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Recurrence of hypoglycaemia and associated factors among neonates admitted with perinatal asphyxia in Northwest Ethiopia: multicentre, retrospective follow-up study with negative binomial regression

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ABSTRACT

Objective To estimate the recurrence of hypoglycaemia and the associated factors in neonates with birth asphyxia admitted to the neonatal intensive care unit in Northwest Amhara region's comprehensive specialised hospitals, Northwest Ethiopia, in 2024.

Design A multicentre, institution-based, retrospective follow-up study.

Setting Tertiary hospitals in Northwest Amhara Regional State, Northwest Ethiopia, from 1 July 2020 to 30 July 2024.

Participants A total of 761 neonates with perinatal asphyxia were admitted to the neonatal intensive care unit of selected public hospitals in Northwest Amhara from July 2020 to July 2024.

Outcome measure The primary outcome measure of this study was recurrence of hypoglycaemia. Furthermore, the factors associated with recurrence of hypoglycaemia in newborns with perinatal asphyxia were noted.

Results The average number of hypoglycaemia cases among neonates with birth asphyxia was 2.05 (95% CI 1.939, 2.163) over the 28-day follow-up period. Meningitis (adjusted incidence rate ratio (AIRR)=1.16; 95% CI 1.04, 1.30), feeding in less than 72 hours (AIRR=1.17; 95% CI 1.05, 1.31), stage 3 hypoxic-ischaemic injury (AIRR=1.20; 95% CI 1.04, 1.39), length of hospital stay (AIRR=1.01; 95% CI 1.01, 1.03) and macrosomia (AIRR=1.39; 95% CI 1.19, 1.63) were significant factors associated with recurrence of hypoglycaemia.

Conclusions and recommendations The current study indicated that the mean recurrence of hypoglycaemia in newborns experiencing perinatal asphyxia was considerably higher. Presence of neonatal meningitis, delayed initiation of feeding 72 hours after birth, stage 3 hypoxic-ischaemic injury, length of hospital stay and macrosomia were the key factors associated with recurrence of hypoglycaemia.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study's retrospective design relied on potentially incomplete or inaccurate medical records, risking missing data and misclassification bias.
⇒ The diagnosis of perinatal asphyxia was made based on Apgar score, without using umbilical cord blood gas analysis or any confirmatory method.
⇒ The study's multicentre design increased the sample size and the diversity of the study population, enhancing the generalisability of the findings within the Northwest Amhara region of Ethiopia.
⇒ The study used appropriate statistical methods.

INTRODUCTION

Perinatal asphyxia occurs when a newborn experiences lack of oxygen before, during or immediately after birth, leading to significant morbidity and mortality. It is associated with various complications, including hypoglycaemia, which can exacerbate the infant's condition. Studies indicate that neonates with perinatal asphyxia are at heightened risk of developing hypoglycaemia due to metabolic disturbances and impaired glucose production.[1–3] The physiological stress caused by asphyxia can disrupt normal metabolic processes, leading to an increased demand for glucose and a compromised ability to maintain adequate blood glucose levels.

Neonatal hypoglycaemia is a significant metabolic disorder characterised by abnormally low blood glucose levels in newborns, which can lead to severe neurological complications and increased mortality if not promptly addressed. The incidence of

neonatal hypoglycaemia varies globally, affecting approximately 5%–15% of all newborns, with higher rates observed in at-risk populations, including those with perinatal asphyxia.[1 2 4]

Understanding the recurrence of hypoglycaemia and its associated factors among neonates with perinatal asphyxia is crucial in developing effective prevention and management strategies. Early identification and intervention can significantly reduce the risk of long-term neurological damage and improve the overall outcomes of affected infants. Given the high rates of neonatal mortality and morbidity associated with hypoglycaemia, particularly in resource-limited settings, targeted research is essential to inform clinical practice and public health policies. Neonatal hypoglycaemia is a critical health issue in Ethiopia, contributing significantly to neonatal morbidity and mortality. Despite its preventable nature, the condition remains underdiagnosed and inadequately managed, particularly among vulnerable populations such as those with perinatal asphyxia. The prevalence of neonatal hypoglycaemia in Ethiopia has been reported to range from 21.2% to 25% in various studies, indicating a substantial public health concern. Furthermore, the lack of comprehensive epidemiological data on the determinants of neonatal hypoglycaemia in Ethiopia hampers effective intervention strategies and resource allocation.

