Hypoglycemia and Associated Factors among Neonates Admitted to Neonatal Intensive Care Unit in Eastern Ethiopia

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Abstract

Background: Neonatal hypoglycemia is the most frequent metabolic disease in newborn infants worldwide; yet, published data on the magnitude of neonatal hypoglycemia and associated factors in Ethiopia is sparse. As a result, the purpose of this study was to investigate the severity of hypoglycemia and associated factors in neonates admitted to Hiwot Fana Comprehensive Specialized University Hospital in Eastern Ethiopia.

Methods: A cross-sectional study was conducted among 316 newborns admitted to the neonatal intensive care unit from November 2021 to February 2022. The data were collected using pretested structured questionnaires and random blood glucose measurements. Data were analysed using Statistical Package for Social Sciences version 21.0. An adjusted odds ratio (AOR) with a 95% confidence interval (CI) was used to measure the strength of the association, and a P-value < 0.05 was considered statistically significant.

Results: The overall magnitude of hypoglycemia in the neonates was 27.8% (95% CI: 23.1, 32.6). Very low birth weight (AOR= 3.32; 95% CI: 1.01, 10.83), macrosomia (AOR= 8.16; 95% CI: 2.52, 26.38), preterm birth (AOR= 2.52; 95% CI: 2.01, 8.38), birth at 32-34 weeks (AOR= 1.98; 95% CI: 1.73, 6.57), late preterm birth (AOR= 2.58; 95% CI: 1.16, 5.56), hypothermia (AOR= 2.90; 95% CI: 1.44, 5.36), perinatal asphyxia (AOR= 5.30; 95% CI: 5.23, 9.64), pregnancy-induced hypertension (AOR= 2.18; 95% CI: 1.15, 4.21), and infant of diabetic mothers (AOR= 4.30; 95% CI: 1.32, 14.03) were significant predictors of neonatal hypoglycemia.

Conclusion: One in four neonates admitted to the neonatal intensive care unit had hypoglycemia. Hence, early detection and treatment of hypothermia, perinatal asphyxia, and maternal pregnancy-induced hypertension and diabetes, as well as monitoring blood glucose in high-risk neonates, are crucial to minimizing the burden of neonatal hypoglycemia.

***Keywords*:** Hypoglycemia; Neonates; newborn; Intensive Care Unit; Ethiopia

How to cite: Shafi, I., Yisehak, Y., Ketema, I., Mehadi, A., Husen, A, M., Weyessa, A, D., Abdulahi, I, M., Debella, A, and Weldegebreal, F.2023. Hypoglycemia and Associated Factors among Neonates Admitted to Neonatal Intensive Care Unit in Eastern Ethiopia. *East African Journal of Health and Biomedical Sciences, Volume* 7 (1): 13-24

Introduction

Neonatal hypoglycemia (NH) is one of the most common metabolic abnormalities seen in newborn infants (Harris *et al*., 2012; Rozance and Hay, 2016; Harding *et al*., 2017). In normal neonates, the blood glucose level is reduced in the first few hours of life. This reduction is transient, mild in severity, and part of normal transitional adaptation that generally resolves within the first 72 to 96 hours of life (Thompson-Branch and Havranek, 2017). Failure in this normal transition will result in hypoglycemia (Stanley *et al*., 2015; Lord and De León, 2018). Prolonged and severe hypoglycemia can cause long-term neurological sequelae and brain damage if unrecognized or poorly treated (Yang *et al*., 2016).

Globally, the overall incidence of NH has been estimated to be 1 to 5 per 1000 live births, with higher rates in risk groups (Sharma *et al*., 2017; McGowan, 1999). Its prevalence is high among high-risk neonates. For instance, 54% are in late preterm, 52% are in small-for-gestational-age (SGA), 48% are in neonates of diabetic mothers, and 47% are in large-for-gestational-age (LGA) (Harris *et al*., 2012). In newborns delivered before 37 weeks and with birth weights < 2500 g, the prevalence is nearly 62% (Goode *et al*., 2016).

