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Original Research

Determinants of Birth Asphyxia Among Newborns Delivered in Public Health Facilities in Dire Dawa, Eastern Ethiopia, 2025: Unmatched Case-Control Study

Yohannes Tegegne[1], Aliya Nuri[2], Nigus Kassie Worku[2*]

[1]Eastern Command Level 3 Referral Hospital, Dire Dawa, Ethiopia
[2]Department of Public Health, College of Medicine and Health Sciences, Dire Dawa University, P.O. Box: 1362, Dire Dawa, Ethiopia

Abstract

Background: Birth asphyxia is a major cause of neonatal morbidity and mortality worldwide and remains a significant public health problem in Ethiopia. Despite the implementation of various maternal and neonatal health interventions, including the expansion of antenatal care (ANC) contacts to eight visits, birth asphyxia continues to contribute substantially to neonatal deaths. This study aimed to identify the determinants of birth asphyxia in public health facilities of Dire Dawa City Administration, Eastern Ethiopia.

Methods: A facility-based unmatched case–control study was conducted in four health centers and two hospitals in Dire Dawa City Administration from February 20 to April 30, 2025. A total of 308 newborns, comprising 103 cases and 205 controls, were included. Data were collected using structured questionnaires and checklists through the KoboCollect application and analyzed using SPSS version 26. Variables with a p-value less than 0.25 in bivariate analysis were entered into a multivariable logistic regression model. Determinants of birth asphyxia were identified using adjusted odds ratios with 95% confidence intervals, and statistical significance was declared at p-value less than 0.05.

Results: Newborns born to mothers who had fewer than four ANC visits were five times more likely to develop birth asphyxia compared to those whose mothers had four or more visits (AOR = 5.00; 95% CI: 2.57, 9.66). Prolonged labor significantly increased the likelihood of birth asphyxia by more than fourfold (AOR = 4.25; 95% CI: 2.12, 7.79). Neonates delivered through instrumental methods had nearly three times higher odds of experiencing birth asphyxia than those delivered spontaneously (AOR = 2.70; 95% CI: 1.11, 7.36). Additionally, neonates born at non-term gestational age were more than five times more likely to develop birth asphyxia (AOR = 5.58; 95% CI: 1.91, 19.63). Low birth weight was also a significant determinant, with affected neonates having more than four times higher odds of birth asphyxia (AOR = 4.51; 95% CI: 2.07, 11.67).

Conclusion: This study identified fewer than four ANC visits, prolonged labor, instrumental delivery, non-term gestational age, and low birth weight as significant determinants of birth asphyxia. Strengthening the quality and continuity of antenatal, intrapartum, and immediate newborn care is essential to reduce the burden of birth asphyxia in public health facilities.

Keywords: Birth asphyxia, Determinants, Ethiopia, Newborns, Significant

**Corresponding author: Nigus Kassie Worku: niguskassie19@gmail.com, +251918215699*

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1. Introduction

Birth asphyxia (BA) is an insult to the fetus or newborn resulting from failure to breathe or inadequate breathing at birth, leading to reduced oxygen perfusion to vital organs. The World Health Organization (WHO) defines neonatal asphyxia as the failure of a newborn to initiate and sustain spontaneous respiration, or a delay in establishing normal respiration within the first minute after birth. This condition results in progressive hypoxia, carbon dioxide retention, and significant metabolic acidosis. According to the WHO, approximately four million neonatal deaths occur annually due to birth asphyxia, accounting for about 38% of deaths among children under five years of age [1].

Severe birth asphyxia can lead to extensive multi-organ damage, including brain injury, pulmonary dysfunction, renal failure, hepatic failure, and necrotizing enterocolitis. It is one of the leading causes of perinatal mortality and long-term neurological morbidity. Among survivors, up to 80% experience lifelong complications such as developmental delay, intellectual disability, seizures, coma, hypotonia, neonatal encephalopathy, and behavioral disorders [2–5].

When birth asphyxia results in brain injury, affected newborns commonly develop hypoxic-ischemic encephalopathy (HIE) shortly after birth. HIE is a neurological condition caused by reduced or absent oxygen supply to the brain and is a major contributor to infant mortality and severe long-term neurological impairment [6–8]. Survivors of birth asphyxia often suffer from neurodevelopmental sequelae that impose substantial emotional, physical, and financial burdens on affected children, families, and healthcare systems. Epidemiological studies from developed countries indicate that perinatal asphyxia accounts for approximately 8–15% of cerebral palsy cases. The risk of neurological sequelae is particularly high among children with severe HIE, with common outcomes including intellectual disability, cerebral palsy, and epilepsy [9].

