Determinants of birth asphyxia among newborns in Ethiopia: A systematic review and meta-analysis

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ABSTRACT

Objective: The aim of this systematic review and meta-analysis was to estimate the pooled magnitude of birth asphyxia and its determinants in Ethiopia.

Methods: The databases, including PubMed, Medline, CINAHL, EMBASE, and other relevant sources, were used to search relevant articles. Both published and unpublished studies, written in English and carried out in Ethiopia, were included in the study. Quality of evidence was assessed by the relevant of the Joanna Briggs Institute tool. RevMan v5.3 statistical software was used to undertake the meta-analysis using a Mantel-Haenszel random-effects model. Heterogeneity was evaluated using the Cochran Q test, and I^2 statistics was considered to assess its level. The outcome was measured using a 95% confidence interval (CI).

Results: The pooled prevalence of birth asphyxia was 22.8% (95% CI: 13–36.8%]. Illiterate mothers (adjusted odds ratio [AOR]; 1.96, 95% CI: 1.44–2.67), antepartum hemorrhage (APH) (AOR; 3.43, 95% CI: 1.74–6.77), cesarean section (AOR; 3.66, 95% CI: 1.35–9.91), instrumental delivery (AOR; 2.74, 95% CI: 1.48–5.08), duration of labor (AOR; 3.09, 95% CI: 1.60–5.99), pregnancy induced hypertension (AOR; 4.35, 95% CI: 2.98–6.36), induction of labor (AOR; 3.69, 95% CI: 2.26–6.01), parity (AOR; 1.29, 95% CI: 1.03–1.62), low birth weight (LBW) (AOR; 5.17, 95% CI: 2.62–10.22), preterm (AOR; 3.98, 95% CI: 3.00–5.29), non-cephalic presentation (AOR; 4.33, 95% CI: 1.97–9.51), and meconium staining (AOR; 4.59, 95% CI: 1.40–15.08) were significantly associated with birth asphyxia.

Conclusion: The magnitude of birth asphyxia was very high. Maternal education, APH, mode of delivery, prolonged labor, induction, LBW, preterm, meconium-staining, and non-cephalic presentation were determinants of birth asphyxia. Hence, to reduce birth asphyxia and associated neonatal mortality, attention should be directed to improve the quality of intrapartum service and timely communication between the delivery team. In addition, intervention strategies aimed at reducing birth asphyxia should target the identified determinants.

Keywords: Birth asphyxia, determinant, Ethiopia, newborn

Introduction

Neonatal asphyxia is defined as the failure of initiating and maintaining of breathing at birth.[1,2] Worldwide, more than 1 million neonatal mortality occurred due to birth asphyxia every year.[3,4] A diagnosis of asphyxia is established, when the newborn has a <7 APGAR score at 1st or 5th min after birth.[1,5,6] The acidity of umbilical cord blood can also indicate infants' oxygen shortage.[5,6] Birth asphyxia results in impairment of tissue perfusion and then yielding to hypoxemia and hypercarbia.[7-9] It is due to the newborn fail to breath normally, which leads to decreased oxygen perfusion to various organs.[5,10,11]

Globally, an estimated 4 million newborns die in the neonatal period; 3 million of them died within 7 days.[12] This accounts for 46% of under-five mortality[13-15] and estimated to increase to 52% in 2030.[16,17] More than 99% of neonatal mortality occurs in developing countries.[18] Neonatal asphyxia is responsible for 42 million disability-adjusted life years.[1,3,10,19-26] The proportion of birth asphyxia is 2 per 1000 births in developed countries but more than 10 times higher in developing countries, where the setting with limited access to quality maternal and neonatal care.[9] Birth asphyxia contributes to a significant burden of neonatal mortality and morbidities. It may result in multi-organ dysfunctions or death. Moreover, survivors of neonatal asphyxia and its main complication

(hypoxic-ischemic encephalopathy) may suffer from epileptic disorder, cerebral palsy, mental retardation, blindness, hearing, learning, and behavioral disabilities.[3,9,19,23]

In developing countries, newborns had a high chance of being asphyxiated and stillbirth.[25] The available evidence on neonatal mortality rates (NMR) ranged from 0.2% to 64.4% in these settings.[27] The majority of neonatal mortality happened in Asia 39% and Sub-Saharan Africa (SSA) 38%. Around 70–80% of these neonatal deaths occur due to preventable and treatable conditions with access to simple, affordable interventions.[12-28] Ethiopia is among countries accounting for more than half of newborn deaths in developing counties.[13-18] Birth asphyxia, septicemia, and complications of preterm birth, jaundice, meningitis, and tetanus are the main cause of neonatal mortality in SSA.[29,30] According to the Ethiopian demographic and health survey, the NMR was 29 out of 1000 live births,[31] and more than 50% of neonatal deaths occurred within the 1st day of life.[17] A complication of prematurity, neonatal asphyxia, and neonatal sepsis were the three common causes of newborn death in Ethiopia.[32-36]

Multiple published studies showed that poor antenatal care (ANC),[37,38] cesarean section, meconium-stained amniotic fluid (MSAF), preterm birth, preeclampsia or eclampsia, and instrumental delivery were major contributing factor for birth asphyxia.[39,40] Occurrences of more serious complications and limited access to quality intrapartum care increased the burden and magnitude of asphyxia in resources limited countries.[23]

For effective health care to be achieved, attention has to be directed to reduce neonatal deaths secondary to birth asphyxia.[38] Supporting with basic newborn resuscitation alone reduce about 30% of intrapartum-related deaths.[1,2,41-43] Moreover, 1-day Helping Babies Breath training can improve the capacity of birth attendants but its implementation of the real action is uncertain.[44] Furthermore, interventions directed to birth asphyxia are less dependent on technology and commodities than trained people.[45] Therefore, improving skills of birth attendance, emergency obstetric care and retraining of this personnel with access to resuscitation equipment is crucial for reductions of mortality due to birth asphyxia.[25,28,46]

Although promising advancement in maternal and childcare occur in the past 10 years, prenatal asphyxia still remains as the main cause of neonatal morbidities and mortality.[38,47-49] With an accelerated increment in facilities-based delivery, attention has to shift toward the quality of service as poor quality would further increase the burden of birth asphyxia.[2] In SSA, including Ethiopia, the main challenges to reducing birth asphyxia are the lack of skilled workers and resuscitation equipment.[46] Evidence pinpointed that birth attendance has insufficient knowledge of birth asphyxia and poor skills in newborn resuscitation.[50] To the best of our knowledge, there is a lack of compressive and solicited evidence for determinants

of birth asphyxia in this country. Therefore, the main aim of this meta-analysis was to determine the pooled magnitude of birth asphyxia and its determinants in Ethiopia.

The review questions were:
What was the pooled estimate of birth asphyxia in Ethiopia?
What were the main determining factors of birth asphyxia in Ethiopia?

Methods

This systematic review and meta-analysis process, identification, screening, and eligibility assessment of full articles were carried out according to Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) statement[51] [Additional file 1]. The review protocol was registered in an international prospective register of systematic Review (PROSPERO ID: CRD42018105467). This can be accessed from http://www.crd.york.ac.uk/PROSPERO/display record.php?ID: CRD 4201 810 5467.