There is little evidence on the magnitude and associated factors of neonatal hypoglycemia in developing countries such as Ethiopia (Bereket *et al*., 2021; Dashti *et al*., 2007). According to previous studies conducted

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Haramaya University, 2023
ISSN 2519-917X

in Addis Ababa, Ethiopia, approximately 14.9% and 25% of newborn infants developed neonatal hypoglycemia in their first few hours of life (Mohammed and Mekasha, 2010; Fantahun and Nurussen, 2020).

Several risk factors have been identified for neonatal hypoglycemia, including prematurity, SGA, LGA, multiple gestations, maternal toxemia, perinatal birth asphyxia, hypothermia, sepsis, and delayed initiation of feeding (Bromiker *et al*., 2019; Hassan et al., 2020; Pal et al., 2000). The mechanisms by which these factors result in hypoglycemia might be due to disruption of glycogenolysis or gluconeogenesis, increased glucose demand, and failure to receive or absorb nutrients (McGowan, 1999). Hence, early detection of neonates at risk for hypoglycemia and timely treatment can help to prevent long-term neurological sequelae and related complications (Sasidharan *et al*., 2010; Stomnaroska *et al*., 2017).

In Ethiopia, published data on the magnitude of neonatal hypoglycemia and associated factors is limited (Mohammed and Mekasha, 2010). Therefore, this study aimed to determine the magnitude of hypoglycemia and associated factors among neonates admitted to the neonatal intensive care unit (NICU) at Hiwot Fana Comprehensive Specialized University Hospital, Eastern Ethiopia.

Materials and Methods

Study Area and Period

The study was conducted at Hiwot Fana Comprehensive Specialized University Hospital (HFCSUH) from November 2021 to February 2022. The hospital is found in Harar town, which is located 525 km from Addis Ababa, Ethiopia. It is currently serving as a referral and teaching hospital for students from eastern Ethiopia under the auspices of Haramaya University. It provides 24-hour emergency medicine, internal medicine, general surgery, orthopedics, neurosurgery, obstetrics and gynecology, pediatrics and child health, radiology, dermatology, pathology, oncology, anesthesiology, and neonatal care specialty services for a population of more than 5.8 million in the eastern part of the country. The Department of Pediatrics and Child Health has six units, including a pediatric ward, pediatric intensive care unit, neonatal intensive care unit, pediatric outpatient department, nutritional rehabilitation unit, and chronic care and follow-up unit (Hiwot Fana-HMIS 2020). The NICU is equipped with special equipment used for diagnostic and therapeutic purposes, with adequately trained human personnel working in the unit. It provides services for newborn babies delivered at HFCSUH and referred from surrounding health facilities.

Study Design and Population

An institutional-based cross-sectional study was conducted among neonates whose age was less than 48 hours of life who were admitted to the NICU of HFCSUH during the data collection period was included. However, neonates whose mothers were very sick and mothers who did not give consent were excluded.

Sample Size and Sampling Technique

The sample size required for prevalence estimation was determined using a single population proportion formula with the assumptions of a 25% prevalence of neonatal hypoglycemia taken from a previous study conducted in Addis Ababa, Ethiopia (Fantahun and Nurussen, 2020), a 95% confidence interval (CI), a 5% margin of error, and a 10% non-response rate. Hence, the minimum sample size for the study was 317. All neonates whose age was less than 48 hours of life who were admitted to the NICU of HFCSUH during the data collection period were included.

Methods of Data Collection

Data were collected by the following method;

Face-to-face interview: was conducted by BSc nurses with mothers using a pretested structured questionnaire and checklists adopted from the American Academy of Pediatrics protocols (Thompson-Branch and Havranek, 2017) and available literature (Hassan et al., 2020; Abramowski et al., 2021). The questionnaires consisted of neonatal and maternal socio-demographic and clinical characteristics, obstetric factors, and other related variables.

