Heliyon 10 (2024) e23856

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Determinants of birth asphyxia among neonates admitted to neonatal intensive care units in hospitals of the Wolaita zone, Southern Ethiopia: A case-control study

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ARTICLE INFO

Keywords:
Birth asphyxia
Determinants
Neonates
Newborns
Wolaita sodo
Ethiopia

ABSTRACT

Background: Birth asphyxia, according to the World Health Organization (WHO), is the inability of breathing to start and continue automatically at birth. Blood-gas exchange is impaired, which results in increased hypoxia, hyperapnea, and substantial metabolic acidosis. The aim of this study was to determine the factors contributing to birth asphyxia in infants admitted to neonatal intensive care units in hospitals in the Wolaita Zone.

Methods: An institution-based, unmatched case-control study among neonates admitted to neonatal intensive care units in Wolaita Zone hospitals was conducted from March 1 to April 15, 2021. With 148 cases and 294 controls and a case-to- control ratio of 1:2, a sample size of 442 was determined. The pre-tested and structured Open Data Kit collect mobile application (v1.26.1) was used to collect the data, and SPSS version 25 was used for analysis. Using adjusted odd ratios and their corresponding 95 % confidence intervals, bivariate and multivariable logistic regression analyzes were performed.

Results: A total of 143 cases and 286 controls were included making. the response rate 97 %. Meconium or blood-stained amniotic fluid (AOR = 5.43, 95%CI:3.10–9.50), mothers who experienced any of dangerous symptom during pregnancy (AOR = 3.71, 95%CI: 1.56–8.65), premature rupture of membrane (AOR = 3.12, 95%CI: 1.42–6.83), hypothermic newborn (AOR = 4.57, 95CI: 1.77–11.81), labor not supported by Basic Emergency Obstetric and Neonatal Care (BEMONC) trained health professional (AOR = 3.23, 95%CI: 1.83–5.71), birth weight of less than 2500 gm (AOR = 2.68, 95%CI: 1.04-6.92), sub-standard filling of partograph (AOR = 4.03, 95% CI: 2.19–7.41), not filling on partograph during follow-up (AOR = 8.16, 95%CI: 2.24-29.66) and assisted vaginal delivery (AOR = 1.87, 95%CI:1.03–3.39) were identified as determinants of birth asphyxia.

Conclusion: In this study, fetal conditions such as hypothermia and low birth weight, changes in the color of amniotic fluid, dangerous pregnancy symptoms, membrane rupture, standard filling of the partograph, and BEMONC training were factors that predicted birth asphyxia. Therefore, prompt and effective management of fetal and maternal problems and as well as the development of health professionals' BEMONC competence are crucial.

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https://doi.org/10.1016/j.heliyon.2023.e23856
Received 4 May 2023; Received in revised form 13 December 2023; Accepted 14 December 2023
Available online 18 December 2023

Abbreviations (acronyms and abbreviations)

AOR	Adjusted Odd Ratio
CI	Confidence Interval
CVS	Cardio-Vascular System
DM	Diabetes Mellitus
EDHS	Ethiopian Demographic Health Survey
GA	Gestational Age
GIS	Gastro-Intestinal System
NICU	Neonatal Intensive Care Unit
ODK	Open Data Kit
PROM	Premature Rupture of Membrane
SDG	Sustainable Development Goal
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan Africa
VIF	Variance of Inflation
WHO	World Health Organization
WSURTH	Wolaita Sodo Referral and Teaching Hospital.

1. Introduction

Birth asphyxia, as defined by the WHO, is the inability of breathing to begin and continue automatically upon birth [1]. A circumstance occurring just before, during, or after delivery that is characterized by generalized ischemia and hypoxia [2]. Blood-gas exchange impairment is a consequence of this condition. In the long run, this mechanism would result in severe metabolic acidosis, apnea, and progressive hypoxemia [3].

According to hospital definitions, a newborn was considered to have asphyxia at birth if their APGAR score was less than 3 for more than 5 min, their umbilical cord arterial pH was below 7, they displayed neurological symptoms such as seizures or hypertonicity, and they failed multiple organ systems such as the cardiovascular, gastrointestinal, hematological, pulmonary, or renal systems [4]. Hypoxic-ischemic encephalopathy with convulsions, neonatal jaundice, septicemia, transitory neonatal tachypnea, hypoglycemia, respiratory distress syndrome, caput succedaneum, and feeding issues were among the serious neonatal sequelae observed in asphyxiated infants [5].