Searching strategies

The databases, including PubMed, Medline, CINAHL, EMBASE, and other relevant sources including Google search engine, Google Scholar, and World Health Organization websites were used to search relevant articles. The following keywords were served as search strings (a) population (newborn, neonate, and fetus), (b) outcome (birth asphyxia, perinatal asphyxia, intrapartum asphyxia, asphyxia neonatorum, perinatal suffocation, suffocation, APGAR score, determinants, associated factors, correlates, predictors, and risk factors), (c) study design (observational studies), and (d) setting (Ethiopia). Finally, all studies which are in agreement with the review title were retrieved and screened for inclusion criteria [Additional file 2].

Eligibility criteria

All studies with cross-sectional, cohort, and case–control study design and survey results were eligible in this meta-analysis. However, case series and reports were excluded from this meta-analysis. Articles with the main aim of determining the proportion of its determinants of birth asphyxia within Ethiopia were considered. Both facility and community-based articles were also included. Both published and unpublished studies at any time point until the last date of search (June 2, 2019), written in the English language and fulfill all other criteria were eligible in the selection process.

Studies screening and selection process

With the possible and appropriate capacity, online documents from the main dataset or directory were transferred into ENDNOTE reference manager software version X8. Then, the articles were collected into a single folder to find duplicates

files and removed with the above software. After that, two authors (GT and AD) were separately screened the articles based on preset inclusion criteria. Through title screening, the studies that mentioned birth asphyxia were nominated for abstract screening. Consequently, studies that fulfill eligibility criteria with titles and abstracts were retrieved for full-text screening. Then, full-text screenings were carried out with two independent authors (AD and GT). In any disagreement between the first two authors, the third (AS) was asked to reach into the final decision. The studies screening process based on PRISMA guidelines follows the diagram, as shown in Figure 1.[51]

Critical appraisal of studies

Studies were critically assessed for the validity of results. To ensure the methodological and evidence quality of the studies, we used the Joanna Briggs Institute (JBI) appraisal tool for observational studies.[52] This JBI critical appraisal checklist had nine questions to assess prevalence data (Q1-Q9), which mainly addresses the methodological area of every article. The results of two authors (GT and AD) with consulting the third author (AS) (in case of discrepancy in the first two authors) were reached into the final judgment. Then, articles with positive answers (yes) for more than 50% of the checklists (i.e., yes for five or more) were included in this meta-analysis.

Particular attention was focused on the appropriateness of the design, sampling techniques, data collection, objective, statistical analysis, and any sources of bias [Additional file 3].

Data extraction

Based on the inclusion criteria, two authors (AD and AS) set an extraction template in the Microsoft Excel sheet (2013). Then, the reviewers independently extracted information from all eligible publications. The study description table was formulated to summarize the study design, sample, population, aim, key finding (prevalence of birth asphyxia), and secondary outcome (determinants) [Table 1]. The extracted numerical data were documented and stored in a Microsoft Excel separate sheet.

Data synthesis and statistical analysis

A summary table was prepared to describe the characteristics of the included studies. The quantitative data were extracted using Microsoft Excel. Then, data were moved into comprehensive meta-analysis (CMA)[53] and RevMan v5.3 statistical software for the meta-analysis. The pooled prevalence of birth asphyxia was calculated with CMA statistical software, while the factors associated with birth asphyxia were analyzed using RevMan software. The data analysis was performed by AD and GT.
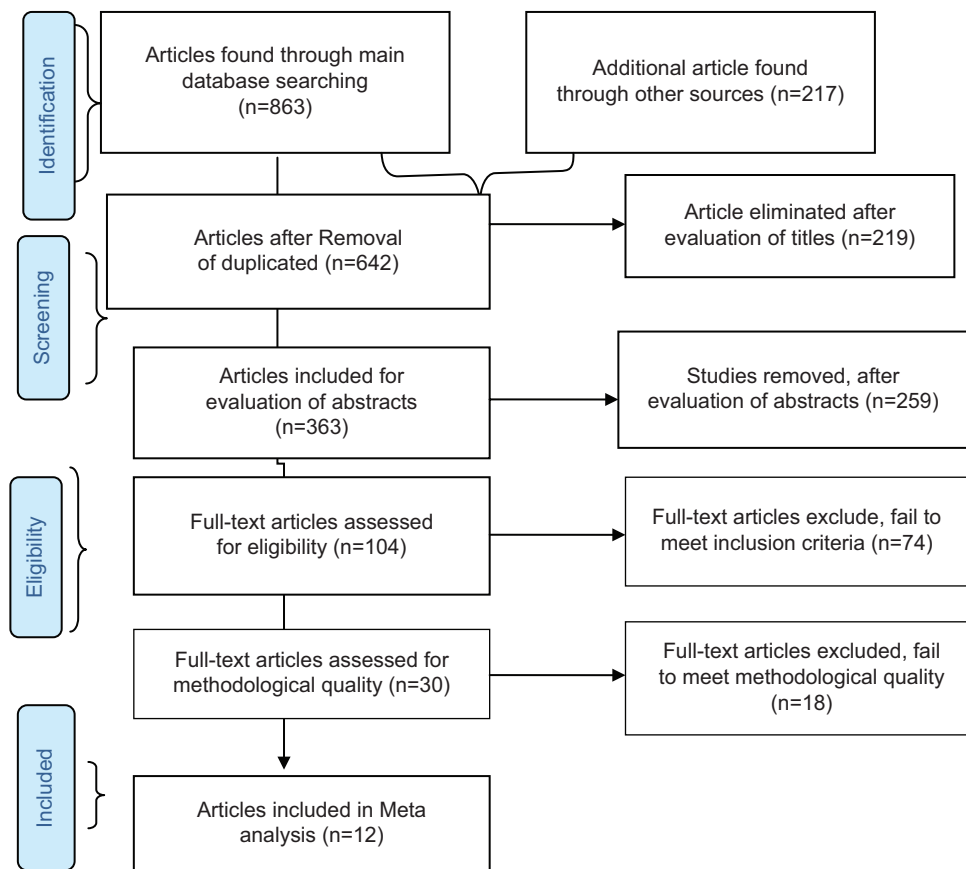

Figure 1: Preferred Reporting Items for Systematic Review and Meta-analysis 2009 flow diagram illustrating the screening process for the meta-analysis in identifying the determinant of birth asphyxia in Ethiopia

Table 1: Describe the characteristics of included studies for outcome variables in the systematic review and meta-analysis

