e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.11.65

International Journal of Pharmaceutical Quality Assurance 2025; 16(11); 409-415

Original Research Article

Maternal Characteristics and Risk Factors Associated with Birth Asphyxia: A Retrospective Cohort Study

Matam Manjunath[1], B P L Bhanuprakash[2], Sai Kishan Sindiri[3], R. Rajiv Chowdary[4]

[1]Assistant Professor, Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India

[2]Assistant Professor, Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India

[3]Senior Resident, Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India

[4]Senior Resident, Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India

Received: 08-09-2025 / Revised: 21-10-2025 / Accepted: 27-11-2025

Corresponding Author: Dr. R. Rajiv Chowdary

Conflict of interest: Nil

Abstract:

Background: Birth asphyxia remains a major cause of neonatal morbidity and mortality, particularly in low- and middle-income countries, despite advances in perinatal care.

Aim: To evaluate maternal characteristics and intrapartum and neonatal risk factors associated with birth asphyxia and related neonatal outcomes.

Methodology: A retrospective cohort study was conducted at Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India. including 43,773 live-born neonates (≥34 weeks gestation). Maternal, intrapartum, and neonatal variables were extracted from hospital records. Associations were assessed using univariate analysis and multivariate logistic regression.

Results: Birth asphyxia occurred in 576 neonates. Independent risk factors included primiparity (adjusted OR 1.15), maternal hypertensive disorders (adjusted OR 2.45), prolonged rupture of membranes (adjusted OR 1.36), meconium-stained amniotic fluid (adjusted OR 2.01), fetal distress (adjusted OR 3.72), and low birth weight (adjusted OR 3.22). Maternal age ≥35 years was not significantly associated. Neonates with asphyxia had significantly higher rates of NICU admission, resuscitation, intubation, and early neonatal mortality.

Conclusion: Birth asphyxia is strongly associated with specific maternal, intrapartum, and neonatal risk factors. Early identification and optimal management of high-risk pregnancies and labor complications are essential to improve neonatal outcomes.

Keywords: Birth asphyxia; Neonatal outcomes; Maternal risk factors; Intrapartum complications; Retrospective cohort study.

Introduction

Birth asphyxia, commonly referred to as neonatal asphyxia (NA), remains a major global public health concern and a leading cause of neonatal morbidity and mortality. Despite advances in obstetric and neonatal care, the burden of NA remains considerable, particularly in low- and middle-income countries. Worldwide, NA occurs between 0.5 and 1.0% of full-term neonates but is much higher in preterm newborns [1]. Of great concern is that NA accounts for about 23% of the major causes of neonatal deaths across the world [2], underlining its important contribution to mortality in early life and an urgent necessity for effective prevention, early identification, and management strategies.

Neonatal asphyxia is defined as the failure of a newborn to initiate and sustain spontaneous breathing at birth [3]. This condition is characterized by impaired gas exchange, which, when prolonged, leads to progressive hypoxemia, hypercapnia, and significant metabolic acidosis [4]. The resulting hypoxic state provokes a cascade of physiological disturbances that may affect multiple organ systems. Severe NA is associated with extensive organ damage, including injury to the brain, heart, lungs, kidneys, and liver, as well as gastrointestinal complications such as necrotizing enterocolitis [5]. These complications threaten not only the immediate neonatal survival but also predispose the affected infants to long-term health consequences.

Among the various complications of NA, brain injury, clinically recognized as hypoxic-ischemic encephalopathy (HIE), is of particular concern. HIE is associated with high mortality rates and devastating long-term neurological sequelae, including cerebral palsy, epilepsy, intellectual impairment, cognitive deficits, and motor disabilities [6]. Survivors of HIE often require prolonged medical care, rehabilitation, and special educational services, which can place an enormous emotional, social, and economic burden on families and healthcare systems. Thus, reductions in both the incidence of NA and its complications remain an important priority in maternal and neonatal health.