In 2020, more than 5 million children died before turning five, with newborns accounting for nearly half of those deaths (2.4 million) [6].

The number of newborn fatalities has decreased internationally, from 5.1 million in 1990 to 2.6 million in 2016. However, the Ethiopian Demographic and Health Survey (EDHS) 2016 reports that Ethiopia has reduced child mortality in a spectacular manner while reducing neonatal death in a non-significant manner [7]. Neonatal mortality decreased from 39 to 29 between the 2005 and 2016 EDHS, but has remained relatively stagnant since the 2016 EDHS, according to mini EDHS 2019 report [8].

A United Nations UNICEF report states that birth asphyxia is responsible for 23 % of all newborn deaths [9]. Birth asphyxia dramatically decreased between 1999 and 2010, according to a national cohort study research. However, it continues to be a significant factor in perinatal mortality [10].

Neonatal sepsis is largely determined by birth asphyxia, and, it frequently results in admission to neonatal intensive care units [11]. It causes multi-organ cell destruction, which results in organ dysfunction [12]. Due to a disruption in blood-gas exchange that causes hypoxia and ischemia, birth asphyxia is responsible for long-term neurological dysfunction and impairment [13]. Therefore, this study aimed to determine the causes of birth asphyxia in neonates admitted to hospitals in the Wolaita Zone's neonatal inetsnsive care units.

2. Methods

2.1. Study setting and design

The study was conducted at the hospitals of the Wolaita Zone. The Wolaita Zone is one of the zonal administrations found in the Southern region and is located 327 km south of Addis Ababa. Based on the 2021 projected population estimation obtained from the Regional Health Bureau, it has a total population of 2,114,382. The administrative center of the zone is Wolaita Sodo city. The zone has a total of seven hospitals equipped with NCIU(Neonatal Intensive Care Unit), these are one referral and teaching hospital, one general hospital, and five primary hospitals [14]. All hospitals provide maternity, NICU, and pediatric services. In the hospitals, the NICU service was provided by neonatal specialized nurses, emergency surgeons, pediatricians, obstetricians, and gynecologists.

2.2. Source population

All newborns admitted to the NICU in hospitals of the Wolaita Zone. Cases and controls were drawn from the same hospital.

2.3. Study population

All newborns admitted to the NICU in five selected hospitals in the Wolaita zone.

2.4. Study subjects

Case: Newborns admitted to the NICU with an admission criterion of birth asphyxia (APGAR score of less than seven at 5 min and less than 3 at more than 5 min).

Control: Newborns admitted to the NICU with normal APGAR score (APGAR score of greater than or equals to seven at 5 min).

2.5. Inclusion criteria

Newborns admitted to the NICU were included in the study.

Neonates with different clinical conditions, such as newborns with jaundice, congenital anomalies, sepsis, and haemorrhagic disease, were included in the study as controls.

2.6. Exclusion criteria

Newborns who had no mothers (caregivers) due to loss or death, mothers who were sick and unable to respond and the deformed baby were excluded from the study.

2.7. Sample size and sampling procedure

The sample size was calculated on the basis of Kelsey's unmatched case-control formula with the assumptions of power = 80 % and 95 % CI using Open-Epi Version 303. The variable that gave a high sample size from previous case-control studies on determinants of birth asphyxia (described in Table 1, was used as the sample size for the study. To increase the statistical efficiency of the study, the case-to- control ratio was set at a 1:2 ratio. The highest sample size was 402, and after adding a non-response rate of 10 %, it was 442. Therefore, the cases were 148 and, the controls were 294(See Table-1).

2.8. Sampling procedure

There were seven hospitals in the Wolaita zone that were equipped with NICU service. The seven hospitals were Wolaita Sodo University Teaching and Referral Hospital (WSUTRH), Sodo Christian General Hospital (SCGH), and five primary level hospitals (Bitena, Bombe, Bale, K/Halale and Dubbo St. Mary). Based on the hospital types (teaching, general and primary) five hospitals were selected for the study; WSUTRH and SCGH were selected purposively, whereas Bitena PH, Bale PH, and Dubbo St. Mary PH were selected randomly. A proportional allocation of sample size was employed for each selected hospital based on the previous year's NICU service report. Then, the mothers of the newborn were selected based on the newborns registered in the NICU. Every case of birth asphyxia admitted during the study period was selected, and two controls for each case were selected consecutively to the cases among other newborns with normal APGAR scores.