Author, year and country	Site	Design of studies	Aim	Sample (n)	Sampling method	1st min APGAR score	5th min APGAR score	Outcome of interest (%)	Study-specific determinants birth asphyxia at odds ratio/relative risk (95% confidence interval)	Secondary outcome/any others morbidity or mortality
Tasew et al., 2018[54]	Tigray	Unmatched case–control	Identification of factors associated with birth asphyxia from newborns	264	Systematic sampling	-	Yes	33.3	Non-attendance of formal education, being low birth weight, being preterm, prim parity, suffering from antepartum hemorrhage and MSAF	-
Gudayu, 2017[55]	Gondar	Cross-sectional	Determining the magnitude and associated factors with low 5th min APGAR score	261	Systematic sampling	-	Yes	13.80	Non-vertex presentation, induced/augmentation of labor, prolonged labor duration >24 h, presence of MSAF and LBW	-
Gebreheat et al., 2018[35]	Tigray	Cross-sectional	Assessing prevalence and risk factors of perinatal asphyxia	421	SRS	Yes	-	22.10	Cesarean section delivery, MSAF, LBW and prolonged duration of labor	-
Wosenu et al., 2018[56]	Gondar	Unmatched case–control	To identify the determinants of birth asphyxia	273	Systematic sampling	-	Yes	33.00	Prolonged labor, cesarean section delivery, MSAF, fetal distress, and LBW	-
Wayessa et al., 2018[57]	Jimma	Cross-sectional	To address birth asphyxia and its associated factors	368	Systematic sampling	Yes	Yes	32.90	Maternal medical complications, obstetric complications, prolonged duration of labor, LBW, MSAF, not attending antenatal care, non-cephalic presentation and caesarean section delivery	-
Shitemaw et al., 2019[58]	Arbaminch	Cross-sectional	To determine the level of APGAR score and associated factors	346	SRS	Yes	-	31.80	Preterm birth preeclampsia/eclampsia, cord prolapsed, a cesarean section in an emergency, undergone general anesthesia and hemoglobin is <11 g/dl	-
Ibrahim et al., 2017[59]	Dire Dawa	Cross-sectional	Find out the magnitude and risk factors of birth asphyxia	9738	SRS	-	Yes	2.50	Non-attendance of formal education, age ranges between 15 and 25, born with vacuum delivery or forceps delivery and prolonged duration of labor	-
Meshesha et al., 2019[60]	Amhara	Case–control	To identify determinants of birth asphyxia	384	Systematic sampling	Yes	-	50	Low birth weight, born at health centers, instrumental delivery, and prolonged duration of labor	-
Kibret et al., 2019[61]	Dessie	Unmatched case–control	To identify determinants of birth asphyxia	380	SRS	Yes	Yes	20.4	Instrumental delivery, maternal short stature, below 23 cm MUAC prolonged labor, complication during labor	-
Necho and Yesuf, 2018[62]	Debertabor	Cross-sectional	To assess neonatal asphyxia and its associated factors	154	SRS	Yes	-	29.90	Preterm birth, and MSAF	-
Worku et al., 2012[63]	Addis Ababa	Cohort	Determining predictors of neonatal mortality	3789	Mini-survey	Yes	-	30.20	-	Prenatal asphyxia independent predictors of
Demisse et al., 2017[64]	Gondar	Cross-section	Patterns of neonatal admission and factors associated with neonatal mortality	769	Mini-survey	-	Yes	12.5	-	Prenatal asphyxia strongly associated with neonatal mortality

MSAF: Meconium-stained amniotic fluid, LBW: Low birth weight, SRS: Simple random sampling, MUAC: Mid-upper arm circumference

The Cochran Q test was applied to find out the occurrence of significant statistical heterogeneity and the level was measured using I^2 statistics. When the included studies have high heterogeneity, we used a random-effects model. Sub-group analysis was also conducted considering the APGAR score at the 1st min and 5 min. Any bias related to publication was checked with a funnel plot.

Results

Search results

From 1080 articles retrieved through main databases and direct searches, 438 studies were removed due to duplication through ENDNOTE citation manager. Then, 478 studies were excluded after the title and abstract screening. Full publications of 104 articles were checked in detail for the presence of one of the outcomes variables, and 74 studies were removed. The remaining 30 studies undergone a critical appraisal and 18 studies were excluded in the final meta-analysis because of relative poor method related quality, inconsistency, and unavailability of the data. Finally, 12 publications were included in the pooled estimation of the magnitude of birth asphyxia and eight studies were considered for the analysis of factors associated with birth asphyxia [Figure 1].

Characteristics of studies

Twelve articles with 17147 newborns and 2328 cases of birth asphyxia were incorporated in meta-analysis. Among the studies included in the final analysis, seven were cross-sectional, four were case–control, and the others were prospective cohort. All included studies had sample sizes ranged from 154 to 9738. All articles were written in English. The characteristics of included articles in the meta-analysis were described in the following [Table 1].[54-64]

The prevalence of birth asphyxia

The pooled proportion of birth asphyxia in Ethiopia was found to be 22.8% (95% confidence interval [CI]: 13–36.8%), as shown in Figure 2. In sub-group analysis, the prevalence of birth asphyxia in the 1st min was 30.4% (95% CI: 24.6–37%), and at the 5th min was 14.6% (95% CI: 4.3–39.5%).

Determinants of birth asphyxia

The present meta-analysis found various determinants for birth asphyxia in Ethiopia. Maternal illiteracy, low birth weight (LBW), antepartum hemorrhage (APH), preterm births, newborn with MSAF, cesarean section delivery, prolonged duration of labor, instrumental delivery, non-cephalic fetal presentation, and induction or augmentation of labor were found to have a statistically significant association with birth asphyxia. However, ANC use, parity, and maternal anemia were not significantly associated with the outcome variable [Figures 3-16].

LBW

In this meta-analysis, LBW (<2.5 kg) found a statistically significant association with birth asphyxia with adjusted odds ratio (AOR; 5.17, 95% CI: 2.62–10.22). These indicated that LBW newborns were 5 times more likely to be affected with birth asphyxia compared with their counterparts. Despite the presence of heterogeneity between the studies, LBW was associated with birth asphyxia, as illustrated in Figure 3.

Preterm

According to this meta-analysis, preterm births were found as significant determinants of birth asphyxia. Babies born
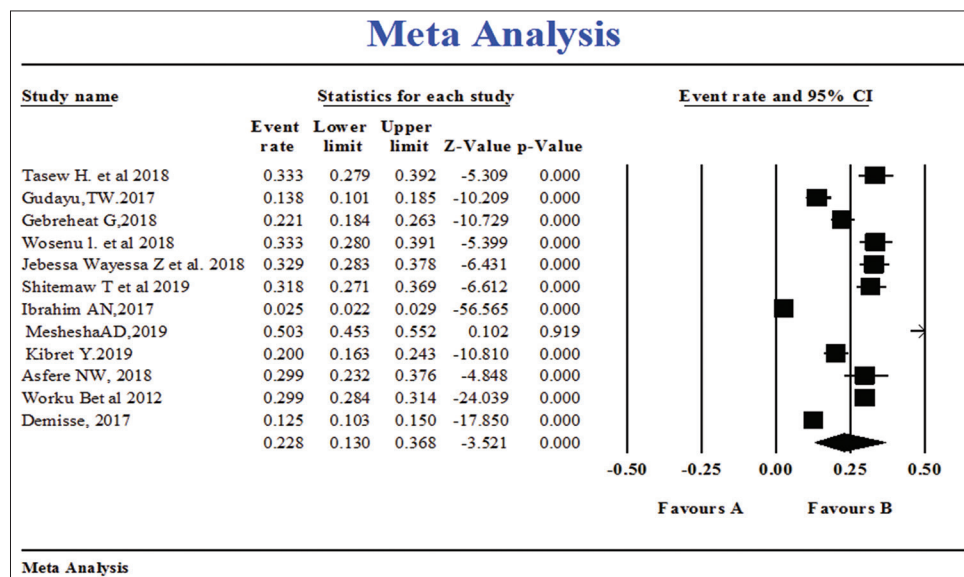

