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Preeclampsia and the severity of neonatal asphyxia: A retrospective cross-sectional study

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Abstract:
Neonatal asphyxia remains a major cause of early neonatal death and disability in low- and middle-income countries, and preeclampsia may worsen it by impairing uteroplacental perfusion. This study aimed to examine the association between maternal preeclampsia and the severity of neonatal asphyxia at Aura Syifa Hospital, Kediri Regency, Indonesia. An analytical observational study with a retrospective cross-sectional design was conducted using the medical records of neonates with asphyxia born between October and December 2017. From 166 eligible records, 118 were selected by simple random sampling. Asphyxia severity was classified using the first-minute Apgar score. Data were analyzed using the chi-square test and odds ratios with 95% confidence intervals. Overall, 65.3% of mothers had preeclampsia and 54.2% of neonates had mild asphyxia. Moderate-to-severe asphyxia occurred in 57.1% of neonates born to mothers with preeclampsia, compared with 24.4% of those born to mothers without preeclampsia ($\chi^2 = 11.88$, $p = 0.003$). Preeclampsia was associated with four-fold higher odds of moderate-to-severe asphyxia (OR = 4.13; 95% CI: 1.78–9.61). Maternal preeclampsia was significantly associated with more severe neonatal asphyxia. Early detection of preeclampsia, close intrapartum fetal monitoring, and readiness for neonatal resuscitation are recommended for these pregnancies.

Keywords:
preeclampsia; neonatal asphyxia; Apgar score; hypertensive disorders of pregnancy; neonatal outcome

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INTRODUCTION

The neonatal period is the most vulnerable stage of human life. In 2022, an estimated 2.3 million newborns died within the first 28 days of life, accounting for nearly half of all deaths among children under five years of age (World Health Organization, 2024). Intrapartum-related events, including birth asphyxia, are among the three leading causes of neonatal death worldwide, together with complications of preterm birth and neonatal infections (Perin et al., 2022). Most of these deaths occur in low- and middle-income countries, where access to skilled birth attendance, intrapartum monitoring, and neonatal resuscitation remains uneven (Moshiro et al., 2019).

Indonesia faces a similar challenge. In 2023, 27,530 infant deaths occurred during the neonatal period, representing 80.4% of all infant deaths in the country (Kementerian Kesehatan

Volume 01 Number 02 (November 2025)
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RI, 2023). Birth asphyxia is one of the main contributors to this burden. It is defined as the failure to initiate and sustain spontaneous breathing at birth, resulting in hypoxemia, hypercapnia, and metabolic acidosis (Mota-Rojas et al., 2022). Neonates who survive moderate or severe asphyxia are at risk of hypoxic-ischemic encephalopathy, multi-organ dysfunction, and long-term neurodevelopmental impairment (Bayih et al., 2021). Because the severity of asphyxia determines the intensity of resuscitation needed and the likelihood of complications, identifying maternal conditions that predict more severe asphyxia is clinically important.

Preeclampsia is one of the most important of these maternal conditions. It is a hypertensive disorder of pregnancy that develops after 20 weeks of gestation and is characterized by new-onset hypertension accompanied by proteinuria or other signs of maternal organ dysfunction (American College of Obstetricians and Gynecologists, 2020; Magee et al., 2022). Globally, preeclampsia is responsible for approximately 46,000 maternal deaths and 500,000 fetal and neonatal deaths each year, and it remains a leading cause of maternal and perinatal morbidity in Asia and Africa (World Health Organization, 2025).

The link between preeclampsia and neonatal compromise is biologically plausible. Defective trophoblast invasion and incomplete remodeling of the spiral arteries reduce uteroplacental perfusion, cause placental oxidative stress, and release antiangiogenic factors into the maternal circulation (Dimitriadis et al., 2023; Ives et al., 2020). For the fetus, the consequences are chronic hypoxia, growth restriction, and reduced physiological reserve (Gatford et al., 2020). During labor, uterine contractions further interrupt placental blood flow, and a fetus with limited reserve is less able to tolerate this repeated hypoxic stress (Turner et al., 2020). In addition, preeclampsia frequently requires early delivery, which exposes the infant to the respiratory and cardiovascular immaturity of prematurity (Frost et al., 2021).