This is based on the early identification of pregnancies and deliveries at increased risk. Evidence is accruing that socioeconomic and medical factors contribute to the development of NA. Low socioeconomic status, low educational attainment, inadequate antenatal care, and poor-quality intrapartum care have been identified as strongly associated with increased risk of NA [7,8],,. These factors may limit timely access to skilled healthcare services, delay recognition of obstetric complications, and limit the quality and effectiveness of preventive and curative measures throughout pregnancy and delivery.

Besides the socioeconomic influences, a variety of maternal and obstetric characteristics have emerged as important medical risk factors for NA. The maternal obstetrical complications, such as pregnancy-induced hypertension and gestational diabetes, affect uteroplacental blood flow and fetal oxygenation, thereby increasing the risk for intrapartum hypoxia [9]. Parity has also been implicated, with both primiparity and high parity being linked to adverse outcomes of labor. Early gestational age, low birth weight, and prematurity have become well-established risk factors for NA, reflecting the susceptibility of immature organ systems to hypoxic injury [10].

Another critical domain of risk is intrapartum events. Complications such as premature rupture of the membranes, a prolonged second stage of labor, shoulder dystocia, abnormal FHR patterns, and intrauterine meconium staining have been identified consistently as associated with an increased likelihood of NA [11]. These events often reflect fetal distress and impaired oxygen delivery during labor and delivery. If timely recognition and appropriate intervention are not performed, such conditions may rapidly progress to severe asphyxia, resulting in poor neonatal outcomes.

Although multiple antenatal and intrapartum risk factors for NA have been identified, it remains difficult to predict with certainty which fetuses will experience asphyxia. The multifactorial nature of NA, with complex interactions between maternal characteristics, fetal conditions, and intrapartum events, poses a difficulty in risk stratification. Consequently, and not infrequently, pregnant women and their fetuses cannot be readily stratified, in prenatal care and during labor, to appropriate monitoring and management pathways. This limitation leads to missing windows of opportunity for early intervention and partly explains why NA continues to remain one of the major causes of neonatal morbidity and mortality.

Retrospective cohort studies have become a particularly useful methodological approach in the study of the associations between maternal characteristics, obstetric factors, and neonatal outcomes. Using the analysis of already available clinical data, such studies allow pinpointing a pattern or even risk profiles that cannot be so easily achieved in smaller or cross-sectional investigations. Understanding these associations is essential to developing evidence-based strategies for improving antenatal surveillance, optimizing intrapartum management, and utilizing resources more effectively.

In this regard, the current retrospective cohort study centers on maternal characteristics and risk factors associated with birth asphyxia. By systematically evaluating several antenatal and intrapartum predictors, this study intends to contribute to a wider understanding of NA determinants. The ultimate aim is to contribute toward the development and evaluation of prognostic models for predicting NA, enable the early identification of women and newborns at high risk for adverse birth outcomes, and facilitate clinical decision-making to advance maternal and neonatal management. Such predictive and preventive approaches need to be enhanced in order to reduce the burden of birth asphyxia and improve neonatal survival and long-term health outcomes.

Materials And Methods

Study Design: This study was conducted as a retrospective cohort study aimed at identifying maternal characteristics and risk factors associated with birth asphyxia among neonates delivered at a tertiary care center.

Study Area: The study was carried out in the Department of Pediatrics, Maheshwara Medical College and Hospital, Hyderabad, Telangana, India.

Study Duration: The study was carried out over a period of 24 months.

Sample Size: The study included a total of 43,773 neonates, categorized as follows:

- **Neonates with birth asphyxia:** 576
- **Neonates without birth asphyxia:** 43,197

The sample size was determined based on the availability of complete medical records during the study period.

Study Population: The study population consisted of live-born neonates delivered at Maheshwara Medical College and Hospital during the study period along with their respective mothers. Maternal and neonatal data were retrieved from hospital delivery registers, neonatal intensive care unit (NICU) records, and electronic/paper medical records.