Neonates with perinatal asphyxia are particularly at risk of developing hypoglycaemia due to metabolic disturbances and the physiological stress associated with asphyxia. This population often experiences prolonged hospital stays and increased healthcare costs, further straining the already limited healthcare resources in the country.[3 5] The interplay of factors such as delayed initiation of breastfeeding, maternal diabetes and environmental conditions such as hypothermia exacerbates the risk of hypoglycaemia; however, these determinants are not well understood in the Ethiopian context.

Management of hypoglycaemia in neonates depends on their specific conditions, particularly in those with perinatal asphyxia, premature infants or infants of mothers with diabetes. For cases of hypoglycaemia, we prepare a dextrose solution, typically starting with 5% dextrose and combining it with 40% glucose to create a 10% dextrose fluid. Neonates presenting with blood glucose levels below 40 mg/dL within the first 4 hours, asymptomatic infants with levels below 45 mg/dL up to 24 hours and those aged 48–72 hours with levels below 60 mg/dL are closely monitored. Additionally, neonates with hyperinsulinaemia also require intervention if their blood glucose falls below 60 mg/dL. For those not exhibiting seizures, we prescribe 2 mL/kg of the dextrose solution for 8 hours, checking glucose levels every 30 min. If seizures occur, we administer 4 mL/kg and continue monitoring every 30 min. If the seizures cease, we maintain management for up to 8 hours. However, if seizures persist, we then evaluate calcium levels and consider imaging, as outlined in our national management protocol.

This study aims to investigate the recurrence of hypoglycaemia and its associated factors among neonates with perinatal asphyxia admitted to various healthcare facilities across Northwest Ethiopia. Using a multicentre approach and employing negative binomial regression analysis, this research seeks to provide a comprehensive understanding of the recurrence and predictors of recurrent hypoglycaemia in this vulnerable population. The findings will contribute to enhancing clinical management protocols and guiding health policies aimed at improving neonatal outcomes in the region.

METHODS

Study design, period and setting

A multicentre, institution-based, retrospective follow-up study was conducted from 1 July 2020 to 30 July 2024. Data were retrospectively extracted from 15 to 30 August 2024. This study was conducted at two specialised hospitals in the Northwest Amhara region: Debre Tabor Comprehensive Specialized Hospital (DTCSH) and University of Gondar Comprehensive Specialized Hospital (UoGCSH). Each year, approximately 6408 newborns are admitted to these hospitals, of whom 696 are neonates diagnosed with perinatal asphyxia. The DTCSH and the UoGCSH admit an average of 240 and 456 newborns annually, respectively. These hospitals serve as the final referral option for other healthcare facilities. The neonatal units are staffed by a diverse team, including neonatal nurses, general practitioners, paediatricians and other personnel, who work together to provide comprehensive care for neonates. This care includes the diagnosis and documentation of their conditions. The neonatal unit offers various services for neonates with perinatal asphyxia, such as blood and exchange transfusions, antibiotic treatment, phototherapy and ventilatory support, including continuous positive airway pressure.

Population

Source population and study population

The study focused on neonates with perinatal asphyxia who were admitted to the neonatal intensive care units (NICUs) of selected comprehensive specialised hospitals in the Northwest Amhara region of Ethiopia. All neonates with perinatal asphyxia admitted to these NICUs between 1 July 2020 and 30 July 2024 were included in the study.