The assessment of neonatal asphyxia severity requires careful interpretation because clinical indicators at birth do not always reflect the extent of hypoxic injury. Apgar scores are commonly used to assess a newborn's condition and the need for immediate support, but they may also be influenced by gestational age, maternal medications, and the mode of delivery. Therefore, examining severity categories rather than the occurrence of asphyxia alone may provide a more clinically relevant understanding of neonatal outcomes. This distinction is particularly important in pregnancies complicated by preeclampsia, where placental dysfunction, fetal growth restriction, and medically indicated preterm delivery may contribute to neonatal compromise through different pathways.

Several studies, mostly from sub-Saharan Africa, have reported preeclampsia or pregnancy-induced hypertension as a risk factor for birth asphyxia (Berhe et al., 2020; Gebregziabher et al., 2020; Igboanugo et al., 2020). However, the findings are not consistent. A study of preterm infants in a tertiary center found no significant association between early preeclampsia and low Apgar scores or the need for ventilation, suggesting that the quality of obstetric and neonatal care may modify this risk (Matyas et al., 2022). Moreover, most studies have treated asphyxia as a simple yes-or-no outcome and have paid little attention to its severity. Evidence from Indonesian hospitals outside major tertiary centers is also limited, even though many births complicated by preeclampsia are managed in district and private hospitals. Research in Indonesian communities has shown that

Volume 01 Number 02 (November 2025)
e-ISSN: 3164-8835; p-ISSN: 3164-8827

local social and environmental conditions shape women's reproductive health (Kurniyawan et al., 2024), which underlines the need for locally generated evidence.

Understanding this association may also help hospitals strengthen preparation for high-risk deliveries. If maternal preeclampsia is associated with more severe neonatal asphyxia, identifying affected pregnancies before delivery could support timely referral, closer fetal surveillance, and preparation of personnel and equipment for neonatal resuscitation. However, the magnitude of this association may vary with disease severity, gestational age, delivery management, and the availability of neonatal services. Local hospital-based evidence is therefore needed to assess whether the association is present in specific care settings and to inform context-appropriate clinical planning without assuming that findings from other populations apply equally to Indonesian hospitals. Therefore, this study aimed to examine the association between maternal preeclampsia and the severity of neonatal asphyxia at Aura Syifa Hospital, Kediri Regency, East Java, Indonesia. The findings are expected to inform risk-based intrapartum and neonatal care in similar hospital settings.

METHODS

This study used an analytical observational design with a retrospective cross-sectional approach. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies. The study was conducted at Aura Syifa Hospital, a private hospital that provides maternity and neonatal services in Kediri Regency, East Java, Indonesia. The study population comprised all neonates diagnosed with asphyxia who were born at the hospital between October and December 2017 (N = 166). Records were eligible if they contained complete information on the maternal diagnosis of preeclampsia and the neonatal Apgar score; incomplete or illegible records were excluded. The sample size was calculated using the Slovin formula with a 5% margin of error, giving a minimum of 118 neonates. Participants were selected by simple random sampling, using random numbers applied to a sampling frame of eligible medical record numbers.

The independent variable was maternal preeclampsia, recorded as present or absent based on the attending obstetrician's diagnosis in the medical record. Preeclampsia was defined as new-onset hypertension (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg on two occasions at least 4 hours apart) after 20 weeks of gestation, accompanied by proteinuria (≥300 mg/24 hours or a protein-to-creatinine ratio ≥0.3) or other signs of maternal organ dysfunction (American College of Obstetricians and Gynecologists, 2020; Magee et al., 2022).

The dependent variable was the severity of neonatal asphyxia, as documented in the medical record using the hospital's classification based on the first-minute Apgar score: severe (0–3), moderate (4–6), and mild (≥7). For the analysis of odds, severity was further dichotomized into moderate-to-severe asphyxia (Apgar score 0–6) and mild asphyxia, consistent with the clinically recognized threshold of an Apgar score below 7 (American Academy of Pediatrics & American College of Obstetricians and Gynecologists, 2015).