2.9. Data collection procedure

The data were collected by a mobile ODK data collection application. Data collection was executed with a pretested structured questionnaire and checklist developed by reviewing different types of literature [14,16,17,18,19–23]. The questionnaire was prepared in English and translated into to the local (Wolaitgna) language, then translated back to English to check for consistency. The checklist

Table 1
Sample size determination based on determinants of Birth Asphyxia.

S·N	Risk factors for birth asphyxia used for sample size determination	AOR	P (proportion of exposure among controls)	Sample size determined	References
1	*Prolonged Labour*	*2.00*	*43.2 %*	*402*	[15]
2	*Low birth weight*	*3.309*	*36.2 %*	*123*	[11]
3	*Meconium-stained amniotic fluid*	*3.593*	*63.64 %*	*147*	[12]
4	*Instrumental delivery*	*3.03*	*28.3 %*	*168*	[15]
5	*Primi-para*	*3.77*	*69.9 %*	*195*	[13]
6	*PROM*	*2.98*	*48.84 %*	*177*	[11]
7	*Post-term pregnancy*	*2.73*	*72.6 %*	*324*	[14]
8	*Cord prolapsed or entangling*	*2.95*	*51.6 %*	*87*	[16]
9	*Fetal presentation*	*2.41*	*45.45 %*	*258*	[11]
10	*Preterm*	*3.72*	*23.80 %*	*84*	[16]
11	*Preeclampsia*	*7.94*	*58.82 %*	*81*	[12]

AOR = Adjusted Odds Ratio, PROM=Premature Rapture of Membrane.

was used to collect data that were recorded in medical registrations (NICU register, Integrated ANC, Delivery and PNC register, and cards). The questionnaire was used to collect data related to sociodemographic and provider service factors. Data collectors were midwives working in other hospitals in the Wolaita Zone. The sociodemographic characteristics of mothers were collected first, and then the history of pregnancy or obstetric condition, medical history, and neonatal characteristic information were collected. The medical information recorded in the register of the questionnaire was collected first and then, the remaining questionnaire was used to interview mothers.

2.10. Data quality management

Before data collection, the questionnaire was first prepared in English and translated into Amharic and back to English to maintain the consistency. Two days of training were given to data collectors and supervisors by the principal investigator before data collection.

A pretest was conducted in Bombe primary hospital, which was other than the selected hospitals, and 5 % of the total sample size was tested. Based on the pretest, the questionnaires were revised, and edited and the necessary corrections were made accordingly. Daily check-up of data for completeness and consistency was performed during data collection.

2.11. Data analysis procedures

The data were collected using ODK and exported to SPSS version 25 for analysis. *Descriptive analysis* was performed using frequency and percentage. Logistic regression was used for data analysis. Multi-Collinearity of the independent variable was checked by the diagnostic test of variance of inflation factor (VIF<10). Bi-variable logistic regression analysis was performed to distinguish the association between independent and dependent variables. Variables with a P-value of less than 0.20 were considered candidates for multivariable logistic regression. Multivariable logistic regression analysis was employed, and adjusted odds ratios (AORs) with their respective 95 % CI were used to declare statistically significant associations between risk factors and birth asphyxia. The level of statistical significance was set at $P < 0.05$. The goodness of fit of the final logistic model was tested using the Hosmer and Lemeshow test at a *p*-value >0.05 and Receiver Operating Characteristics (ROC), which can give a better and more complete description of classification accuracy.

2.12. Operational definitions

Birth weight: Newborn weighing below 2500 g was classified as low birth weight and ranged from 2500 to 400 g as a normal weighted baby and above 4000 g as a macrocosmic baby.

Birth asphyxia: The newborn neonate who was born in selected hospitals with a 5-min APGAR score of less than seven.

Pregnancy complication: Any woman with a history of preterm birth, low birth weight, abortion or stillbirth, small for gestational age (SGA), birth asphyxia, prolonged labor, or excessive bleeding during previous pregnancy was categorized as having experienced pregnancy complication.

Dangerous Symptoms of Pregnancy: Any woman experiencing vaginal bleeding, convulsions/fits, severe headaches with blurred vision, fever and weakenes to get out of bed, severe abdominal pain, fast or difficult breathing, and body swelling during the current pregnancy was categorized as having danger symptoms [24].

Medical Problem: A woman classified as having a medical problem was measured by having any of the medical diseases such as DM, cardiac disease, UTI, and anemia.

Table 2
Maternal and newborns sociodemographic characteristics for newborns admitted to NICU in selected hospitals of Wolaita Zone, 2020.