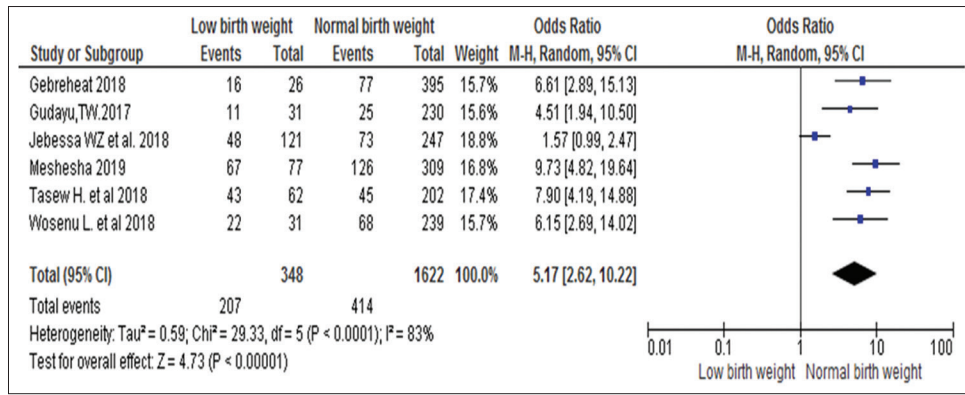**Figure 2:** Overall pooled estimation of birth asphyxia using the random-effect model in Ethiopia

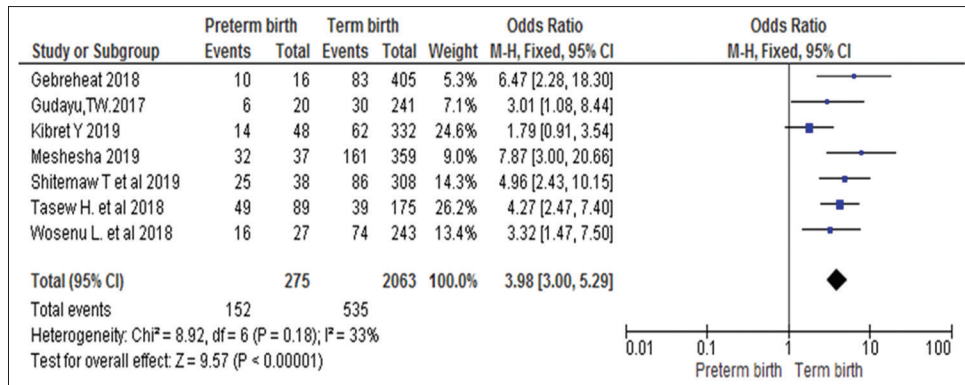**Figure 3:** Association between low birth weights with birth asphyxia in Ethiopia

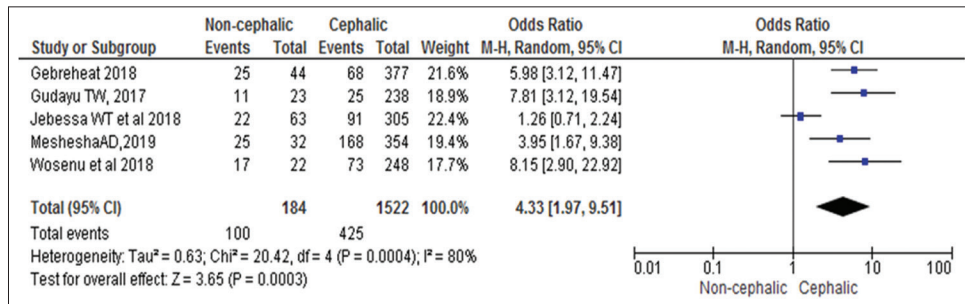**Figure 4:** Association between preterm births with birth asphyxia in Ethiopia

Figure 5: Association between non-cephalic fetal presentations with birth asphyxia in Ethiopia
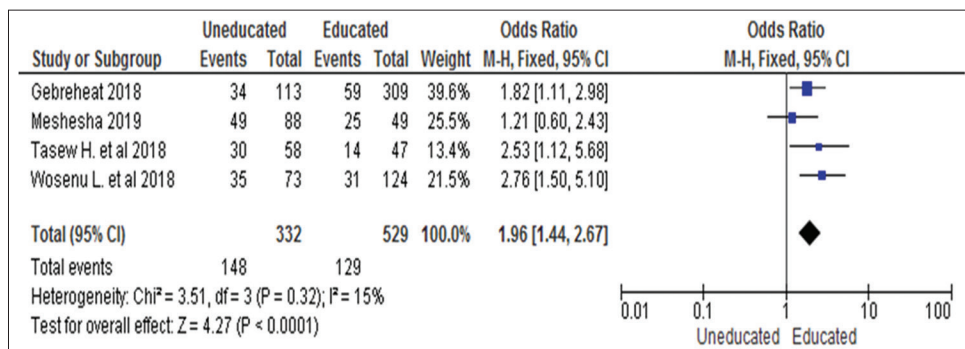

Figure 6: Association between maternal educations with birth asphyxia in Ethiopia