Inclusion criteria and exclusion criteria

All neonates with perinatal asphyxia admitted to the NICU of comprehensive specialised hospitals in Northwest Ethiopia from 1 July 2020 to 30 July 2024 were included in the study. Newborns with incomplete charts (neonates who were not register random blood sugar level and charts with one missed factors of the following: gestational age, birth weight, neonatal age, mode of delivery, type of pregnancy, date of admission and discharge) were excluded.

Sample size determination

The sample size was calculated using a single population formula by assuming 95% CI and 5% margin of error,

frequency of hypoglycaemia, and its associated factors with perinatal asphyxia among neonates.

The following formula was applied: $\mathbf{n} = \frac{\left(\frac{Z_{\alpha}}{2}+ZB\right)2*(0.5*(1-0.5))}{0.05*0.05} = 384$

where n is the minimum sample size and z (α/2) is the desired level at 95% CI (1.96). Sample size becomes, n=sample size was=379. A maximum sample including the design effect (n=768) was used in this study.

Sampling techniques and procedures

The DTCSH and the UoGCSH have annual admissions of 240 and 456 neonates with perinatal asphyxia, respectively. A total of 2784 newborns were admitted to these hospitals from 1 July 2020 to 30 July 2024. From these 2784 neonates, 768 were selected. Proportional allocation was performed for each hospital based on the final sample size. The sampling frame was prepared by collecting the number of admitted patients from the registration book. After identifying patients who met the inclusion criteria, study subjects were selected using a simple random sampling technique with computer-generated methods.

Variables of the study

Dependent variable

- Episodes of hypoglycaemia.

Independent variables

- Sociodemographic and maternal characteristics: age of the mother, place of delivery, current pregnancy and mode of delivery, antenatal care (ANC), gestational diabetes mellitus, prolonged labour and parity.
- Neonatal sociodemographic and clinical factors: sex, gestational age, birth weight, meconium aspiration syndrome (MAS), feeding time, intraventricular haemorrhage, hypoxic-ischaemic encephalopathy (HIE), meningitis and subgaleal haemorrhage.

Operational definition

- Neonatal hypoglycaemia: Neonatal hypoglycaemia was defined as random blood sugar concentrations of <40 mg/dL at any postnatal age.[6]
- Recurrence of hypoglycaemia: The number of hypoglycaemia cases was counted based on the physician's diagnosis on the follow-up sheet.
- Perinatal asphyxia: Perinatal asphyxia was defined as the inability to initiate and maintain breathing at birth and a 5 min Apgar score of 7.[7]
- Prolonged labour: Prolonged labour was defined as the combined duration of the first stage of labour being more than 12 hours in primiparas.[7]
- Prolonged rupture of membrane: Prolonged rupture of membrane was defined as the duration of rupture of the membrane of the amniotic sac and chorion >18 hours until delivery.[7]
- Meconium aspiration syndrome: MAS was based on the physician's diagnosis on the neonatal medical chart.[8]

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Meconium aspiration syndrome: based on the physician's diagnosis in the neonatal medical chart with MAS.[8]

Data collection tool and procedures

Data were gathered through a record review using a structured checklist that was adapted and modified based on various studies. The check list was divided into two sections. Two health professionals with BSc degrees and one supervisor with an MSc in health professions from hospitals outside the study units were recruited as data collectors and supervisor, respectively. Charts were retrieved using patient registration numbers obtained through lottery method, and two data clerks at each hospital assisted in identifying the charts.

Data quality assurance

The questionnaire was preliminarily reviewed at two hospitals to identify important variables. The quality of the data was further ensured through careful planning of the questionnaire to maintain the validity of the tool, which was reviewed by a subject expert. Based on this review, modifications were made to the method. The modified variables included hyperinsulinaemia, parenteral feeding, sepsis and temperature. A half-day training session was delivered to the data collectors and the supervisor to brief them on the study's objectives and expectations. The principal investigator and the supervisor checked the collected data daily for completeness, and corrective measures were taken as needed.