Characteristics		Cases (n = 143) N (%)	Controls (n = 286) N (%)	Total (n = 429) N (%)
Age of mother	*18–20*	*9 (3.5)*	*10 (6.3)*	*19 (4.4 %)*
	21–25	*63 (44.1)*	*96 (22.4)*	*159 (37.1 %)*
	26–30	*50 (35.0)*	*126 (44.1)*	*176 (41.0 %)*
	31–35	*20 (14.0)*	*49 (17.1)*	*69 (16.1 %)*
	>35	*1 (0.7)*	*5 (1.7)*	*6 (1.4 %)*
Sex of newborn	*Male*	*100 (69.9)*	*94 (32.9)*	*194 (45.2)*
	Female	*43 (30.1)*	*192 (67.1)*	*235 (54.8)*
Mother's Marital status	*Married*	*141 (98.6)*	*283 (99.0)*	*424 (98.8)*
	Divorced/separated	*1 (0.7)*	*3 (1.0)*	*4 (0.9)*
	Widowed	*1 (0.7)*	*0 (0.0)*	*1 (0.2)*
Mother's Educational status	*No formal education*	*107(74.8)*	*202 (70.6)*	*309 (72.0)*
	Formal education	*36 (25.2)*	*84 (29.4)*	*120 (28.0)*
Occupation	*Employed (Government or Non-government)*	*4 (2.8)*	*18 (6.3)*	*22 (5.1)*
	Housewife	*92 (64.3)*	*172 (60.1)*	*264 (61.5)*
	Merchant	*44 (30.8)*	*83 (29.0)*	*127 (29.6)*
	Student	*3 (2.1)*	*13 (4.5)*	*16 (3.7)*
Residence	*Urban*	*58 (40.6)*	*141 (49.3)*	*199 (46.4)*
	Rural	*85 (59.4)*	*145 (50.7)*	*230 (53.6)*

BEMONC- trained health professional: A health professional who has trained on the BEMONC manual drafted by FMOH [25].

Standard of partograph: Not filled indicates the mother who has not followed by partograph. Substandard filling of partograph indicates the mothers who have followed with missing of any of eight indicators used for monitoring labor and delivery by partograph. Standard-based filling of partograph indicates the mothers who have followed without missing of any of eight indicators used for monitoring labor and delivery by partograph [26].

3. Result

3.1. Sociodemographic characteristics of the subjects

The total response rate of the question was 97 %, of which 286 controls were selected from 143 cases. The mean ages of mothers with cases and controls were 25.9 ± 3.9 and 26.9 ± 3.9 years, respectively. One hundred ten (69.9 %) of newborns with case and 94 (32.9 %) of newborns with controls were male to sex. Three-fifths 85 (59.4 %) reside in a rural area and two-thirds 92 (64.3 %) were housewives for mothers with cases (Table 2).

3.2. Current pregnancy antepartum and intrapartum characteristics

Nearly half (51.7 %) of mothers with the case were malnourished, and one-fourth (26.9 %) were malnourished for mothers with controls. Thirteen (9.1 %) and 44 (15.45 %) mothers with cases and controls had no ANC follow-up for current pregnancy, respectively. One-fifth (21.7 %) of mothers had experienced any dangerous symptoms during current pregnancy for a newborn with birth asphyxia. One-fourth 35 (24.5 %) of the newborns had a non-cephalic presentation in cases, while only 19 (6.6 %) had a non-cephalic presentation for controls (Table 3).

3.3. Fetal related characteristics

Nearly one-fourth (24.5 %) of the newborn had a non-cephalic presentation for cases, while only 19 (6.6 %) had a non-cephalic presentation for controls. Twenty-two (15.4 %) and 17 (5.9 %) of newborns had weighed less than 2500 g for cases and controls, respectively (Table 4).

3.4. Previous obstetric, medical, and behavioural history

Twenty six (18.2 %) women had experienced any history of pregnancy complications in their previous pregnancy, and five (3.5 %)

Table 3
Antepartum and Intrapartum characteristics for newborns admitted to NICU, Wolaita Zone, 2020.