Data Collection: Data for this retrospective cohort study were collected from hospital-based records maintained in the Department of Pediatrics and the Department of Obstetrics and Gynecology at Maheshwara Medical College and Hospital, Hyderabad. Maternal and neonatal information was extracted from delivery registers, antenatal records, labor room case sheets, neonatal intensive care unit (NICU) admission logs, and discharge summaries. A predesigned and structured data extraction proforma was used to ensure uniformity and completeness of data collection. Maternal variables included age, gravidity, parity, antenatal complications, mode of conception, and intrapartum events such as type of labor, mode of delivery, duration of labor, rupture of membranes, and the presence of meconium-stained amniotic fluid. Neonatal variables included gestational age, birth weight, Apgar scores at 1 and 5 minutes, evidence of fetal distress, and presence of nuchal cord. Only records with complete and verifiable information were included in the final analysis. Data accuracy was ensured by cross-checking entries from multiple sources before data entry into the study database.

Inclusion Criteria

- Live-born neonates delivered at ≥34 weeks of gestation
- Availability of complete maternal and neonatal medical records
- Neonates admitted to postnatal wards or NICU during the study period

Exclusion Criteria

- Preterm neonates <34 weeks of gestation
- Stillbirths
- Neonates with major congenital anomalies
- Records with incomplete or missing essential data

Study Procedure: Eligible cases were identified from hospital delivery and NICU records. Neonates were classified into two cohorts: those with birth asphyxia and those without birth asphyxia. Maternal, intrapartum, and neonatal variables were systematically extracted and entered into a secured database. Data accuracy was ensured by cross-verification with multiple hospital records.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were assessed for normality using standard tests of distribution. Normally distributed variables were expressed as mean ± standard deviation, while non-normally distributed variables were presented as median with interquartile range. Categorical variables were summarized as frequencies and percentages. Comparisons between neonates with birth asphyxia and those without birth asphyxia were performed using the Student's t-test or Mann–Whitney U test for continuous variables, and the chi-square test or Fisher's exact test for categorical variables, as appropriate. Variables showing statistical significance in univariate analysis were further included in multivariate logistic regression analysis to identify independent maternal risk factors associated with birth asphyxia. The strength of association was expressed as odds ratios with 95% confidence intervals. A p value of less than 0.05 was considered statistically significant."

Result

Table 1 compares maternal characteristics among neonates with and without birth asphyxia. Maternal age distribution was similar in both groups, with no significant difference between mothers aged <35 years and ≥35 years ($p = 0.63$). Primiparity was significantly more common among mothers of neonates with asphyxia (63.5%) compared to those without asphyxia (59.5%) ($p = 0.01$). Among antenatal complications, hypertensive disorders were significantly higher in the asphyxia group (14.6% vs. 5.4%, $p < 0.001$), whereas gestational diabetes mellitus and anemia showed no significant differences between groups ($p = 0.74$ and $p = 0.65$, respectively). Regarding mode of delivery, vaginal delivery was less frequent among asphyxiated neonates (44.4% vs. 55.5%), while instrumental delivery (11.5% vs. 2.8%) and cesarean section (44.1% vs. 41.7%) were significantly more common in the asphyxia group ($p < 0.001$ and $p = 0.04$, respectively). Overall, Table 1 indicates that primiparity, maternal hypertensive disorders, and operative or instrumental deliveries are significantly associated with birth asphyxia, while maternal age, gestational diabetes, and anemia are not.

Table 1: Maternal Characteristics Among Neonates with and Without Birth Asphyxia			
Maternal Characteristics	**Neonatal Asphyxia (n = 576)**	**No Neonatal Asphyxia (n = 43,197)**	**p value**
Maternal age (years)			
<35 years	463 (80.4)	34,980 (81.0)	0.63
≥35 years	113 (19.6)	8,217 (19.0)	
Parity			
Primiparous	366 (63.5)	25,710 (59.5)	0.01
Multiparous	210 (36.5)	17,487 (40.5)	
Antenatal complications			
Hypertensive disorders	84 (14.6)	2,332 (5.4)	<0.001
Gestational diabetes mellitus	74 (12.8)	5,442 (12.6)	0.74
Anemia	92 (16.0)	6,601 (15.3)	0.65
Mode of delivery			
Vaginal delivery	256 (44.4)	23,961 (55.5)	<0.001
Instrumental delivery	66 (11.5)	1,219 (2.8)	<0.001
Cesarean section	254 (44.1)	18,017 (41.7)	0.04