Despite its significance, many studies assessing determinants of birth asphyxia have limitations. Most were conducted before 2020, did not include public health facilities, lacked clearly defined categories of independent variables, and excluded several important maternal, obstetric, and neonatal factors. These gaps limit the understanding of the root causes of birth asphyxia in contemporary clinical settings.

Globally, an estimated 5.3 million children under five years of age die each year, with approximately 45% of these deaths occurring during the neonatal period. In developing countries, neonatal deaths account for about 52% of under-five mortality, largely due to preventable causes such as perinatal

asphyxia [1,4]. In Ethiopia, neonatal mortality remains unacceptably high [10]. In line with Sustainable Development Goal (SDG) Target 3.2, Ethiopia aims to reduce neonatal mortality to 12 or fewer deaths per 1,000 live births by 2030 [11]. Given that birth asphyxia is a major contributor to neonatal mortality and is frequently associated with complications during labor and delivery, identifying childbirth-related determinants within the local context is essential. However, such determinants have not been adequately studied in this setting.

Furthermore, many earlier studies were conducted before the widespread implementation of key interventions for birth asphyxia, including immediate neonatal resuscitation, therapeutic hypothermia, continuous monitoring and assessment, multidisciplinary neonatal care, and early initiation of feeding. Therefore, updated evidence reflecting current clinical practices is needed.

This study aims to identify significant determinants of birth asphyxia in the local context to inform effective prevention and intervention strategies. The findings are expected to enhance healthcare providers' ability to identify and manage key risk factors, thereby improving maternal and neonatal outcomes. In addition, the study may increase awareness among pregnant women regarding maternal and obstetric risk factors and promote healthier pregnancy-related behaviors through improved health education. The results will also serve as evidence to support policy revision, contribute to the improvement of neonatal care guidelines, and provide baseline data for future research.

2. Methods

2.1. Study Area, Period and Design

Dire Dawa City Administration is located approximately 516 kilometers east of Addis Ababa, the capital city of Ethiopia. Administratively, the city comprises four rural and five urban districts and is bordered by the Somali Region to the north and east and the Oromia Region to the south and west. These districts are further subdivided into 10 urban and 37 rural kebeles, which are the smallest administrative units in Ethiopia [12].

According to the 2016 Ethiopian Fiscal Year (EFY) annual report of the Dire Dawa City Administration Health Bureau, the estimated population of the city is approximately 581,506, of whom about 68% reside in urban areas and 32% in rural settings. The city administration has a total of three government-owned hospitals, 16 public health centers, and 31 health posts. In addition, there are five private hospitals and 21 private clinics providing health services. The catchment populations of selected Primary Health Care Units (PHCUs) are as follows: Goro PHCU serves

approximately 55,855 people, Dire Dawa PHCU 33,730, Dechatu PHCU 28,479, and Gendekore PHCU 35,955.

Climatically, Dire Dawa City Administration encompasses arid and semi-arid zones and lies at an average altitude of about 1,200 meters above sea level, with a mean monthly temperature of approximately 24.8 °C [57]. A facility-based unmatched case–control study was conducted from February 20 to April 30, 2025, in selected public health institutions within Dire Dawa City Administration.

2.2. Population

All Newborns with their respective mothers in health institutions of Dire Dawa Administration was source population and all Newborns with their respective mothers in the selected health facilities of Dire Dawa Administration during data collection period was study population.

- **Cases (asphyxiated newborns):** all neonates diagnosed with asphyxia by the attending health professionals using an Apgar score of less than 7 at 1st & 5th minutes after birth were considered as cases [13,14].
- **Controls (non-asphyxiated newborns):** all neonates diagnosed as non-asphyxiated by the attending health professionals using an APGAR score of more than 7 at 1st & 5th minutes were considered as controls [13,15].

2.3. Eligibility Criteria

All mothers whose newborns met the case or control definitions of the study, developed birth asphyxia, were delivered at a gestational age of ≥28 weeks, and had complete medical records were included in the study. Newborns with one or more identified life-threatening congenital malformations, mothers who were critically ill, and cases in which either the mother or the newborn had incomplete medical records such as missing first- or fifth-minute Apgar scores were excluded from the study.