Characteristics		Cases (n = 143) N (%)	Controls (n = 286) N (%)	Total (n = 429) N (%)
MUAC	<23 cm	*74 (51.7)*	*77 (26.9)*	*151 (35.2)*
	>=23 cm	*69 (48.3)*	*209 (73.1)*	*278 (64.8)*
Parity	*1–4*	*129 (90.2)*	*251 (87.8)*	*380 (88.6)*
	>=5	*14 (9.8)*	*35 (12.2)*	*49 (11.4)*
ANC visit during the current pregnancy	*Yes*	*130 (90.9)*	*242 (84.6)*	*372 (86.7)*
	No	*13 (9.1)*	*44 (15.4)*	*57 (13.3)*
Danger symptoms of pregnancy	*Yes*	*31 (21.7)*	*20 (7.0)*	*51 (11.9)*
	No	*112 (78.3)*	*266 (93)*	*378 (88.1)*
Labor Duration	Less than 12 h	*114 (79.7)*	*263 (92.0)*	*377 (87.9)*
	12 h and above	*29 (20.3)*	*23 (8.0)*	*52 (12.1)*
Cervical dilatation at admission	*Closed*	*134 (93.7)*	*271 (94.8)*	*405 (94.4)*
	Open	*9 (6.3)*	*15 (5.2)*	*23 (5.6)*
Mode of delivery	*SVD*	*62 (43.4)*	*190 (66.4)*	*252 (58.7)*
	Instrumental delivery	*66 (46.2)*	*76 (26.6)*	*142 (33.1)*
	CS delivery	*15 (10.5)*	*20 (7.0)*	*35 (8.2)*
Amniotic fluid status	*Normal stained*	*100 (69.9)*	*94 (32.9)*	*194 (45.2)*
	Blood or meconium-stained	*43 (30.1)*	*192 (67.1)*	*235 (54.8)*
Cord prolapses	*Yes*	*8 (5.6)*	*28 (9.8)*	*36 (8.4)*
	No	*135 (94.4)*	*258 (90.2)*	*393 (91.6)*
Premature rupture of membrane	*Yes*	*34 (23.8)*	*25 (8.7)*	*59 (13.8)*
	No	*109 (76.2)*	*261 (91.3)*	*370 (86.2)*
Filling of partograph	*To standard*	*26 (18.2)*	*141 (49.3)*	*167 (38.9)*
	Substandard	*104 (72.7)*	*132 (46.2)*	*236 (55.0)*
	Not recorded	*13 (9.1)*	*13 (4.5)*	*26 (6.1)*
Delivery was supported by BEMONC trained health professional	*Yes*	*37 (25.9)*	*159 (55.6)*	*196 (45.7)*
	No	*106 (74.1)*	*127 (44.4)*	*233 (54.3)*
Active management of the third stage of labor	*Yes*	*88 (61.5)*	*231 (80.8)*	*319 (74.4)*
	No	*55 (38.5)*	*55 (19.2)*	*110 (25.6)*

had a history of a medical problem for mothers with cases. Regarding smoking and alcohol intake, 6 (4.2 %) mothers had a smoking history of cigars and 8 (5.6 %) mothers had an alcohol intake history for mothers with cases (Table 5).

3.5. Determinants of birth asphyxia

After controlling for confounding, the multivariable logistic regression analysis yielded that amniotic fluid status, danger symptoms during pregnancy, premature rupture of the membrane, the temperature of new-born, filling status of the partograph, labor supported by a BEMONC trained health professional, fetus presentation, birth weight of newborn and assisted vaginal delivery were determinants of birth asphyxia. Newborns who experienced meconium or blood-stained amniotic fluid had more than five times (AOR = 5.43, 95% CI: 3.10–9.50) higher odds of developing birth asphyxia than their counterparts. Mothers who experienced any danger symptom during the pregnancy period had 3.71 times (AOR = 3.71, 95%CI: 1.56–8.65) increased odds of developing birth asphyxia than those mothers who do not have experienced danger symptoms. Births with premature rupture of the membrane were three times (AOR = 3.12, 95%CI: 1.42–6.83) more likely to develop birth asphyxia than their counterparts. Hypothermic babies were nearly 4.6 times (AOR = 4.57, 95CI: 1.77–11.81) increased odd of developing birth asphyxia than normothermic babies. Labor not supported by BEMONC trained health professionals was 3.23 (AOR = 3.23, 95%CI: 1.83–5.71) times higher odds of developing birth asphyxia than counterparts. Those newborn born babies with a birth weight of less than 2500 g had 2.68 (AOR = 2.68, 95%CI: 1.04-6.92) times increased odds of developing birth asphyxia than a normal weighed baby. Non-cephalic presented newborns had 5.54 five times (AOR = 5.54, 95%CI: 1.89–16.3) increased risk of developing birth asphyxia than cephalic presented newborn baby, and newborns with assisted vaginal delivery had 1.87 times (AOR = 1.87, 95%CI: 1.03–3.39*)* increased risk of developing birth asphyxia than newborns delivered by other modes (See Table 6).