before 37 weeks of gestation (preterm) have an increased odds of experiencing birth asphyxia with three folds as compared to infants born after term gestations (AOR; 3.98, 95% CI: 3.00–5.29) [Figure 4].
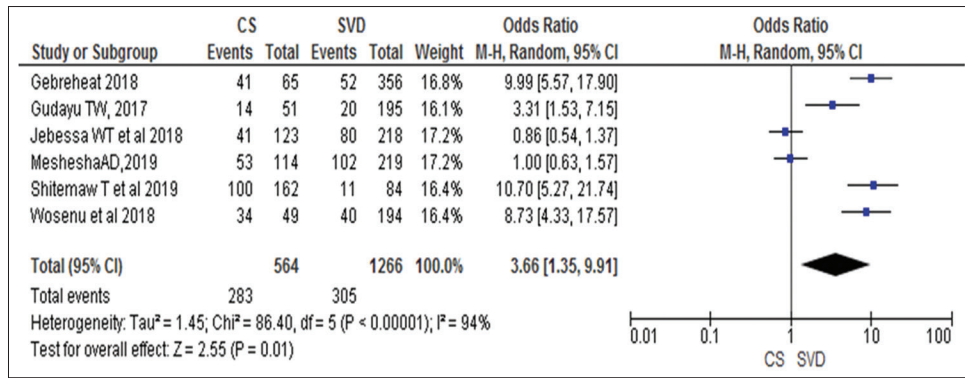
Figure 7: Association between cesarean section with birth asphyxia in Ethiopia
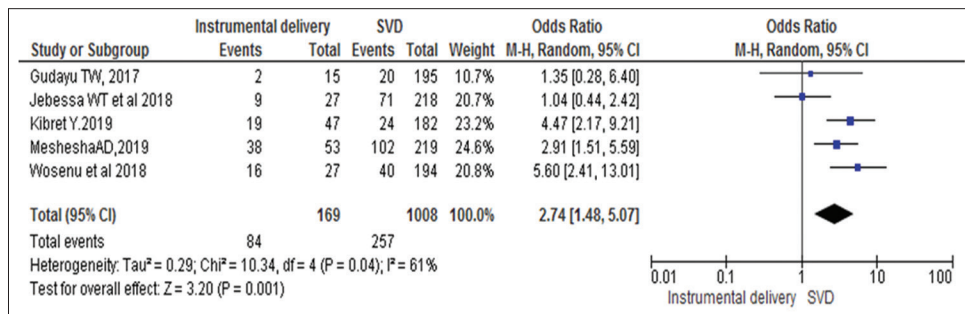
Figure 8: Association between instrumental deliveries with birth asphyxia in Ethiopia
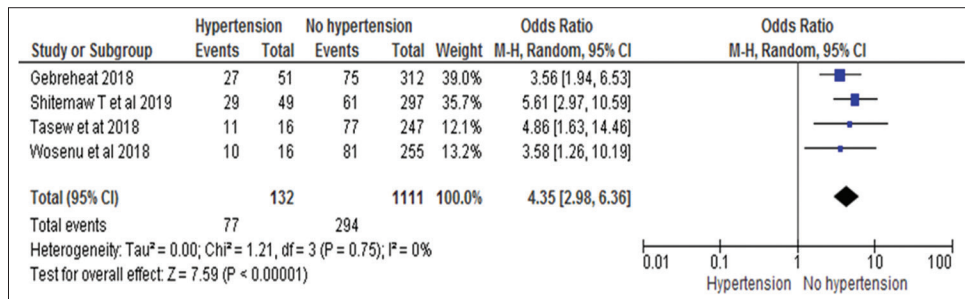
Figure 9: Association between hypertension during pregnancy with birth asphyxia in Ethiopia
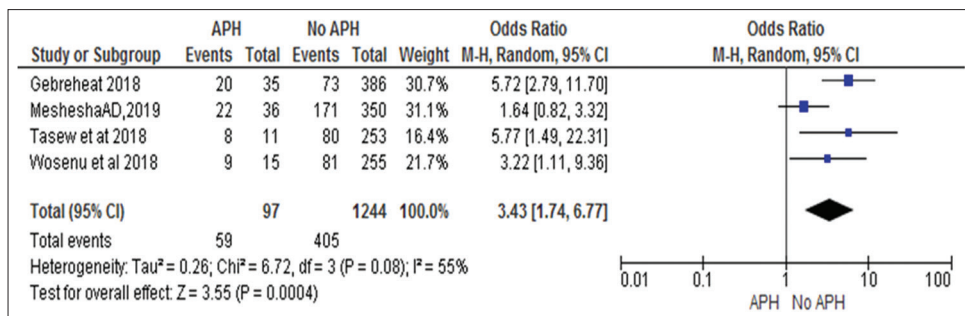
Figure 10: Association between antepartum hemorrhages with birth asphyxia in Ethiopia

Fetal presentation

According to this meta-analysis, non-cephalic fetal presentation was significantly associated with birth asphyxia. Fetuses who present in non-cephalic ways had more risk of being affected with birth asphyxia (AOR; 4.33, 95% CI: 1.97–9.51) [Figure 5].

Maternal education

Maternal education level has a statistically significant association with birth asphyxia. Illiterate women were more likely to give asphyxiated newborn when compared with mothers who have attended at least primary and above
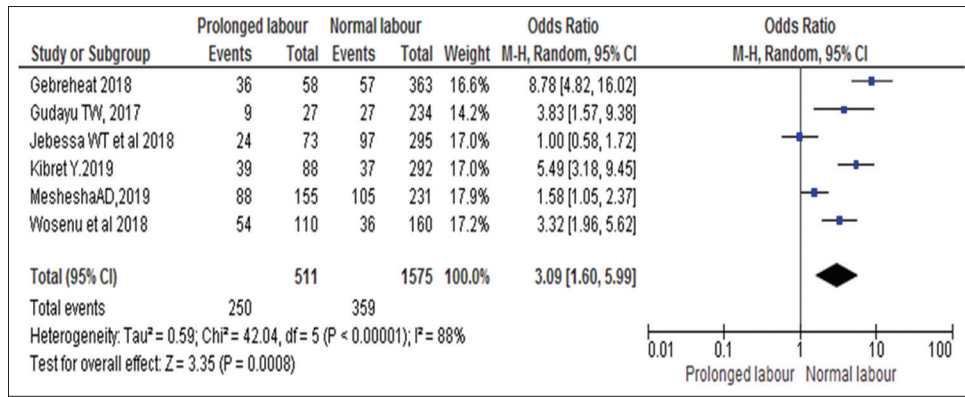
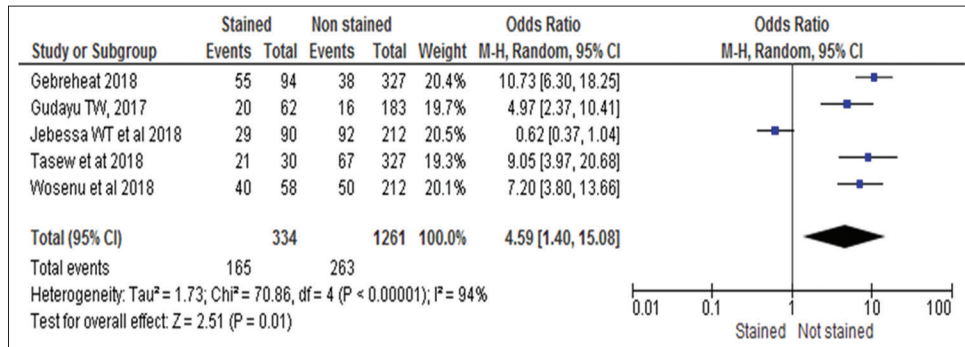**Figure 11:** Association between duration of labor with birth asphyxia in Ethiopia

Figure 12: Association between meconium-stained amniotic fluids with birth asphyxia in Ethiopia
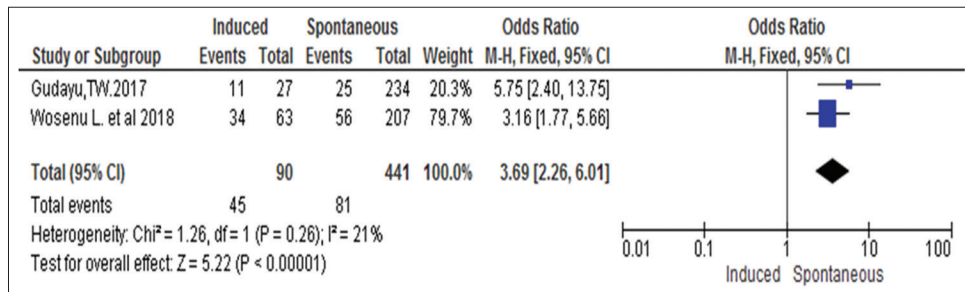