Medical record review: was done to collect clinical information on neonatal and maternal factors such as the presence of polycythemia, maternal drug usage, gestational age, duration of labor, pregnancy-induced hypertension and diabetes, and other related variables.

Blood glucose measurements: were done three times using an Accu-Chek glucometer with a test strip. The procedure was performed by general practitioners and residents working in the NICU. The heel of a neonate was warmed and cleaned with an alcohol swab, and

then the postero-lateral aspect of the heel was punctured by a lancet. The first drop of blood was discarded, and the second drop of blood was applied to the test strip for blood glucose determination. The first, second, and third blood glucose measurements were performed within the first 4 h, 4-24 h, and 24-48 h of birth, respectively. A random blood glucose (RBS) level of third measurement with less than 47 mg/dl was taken as a cutoff point to define hypoglycemia for any gestational or postnatal age (McGowan, 1999; Abramowski et al., 2021). The weight and height of the study participants were measured using a digital standing weight scale and stadiometer. The body mass index (BMI) of the study participants was calculated by dividing a person's weight in kilograms by the square of their height in meters (WHO, 1995).

Body temperature measures: were taken during blood glucose tests to determine the presence of hypothermia. An auxiliary temperature of a third measurement with less than 36.5°C was used to assess hypothermia in neonates (Thompson-Branch and Havranek, 2017; Mathur et al., 2005).

Definition of Terms

Transient neonatal hypoglycemia: is a type of hypoglycemia that occurs in neonates in the first 48 hours of life (Thornton et al., 2015).

Neonatal sepsis: is an infection that occurs in newborn infants less than 28 days old (McGovern et al., 2020).

Suspected sepsis: having clinical signs and symptoms suggestive of sepsis, such as fever, tachypnea, tachycardia, and hypotension, with a negative blood culture (McGovern et al., 2020).

Proven sepsis: having clinical signs and symptoms suggestive of sepsis with a positive blood culture (McGovern et al., 2020).

Perinatal asphyxia: a new-born with an Apgar score of less than 3 at the 5th minute and evidence of altered neurologic status (Fattuoni *et al*., 2015).

Polycythemia: a venous hematocrit of more than 65% or venous hemoglobin greater than 22 g/dl (Spivak et al., 2008; Kordyasz, 1985).

Small for gestational age: a birth weight of less than the 10th percentile for the same gestational age and sex (Kramer *et al*., 2001).

Appropriate for gestational age: a birth weight between the 10th and 90th percentiles for the same gestational age and sex (Harris *et al*., 2012).

Large for gestational age: a birth weight of more than 90th percentile for the same gestational age and sex (Kramer *et al*., 2001).

Low birth weight: a newborn with a weight less than 2500 g at birth (Sasidharan *et al*., 2010).

Very low birth weight: a newborn with a weight less than 1500 g at birth (Efe *et al.,* 2019).

Macrosomia: a newborn with a weight greater than or equal to 4000 g at birth (Efe *et al*., 2019; Sasidharan et al., 2010).

Preterm birth: born alive before 37 weeks of gestation (Dedeke *et al*., 2011)

Post-term birth: birth after 42 completed weeks of gestation (Sasidharan *et al*., 2010).

Data Quality Assurance

The questionnaire was initially developed in English, translated to the local languages (Afan Oromo and Amharic), and then back-translated into English by language experts to check for consistency. The questionnaire was validated by following the face validity method. The data were collected by trained data collectors and supervisors after they were provided with two days of training on the objectives of the study, the contents of data collection tools, and how to collect and record data appropriately. A pre-test was conducted on 5% of the sample size prior to data collection to ensure tool reliability and validity. The appropriate adjustments were made based on the pre-test results. Blood glucose measurement was assured by standardized procedures (SOP) during blood sample collection, storage, and analytical processes. The collected data were carefully checked for completeness, accuracy, and consistency by the supervisors and the principal investigator daily.