4. Discussion

In this study, fetal conditions such as meconium or blood-stained amniotic fluid, hypothermic baby, non-cephalic fetus presentation, and low weighed baby were determinants of birth asphyxia. Maternal obstetric conditions such as premature rupture of membrane, the experience of danger symptoms during pregnancy were determinants of asphyxia at birth. Moreover, the training of health professionals on BEMONC to support the work and the standard of filling of partograph determines the asphyxiation of newborns at birth.

Newborns with meconium or blood stained with amniotic fluid had 5.43 times increased risk of developing asphyxia at birth. This study was consistent with the studies conducted in different parts of Ethiopia [18,27,21,23,28], Kenya [29], Accra, Ghana [30], and India [31]. This might possibly be explained by the possibility that meconium found in the amniotic fluid could cause lung aspiration. Lung inflammation, blockage, and restricted lung movement can all result from this. As a result of limited gas exchange, asphyxia can eventually occur [28].

The newborns had 3.71 times an increased risk of developing birth asphyxia for women who had experienced any danger symptom such as severe headache, blurred vision, epigastric pain, and vaginal bleeding during pregnancy than women who did not experience any danger symptoms. This finding was similar by the evidence from Ethiopia [28,32,33] and Indonesia [34]. This could be due to the danger signs such as antepartum hemorrhage which causes decreased placental blood flow that will lead to fetal hypoxemia and perinatal asphyxia.

In this study, newborns delivered after premature membrane rupture had nearly three times more likely to have birth asphyxia than newborns delivered without premature rapture of membrane. This result is consistent with a study conducted in Asella Referral Hospital and Northeast Amhara, Ethiopia [17,18] and Cameroon [35]. A possible explanation for this is that the risk of birth asphyxia, fetal distress, and even fetal death were increased for births with rupture of membrane before the onset of labor [36].

This study has shown that the newborns delivered with partograph filled in substandard and not recorded at all were nearly five times more likely to develop birth asphyxia than newborns delivered with partograph filled in standard. This finding is comparable with a study conducted in West Showa, Ethiopia [37] and India [38]. A possible explanation could be, following labor with the partograph helps health professionals monitor the progress of labor, maternal, and fetal condition, which indicates them to take urgent

Table 4
Fetal-related characteristics for newborns admitted to NICU, Wolaita Zone, 2020.

Characteristics		Cases (n = 143) N (%)	Controls (n = 286) N (%)	Total (n = 429) N (%)
Fetus Presentation	*Cephalic*	*108 (75.5)*	*267 (93.4)*	*375 (87.4)*
	Non-cephalic presentation	*35 (24.5)*	*19 (6.6)*	*54 (12.6)*
Temperature of newborn	*Normothermic*	*8 (5.6)*	*61 (21.3)*	*69 (16.1)*
	Hypothermic	*135(94.4)*	*225 (78.7)*	*360 (83.9)*
Gestational age at birth	*<37 week*	*66 (46.2)*	*84 (29.4)*	*150 (35.0)*
	37-42 week	*77 (53.8)*	*202 (70.6)*	*279 (65.0)*
Birth weight	<2500 gm	*22 (15.4)*	*17 (5.9)*	*39 (9.1)*
	>=2500 gm	*121 (84.6)*	*269 (94.1)*	*390 (90.9)*
Number of newborns delivered during the current pregnancy	*Single-tone*	*140 (97.9)*	*276 (96.5)*	*416 (97.0)*
	Multiple tones	*3 (2.1)*	*10 (3.5)*	*13 (3.0)*

Table 5
Obstetric and medical history of newborns admitted to NICU, Wolaita Zone, 2020.

Variable		Cases (n = 143) N (%)	Controls (n = 286) N (%)	Total (n = 429) N (%)
History of pregnancy complication	*Yes*	*26 (18.2)*	*32 (11.2)*	*58 (13.5)*
	No	*117 (81.8)*	*254 (88.8)*	*371 (86.5)*
History of medical problem	*Yes*	*5 (3.5)*	*7 (2.4)*	*12 (2.8)*
	No	*138 (96.5)*	*279 (97.6)*	*417 (97.2)*
Smoking history	*Yes*	*6 (4.2)*	*6 (2.1)*	*12 (2.8)*
	No	*137 (95.8)*	*280 (97.9)*	*417 (97.2)*
Alcohol intake history	*Yes*	*8 (5.6)*	*14 (4.9)*	*22 (5.1)*
	No	*135 (94.4)*	*272 (95.1)*	*407 (94.9)*

Table 6
Determinants of birth asphyxia identified through COR and AOR for newborns admitted to NICU, Wolaita Zone, 2020.