Data management and statistical analysis

Data were checked, coded and analysed using STATA V.14. Descriptive statistics were calculated and presented in tables, graphs and text, including percentages, mean and SD. The assumption of a Poisson distribution regarding the independence of variation was validated, and the mean (2.051) and variance (2.477) of the model were checked accordingly.

Multicollinearity was assessed using the variance inflation factor, and model adequacy was tested by plotting the residuals against the fitted values, using an extension of the Poisson family. The best-fit negative binomial regression model was selected. Variables with a p value of <0.25

in the bivariable Poisson regression analysis were considered candidates for multivariable analysis.

Finally, in the multivariable analysis, an adjusted incidence rate ratio (AIRR) with 95% CI was reported to indicate an association between the number of hypoglycaemia events and the associated factors at a p value of 0.05.

Patient and public involvement in this study

The study participants or the public were not directly involved in the design, conduct, reporting or dissemination of this study.

RESULTS

A total of 761 neonatal charts were obtained from 1 July 2020 to 30 July 2024. The data were retrospectively extracted from 15 to 30 August 2024. The charts were included from comprehensive specialised hospitals selected from Amhara based on the determined sample size.

Maternal sociodemographic and obstetric characteristics

A total of 768 charts of PNA (Perinatal asphyxia) neonates were reviewed, of which 761 (99.09%) met the enrolment criteria. The various maternal sociodemographic and obstetric characteristics of the participants are presented. The mean (SD) maternal age was 28.91 (5.64) years, with majority of the mothers aged between 20 and 34 years. In terms of residency, 59.66% of the mothers lived in urban areas. A significant proportion (50.72%) had four or more ANC visits. The predominant mode of delivery was spontaneous vaginal delivery, making up 63.86% of the cases (table 1).

Table 1 Maternal sociodemographic and obstetric characteristics of mothers in Northwest Amhara, Ethiopia, 2024 (N=761)

Covariates	Category	n (%)
Age of the mother	<20	42 (5.52)
	20–34	580 (76.22)
	>35	139 (18.27)
Residency	Rural	307 (40.34)
	Urban	454 (59.66)
Parity	Primipara	338 (44.42)
	Multipara	423 (55.58)
Place of delivery	Health centre	251 (32.98)
	Hospital	510 (67.02)
Current pregnancy	Single	647 (85.02)
	Twin	114 (14.98)
ANC	No follow-up	86 (11.30)
	1–3	289 (37.98)
	≥4	386 (50.72)
Mode of delivery	Spontaneous VD	486 (63.86)
	Instrumental	94 (12.35)
	C/S	181 (23.78)
Prolonged labour	Yes	218 (28.65)
	No	543 (71.35)
GDM	Yes	77 (10.12)
	No	684 (89.88)

ANC, antenatal care; CS, Cesarean Section; GDM, Gestational Diabetic Diabetes Mellitus; VD, Vaginal Delivery.

Neonatal sociodemographics and comorbidities

On the neonatal side, sex distribution indicated 54.93% of the newborns were male. Majority of the neonates were born at term (82.39%), with a median birth weight of 2900 g. Analysis showed that 81.44% of the newborns had a normal birth weight. The mean (±SD) gestational age was 38.46 (1.73) weeks, indicating that most of the neonates were full term. Feeding patterns revealed a near-even split, with 50.33% of the newborns receiving feedings after 72 hours. In terms of neonatal health, 34.30% had meningitis, while 13.80% had MAS (table 2).

Recurrence of hypoglycaemia

The average number of hypoglycaemia cases among neonates with birth asphyxia was 2.05 (95% CI 1.939, 2.163) over the 28-day follow-up period. The minimum and maximum values recorded were 0 and 6, respectively. During this period, approximately 434 (57.03%) patients with perinatal asphyxia experienced recurring hypoglycaemia (figure 1).