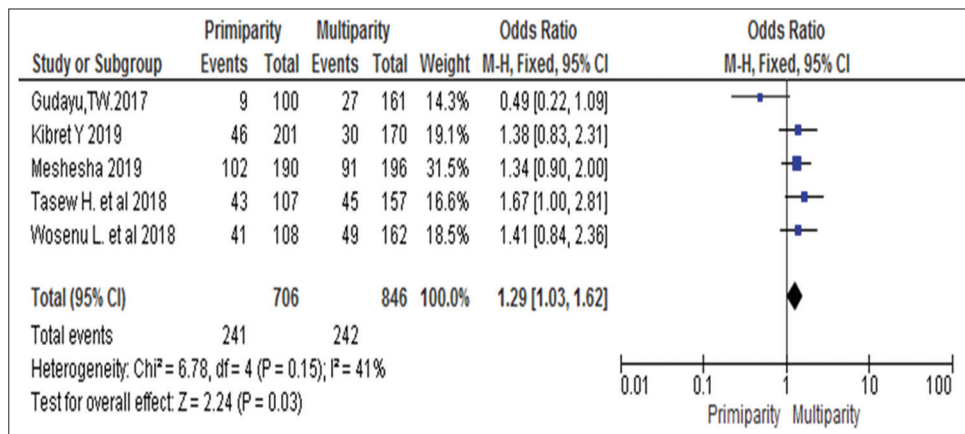**Figure 13:** Association between induction and augmentation of labor with birth asphyxia in Ethiopia

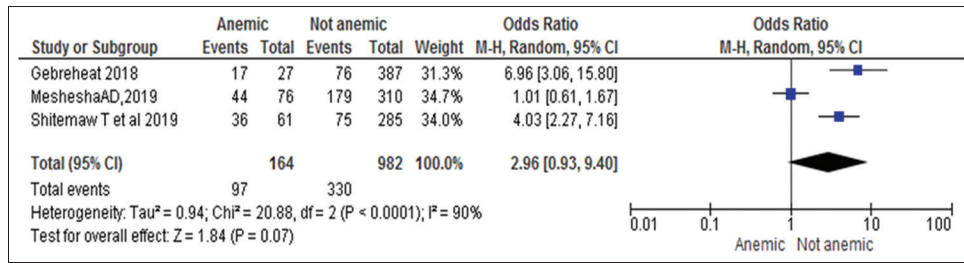**Figure 14:** Association between parity with birth asphyxia in Ethiopia

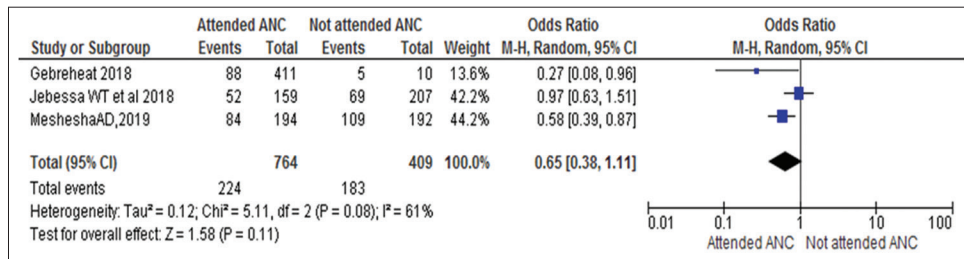**Figure 15:** Association between maternal anemia with birth asphyxia in Ethiopia

Figure 16: Association between antenatal care follow-up with birth asphyxia in Ethiopia, 2019

education level (AOR; 1.96, 95% CI: 1.44–2.67) [Figure 6] and found a statistically significant association with birth asphyxia.

Mode of delivery

Newborn delivered through cesarean section had about 4 times the chance of experiencing severe asphyxia than newborns delivered with spontaneous vaginal birth (AOR; 3.66 [95% CI: 1.35–9.91]) [Figure 7]. Similarly, newborns delivered by assisting instrumental delivery were 2.7 times more likely to be asphyxiated than newborns delivered through spontaneous vaginal mode (AOR; 2.74, 95% CI: 1.48–5.08) [Figure 8]. Giving birth through a cesarean section or instrumental delivery was more likely to expose their newborn for birth asphyxia as compared with newborn delivered through spontaneous vaginal delivery.

Hypertension during pregnancy

Having hypertensive disorders of pregnancy showed a significant association with the outcome variable. Mothers who had preeclampsia or eclampsia have 4 times the chance of giving asphyxiated newborn than mothers without these disorders (AOR; 4.35, 95% CI: 2.98–6.36) [Figure 9].

APH

The presence of APH was found to have a statistically significant association with birth asphyxia. Neonates from mothers with APH were at high risk of being asphyxiated than newborns from mothers without APH (AOR; 3.43, 95% CI: 1.74–6.77) [Figure 10].

Prolonged duration of labor

The prolonged duration of labor was found as one of the determinants of birth asphyxia. Baby born after a prolonged

duration of labor had about 3 times more likely to experience asphyxia than those born in the normal duration of labor (OR; 3.09, 95% CI: 1.60–5.99) [Figure 11].

MSAF

MSAF was found to have a statistically significant association with birth asphyxia. Newborn delivered with MSAF were 4 times more likely to be asphyxiated as compared with those delivered with clear fluids (AOR; 4.59, 95% CI: 1.40–15.08) [Figure 12].

Induction of labor

Newborns delivered after induction or augmentation labor to facilitate the delivery process had almost 4 times the chance of suffering from birth asphyxia as compared with their counterparts (AOR; 3.69, 95% CI: 2.26–6.01) [Figure 13].

Parity

Babies born from primipara mothers also had a higher chance of getting birth asphyxia than newborns from multipara mothers (AOR; 1.29, 95% CI: 1.03–1.62) [Figure 14].

Anemia

Newborn babies from anemic mothers had a chance of giving asphyxiated babies than non-anemic mothers, but it was not statistically significant association (AOR; 2.96, 95% CI: 0.93, 9.40) [Figure 15].

Use of ANC follow-up

Women who had ANC follow-up were 35% less likely to have asphyxiated babies than women who had no visit; however, there was no statistical association (AOR; 0.65, 95% CI: 0.38–1.11) [Figure 16].

Discussion

The present finding indicates that maternal education, APH, caesarian section, instrumental delivery, prolonged duration of labor and induction or augmentation, mode of delivery, being primiparous, LBW, preterm births, MSAF, and non-cephalic presentations were associated with birth asphyxia in Ethiopia. We found out that nearly one-fourths of the newborn were suffering from birth asphyxia in Ethiopia. However, in this analysis, maternal anemia and current use of ANC were not associated with birth asphyxia. The present finding provides important information because; to the best of our knowledge, this paper is the first meta-analysis with regard to determinants of birth asphyxia.

The present meta-analysis provides a summary of available compressive evidence of birth asphyxia and its determinant in the country. Maternal education and prevention of APH are believed to decrease birth asphyxia.[65,66] In current circumstances specifically, in developing countries, where maternal illiteracy is high, it is clear that mothers may not use the prevention strategies as they had inadequate awareness about the burden of birth asphyxia and the determining factors. Therefore, there is a need to refocus the attention to improve birth outcomes with quality intrapartum service including proper resuscitation and early detection of the preventable factors of birth asphyxia in resource-limited countries, particularly in Ethiopia. With regard to the association of APH with birth asphyxia, this may be explained by the fact that there is a reduced blood movement from the placenta to the fetus, resulting in hypoxemia and lead to asphyxia or stillbirth if maternal transfusion is delayed at the time of delivery.