		Cases (n = 143) N (%)	Controls (n = 286) N (%)	COR (95%CI)	AOR (95%CI)	Corresponding P-value
Educational status	*No formal education*	*107(74.8)*	*202 (70.6)*	*1.24 (0.78–1.95)*	*1.79 (0.93–3.46)*	*0.08*
	Formal education	*36 (25.2)*	*84 (29.4)*	*1*	*1*	
Residence	*Urban*	*58 (40.6)*	*141 (49.3)*	*0.70 (0.47–1.05)*	*1.06 (0.60–1.87)*	*0.83*
	Rural	*85 (59.4)*	*145 (50.7)*	***1***	*1*	
MUAC	Less than 23 cm	*74 (51.7)*	*77 (26.9)*	***2.91 (1.91–4.43)***	*1.48 (0.83–2.64)*	*0.18*
	Greater than or equals 23 cm	*69 (48.3)*	*209 (73.1)*	*1*	*1*	
ANC visit	*Yes*	*130 (90.9)*	*242 (84.6)*	*1.82 (0.94–3.5)*	*0.75 (0.34–1.65)*	*0.48*
	No	*13 (9.1)*	*44 (15.4)*	*1*	*1*	
Danger symptoms of pregnancy	*Yes*	*31 (21.7)*	*20 (7.0)*	***3.68 (2.01–6.73)***	***3.71 (1.56–8.65)***	*0.002***
	No	*112 (78.3)*	*266 (93)*	*1*	*1*	
Cord Prolapse	*Yes*	*8 (5.6)*	*28 (9.8)*	*0.55 (0.24–1.23)*	*0.34 (0.12–1.02)*	*0.06*
	No	*135 (94.4)*	*258 (90.2)*	*1*	*1*	
Amniotic fluid status	*Normal*	*100 (69.9)*	*94 (32.9)*	***1***	***1***	*<0.001***
	Blood or meconium-stained	*43 (30.1)*	*192 (67.1)*	***4.75 (3.08–7.33)***	***5.43 (3.10–9.50)***	
Premature rupture of membrane	*Yes*	*34 (23.8)*	*25 (8.7)*	***3.26 (1.86–5.72)***	***3.12 (1.42–6.83)***	*0.004 ***
	No	*109 (76.2)*	*261 (91.3)*	*1*	*1*	
History of pregnancy complication	*Yes*	*26 (18.2)*	*32 (11.2)*	***1.76 (1.01–3.09)***	*1.06 (0.49–2.31)*	*0.88*
	No	*117 (81.8)*	*254 (88.8)*	*1*	*1*	
The temperature of the newborn	*Normothermic*	*8 (5.6)*	*61 (21.3)*	***1***	*1*	*0.001****
	Hypothermic	*135(94.4)*	*225 (78.7)*	***4.57 (2.12–9.85)***	***4.57 (1.77–11.81)***	
Gestational age at birth	*<37 week*	*66 (46.2)*	*84 (29.4)*	***2.06 (1.36–3.12)***	*1.19 (0.68–2.08)*	*0.55*
	>=37 week	*77 (53.8)*	*202 (70.6)*	*1*	*1*	
Partograph fill standard	*To standard*	*26 (18.2)*	*141 (49.3)*	***1***	*1*	
	To substandard	*104 (72.7)*	*132 (46.2)*	***1.27* (1.17–6.98)**	***4.03 (2.19–7.41)***	*<0.001****
	Not recorded	*13 (9.1)*	*13 (4.5)*	***5.42 (2.26–13.01)***	***8.16 (2.24–29.66)***	*0.001****
BEMONC trained	*Yes*	*37 (25.9)*	*159 (55.6)*	*1*	*1*	*<0.001****
	No	*106 (74.1)*	*127 (44.4)*	***3.59 (2.31–5.57)***	***3.23 (1.83–5.71)***	
Fetus presentation	*Cephalic*	*108 (75.5)*	*267 (93.4)*	***1***	*1*	*0.02***
	Non-cephalic	*35 (24.5)*	*19 (6.6)*	***3.74 (2.07–6.75)***	***5.54 (1.89–16.3)***	
Mode of delivery	*SVD*	*62 (43.4)*	*190 (66.4)*	*1*	*1*	
	Assisted vaginal delivery	*66 (46.2)*	*76 (26.6)*	***2.66 (1.72–4.12)***	***1.87 (1.03–3.39)***	*0.04***
	CS delivery	*15 (10.5)*	*20 (7.0)*	***2.29 (1.11–4.76)***	*0.42 (0.11–1.68)*	*0.22*
Birth weight	*<2500 gm*	*22 (15.4)*	*17 (5.9)*	***2.87 (1.47–5.61)***	***2.68 (1.04–6.92)***	*0.04***
	>=2500 gm	*121 (84.6)*	*269 (94.1)*	*1*	*1*	

COR=Crude Odds Ratio, CI= Confidence Interval.

interventions if complications occur. Therefore, if labor is not followed by partograph newborns have high chance of developing birth asphyxia [39].