2.4. Sample Size Determination and Sampling Procedure

The sample size was estimated using an unmatched case-control, double population proportion formula, using Epi Info version 7.1.2 from the factors reviewed which gives maximum value by assumed 95% CI, 80% power, case to control ratio 1:2, Odds Ratio=2.21 which is the ratio of odds of cases among neonates with birth asphyxia to odds of controls among neonates free of birth asphyxia; proportion of controls 22.7% and proportion of cases as 39.3%, preterm, unable to read and write, primiparous and ante partum hemorrhage as a variable and got

maximum sample size is 293 (98 cases & 195 controls); after adding 5% non-respondent rate it became 308 (103 cases & 205 controls).

From 16 health centers and three hospitals: Goro, Gendekore, Dire Dawa, Dechatu health centers, Sabian general hospital and Dilchora referral hospital were chosen using a lottery method, employing a simple random sampling technique to ensure fairness and randomness in the selection process. Cases were recruited starting from first day of data collection period consecutively from asphyxiated neonates by using medical records to select for interview of mothers; whereas controls were selected from non-asphyxiated newborn by using systematic random sampling in registration book. Both primary (by interviewing mothers) and secondary (from medical records) data sources were used to get information about independent variables.

2.5. Variables of the Study

2.5.1. Dependent variable

- Birth Asphyxia

2.5.2. Independent variables

- **Socio-demographic & Behavioral determinants:** (Age, Religion, Maternal educ., Residence, Occupation, Marital status & Substance use)
- **Obstetrics determinants:** (Birth spacing (Years), History of adverse pregnancy outcome, Type of adverse pregnancy outcome, Number of ANC follow up, Parity, Hospital arrival, Pre-eclampsia, Eclampsia, Polyhydramnios & Oligohydramnios)
- **Maternal health related determinants:** (Anemia, Hypertension, Diabetes mellitus, STI & Asthma)
- **Antepartum and Intra-partum determinants:** (Labor started, Labor attend by, Duration of labor, Mode of delivery, premature rupture of membrane, fetal presentation, Delivery outcome & APH)
- **Neonatal determinants:** (Gestational age, Baby cry at birth, Sex of neonate & Newborn weight)

2.6. Operational Definition

- **Birth asphyxia:** a neonate who had <7 Apgar score and fail to start & sustain sufficient respiration within 5 minutes of birth [15].
- **Cases (asphyxiated newborns):** all neonates diagnosed with asphyxia by the attending health professionals using an Apgar score of less than 7 at 1 & 5 minutes after birth will be considered as cases [14].

- **Controls (non-asphyxiated newborns):** all neonates diagnosed as non-asphyxiated by the attending health professionals using an APGAR score of more than 7 at 5th minutes will be considered as controls [15].

2.7. Data Collection Tools and Data collectors and Procedures

Data was collected by using a pre-tested structured interview administered questionnaire and check list using KoboCollect apk. It was taken approximately 20 minutes to interview mothers of the new born. The questions prepared by English language which translated to three local languages (Amharic, Afan Oromo & Somali) then translated back to English to check the consistency. The questionnaire and checklist are adopted from peer reviewed journals [13].

There were three BSc nurse data collectors which supervised by one BSc nurse who works on out of the selected health institutions.

2.8. Data Quality Control

Prior to data collection, a two-day training was provided to data collectors and supervisors. The training covered the objectives of the study, detailed review of the questionnaire, data collection procedures, and ethical considerations. A pretest of the data collection tools was conducted on 5% of the total sample size (15 delivered mothers) in an adjacent area using private health facilities before the commencement of the actual data collection. Throughout the data collection period, close supervision was carried out by the supervisor and principal investigator. Data were reviewed daily for completeness and accuracy at the end of each data collection day.

2.9. Data processing, Analysis and Interpretation

Data were cleaned, coded, and entered using the KoboCollect mobile application and then exported to SPSS version 26 for analysis. Descriptive analyses were performed to summarize the data, and the study findings were presented using text, tables, and figures. Binary logistic regression analysis was conducted to assess the crude association between each independent variable and birth asphyxia by calculating crude odds ratios (ORs) with 95% confidence intervals. Independent variables with a p-value ≤0.25 in the bivariate analysis were included in the multivariable logistic regression model. Variables with a p-value <0.05 and adjusted odds ratios (AORs) with 95% confidence intervals were considered statistically significant. Model fitness was assessed using the Hosmer–Lemeshow goodness-of-fit test, which indicated a good model fit (p = 0.938).