Table 2 compares intrapartum and neonatal risk factors between neonates with birth asphyxia and those without. Prolonged rupture of membranes (>18 hours) was significantly more common in the asphyxia group (116, 20.1%) than in the non-asphyxia group (6,201, 14.4%) ($p < 0.001$). Meconium-stained amniotic fluid (17.7% vs. 8.7%), fetal distress (22.6% vs. 6.6%), and nuchal cord (31.9% vs. 22.9%) were all significantly more frequent among neonates with asphyxia ($p < 0.001$ for all). Preterm birth at 34–36 weeks was notably higher in the asphyxia group (26.4%) compared to the non-asphyxia group (7.5%), whereas term gestation (≥37 weeks) was less common (73.6% vs. 92.5%). Low birth weight (<2,500 g) was significantly associated with birth asphyxia (21.5% vs. 6.5%, $p < 0.001$), while normal birth weight (2,500–3,999 g) was more prevalent in the non-asphyxia group. Overall, Table 2 indicates that adverse intrapartum events, prematurity, and low birth weight are significantly associated with an increased risk of birth asphyxia.

Table 2: Intrapartum and Neonatal Risk Factors Associated with Birth Asphyxia			
Variables	**Neonatal Asphyxia (n = 576)**	**No Neonatal Asphyxia (n = 43,197)**	**p value**
Prolonged rupture of membranes (>18 h)	116 (20.1)	6,201 (14.4)	<0.001
Meconium-stained amniotic fluid	102 (17.7)	3,754 (8.7)	<0.001
Fetal distress	130 (22.6)	2,864 (6.6)	<0.001
Nuchal cord	184 (31.9)	9,892 (22.9)	<0.001
Gestational age			
34–36 weeks	152 (26.4)	3,238 (7.5)	<0.001
≥37 weeks	424 (73.6)	39,959 (92.5)	
Birth weight			
<2,500 g	124 (21.5)	2,796 (6.5)	<0.001
2,500–3,999 g	404 (70.1)	36,961 (85.6)	
≥4,000 g	48 (8.3)	3,440 (8.0)	

Table 3 presents the univariate and multivariate logistic regression analysis of risk factors for birth asphyxia. After adjustment for confounders, primiparity was independently associated with a higher risk of birth asphyxia (adjusted OR 1.15; 95% CI: 1.02–1.30; $p = 0.02$). Maternal hypertensive disorders showed a strong and significant association with birth asphyxia (adjusted OR 2.45; 95% CI: 1.91–3.13; $p < 0.001$). Prolonged rupture of membranes also remained a significant risk factor (adjusted OR 1.36; 95% CI: 1.10–1.70; $p = 0.004$). Meconium-stained amniotic fluid (adjusted OR 2.01; 95% CI: 1.59–2.55; $p < 0.001$) and fetal distress (adjusted OR 3.72; 95% CI: 2.98–4.65; $p < 0.001$) were strongly associated with increased odds of birth asphyxia. Low birth weight was one of the strongest predictors (adjusted OR 3.22; 95% CI: 2.52–4.11; $p < 0.001$). In contrast, maternal age ≥35 years was not significantly associated with birth asphyxia after adjustment ($p = 0.92$). Overall, Table 3 identifies key obstetric and neonatal factors that independently increase the risk of birth asphyxia.