Data Processing and Analysis

Data were cleaned, coded, and entered into Epi Data version 7.0 and analyzed using Statistical Package for Social Sciences (SPSS) version 21.0 software. Data were summarized using frequency tables and proportions for descriptive analysis. A bivariable logistic analysis was conducted to determine the candidate variables for the multivariable logistic analysis. Variables with a P-value of less than 0.25 were fitted into

the multivariate logistic analysis to identify factors significantly associated with neonatal hypoglycemia. In the multivariable logistic analysis, variables with a P-value < 0.05 at 95% confidence interval (CI) were considered statistically significant factors associated with neonatal hypoglycemia.

Ethical Consideration

Ethical clearance was obtained from the Institutional Health Research and Ethics Review Committee (IHRERC) of the College of Health and Medical Sciences, Haramaya University, with Ref. No. IHRERC/190/2021. A written official letter of cooperation was submitted to the HFCSUH before the commencement of the actual data collection period to obtain permission. Informed voluntary, written, and signed consent was obtained from the study participants after they were informed about the study's aim, purpose, and benefits. The confidentiality of the information was maintained throughout the data collection and dissemination processes.

Neonates who were identified to have hypoglycemia and hypothermia were managed by general practitioners and residents as per the NICU protocol.

Results

Socio-demographic and clinical characteristics of neonates

A total of 316 neonates with mothers were included in the study, yielding a response rate of 99.7%. Among the neonates, more than half (53.8%) were males, and nearly half (49.7%) were aged less than 4 hours. The mean (SD) age of the study participants was 10.2 (±13.3) hours. The mean weight (SD) and gestational age (SD) of the study participants were 2529.8 (±789.25) grams and 37.2 (±2.52) weeks, respectively. In this study, 37.7% of the neonates were preterm, and 42.4% weighed 1500-2499 g at birth. The majority (76.9%) were appropriate for gestational age, and more than half (58.2%) started feeding during the first 2 hours of life (Table 1)

Table 1: Socio-demographic and clinical characteristics of neonates admitted to the NICU at HFCSUH, eastern Ethiopia, 2022 (n = 316)

Variables	Category	Frequency (N)	Percentage (%)
Sex	Male	170	53.8
	Female	146	46.2
Age (in hours)	< 4	157	49.7
	4-24	115	36.4
	24-48	44	13.9
Birth weight (in grams)	1000-1499	35	11.1
	1500-2499	134	42.4
	2500-3999	128	40.5
	≥ 4000	19	6.0
Gestational age (in weeks)	< 32	16	5.1
	32-34	36	11.4
	34-37	67	21.2
	37-42	189	60.1
	≥ 42	8	2.2
Weight for gestational age in gram	SGA	51	16.1
	AGA	243	76.9
	LGA	22	7.0
Time at feeding initiated (hour)	Before 2	184	58.2
	After 2	132	41.8
Hypothermia	Yes	202	63.9
	No	114	36.1
Perinatal asphyxia	Yes	97	30.7
	No	219	69.3
Neonatal sepsis	Suspected	101	32.0
	Proven	82	25.9
	No	133	42.1
Respiratory Distress Syndrome	Yes	49	15.5
	No	267	84.5
Polycythemia	Yes	13	4.1
	No	303	95.9

HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital, NICU: Neonatal Intensive Care Unit, SGA: Small for Gestational Age, AGA: Appropriate for gestational age, LGA: large for gestational age.

Clinical Characteristics

Among 316 mothers enrolled in the study, 72.2% were within the age group of 21–35 years. More than half (52%) of the neonates were born to primiparous mothers. The majority (76.6%) had neither pregnancy-nduced hypertension (PIH) nor Infants of diabetic mothers (IDM), and about 103 (32.6%) of mothers used drugs like antibiotics and steroids during pregnancy. More than half (54.7%) had a 4 to 18-hour duration of labor, and 57.3% of them gave birth by spontaneous vaginal delivery (Table 2).

Table 2: Socio-demographic and obstetric characteristics of mothers of neonates admitted to the NICU at HFCSUH, eastern Ethiopia, 2022 (n = 316).