Data were extracted from the medical records by the researchers using a structured data extraction form developed for this study. The form captured the maternal diagnosis of

Volume 01 Number 02 (November 2025)
e-ISSN: 3164-8835; p-ISSN: 3164-8827

preeclampsia, the first-minute Apgar score, and the recorded asphyxia category. Each extracted record was cross-checked against the original file to minimize transcription errors. Data extraction was carried out from July to August 2025. Categorical variables were summarized as frequencies and percentages. The association between preeclampsia and the three categories of asphyxia severity was tested using Pearson's chi-square test. Because two cells had expected counts below five, the analysis was repeated after combining severe and moderate asphyxia into a single moderate-to-severe category, using Fisher's exact test. The strength of the association was expressed as an odds ratio (OR) with a 95% confidence interval (CI). Statistical significance was set at $p < 0.05$. All data were anonymized, and patient identities were kept confidential throughout the study.

RESULTS

Distribution of Preeclampsia and Neonatal Asphyxia

A total of 118 neonates with asphyxia were included in the analysis. As shown in Table 1, almost two-thirds of the neonates (65.3%) were born to mothers with preeclampsia. Mild asphyxia was the most common category (54.2%), followed by moderate (44.1%) and severe asphyxia (1.7%).

Table 1. Distribution of Maternal Preeclampsia and Neonatal Asphyxia Severity (n = 118)

Variable	Frequency (n)	Percentage (%)
Maternal obstetric history		
Preeclampsia	77	65.3
Non-preeclampsia	41	34.7
Neonatal asphyxia severity		
Severe asphyxia	2	1.7
Moderate asphyxia	52	44.1
Mild asphyxia	64	54.2

Association between Preeclampsia and the Severity of Neonatal Asphyxia

Table 2 presents the distribution of asphyxia severity according to maternal preeclampsia status. Among neonates of mothers with preeclampsia, 54.5% had moderate and 2.6% had severe asphyxia, whereas among neonates of mothers without preeclampsia, 24.4% had moderate asphyxia and none had severe asphyxia. The chi-square test showed a significant association between preeclampsia and asphyxia severity ($\chi^2 = 11.88$, df = 2, $p = 0.003$).

Table 2. Severity of Neonatal Asphyxia by Maternal Preeclampsia Status (n = 118)

Maternal status	Severity of neonatal asphyxia, n (%)			Total, n	p-value	χ^2
	Severe	Moderate	Mild			
Preeclampsia	2 (2.6)	42 (54.5)	33 (42.9)	77	0.003	11.88
Non-preeclampsia	0 (0.0)	10 (24.4)	31 (75.6)	41		
Total	2 (1.7)	52 (44.1)	64 (54.2)	118		

Volume 01 Number 02 (November 2025)
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Odds of Moderate-to-Severe Asphyxia

When severe and moderate asphyxia were combined (Table 3), moderate-to-severe asphyxia occurred in 57.1% of neonates born to mothers with preeclampsia, compared with 24.4% of those born to mothers without preeclampsia. Neonates of mothers with preeclampsia had about four times higher odds of moderate-to-severe asphyxia (OR = 4.13; 95% CI: 1.78–9.61; Fisher's exact $p < 0.001$).

Table 3. Odds of Moderate-to-Severe Neonatal Asphyxia According to Maternal Preeclampsia Status

Maternal status	Moderate-to-severe asphyxia, n (%)	Mild asphyxia, n (%)	OR (95% CI)	p-value
Preeclampsia	44 (57.1)	33 (42.9)	4.13 (1.78–9.61)	<0.001
Non-preeclampsia	10 (24.4)	31 (75.6)	1.00 (Ref.)	

DISCUSSION

This study found that maternal preeclampsia was significantly associated with the severity of neonatal asphyxia. Neonates born to mothers with preeclampsia were more than twice as likely to have moderate-to-severe asphyxia as those born to mothers without preeclampsia, and their odds were about four times higher. Both cases of severe asphyxia occurred in the preeclampsia group. These findings suggest that preeclampsia is linked not only to the occurrence of asphyxia, as reported in earlier studies, but also to how severe the asphyxia is at birth.