3. Results

3.1. Socio-Demographic Characteristics

A total of 308 participants (103 cases and 205 controls) were included in the study, yielding a 100% response rate. The mean age of mothers of cases was 24.6 years (SD ± 5.57), while the mean age of mothers of controls was 26.5 years (SD ± 5.39). Regarding educational status, 42 (40.8%) mothers of cases and 91 (44.4%) mothers of controls had attended primary education. The majority of participants were urban residents, accounting for 78 (75.7%) mothers of asphyxiated neonates and 167 (81.5%) mothers of non-asphyxiated neonates (Table 1).

Table 1: Socio-demographic & behavioral factors for the determinants of birth asphyxia among newborns delivered at public health facilities in Dire Dawa , Eastern Ethiopia 2025

Variable	Category	Case	Control	Total	*p-value*
		n=103(%)	n=205(%)	n=308(%)	
Age of mother	18-29	73 (70.9)	175 (85.4)	248 (80.5)	0.006
	<18	15 (14.6)	11 (5.4)	26 (8.4)	
	>=30	15 (14.6)	19 (9.3)	34 (11.0)	
Religion	Orthodox	13 (12.6)	60 (29.3)	73 (23.7)	0.001
	Muslim	89 (86.4)	137 (66.8)	226 (73.4)	
	Protestant	1 (1.0)	8 (3.9)	9 (2.9)	
Maternal educational status	Can not read & write	41 (39.8)	41 (20.0)	82 (26.6)	0.000
	Primary school_1-8	42 (40.8)	91 (44.4)	133 (43.2)	
	Secondary school_9-12	18 (17.5)	47 (22.9)	65 (21.1)	
	Certificate	1 (1)	5 (2.5)	6 (2)	
	Diploma & above	1 (1)	21 (10.3)	22 (7.1)	
Residence	Urban	78 (75.7)	167 (81.5)	245 (79.5)	0.239
	Rural	25 (24.3)	38 (18.5)	63 (20.5)	
Occupation	Gov't employed	2 (1.9)	17 (8.3)	19 (3.2)	0.017
	Private employed	12 (11.7)	42 (20.5)	54 (17.5)	
	Merchant	2 (1.9)	6 (2.9)	8 (2.6)	
	House wives	87 (84.5)	140 (68.3)	227 (73.7)	
Marital status	Married	103 (100.0)	203 (99.0)	306 (99.4)	0.315
	Single	0 (0.0)	1 (0.5)	1 (0.3)	
	Divorced	0 (0.0)	1 (0.5)	1 (0.3)	
Substance use	Yes	6 (5.8)	16 (7.8)	22 (7.1)	0.524
	No	97 (94.2)	189 (92.2)	286 (92.9)	

3.2. Obstetrics Determinants

Among the study participants, 53 (51.5%) mothers of cases and 68 (33.2%) mothers of controls were primiparous. Short birth spacing of two years or less was reported among 19 (34.5%) mothers of cases and 20 (14.2%) mothers of controls. Nearly three-quarters of mothers of cases, 78 (75.7%), had fewer than four antenatal care (ANC) visits, compared with 90 (43.9%) mothers of controls.

3.3. Maternal Health Related Determinants

Among maternal health–related determinants, 23 (22.3%) mothers of asphyxiated neonates and 27 (13.2%) mothers of non-asphyxiated neonates had anemia. In addition, hypertension was reported among 1 (1.0%) mother in the case group and 3 (1.5%) mothers in the control group (Table 2).

Table 2: Maternal health related factors of Birth asphyxia among newborns delivered at public health facilities in Dire Dawa, Eastern Ethiopia 2025.

Variable	Category	Case	Control	Total	*p-value*
		n=103(%)	n=205(%)	n=308(%)	
Anemia	Yes	23 (22.3)	27 (13.2)	50 (16.2)	0.040
	No	80 (77.7)	178 (86.8)	258 (83.8)	
Hypertension	Yes	1 (1.0)	3 (1.5)	4 (1.3)	0.719
	No	102 (99.0)	202 (98.5)	304 (98.7)	
Diabetes mellitus	Yes	0 (0.0)	3 (1.5)	3 (1.0)	0.217
	No	103 (100.0)	202 (98.5)	305 (99.0)	
Asthma	Yes	0 (0.0)	3 (1.5)	3 (1.0)	0.045
	No	103 (100.0)	202 (98.5)	305 (99.0)	

3.4. Antepartum & Intrapartum Determinants

Among the study participants, prolonged labor was reported in 45 (43.7%) mothers of cases and 31 (15.1%) mothers of controls. Regarding the mode of delivery, 41 (39.8%) mothers of asphyxiated neonates and 62 (30.2%) mothers of non-asphyxiated neonates delivered by caesarean section. Premature rupture of membranes occurred in 26 (25.2%) cases and 32 (15.6%) controls. In addition, non-cephalic fetal presentation was observed in 4 (3.9%) cases and 6 (2.9%) controls (Table 3).