Variables	Category	Frequency (N)	Percentage (%)
Maternal age (in years)	< 21	69	21.8
	21-35	228	72.2
	> 35	19	6.0
Parity	Primipara	164	51.9
	Multipara	152	48.1
Infants of diabetic mothers	Yes	16	5.1
	No	300	94.9
Pregnancy-induced hypertension	Yes	54	17.1
	No	262	82.9
Types of drugs taken (n= 103)	Antibiotics	40	38.8
	Steroids	63	61.2
Body Mass Index (kg/m2)	< 30	297	94.0
	≥ 30	19	6.0
Duration of labor (in hours)	< 4	94	29.7
	4-18	173	54.7
	> 18	49	15.6
Rupture of membrane	Before the start of labor	104	32.9
	Intrapartum	212	67.1
Duration of pre-labor ROM (in hours)	< 18	68	65.4
	≥ 18	36	34.6
Mode of delivery	SVD	181	57.3
	Instrumental	53	16.8
	Cesarean section	82	25.9
Place of delivery	Home	21	6.6
	Health center	99	31.4
	HFCSUH	179	56.6
	Private clinic	17	5.4

HFSUH; Hiwot Fana specialized university Hospital, NICU; Neonatal Intensive Care Unit, ROM; Rapture of membrane, SVD; Spontaneous Vaginal Delivery

Magnitude of Neonatal Hypoglycemia

The overall magnitude of hypoglycemia in the neonates admitted to the NICU at HFCSUH was 27.8% (95% CI: 23.1-32.6). Among the hypoglycemic neonates, the majority (35%) developed hypoglycemia during the first 4 hours of life. More than half (56.8%) of them were born before 37 weeks of pregnancy. Sixty (68.2%) hypoglycemic neonates were admitted with a birth weight of less than 2500 g.

Factors Associated with Neonatal Hypoglycemia

In the multivariable logistic analysis, very low birth weight, macrosomia, preterm birth, hypothermia, perinatal asphyxia, infant of diabetic mothers, and pregnancy-induced hypertension were significantly associated with neonatal hypoglycemia. In this study, neonates born before 32 weeks (AOR = 2.52; 95% CI: 2.01, 8.38), born at 32-34 weeks (AOR = 1.98; 95% CI: 1.73, 6.57) and born at 34-37 weeks of pregnancy (AOR = 2.58; 95% CI: 1.16, 5.56) were 2.52, 1.98 and 2.58 times more likely to develop NH, respectively, compared to term newborns. Neonates with very low birth weight (AOR = 3.32; 95% CI: 1.01, 10.83) and macrosomic neonates (AOR = 8.16; 95% CI: 2.52, 26.38) were 3.32 and 8.16 times more likely to develop NH than neonates with normal birth weight, respectively. Hypothermic neonates were 2.9 times (AOR = 2.90; 95% CI: 1.44, 5.36) more likely to get NH than their counterparts. Neonates with perinatal asphyxia were 5.3 times (AOR = 5.30; 95% CI: 5.23, 9.64) more likely to acquire NH than their counterparts. Moreover, neonates born to mothers with pregnancy-induced hypertension (AOR = 2.18; 95% CI: 1.15, 4.21) and diabetes (AOR = 4.30; 95% CI: 1.32, 14.03) were 2.18 and 4.3 times more likely to develop NH than their counterparts, respectively (Table 3).

Table 3: Factors associated with neonatal hypoglycemia among neonates admitted to the NICU of HFCSUH, eastern Ethiopia, 2022 (n = 316).