Newborns delivered after labors not supported by BEMONC trained health professionals had three times increased risk of developing birth asphyxia than their counterparts. This could be due to knowledge and skill of BEMONC not trained health professionals may miss some of essential procedures that should be provided during labor and delivery because of lack of raining. Approximately 15 % of all pregnant women develop a potentially life-threatening complication that requires calls for skilled care, and some require major obstetrical intervention to survive [40]. The Federal Ministry of Health of Ethiopia (FMOH) developed standard BEMONC in-service training curricula to respond to the high demand for competency in EmONC in 2010 [25]. In 2008, Ethiopia had just 11 % of the

recommended number of fully functioning EmONC facilities, nationally; in 2016, the proportion increased to 40 %. Despite the improvement, a large gap remains to reach 100 % of the recommendation [29].

In this study, non-cephalic presenting newborns had more than 5.5 times increased odds of developing birth asphyxia than cephalic presented newborns. This was supported by other studies conducted in Ethiopia [18,23]. This might due to fetal mal-presentation is a leading cause of cesarean delivery and other assisted deliveries which leads to fatal complications during birth including birth asphyxia [40].

This study has revealed that newborns with birth weight less than 2500 gm had 2.68 times increased risk of developing birth asphyxia than normal weighed newborns. This finding is supported by different studies from Ethiopia [16,17,20,23] and Bangladesh [41]. This might be due to the fact that low birth weight can be caused by maternal medical conditions such as hypertension and diabetes mellitus that would increase the burden of birth asphyxia [42].

Newborns delivered by assisted vaginal delivery had 1.87 higher odds of developing birth asphyxia compared to those who delivered through spontaneous vaginal delivery respectively. This finding is consistent with the studies conducted in Gondar, Dessie, and Asella in Ethiopia [17,41,42] and Pakistan [43]. And also both vacuum and forceps extraction exert pressure on the newborn's brain and it might cause the brain to bleed on the cranium contributes to intracranial hemorrhage and birth asphyxia [44].

This study showed that hypothermic newborns have 4.6 times increased risk of developing birth asphyxia than normothermic newborns. This is might because neonatal hypothermia was associated with increased risk pulmonary vasoconstriction, metabolic acidosis, jaundice, and respiratory distress syndrome among newborn babies [45].

5. Limitations of the study

The study was based on institutions where the majority of births were attended by qualified health personnel. This may not reflect exact risk factors in the community.

6. Conclusion

This study has shown that maternal and fetal conditions such as hypothermic and low-weight babies change in color of amniotic fluid, dangerous symptoms of pregnancy and premature rupture of the membrane were determinants of birth asphyxia. Furthermore, service-related factors such as supporting labor by a trained health professional on BEMONC and partograph filling standard were also determinants of birth asphyxia. Therefore, the successful and timely management of fetal and maternal complications and capacity building of health professionals on BEMONC would reduce the occurrence of birth asphyxia among newborns.

Ethical consideration

Ethical clearance (approval) was obtained from the Wolaita Sodo University Institutional Review Board (IRB) ethical clearance number CHSM/ERC/18/21. Written permission was obtained from the Wolaita Zone Health Department. During data collection, all respondents were asked for their permission, and informed oral consent was obtained from each study participant. Mothers also gave consent to access the medical recorded information on newborns. Confidentiality of all results was maintained at all stage of the study and withdrawal from the study at any time was assured.

Funding

This study is not funded

Data availability statement

Data will be made available on request.

Consent for publication

Not applicable.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Tesfaye Tunta: Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Tadele Dana:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Abiyot Wole:** Writing – original draft, Visualization, Validation, Supervision, Software, Methodology, Conceptualization. **Temesgen Lera:** Writing – review & editing, Visualization, Validation, Supervision, Methodology, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to express our gratitude to Wolaita Sodo University, College of Health Sciences and Medicine. We also thank Wolaita Zone administrators, supervisors, respondents, and data collectors.

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