Table 3: Ante/Intrapartum related factors of Birth asphyxia among newborns delivered at public health facilities in Dire Dawa, Eastern Ethiopia 2025

Variable	Category	Case	Control	Total	*p-value*
		n=103(%)	n=205(%)	n=308(%)	
Labor started at	Spontaneous	67 (65.0)	127 (62.0)	194 (63.0)	0.595
	Induced	36 (35.0)	78 (38.0)	114 (37.0)	
Labor attend by	Intern	15 (14.6)	16 (7.8)	31 (10.1)	0.164
	Midwives	64 (62.1)	133 (64.9)	197 (64.0)	
	Obstetrician	24 (23.3)	56 (27.3)	80 (26.0)	
Duration of labor	Normal	58 (56.3)	174 (84.9)	232 (75.3)	0.000
	Prolonged	45 (43.7)	31 (15.1)	76 (24.7)	
Mode of delivery	Spontaneous	44 (42.7)	129 (62.9)	173 (56.2)	0.001
	*CS	41 (39.8)	62 (30.2)	103 (33.4)	
	Instrumental	18 (17.5)	14 (6.8)	32 (10.4)	
Premature rupture of membrane	Yes	26 (25.2)	32 (15.6)	58 (18.8)	0.041
	No	77 (74.8)	173 (84.4)	250 (81.2)	
Fetal presentation	Cephalic	99 (96.1)	199 (97.1)	298 (96.8)	0.655
	Non-cephalic	4 (3.9)	6 (2.9)	10 (3.2)	
Delivery outcome	Singleton	97 (94.2)	201 (98.0)	298 (96.8)	0.070

	Multiple	6 (5.8)	4 (2.0)	10 (3.2)	
*APH	Yes	0 (0.0)	2 (1.0)	2 (0.6)	0.315
	No	103 (100.0)	203 (99.0)	306 (99.4)	
Amniotic fluid status	Meconium stained	1 (1.0)	2 (1.0)	3 (1.0)	0.997
	Clear	102 (99.0)	203 (99.0)	305 (99.0)	
Use of partograph	Yes	86 (83.5)	162 (79.0)	248 (80.5)	0.350
	No	17 (16.5)	43 (21.0)	60 (19.5)	

*APH: Antepartum hemorrhage *CS: caesarean section

3.5. Neonatal determinants

Concerning to neonatal determinants, nearly three-quarter of cases (68.9%) cases & 101(49.3) controls were males, 95(92.2%) cases and 4(2.0%) controls were not cry at birth, 23(22.3%) cases & controls 7(3.4%) were non-term. Additionally, 33(32.0%) cases & 14(6.8%) controls were underweighted during birth (Figure 1).