Factors associated with hypoglycaemia among PNA neonates

All independent variables were regressed against the dependent variable using bivariate negative binomial regression analysis. This analysis included feeding time, stage of hypoxic-ischaemic injury, length of hospital stay, maternal age, ANC follow-up, gestational age, weight of neonate and neonatal meningitis, all of which were found to be eligible (p<0.25) for the multivariable analysis on the number of hypoglycaemia cases among preterm neonates. The negative binomial regression analysis indicated that feeding time, stage 3 hypoxic-ischaemic injury, neonates with macrosomia, neonatal meningitis and length of hospital stay were significantly associated with the number of hypoglycaemia recurrences.

The risk of neonatal hypoglycaemia was 16% (CI 4%, 30%) and was greater among neonates who developed meningitis compared with those who did not have meningitis (AIRR=1.16; 95% CI 1.04, 1.30). Neonates who were fed after 72 hours had an increased risk of hypoglycaemia by 17% (CI 5%, 31%) compared with patients fed in less than 72 hours (AIRR=1.17; 95% CI 1.05, 1.31). Additionally, patients who had stage 3 hypoxic-ischaemic injury showed an increased risk of hypoglycaemia by 20% (CI 4%, 39%) compared with those with stage 1 and stage 2 hypoxic-ischaemic injuries (AIRR=1.20; 95% CI 1.04, 1.39). The risk of neonatal hypoglycaemia was 10% (CI 1%, 3%) and was greater among neonates who stayed

Table 2 Neonatal sociodemographic characteristics and comorbidities of mothers in Northwest Amhara, Ethiopia, 2024 (N=761)

Variables	Category	n (%)
Sex	Male	378 (62.07)
	Female	418 (54.93)
GA	Term	627 (82.39)
	Late preterm	70 (9.20)
	Post-term	64 (8.41)
Birth weight	NBW	496 (81.44)
	LBW	137 (18.00)
	Macrosomia	46 (6.04)
Feeding	48–72 hours	378 (49.67)
	After 72 hours	383 (50.33)
Meningitis	Yes	237 (31.14)
	No	524 (68.86)
MAS	Yes	105 (13.80)
	No	656 (86.20)
Weight for age	AGA	674 (88.57)
	SGA	47 (6.18)
	LGA	40 (5.26)
HIE stage	1	223 (29.30)
	2	323 (42.44)
	3	215 (28.25)

AGA, Apropriate Gestational Age; GA, Gestational Age; HIE, hypoxic-ischaemic encephalopathy; LBW, Low Birth Weight; LGA, Large Gestational Age; MAS, meconium aspiration syndrome; NBW, Normal Birth Weight; SGA, Small Gestational Age.

for 1 day at the hospital compared with those who were discharged early (AIRR=1.01; 95% CI 1.01, 1.03). Moreover, the risk of hypoglycaemia was 22 times greater in newborns with macrosomia compared with those with constant variables (AIRR=1.39; 95% CI 1.19, 1.63) (table 3).

DISCUSSION

This study aimed to estimate the recurrence of hypoglycaemia and the associated factors among neonates with perinatal asphyxia admitted to Northwest Amhara region's comprehensive specialised hospitals in Northwest Ethiopia. The average number of hypoglycaemia cases among neonates with birth asphyxia was 2.05 (95% CI 1.939, 2.163) over a 28-day follow-up period. The minimum and maximum values recorded were 0 and 6, respectively. During the follow-up, approximately 434 (57.03%) patients with perinatal asphyxia experienced recurrent hypoglycaemia.

The study found that 16.9% of neonates did not experience hypoglycaemia, while 26.28% had one episode, 24.18% had two episodes, 12.22% had three episodes, 11.04% had four episodes, 7.88% had five episodes and 1.71% had six episodes. The possible reason for this is that neonates admitted for perinatal asphyxia often require prolonged hospitalisation,[9] during which they may not receive adequate maternal or parenteral feeding.[10] This lack of nutrition can lead to one or more episodes of hypoglycaemia. Additionally, these neonates may develop medical conditions that necessitate cessation of feeding to minimise gastric-related injuries, further contributing to the risk of hypoglycaemia.[11]