According to present meta-analysis, cesarean sections, instrumental deliveries, induction or augmentations, and prolonged durations of labor were found statistically significant with neonatal asphyxia. This finding was consistent with the different studies conducted in other settings.[47,67-74] The burdens related to birth asphyxia may be related to instrumental delivery because of prolonged labor and delayed interventions so that close monitoring of labor processes, early detection of the main complications, and timely appropriates decision and avoiding unnecessary indications for cesarean section are essential to reducing the burden of birth asphyxia.

Furthermore, preeclampsia or eclampsia has found a statistically significant association with birth asphyxia. The finding is in agreement with evidence in Africa such as Ghana and Egypt.[39,68,70] This may be due to the reduction of blood follow, nutrients and oxygen movement to the fetus, which may increase the risk of in intrauterine development restriction, which may result in perinatal asphyxia. In addition, MSAF was found as a determinant of birth asphyxia. This was in agreement with studies from different countries.[69,73-78] The possible reason

may be related to inhalation of MSAF, which causes irritation and inflammation of the lung tissues or may obstruct the airway further inducing hypoxia and birth asphyxia.

Moreover, LBW and pre-term births were found to be significant determinants of birth asphyxia, which was similar to different findings in many settings.[10,39,78-81] In fact, much of LBW newborns are more likely to be pre-term that they are not able to produce adequate surfactant and prone to multiple morbidities, including organ system immaturity, including the inability of initiation of breathing, face challenges in cardiopulmonary transition, and finally, develop birth asphyxia.[75,77] Moreover, a non-cephalic fetal presentation was found independent predictor of birth asphyxia and it is in agreement with other articles in different countries.[6,10,79] In fact, non-cephalic presentation has long been well known to face greater hazards during the process of birth including birth asphyxia, birth trauma, and death. This may be because fetuses presenting with non-cephalic way are more likely to have other associated problems such as umbilical cord prolapsed and head entrapment that predispose them to birth asphyxia.

Limitations and strengths

The present review had certain limitations. The first one was not including qualitative studies in the review, which might identify other determinants of birth asphyxia or might support the quantitative findings. Second, conducting meta-analysis despite the heterogeneity between the included studies might affect the findings. Third, the search was only limited to articles published in the English language. Finally, despite the incorporation of studies from different parts of the country, the representativeness of the population is not as strong as the studies were observational in nature and the majority of them were conducted among newborns admitted to the neonatal intensive care unit. This meta-analysis also has strengths such as the selection and inclusion of both published and unpublished literature which has the potential to minimize publication bias. Moreover, our search strategy was extensive using multiple reputable databases and search engines.

Conclusion

The pooled magnitude of birth asphyxia was very high. Maternal education, APH, caesarian section, instrumental delivery, prolonged duration of labor, induction or augmentation, MSAF, and non-cephalic presentation were factors associated with birth asphyxia. LBW and preterm births were found as fetal related determinants of birth asphyxia. Hence, to reduce birth asphyxia and associated neonatal mortality, attention should be directed to improve the quality of intrapartum service and timely communication between the delivery team. In addition, intervention strategies that aim to reduce birth asphyxia should target the identified factors.

Authors' Contributions

AD and AS initiated and formulated this meta-analysis. AD conducted activities from initiation to finalization of the manuscript. AD, AS, and GT build-up the search strategies, meta-analysis, and interpretation of the findings. All authors thoroughly revised the manuscript.

Acknowledgments

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Additional files

Additional file 1: Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols; recommended items to address in a systematic review and meta-analysis protocol

Title: Determinants of birth asphyxia among newborns in Ethiopia: A systematic review and metal analysis

Section and topic	Item no.	Checklist item	Self-evaluation
Administrative information			
Title			
Identification	1a	Identify the report as a protocol of a systematic review	Yes, identified
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	Not applicable
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	PROSPERO (CRD42018105467)
Authors			
Contact	3a	Provide name, institutional affiliation, the e-mail address of all protocol authors provide physical mailing address of the corresponding author	Yes, it was provided
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	Yes, this was provided
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	Not applicable
Support			
Sources	5a	Indicate sources of financial or other support for the review	Not applicable
Sponsor	5b	Provide a name for the review funder and/or sponsor	Not applicable
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	Not applicable
Introduction			
Rationale	6	Describe the rationale for the review in the context of what is already known	Yes, this was done
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to PICO	Yes, this was clearly stated
Methods			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, and publication status) to be used as criteria for eligibility for the review	Yes, this was specified.
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	Yes, this was described
Search strategy	10	The present draft of the search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Yes this provided as an additional file
Study records			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	Yes, this was described
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility, and inclusion in meta-analysis)	Yes this was stated
Data collection process	11c	Describe the planned method of extracting data from reports (such as piloting forms, done independently, and in duplicate) and processes for obtaining and confirming data from investigators	Yes this was described
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	Yes this was provided
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	Yes, this was done
Risk of bias in individual studies	14	Describe anticipated methods for assessing the risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	Yes, this was done

Section and topic	Item no.	Checklist item	Self-evaluation
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	Yes, this was described
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, and Kendall's τ)	Yes, this was stated
	15c	Describe any proposed additional analyses (such as sensitivity or sub-group analyses, meta-regression)	Yes, this was described
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, and selective reporting within studies)	Yes, this was described
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	Yes (Joanna Briggs Institute tool)

PICO: Participants, interventions, comparators, and outcomes

*It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. BMJ. 2015 Jan 2; 349(jan02 1):g7647.

Additional file 2: Search strategy

Title of the review: Determinants of birth asphyxia among live birth newborns in Ethiopia: A systematic review and meta-analysis

S. No.	Database	Search filters (year, June 2, 2019, Language=English)	Search results
		Sample build search methods	
1.	PubMed	((((((((("asphyxia neonatorum"[MeSH Terms] OR ("asphyxia"[All Fields] AND "neonatorum"[All Fields]) OR "asphyxia neonatorum"[All Fields] OR ("birth"[All Fields] AND "asphyxia"[All Fields]) OR "birth asphyxia"[All Fields]) OR (Perinatal[All Fields] AND ("asphyxia"[MeSH Terms] OR "asphyxia"[All Fields]))) OR ("asphyxia neonatorum"[MeSH Terms] OR ("asphyxia"[All Fields] AND "neonatorum"[All Fields]) OR "asphyxia neonatorum"[All Fields] OR ("intrapartum"[All Fields] AND "asphyxia"[All Fields]) OR "intrapartum asphyxia"[All Fields])) OR ("asphyxia neonatorum"[MeSH Terms] OR ("asphyxia"[All Fields] AND "neonatorum"[All Fields]) OR "asphyxia neonatorum"[All Fields]) OR (Perinatal[All Fields] AND ("asphyxia"[MeSH Terms] OR "asphyxia"[All Fields] OR "suffocation"[All Fields]))) OR ("asphyxia"[MeSH Terms] OR "asphyxia"[All Fields] OR "suffocation"[All Fields])) OR ("apgar score"[MeSH Terms] OR ("apgar"[All Fields] AND "score"[All Fields]) OR "apgar score"[All Fields])) AND ((((Determinants[All Fields] OR (Associated[All Fields] AND factors[All Fields])) OR Correlates[All Fields]) OR Predictors[All Fields]) OR ("risk factors"[MeSH Terms] OR ("risk"[All Fields] AND "factors"[All Fields]) OR "risk factors"[All Fields]))) AND ("Ethiopia"[MeSH Terms] OR "Ethiopia"[All Fields]) AND "humans"[MeSH Terms]) AND "humans"[MeSH Terms]	28
2.	Medline	#	Searches	Results