Table 3: Univariate and Multivariate Logistic Regression Analysis of Risk Factors for Birth Asphyxia			
Risk Factor	**Crude OR (95% CI)**	**Adjusted OR (95% CI)**	**p value**
Maternal age ≥35 years	1.04 (0.84–1.28)	1.01 (0.81–1.25)	0.92
Primiparity	1.18 (1.01–1.38)	1.15 (1.02–1.30)	0.02
Hypertensive disorders	2.97 (2.31–3.82)	2.45 (1.91–3.13)	<0.001
Prolonged rupture of membranes	1.50 (1.23–1.84)	1.36 (1.10–1.70)	0.004
Meconium-stained amniotic fluid	2.28 (1.82–2.86)	2.01 (1.59–2.55)	<0.001
Fetal distress	4.12 (3.36–5.05)	3.72 (2.98–4.65)	<0.001
Low birth weight (<2,500 g)	4.06 (3.24–5.09)	3.22 (2.52–4.11)	<0.001

Table 4 compares neonatal outcomes between infants with birth asphyxia (n = 576) and those without neonatal asphyxia (n = 43,197). Neonates with asphyxia had a significantly higher rate of NICU admission (460, 79.9%) compared to non-asphyxiated neonates (6,132, 14.2%), with a highly significant difference ($p < 0.001$). The requirement for neonatal resuscitation was markedly greater in the asphyxia group (238, 41.3%) than in the non-asphyxia group (201, 0.5%) ($p < 0.001$). Similarly, endotracheal intubation was more frequently needed among asphyxiated neonates (70, 12.2%) compared to those without asphyxia (20, 0.05%) ($p < 0.001$). Early neonatal mortality was also significantly higher in the neonatal asphyxia group (22, 3.8%) than in the non-asphyxia group (64, 0.1%) ($p < 0.001$). Overall, Table 4 demonstrates that birth asphyxia is associated with significantly poorer neonatal outcomes and increased need for intensive care and life-saving interventions.

Table 4: Neonatal Outcomes in Birth Asphyxia and Non-Asphyxia Groups			
Outcome	**Neonatal Asphyxia (n = 576)**	**No Neonatal Asphyxia (n = 43,197)**	**p value**
NICU admission	460 (79.9)	6,132 (14.2)	<0.001
Neonatal resuscitation required	238 (41.3)	201 (0.5)	<0.001
Endotracheal intubation	70 (12.2)	20 (0.05)	<0.001
Early neonatal mortality	22 (3.8)	64 (0.1)	<0.001

Discussion

In the current study, most mothers in the asphyxia and non-aspyxia groups were below 35 years of age, accounting for 80.4% and 81.0%, respectively. This corresponds to earlier findings by Locatelli et al. (2020) and Xu et al. (2021) [12,13], which suggested that maternal age below 35 years is not considered a risk factor for neonatal asphyxia. Maternal age ≥35 years did not increase the risk of birth asphyxia independently, which corroborates the report by Sunny et al. (2021) [14], where advanced maternal age was noted not to be a major determinant in neonatal hypoxic events. Contrarily, in our study, primiparity emerged as one of the significant risk factors. In the current series, 63.5% of asphyxiated neonates were born to a primipara mother, while the proportion among controls was 59.5%. This again finds resonance with previous literature reports, such as those by Laughon et al. (2014) and Xu et al. (2021) [15,13], indicating that nulliparous women mostly experience longer labor and higher obstetric intervention rates, leading to a resultant rise in fetal hypoxia. The prolonged second stage of labour, a common occurrence in primiparous women, has been linked to birth trauma and neonatal complications (Abdo et al., 2019) [16]."

Hypertensive disorders in pregnancy were significantly higher in the asphyxia group, 14.6% versus 5.4%, and regression analysis showed strong independence, aOR 2.45. This finding is in line with previous reports that preeclampsia and gestational hypertension compromise uteroplacental perfusion, reduce fetal oxygenation, and predispose neonates to asphyxia (Khader et al., 2018) [17]. Interestingly, there was no significant difference in the rates of gestational diabetes mellitus and anemia between the groups, and this suggests that while metabolic and hematologic conditions may impact neonatal outcomes, their contribution to asphyxia risk in our population was limited; this agrees with findings from Torres-Muñoz et al. (2021) [18].