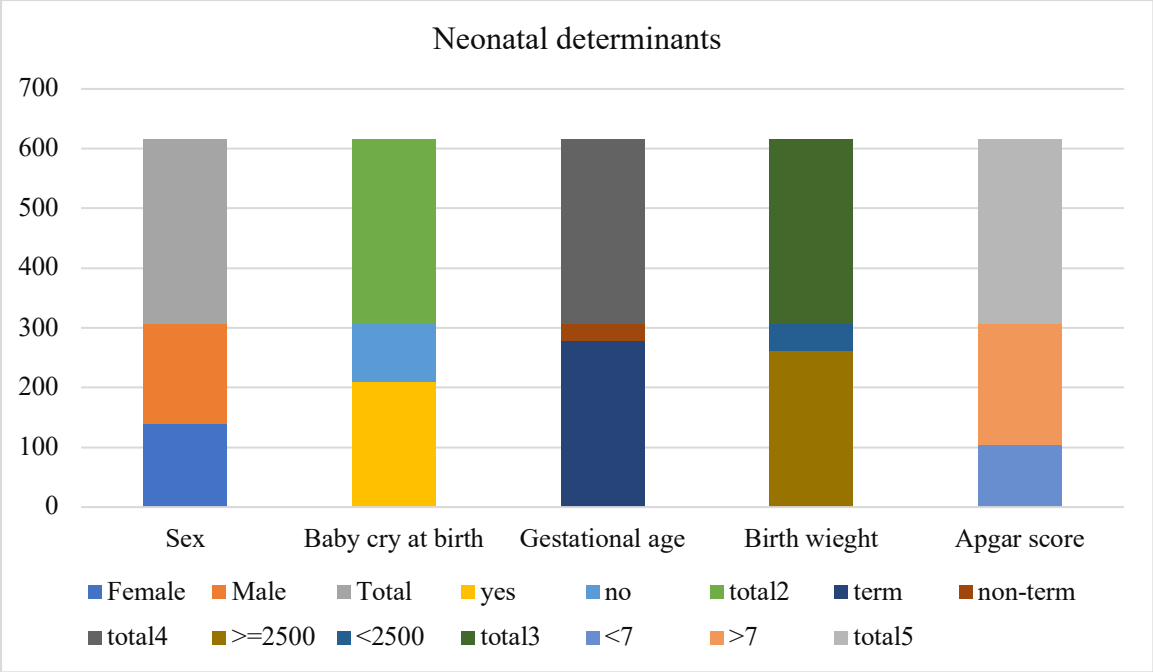

Figure 1: Neonatal related factors of Birth asphyxia among newborns delivered at public health facilities in Dire Dawa, Eastern Ethiopia 2025.

3.6. Determinants of Birth Asphyxia

Bivariable logistic regression analysis was performed to identify candidate variables for multivariable analysis. Maternal age, residence, parity, antenatal care (ANC) follow-up, duration of labor, mode of delivery, premature rupture of membranes, anemia, gestational age, birth weight, and sex of the neonate were included in the bivariable analysis. Variables with a p-value ≤0.25 were subsequently entered into the multivariable logistic regression model. In the final model, ANC follow-up, duration of labor, mode of delivery, gestational age, and birth weight were found to be significantly associated with birth asphyxia.

Neonates born to mothers who had fewer than four ANC visits were approximately five times more likely to develop birth asphyxia compared to those whose mothers had four or more ANC visits (AOR = 5.00; 95% CI: 2.63, 9.50). The likelihood of birth asphyxia was also significantly higher among neonates born after prolonged labor, with more than fourfold increased odds compared to those born after normal labor duration (AOR = 4.25; 95% CI: 2.26, 7.98).

Regarding mode of delivery, neonates delivered by instrumental methods had 2.7 times higher odds of developing birth asphyxia compared to those delivered spontaneously (AOR = 2.70; 95% CI: 1.07, 6.80). Similarly, neonates born at non-term gestational age were more than five times more likely to experience birth asphyxia than term neonates (AOR = 5.58; 95% CI: 1.81, 17.24). Low birth weight was also a significant determinant, with affected neonates having more than fourfold increased odds of birth asphyxia compared to those with normal birth weight (AOR = 4.51; 95% CI: 1.94, 10.47) (Table 4).

Table 4: Bi-variable & multivariable analysis for birth asphyxia among newborns delivered at public health facilities in Dire Dawa, Eastern Ethiopia 2025.