2.	Medline	#	Searches	Results
		1	Asphyxia Neonatorum/ or Birth asphyxia.mp. or Infant, Newborn/	582256
		2	Asphyxia/ or Asphyxia Neonatorum/ or Perinatal asphyxia.mp. or Infant, Newborn, Diseases/ or Infant, Newborn/	587745
		3	Fetal Hypoxia/ or Asphyxia Neonatorum/ or Intrapartum asphyxia.mp. or Infant, Newborn/	583666
		4	Asphyxia Neonatorum.mp. or Asphyxia Neonatorum/	7616
		5	Infant, Newborn/ or Asphyxia/ or Perinatal suffocation.mp. or Asphyxia Neonatorum/	587056
		6	Suffocation.mp. or Asphyxia/	6950
		7	APGAR score.mp. or Apgar Score/	11362
		8	Determinants.mp.	147454
		9	Cross-Sectional Studies/ or Associated factors.mp.	308449
		10	Correlates.mp.	158527
		11	Risk Factors/ or Predictors.mp.	936257
		12	Risk factors.mp. or Risk Factors/	960753
		13	Ethiopia.mp. or Ethiopia/	15245
		14	1 or 2 or 3 or 4 or 5 or 6 or 7	593542
		15	8 or 9 or 10 or 11 or 12	1600261
		16	13 and 14 and 15	401

3.	EMBASE	#	Searches	Results
		1	Birth of asphyxia.mp. or perinatal asphyxia/	5863
		2	Perinatal asphyxia.mp. or perinatal asphyxia/	5952
		3	Asphyxia/ or newborn/ or fetus hypoxia/ or Intrapartum asphyxia.mp. or newborn hypoxia/ or perinatal asphyxia/	610692
		4	Asphyxia Neonatorum.mp. or newborn hypoxia/	6880
		5	Asphyxia/ or Perinatal suffocation.mp.	13395
		6	Suffocation.mp. or asphyxia/ or suffocation/	14988
		7	APGAR score.mp. or Apgar score/	24996
		8	Prevalence/ or Associated factors.mp. or cross-sectional study/	908421
		9	Determinants.mp.	180822
		10	Correlates.mp.	214429
		11	Risk factors.mp. or risk factor/	1154728
		12	1 or 2 or 3 or 4 or 5 or 6 or 7	625459
		13	8 or 9 or 10 or 11	2218958
		14	Ethiopia.mp. or Ethiopia/	16869
		15	12 and 13 and 14	312
		16	limit 15 to (human and English language)	310

S. No.	Database	Search filters (year, June 2, 2019, Language=English)				Search results
		Sample build search methods				
4.	CINAHL	EBSCOhost Sunday, June 02, 2019 6:16:06				

#	Query	Limiters/Expanders	Last Run Via	Results
S17	S12 AND S17 AND S18	Narrow by Language: - English Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	108
S16	S12 AND S14 AND S15	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	108
S15	S8 OR S9 OR S10 OR S11 OR S13	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	569,328
S14	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	117,353
S13	Determinants	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	40,371
S12	Ethiopia.mp. or Ethiopia/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	4,153
S11	Risk factors.mp. or Risk Factors/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database– CINAHL Complete	394,854
S10	Risk Factors/ or Predictors.mp.	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	394,854
S9	Correlates.mp.	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	0
S8	Cross-sectional Studies/ or Associated factors.mp.	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	177,046
S7	APGAR score.mp. or Apgar Score/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	4,176
S6	Suffocation.mp. or Asphyxia/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	3,019
S5	Infant, Newborn/ or Asphyxia/ or Perinatal suffocation.mp. or Asphyxia Neonatorum/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	115,465
S4	Asphyxia Neonatorum.mp. or Asphyxia Neonatorum/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	965
S3	Fetal Hypoxia/ or Asphyxia Neonatorum/ or Intrapartum asphyxia.mp. or Infant, Newborn/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	114,115
S2	Asphyxia/ or Asphyxia Neonatorum/ or Perinatal asphyxia.mp. or Infant, Newborn, Diseases/ or Infant, Newborn/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	2,025
S1	Asphyxia Neonatorum/ or Birth asphyxia.mp. or Infant, Newborn/	Search modes - Boolean/Phrase	Interface – EBSCOhost Research Databases Search Screen – Advanced Search Database – CINAHL Complete	113,954

Additional file 3: Quality assessment of studies using JBI's critical appraisal tools designed for observational studies

Title: Determinants of birth asphyxia among live birth newborns in Ethiopia: A systematic review and meta-analysis

Studies	JBI's critical appraisal questions									Overall score	Include
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9		
(Bogale, 2012)	N	N	U	Y	N	Y	Y	Y	Y	6	✓
(Demisse *et al.*, 2017)	Y	N	Y	Y	Y	Y	Y	Y	Y	8	✓
(Gebreheat *et al.*, 2018)	Y	Y	Y	Y	Y	Y	Y	Y	Y	9	✓
(Gudayu, 2017)	Y	N	Y	Y	Y	N	Y	Y	Y	7	✓
(Ibrahim *et al.*, 2017)	Y	N	U	Y	N	N	N	Y	Y	5	✓
(Kibret *et al.*, 2018)	Y	N	Y	Y	Y	U	U	Y	Y	6	✓
(Meshesha *et al.*, 2019)	Y	N	U	Y	Y	U	U	Y	Y	6	✓
(Shitemaw *et al.*, 2019)	N	N	Y	Y	Y	Y	Y	Y	Y	7	✓
(Tasew *et al.*, 2018)	N	Y	Y	N	Y	U	U	Y	Y	5	✓
(Wosenu *et al.*, 2018)	N	Y	Y	U	Y	Y	U	Y	Y	7	✓
(Necho and Yesuf, 2018)	Y	N	N	Y	Y	Y	Y	N	Y	6	✓
(Zelalem, 2018)	Y	Y	Y	Y	Y	Y	Y	Y	Y	9	✓

Y: Yes, N: No, U: Unclear, Q: Question. The overall score is calculated by counting the number of Y's in each row. Q1: Was the sample frame appropriate to address the target population? Q2: Were study participants sampled in an appropriate way? /Are the patients at a similar point in the course of their condition/illness? Q3: Was the sample size adequate? /Has bias been minimized in relation to the selection of cases and of controls? Q4: Were the study subjects and the setting described in detail? /Are confounding factors identified and strategies to deal with them stated? Q5: Was the data analysis conducted with sufficient coverage of the identified sample? /Are outcomes assessed using objective criteria? Q6: Were valid methods used for the identification of the condition? Q7: Was the condition measured in a standard, reliable way for all participants? Q8: Was there appropriate statistical analysis? /Were outcomes measured in a reliable way? Q9: Was the response rate adequate, and if not, was the low response rate managed appropriately?