case-control study. PLoS One. 2021;16(3):e0248504.
21. Mlesheda AD, Azage M, Worku E, Bogale GG. Determinants of birth asphyxia among newborns in referral hospitals of Amhara National Regional State, Ethiopia. Pediatric health Medicine Therapeut. 2020;11:1.
22. Mulugeta T, Sesibise G, Fenta FA, Shibat M. Risk factors of perinatal asphyxia among newborns delivered at public hospitals in Addis Ababa, Ethiopia: case–control study. Pediatric Health Med Therapeut. 2020;11:297.
23. Onyeyrughua C, Ugbona H. Severe birth asphyxia: risk factors as seen in a tertiary institution in the Niger delta area of Nigeria. Continental J Trop Med. 2010;6(11).
24. Ibrahim N, Muhye A, Abdulie S. Prevalence of birth asphyxia and associated factors among neonates delivered in Dilchora referral hospital, Dire Dawa, eastern Ethiopia Clin mother child Health. 2017;14(4).
25. Ige OI. Risk factors and mortality rate of severely asphyxiated neonates in a tertiary Centre in north-Central Nigeria. Jos J Med. 2013;7(1):10–4.
26. Ilaq BG, Aminu MS, Musa A, Adelakun MB, Adeniji AO, Kolaole T. Prevalence and risk factors for perinatal asphyxia as seen at a specialist hospital in Gusau, Nigeria. Sub-Saharan Afr J Med. 2015;2(2):64.
27. Uwingabire F, Gowan M. Birth asphyxia at a district hospital in Kigali, Rwanda. Rwanda J Med Health Sci. 2019;2(2):96–104.
28. Woday A, Muluken A, St DC. Birth asphyxia and its associated factors among newborns in public hospital, Northeast Amhara, Ethiopia. PLoS One. 2019;14(12):e0226891.
29. Babu BVA, Devi SS, Kumar BK. Birth asphyxia—incidence and immediate outcome in relation to risk factors and complications. Int J Res Health Sci. 2014;2(4):1064–71.
30. Shah G, Singh R, Das B. Outcome of newborns with birth asphyxia. J Nepal Med Assoc. 2005;44(158).
31. Ellenberg JH, Nelson KB. The association of cerebral palsy with birth asphyxia: a definitional quagmire. Dev Med Child Neurol. 2013;55(3):210–6.

32. Ensdal H, Mdimu E, Svensen E, Perlman JM. Early initiation of basic resuscitation interventions including face mask ventilation may reduce birth asphyxia related mortality in low-income countries: a prospective descriptive observational study. Resuscitation. 2012;83(7):869–73.

33. Usman F, Imam A, Farouk ZL, Dayyabu AL. Newborn mortality in sub-Saharan Africa: why is perinatal asphyxia still a major cause? Ann Global Health. 2019;85(1).

34. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 Statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372.

35. Peters M, Godfrey C, McKenzie P, Soares C, Khalil H, Parker D. The Joanna Briggs institute reviewers’ manual 2015: methodology for JBI scoping reviews; 2015.

36. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629-34.

37. Interpretation of tests of heterogeneity and bias in metaanalysis detected by a simple, graphical test. J Eval Clin Pract. 2008;14(5):951–7.

38. Higgins JTS. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21(11):1539–58.

39. Marin-Martínez F, Sánchez-Meca J. Weighting by inverse variance or by sample size in random-effects meta-analysis. Educ Psychol Meas. 2010;70(1):56–73.

40. Khatun MHA, Arzu J, Haque E, Kamal M, Al Mamun MA, Khan MFH, et al. Fetal outcome in deliveries with meconium stained liquor. Bangladesh J Child Health. 2009;33(2):41–5.

41. Aliyu I, Lawal T, Onankpa B. Prevalence and outcome of perinatal asphyxia: our experience in a semi-urban setting. Trop J Med Res. 2017;20(2):161.

42. Halloran D, McClure B, Chomba E, Wright L, Carlo W. 296 BIRTH ASPHYXIA SURVIVORS IN A DEVELOPING COUNTRY. BMJ Publishing Group Limited; 2006.

43. Ugwu GM, Abedi H, Ugwu E. Incidence of birth asphyxia as seen in central hospital and GH children’s clinic both in Wani Niger Delta of Nigeria: an eight year retrospective review. Global J Health Sci. 2012;4(5):140.

44. Mande B, Muyobela K, Hasivirwe V, Batoke L. Clinical features and outcome of birth asphyxia in hôpital du Cinquantenaire of Kisangani: a cross-sectional study. Asian journal of. Pediatr Res. 2018:1–6.

45. Kinney MV, Kerber KJ, Black RE, Cohen B, Nikrimum F, Coovadha I, et al. Sub-Saharan Africa’s mothers, newborns, and children: where and why do they die? PLoS Med. 2010;7(6):e1000294.

46. Lau K. Global trends in incidence and mortality of neonatal encephalopathy due to birth asphyxia and stillbirth. Eur J Pub Health. 2019;29(6):187 18.

47. Kinoti S. Asphyxia of the newborn in east, central and southern Africa. East Afr Med J. 1993;70(7):422–33.

48. Ballot D, Adhikari M, Bolton K. South African handbook of Resuscitation of the newborn. Johannesburg: South African Paediatric Association, 2004.

49. Ahmed R, Mosa H, Sultan M, Helill SE, Assefa B, Abed M, et al. Prevalence and risk factors associated with birth asphyxia among neonates delivered in Ethiopia: a systematic review and meta-analysis. PLoS One. 2021;16(8):e0255488.

50. Sekarwati TA, Darsini N, Husada D. Risk factors for neonatal asphyxia occurrence at general hospital Dr. M. Soewandhi, Surabaya. Indian J Public Health Res Dev. 2020;11(4).

51. Tabassum F, Rizvi A, Ariff S, Soofi S, Bhutta ZA. Risk factors associated with birth asphyxia in rural district Matiari, Pakistan: a case control study. Int J Clin Med. 2014;5(2):11403.

52. Singh G, Chouhan R, Sidhu K. Maternal factors for low birth weight babies. Med J Armed Forces India. 2009;65(1):10–2.

53. Seaward PG, Hannah ME, Myhr TL, Farine D, Ohlsson A, Wang EE, et al. International multicentre term PreBolus riputation of membranes study: evaluation of predictors of clinical chorioamnionitis and postpartum fever in patients with preBolus riputation of membranes at term. Am J Obstet Gynecol. 1997;177(5):1024–9.

54. Mundhra R, Agarwall M. Fetal outcome in meconium stained deliveries. J Clin Diag Res. 2013;7(12):2874.

55. Kopincova J, Calkovska A. Meconium-induced inflammation and surfactant inactivation: specifics of molecular mechanisms. Pediatr Res. 2016;79(4):514–21.

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