Neonates who were fed after 72 hours had an increased risk of hypoglycaemia by 17% (CI 5%, 31%) compared with patients fed in less than 72 hours (AIRR=1.17; 95% CI 1.05, 1.31). This result is supported by studies in India[12] and New Zealand.[13 14] The possible reason for this is that delayed initiation of enteral feeding exacerbates hypoglycaemia in neonates with perinatal asphyxia. The absence of exogenous glucose depletes compromised glycogen stores, resulting in more pronounced and prolonged episodes of hypoglycaemia. This is critical in neonates with asphyxia, as their impaired glucose homeostasis is further challenged by the lack of nutritional glucose. Delays in initiating feeding can be attributed to factors such as clinical instability, maternal issues and the need for resuscitation and stabilisation.[12 14]

The risk of neonatal hypoglycaemia was 16% (CI 4%, 30%) and was greater among neonates who developed meningitis compared with those who did not have meningitis (AIRR=1.16; 95% CI 1.04, 1.30). This finding is supported by studies in India,[15] USA[16] and the Netherlands.[17] The possible reason for this is that neonatal meningitis, a serious infection of the meninges, is often associated with perinatal asphyxia due to a compromised immune system and increased susceptibility to infection. Meningitis contributes to hypoglycaemia, as infants frequently exhibit lethargy, poor feeding reflexes and gastrointestinal symptoms leading to vomiting and diarrhoea, resulting in delayed or inadequate feeding. The inflammatory response linked to meningitis increases metabolic demands, depleting glucose stores. Additionally, treatment, including antibiotics and supportive care, can transiently affect feeding tolerance.[18]

The risk of neonatal hypoglycaemia was 10% (CI 1%, 3%) and was greater among neonates who stayed for 1 day at the hospital compared with those who were discharged early (AIRR=1.01; 95% CI 1.01, 1.03). This result is supported by studies done in Ethiopia.[19–21] The possible reason for this is that neonates admitted to the NICU due to perinatal asphyxia often require respiratory support or treatment for other complications related to asphyxia, which can extend their length of stay. If these issues are not promptly addressed, close monitoring and interventions become necessary, especially if the newborn has hormonal deficiencies or metabolic disorders that lead to recurrent hypoglycaemia.[11 22]

Newborns who had stage 3 hypoxic-ischaemic injury showed an increased risk of hypoglycaemia by 20% (CI 4%, 39%) compared with those with stage 1 and stage 2 hypoxic-ischaemic injuries (AIRR=1.20; 95% CI 1.04,