Variable	Category	Cases	Controls	COR	AOR	*P*-value
		n=103 (%)	n=205 (%)	[95%CI]	[95%CI]	
Maternal age	≥30	15 (14.6)	19 (9.3)	1.89 (0.91-3.93)	1.50 (0.61 3.68)	0.378
	<18	15 (14.6)	11 (5.4)	3.27 (1.43-7.46)	2.10 (0.78-5.64)	0.14
	18-29	73 (70.9)	175 (85.4)	1	1	
Residence	Rural	25 (24.3)	38 (18.5)	1.39 (0.86-2.24)	1.11 (0.53-2.34)	0.769
	Urban	78 (75.7)	167 (81.5)	1	1	
Parity	Primiparous	53 (51.5)	68 (33.2)	2.14 (1.32-3.46)	1.13 (0.59-2.17)	0.709
	Multiparous	50 (48.5)	137 (66.8)	1	1	
ANC follow up	<4 times	78 (75.7)	90 (43.9)	3.99 (2.35-6.76)	5.00 (2.63-9.50)	0.000**
	≥4 times	25 (24.3)	115 (56.1)	1	1	
Anemia	Yes	23 (22.3)	27 (13.2)	1.89 (1.02 3.51)	1.05 (0.48-2.29)	0.902
	No	80 (77.7)	178 (86.8)	1	1	
Duration of labor	Prolonged	45 (43.7)	31 (15.1)	4.36 (2.52-7.51)	4.25 (2.26-7.98)	0.000**
	Normal	58 (56.3)	174 (84.9)	1	1	
Mode of delivery	Instrumental	18 (17.5)	14 (6.8)	3.77 (1.73-8.20)	2.70 (1.07-6.80)	0.035*
	CS	41 (39.8)	62 (30.2)	1.94 (1.150-3.27)	1.89 (1.00-3.58)	0.050*
	Spontaneous	44 (42.7)	129 (62.9)	1	1	
PROM	Yes	26 (25.2)	32 (15.6)	1	1	
	No	77 (74.8)	173 (84.4)	1.82 (1.02-3.27)	1.45 (0.71-2.96)	0.135
Child Sex	Male	62 (60.2)	107 (52.2)	1.41 (0.80-2.50)	1.24 (0.69-2.23)	0.481
	Female	41 (39.8)	98 (47.8)	1	1	
Gestational age	Non-term	23 (22.3)	7 (3.4)	8.13 (3.36-19.70)	5.58 (1.81-17.24)	0.003*
	Term	80 (77.7)	198 (96.6)	1	1	
Birth weight	<2500 g	33 (32.0)	14 (6.8)	6.43 (3.25-12.73)	4.51 (1.94-10.47)	0.000**
	≥2500 g	70 (68.0)	191 (93.2)	1	1	

* Significant at the level *p=<0.05, ** P=<0.01*

4. Discussion

This study revealed that neonates born to mothers who had fewer than four antenatal care (ANC) visits were five times more likely to develop birth asphyxia compared to those whose mothers had four or more ANC visits. This finding is consistent with studies conducted in Nepal [16], Nigeria [17], Debre Berhan [18], and Southern Ethiopia [19]. However, a study conducted in Wolaita [20] did not identify ANC follow-up as a significant independent determinant of birth asphyxia, which may be attributable to differences in study design, sample size, or healthcare service utilization.

Adequate ANC follow-up plays a critical role in monitoring fetal well-being and ensuring timely identification and management of maternal and fetal complications. Reduced ANC attendance limits opportunities to provide essential services such as nutritional supplementation, immunization, health education, and early detection of fetal distress, all of which are vital for optimal fetal growth and development [21]. ANC visits also enable continuous assessment of fetal development and early identification of pregnancy-related risks [22]. Inadequate ANC follow-up, therefore, increases the likelihood of undetected complications that may predispose neonates to birth asphyxia.

The present study also found that neonates born to mothers who experienced prolonged labor had more than fourfold higher odds of developing birth asphyxia compared to those born after normal labor duration. This finding aligns with studies conducted in Pakistan [23], Cameroon [24], Uganda [25], Debre Markos [15], Hawassa [26], Tigray [27], Southern Ethiopia [28], and Debre Berhan [14]. Prolonged labor increases the duration of fetal exposure to hypoxia due to sustained uterine contractions, which may compromise placental blood flow and reduce oxygen and nutrient delivery to the fetus. Prolonged compression of fetal blood vessels within the birth canal further exacerbates oxygen deprivation, potentially leading to hypoxic-ischemic encephalopathy following birth asphyxia.

Additionally, prolonged labor may increase the risk of maternal infections such as chorioamnionitis, which can further compromise fetal oxygenation and contribute to neonatal asphyxia [29,30]. Prolonged labor is often associated with obstructed labor resulting from cephalopelvic disproportion or abnormal fetal presentation, conditions that may lead to meconium aspiration and subsequent respiratory compromise in the newborn [31].

Regarding mode of delivery, this study demonstrated that neonates delivered through instrumental methods had approximately three times higher odds of developing birth asphyxia compared to those delivered spontaneously. This finding is consistent with studies conducted in Dire Dawa and Harar [32] and West Shewa [33]. In contrast, a study from Gondar [34] reported no significant association between instrumental delivery and birth asphyxia, possibly due to differences in sample size, obstetric practices, or variable selection.