The high proportion of preeclampsia in this sample (65.3%) needs to be interpreted with care. This figure is much higher than population estimates and most likely reflects the study population, which consisted only of neonates with asphyxia, as well as the role of the hospital in receiving high-risk pregnancies from the surrounding area. It should therefore not be read as the prevalence of preeclampsia among all births. Nevertheless, it shows that preeclampsia is a common background among asphyxiated neonates in this hospital and that maternity staff regularly care for women whose pregnancies carry a high risk of fetal compromise. Preeclampsia remains a leading cause of maternal and perinatal morbidity and mortality, and women with additional medical conditions face even higher rates of maternal and neonatal complications (Chappell et al., 2021; Tanner et al., 2022).

The association observed is consistent with the pathophysiology of preeclampsia. The disorder begins with poor placentation, in which the spiral arteries are not fully remodeled and remain narrow, high-resistance vessels (Dimitriadis et al., 2023). The stressed placenta releases antiangiogenic factors, such as soluble fms-like tyrosine kinase-1, which cause widespread maternal endothelial dysfunction, vasoconstriction, and hypertension (Chang et al., 2023; Ives et al., 2020). For the fetus, the main consequence is a reduced and unstable supply of oxygen and nutrients. Over several weeks, this may lead to fetal growth restriction and smaller energy reserves, which are the fetus's main defense against acute hypoxia (Gatford et al., 2020).

Labor then adds a further challenge. Each uterine contraction temporarily reduces blood flow to the placenta. A healthy fetus tolerates these short interruptions, but a fetus that is already chronically hypoxic has less reserve and moves more quickly into anaerobic metabolism, lactate

Volume 01 Number 02 (November 2025)
e-ISSN: 3164-8835; p-ISSN: 3164-8827

accumulation, and metabolic acidosis (Turner et al., 2020). At birth, this appears as weak respiratory effort, bradycardia, poor muscle tone, and a low Apgar score (Mota-Rojas et al., 2022). This helps explain why preeclampsia may shift neonates from mild towards moderate or severe asphyxia. In addition, treatments commonly used in preeclampsia, such as antihypertensive drugs, magnesium sulfate, and early or operative delivery, may also influence how the newborn adapts in the first minutes after birth (Overton et al., 2022).

Our findings are in line with several previous studies. In northern Ethiopia, neonates of mothers with pregnancy-induced hypertension had a markedly higher risk of perinatal asphyxia (Gebregziabher et al., 2020), and similar results were reported from public hospitals in Tigray (Berhe et al., 2020). A systematic review of studies from low-resource communities identified hypertensive disorders of pregnancy as a consistent maternal risk factor for birth asphyxia (Igboanugo et al., 2020), and a meta-analysis from Ethiopia also listed maternal hypertension among its main predictors (Ahmed et al., 2021). More recently, a machine-learning study in Iran showed that combinations of maternal and intrapartum factors can be used to identify neonates at risk of birth asphyxia, supporting a risk-based approach to delivery care (Darsareh et al., 2023).

Not all studies, however, have found this association. Matyas et al. (2022) reported no significant difference in low Apgar scores or the need for ventilation between preterm newborns of mothers with and without early preeclampsia in a tertiary center. The difference from our results may be explained by the setting. In tertiary centers, women with preeclampsia usually receive antenatal corticosteroids, continuous fetal monitoring, and planned delivery, and their infants are received by experienced neonatal teams. These measures can reduce the effect of placental insufficiency on the newborn's condition at birth. In contrast, private and district hospitals in Indonesia often receive women at a later stage of the disease, sometimes after referral, which may limit the time available for optimal preparation. This contrast suggests that the effect of preeclampsia on the newborn is not fixed but depends partly on the quality and timeliness of care.

The finding that most neonates had mild asphyxia (54.2%) is reassuring, but the 45.8% with moderate or severe asphyxia represent a group at real risk of complications. Moderate and severe asphyxia are associated with hypoxic-ischemic encephalopathy, seizures, and multi-organ dysfunction (Bayih et al., 2021; Moshiro et al., 2019). Infants of mothers with preeclampsia may also carry long-term cardiovascular changes from their exposure in the womb (Frost et al., 2021). Because preeclampsia was concentrated in this higher-risk group, its presence can serve as a simple early warning sign for the delivery team.