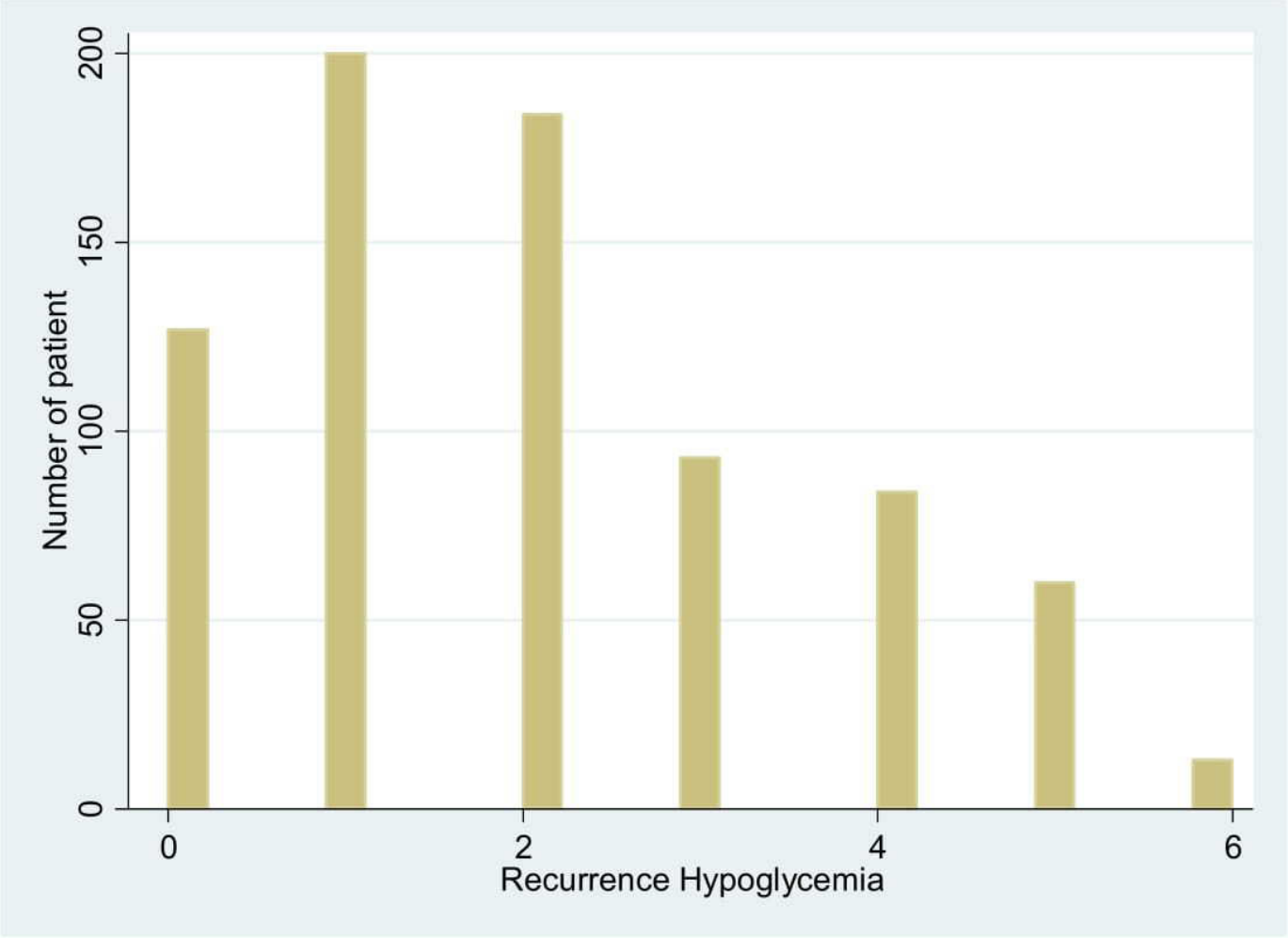

Figure 1 Recurrence of hypoglycaemia among neonates with PNA during the follow-up period at comprehensive specialised hospitals in Northwest Ethiopia from 2020 to 2024 (N=761). PNA, Perinatal asphyxia.

1.39). This finding is supported by studies in the USA,[23 24] the Netherlands[25] and Ireland.[26] The justification for HIE arises from inadequate blood flow (ischaemia), which restricts the delivery of oxygen and glucose to brain cells, thereby impairing their metabolic functions. Neurons depend on glucose for energy, and insufficient oxygen hampers the brain's ability to use glucose effectively. Additionally, HIE can disrupt the hormonal balance that regulates glucose production and usage; elevated stress hormones, such as cortisol, can negatively impact glucose metabolism.[27]

The risk of hypoglycaemia was 22 times greater in newborns with macrosomia compared with those with constant variables (AIRR=1.39; 95% CI 1.19, 1.63). This is supported by studies in Kenya,[28] Belgium,[29] USA[30 31] and Brazil.[32] The possible reason for this is that neonates with macrosomia often have higher insulin levels due to increased maternal glucose during pregnancy. This can result in excessive insulin secretion in response to the stress of birth, contributing to hypoglycaemia. Larger neonates generally have greater metabolic demands. Birth asphyxia can lead to complications. Newborns with macrosomia may have increased glycogen stores in their livers; however, ineffective mobilisation of these stores due to asphyxia-induced metabolic disturbances can also cause recurrent hypoglycaemia.[29]

Strengths and limitations

The study's retrospective design relied on potentially incomplete or inaccurate medical records, increasing the risk of missing data and misclassification bias. Moreover, the diagnosis of perinatal asphyxia was based solely on Apgar score, without using umbilical cord blood gas analysis or any confirmatory methods. However, the study's multicentre design enhanced the sample size and the diversity of the study population, thereby improving the generalisability of the findings within the Northwest Amhara region of Ethiopia. Additionally, the study employed appropriate statistical methods.