Instrumental delivery using forceps or vacuum extractors may increase the risk of birth asphyxia due to potential physical trauma and stress imposed on the fetus, which can impair effective respiration immediately after birth [35,36]. Furthermore, instrumental deliveries are often performed after prolonged or difficult labor when the mother is exhausted [37], reducing effective maternal pushing efforts and increasing fetal distress. These factors collectively heighten the risk of compromised neonatal oxygenation.

In terms of gestational age, non-term neonates had more than fivefold increased odds of developing birth asphyxia compared to term neonates. This finding is consistent with studies conducted in Thailand, Yemen [38], Togo [39], and South Gondar [40]. Preterm neonates often have insufficient pulmonary surfactant production, which impairs alveolar stability and increases the risk of respiratory distress syndrome [41]. Collapsed alveoli and immature respiratory control mechanisms limit effective gas exchange, making preterm infants particularly vulnerable to hypoxia at birth.

Post-term neonates, on the other hand, may experience placental insufficiency or macrosomia, which complicates passage through the birth canal and increases the likelihood of prolonged or obstructed labor [42]. These conditions may result in fetal hypoxia and subsequent birth asphyxia. Therefore, both preterm and post-term deliveries pose significant risks for neonatal asphyxia.

Furthermore, this study identified low birth weight as a significant determinant of birth asphyxia, with affected neonates having more than fourfold higher odds compared to those with normal birth weight. This finding is strongly supported by studies conducted in China [43], Nepal [44], Benishangul Gumuz [45], West Shoa Zone [14], Wolaita [46], Gondar [47], and Ilu Aba Bor Zone [48], where the odds ranged from two to ten times higher.

Low birth weight is often associated with poor maternal nutritional status, intrauterine growth restriction, and placental insufficiency, all of which compromise fetal development [49]. Low birth weight neonates have reduced fat and glycogen reserves, limiting their ability to tolerate the stress of labor and adapt to extrauterine life [50]. These physiological limitations increase susceptibility to hypoxia and impair the neonate's capacity to initiate and sustain effective respiration, thereby increasing the risk of birth asphyxia.

5. Conclusion

The findings demonstrated that fewer than four antenatal care (ANC) visits, prolonged labor, instrumental delivery, non-term gestational age, and low birth weight were significant determinants of birth asphyxia. Among these factors, non-term gestational age and inadequate ANC follow-up showed the highest odds of association. Since most of these determinants are potentially modifiable, timely identification and appropriate management during antenatal, intrapartum, and immediate postnatal periods could substantially reduce the occurrence of birth asphyxia.

Abbreviations

AAP: American Academy of Pediatrics; ACOG: American College of Obstetricians and Gynecologists; AOR: Adjusted Odds Ratio; APH: Antepartum Hemorrhage; APGAR: Appearance, Pulse, Grimace, Activity, and Respiration; CDC: Centers for Disease Control and Prevention; CI: Confidence Interval; COR: Crude Odds Ratio; DDU: Dire Dawa University; EFY: Ethiopian Fiscal Year; HIE: Hypoxic-Ischemic Encephalopathy; ICD: International Classification of Diseases; IRB: Institutional Review Board; LBW: Low Birth Weight; MDG: Millennium Development Goal; PHCU: Primary Health Care Unit; PROM: Premature Rupture of Membranes; RDS: Respiratory Distress Syndrome; SDG: Sustainable Development Goal; WHO: World Health Organization.

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Author's Contribution

All authors contributed equally to the conceptualization and design of the study. They participated in the development of the methodology, data collection, data analysis, and interpretation of the findings. All authors were involved in drafting, reviewing, and revising the manuscript and approved the final version for submission.

Ethical Approval

Ethical clearance was obtained from the Institutional Review Board (IRB) of Dire Dawa University after the research proposal was reviewed and approved prior to the commencement of data collection, as the study involved human participants. The College of Health Sciences and Medicine of Dire Dawa University provided official letters of cooperation to the concerned health institutions, which were formally accepted by the respective facility heads. Written, voluntary, and informed consent was obtained from all participating mothers before data collection. Participants were provided with a clear explanation of the study objectives, procedures, potential benefits, and risks in their local languages. Confidentiality and anonymity were strictly maintained throughout the study period by using coded identifiers and excluding personal identifiers from data collection tools. Participants were informed of their right to decline or withdraw from the study at any time without any consequences to the care they received. These measures were implemented to ensure ethical integrity and to maintain participants' trust in the research process.

Conflicting Interests

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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Availability of Data and Materials

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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