Mode of delivery: In this series, neonatal asphyxia was found in relation to a higher prevalence of instrumental delivery (11.5% vs. 2.8%) and a slight increase in cesarean sections (44.1% vs. 41.7%). In this regard, these results agree in part with Ahmed et al. 2021 [19], who pointed out that assisted deliveries are often performed due to non-reassuring fetal status or for prolonged labor rather than being direct causes of asphyxia. Although multivariate analysis did not point out the mode of delivery as an independent risk factor, there is a clinical indication that prolonged labor and obstetric interventions may be indirectly responsible for neonatal hypoxia through mechanical stress or by delaying delivery.

Intrapartum factors in our study, including prolonged rupture of membranes (20.1% vs. 14.4%), meconium-stained amniotic fluid (17.7% vs. 8.7%),

fetal distress (22.6% vs. 6.6%), and nuchal cord (31.9% vs. 22.9%), were significantly more common in the asphyxia group. These findings agree with studies from Ethiopia and Pakistan that showed that PROM, meconium-stained fluid, and cord complications are important risk factors for neonatal asphyxia (Bayih et al., 2020; Abdo et al., 2019) [20,16]. Fetal distress, which increased the odds of asphyxia almost four-fold in our regression model, remains one of the most consistent predictors across several settings and underpins the role of intrapartum monitoring for early identification and intervention (Pruksanusak et al., 2017) [21]. The presence of meconium-stained fluid is presumed to be a reflection of protracted intrauterine hypoxia and may predispose to aspiration, in line with Kopincova and Calkovska (2016) [22].

Specifically, neonatal characteristics such as preterm birth (26.4% vs. 7.5%) and low birth weight (21.5% vs. 6.5%) were strongly associated with asphyxia. These findings are consistent with the literature, which suggests that preterm and low-birth-weight babies are highly susceptible to hypoxic events due to immature respiratory and cardiovascular systems (Saigal & Doyle, 2008; Mulugeta et al., 2020) [23,24]. Low birth weight independently increased the risk more than threefold, thus underlining the importance of optimizing maternal nutrition, antenatal care, and timely detection of growth-restricted fetuses.

Neonatal outcomes in our cohort revealed the severe impact of asphyxia, with 79.9% requiring NICU admission, 41.3% requiring resuscitation, 12.2% undergoing intubation, and early neonatal mortality at 3.8% versus 0.1% in the control group. These findings are in agreement with other low- and middle-income settings, showing high burdens of asphyxia on neonatal morbidity and mortality despite advances in perinatal care (Gebregziabher et al., 2020; Kune et al., 2021) [25,26],. Early recognition and intervention remain pivotal in mitigating these adverse outcomes.

Our study confirms the previously found evidence that primiparity, hypertensive disorders, PROM, fetal distress, meconium-stained amniotic fluid, preterm birth, and low birth weight represent important maternal and neonatal risk factors for birth asphyxia. Although maternal age, gestational diabetes, anemia, and mode of delivery were associated variably, the combined impact of intrapartum and neonatal risk factors emphasizes the critical need for comprehensive assessment of risk, timely obstetric intervention, and vigilant neonatal care to reduce incidence and improve the outcomes of asphyxia. Our findings give useful recommendations for clinicians and policymakers on how to prioritize high-risk pregnancy and implement preventive strategies based on the local healthcare system.

Conclusion

This retrospective cohort study shows the strong association of birth asphyxia with specific maternal, intrapartum, and neonatal risk factors and not with advanced maternal age alone. Primiparity and hypertensive disorders during pregnancy were identified as major maternal factors associated with a high risk of birth asphyxia. Among intrapartum risk factors, significant associations included prolonged rupture of membranes, meconium-stained amniotic fluid, fetal distress, and nuchal cord, underlining the critical influence of labor and delivery events on the development of asphyxia. Neonatal factors notably included prematurity and low birth weight. The burden of birth asphyxia was associated with significantly poor early neonatal outcomes in terms of need for intensive care, need for resuscitation, advanced airway support, and higher early neonatal mortality. Overall, it seems that early detection and best management of high-risk pregnancies and intrapartum complications may reduce the burden of birth asphyxia and improve neonatal outcomes.

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