CONCLUSIONS

The current study showed that the mean number of hypoglycaemia in newborns with perinatal asphyxia was considerably higher: meningitis, feeding after 72 hours, stage 3 hypoxic-ischaemic injury in the second length

Table 3 Bivariable and multivariable logistic regression of the recurrence of hypoglycaemia among PNA neonates admitted to the NICU of selected Northwest Amhara comprehensive specialised hospitals, Amhara, Ethiopia, 2024 (N=761)

Variable	Category	CIRR (95% CI)	AIRR (95% CI)	P value
Meningitis	Yes	1.17 (1.04, 1.31)	1.16 (1.04, 1.30)	**<0.011**
	No	1	1	1
Feeding time	48–72 hours	1	1	1
	After 72 hours	0.9 (0.82, 1.02)	1.17 (1.05, 1.31)	**0.007**
Length of hospital stay		1.016 (1.01, 1.02)	1.01 (1.01, 1.03)	**<0.001**
Maternal age	1	1	1	1
	<20	0.84 (0.65, 1.08)	0.93 (0.72, 1.20)	0.586
	>35	0.94 (0.82, 1.08)	0.96 (0.825, 1.096)	0.578
ANC	No ANC	0.88 (0.73, 1.07)	0.93 (0.78, 1.12)	0.434
	1–3	1.01 (0.90, 1.14)	1.03 (0.92, 1.16)	0.584
	≥4	1	1	1
GA	Late preterm	0.81 (0.67, 1.00)	0.87 (0.71, 1.06)	0.186
	Post-term	0.86 (0.69, 1.06)	1.01 (0.838, 1.24)	0.880
	Term	1	1	1
HIE stage	1	1		
	2	0.95 (0.84, 1.1)	0.97 (0.84, 1.10)	0.642
	3	1.18 (1.03, 1.37)	1.20 (1.04, 1.39)	**<0.013**
Neonate weight	NBW	1		
	LBW	1.01 (0.87, 1.17)	1.07 (0.91, 1.25)	0.413
	Macrosomia	1.44 (1.24, 1.67)	1.39 (1.19, 1.63)	**<0.001**

Bold values indicate significant variables.
AIRR, adjusted incidence rate ratio; ANC, antenatal care; CIRR, Crude Incidence Rate Ratio; GA, Gestational Age; HIE, hypoxic-ischaemic encephalopathy; LBW, Low Birth Weight; NBW, Normal Birth Weight; NICU, neonatal intensive care unit; PNA, Perinatal asphyxia.

of hospital stay and having macrosomia were significant factors associated with the recurrence of hypoglycaemia. Timely and effective management of perinatal asphyxia can improve the outcomes of affected neonates and is essential in addressing both immediate and long-term needs, particularly in preventing complications such as recurrent hypoglycaemia.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Before conducting this study, an ethical clearance letter was obtained from the Ethical Review Committee of the College of Medicine and Health Sciences Specialized Referral Hospital (ref no: CMHSSH-UOG IRERC/35/17/2016). A waiver permission letter was obtained from hospital administrators before the data collection, and since the neonates were not directly involved in this study (the data were obtained from chart review) informed consent was not required; however, the extracted data from the medical records were kept confidentially. All methods were carried out following the Declaration of Helsinki and relevant guidelines and regulations. Therefore, anonymity was maintained using identification number instead of the patient's name. Besides, all data extracted were kept confidential and were not used for any other purpose than the stated objective.

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Data availability statement Data are available upon reasonable request from the relevant author, the primary investigator.

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