Another important consideration is the interpretation of neonatal asphyxia severity. Apgar scores are useful for assessing a newborn's clinical condition immediately after birth, but they should not be used alone to establish intrapartum hypoxia or predict long-term outcomes. The scores may also be influenced by gestational age, maternal medication, mode of delivery, and the need for resuscitation. Therefore, the association observed in this study should be interpreted in the context of the clinical characteristics of both the mother and the neonate. Future studies incorporating umbilical cord blood gas measurements, resuscitation requirements, and evidence of hypoxic-ischemic encephalopathy could provide a more comprehensive assessment of neonatal compromise and help clarify the relationship between preeclampsia and asphyxia severity.

Volume 01 Number 02 (November 2025)
e-ISSN: 3164-8835; p-ISSN: 3164-8827

These results have several practical implications. First, early detection of preeclampsia during antenatal care remains essential. First-trimester screening that combines maternal history, mean arterial pressure, and biomarkers can identify women at high risk, allowing preventive measures, such as low-dose aspirin, to be initiated early (Chaemsaithong et al., 2022). Second, women with preeclampsia should receive close intrapartum fetal surveillance, and the timing and mode of delivery should be planned according to maternal and fetal condition (American College of Obstetricians and Gynecologists, 2020). Third, a provider skilled in neonatal resuscitation, together with the necessary equipment, should be present at every birth to a mother with preeclampsia, because the first minute after birth is decisive in preventing hypoxic injury (Moshiro et al., 2019). Midwives, who are often the first to assess these women, play a central role in recognizing warning signs and coordinating timely referral. Finally, maternal health programs should consider the wider social and environmental conditions that affect women's access to antenatal care, including those in rural and agricultural communities (Kurniyawan et al., 2024).

This study has several limitations. First, its retrospective design depended on the completeness and accuracy of the medical records, and the diagnoses of preeclampsia and Apgar scores could not be independently verified. Second, the study population included only neonates with asphyxia; the results therefore describe the association between preeclampsia and the severity of asphyxia, not the risk of asphyxia among all births. Third, the mild asphyxia category used in Indonesian clinical practice may include neonates whose first-minute Apgar scores fall within the range considered reassuring in international guidance (American Academy of Pediatrics & American College of Obstetricians and Gynecologists, 2015); for this reason, the moderate-to-severe category was used for the main comparison. Fourth, important confounders, such as gestational age, birth weight, mode of delivery, onset and severity of preeclampsia, and intrapartum complications, were not available for multivariable analysis. Finally, the data came from a single hospital over three months, which limits generalizability. Future prospective, multicenter studies should include these variables and use objective markers such as umbilical cord blood gas analysis.

The findings emphasize the importance of coordinated care for pregnancies complicated by preeclampsia. Antenatal risk assessment, timely referral, intrapartum fetal monitoring, and preparation for neonatal resuscitation should be integrated into the care pathway. Effective communication between midwives, obstetricians, and neonatal teams can help ensure that anticipated maternal and fetal complications are addressed before delivery. Although this study did not directly assess the quality of these practices, the observed association supports a review of local protocols for identifying high-risk pregnancies and preparing neonatal teams. Future quality-improvement studies could evaluate whether standardized referral and delivery-preparation pathways are associated with better neonatal outcomes.

CONCLUSION

This study shows that maternal preeclampsia is significantly associated with more severe neonatal asphyxia at Aura Syifa Hospital, Kediri Regency. Neonates born to mothers with preeclampsia had about four times higher odds of moderate-to-severe asphyxia than those born to mothers without preeclampsia. These findings support early detection of preeclampsia during

antenatal care, close intrapartum fetal monitoring, and the presence of skilled neonatal resuscitation at every birth to a mother with preeclampsia.

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CONFLICT OF INTEREST

The authors declare that they have no financial or personal conflicts of interest related to this study.

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Volume 01 Number 02 (November 2025)
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