Variables	Category	Neonatal Hypoglycemia		COR (95% CI)	P-value	AOR (95% CI)
		YES	NO			
		N (%)	N (%)			
Age of neonates (in hours)	< 4	55 (35.1)	102 (64.9)	3.41(1.36-8.58)	0.525	1.39(0.45-4.28)
	4-24	27 (23.5)	88 (76.5)	1.94(0.74-5.09)	1.232	1.49(0.60-4.46)
	24-48	6 (13.6)	38 (86.4)	1		1
Gestational age (in weeks)	< 32	7 (43.8)	9 (56.2)	3.44(1.20-9.88)	0.126	2.52(2.01-8.38)*
	32-34	13 (31.1)	23 (68.9)	2.50(1.16-5.42)	0.235	1.98(1.73-6.57)*
	34-37	30 (44.8)	37 (55.2)	3.59(1.96-6.58)	0.123	2.58(1.16-5.56)*
	37-42	35 (18.5)	154 (81.5)	1		1
Birth weight (in grams)	1000-1499	16 (45.7)	19 (54.3)	5.14(2.24-11.81)	0.076	3.32(1.01-10.83)*
	1500-2499	44 (32.8)	90 (67.2)	2.99(1.61-5.53)	1.362	1.82(0.794-4.01)
	≥ 4000	10 (52.6)	9 (47.4)	6.79(2.43-19.01)	0.063	8.16(2.52-26.38)*
	2500-3999	18 (14.1)	110 (85.9)	1		1
Hypothermia	Yes	69 (34.2)	133 (65.8)	2.59(1.46-4.59)	0.079	2.90(1.44-5.36)*
	No	19 (16.7)	95 (83.3)	1		1
Perinatal asphyxia	Yes	48 (49.5)	49 (50.5)	4.38(2.59-7.41)	0.167	5.30(5.23-9.64)*
	No	40 (18.3)	179 (81.7)	1		1
Neonatal sepsis	Suspected	24 (23.8)	77 (76.2)	0.65(0.36-1.17)	0.378	1.37(0.68-2.78)
	Culture positive	21 (25.6)	61 (74.4)	0.72(0.39-1.33)	0.674	1.57(0.74-3.33)
	No	43 (32.3)	90 (67.7)	1		1
Respiratory Distress Syndrome	Yes	17 (34.7)	32 (65.3)	1.46(0.77-2.80)	0.693	0.57(0.23-1.45)
	No	71 (26.6)	196 (73.4)	1		1
Place of delivery	HC and clinic	23(19.8)	93 (80.2)	1.05(0.46-9.59)	0.452	1.01(0.45-6.458
	Hospital	61 (34.1)	118 (65.9)	2.19(1.83-3.67)	0.369	2.12(1.23-9.24)
	Home	4 (19.1)	17 (80.9)	1		1
Mode of delivery	SVD	44 (24.3)	137 (75.7)	0.69(0.39-1.23)	0.975	0.94(0.48-1.85)
	OVD	18 (33.9)	35 (66.1)	1.11(0.53-2.31)	0.487	1.38(0.60-3.48)
	CS	26 (31.7)	56 (68.3)	1		1
Infants of diabetic mothers	Yes	10 (62.5)	6 (37.5)	4.74(1.67-13.48)	0.075	4.30(1.32-14.03)*
	No	78 (26.0)	222 (74.0)	1		1
PIH	Yes	23 (42.6)	31 (57.4)	2.25(0.22-4.13)	0.157	2.18(1.15-4.21)*
	No	65 (24.8)	197 (71.2)	1		1
Body Mass Index (kg/m2)	< 30	78 (26.3)	219 (73.7)	0.32(0.13-0.82)	1.360	0.58(0.20-1.45)
	≥ 30	10 (52.6)	9 (47.4)	1		1

*CS: Cesarean section, HC; Health Center, HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital, NICU: Neonatal Intensive Care Unit, PIH; Pregnancy Induced Hypertension, SVD: Spontaneous Vaginal Delivery, OVD Operative Vaginal Delivery, *: P< 0.05*

Discussion

In this study, the overall magnitude of hypoglycemia among neonates admitted to the NICU at HFCSUH was found to be 27.8%. Variables such as very low birth weight, macrosomia, preterm birth, hypothermia, perinatal asphyxia, pregnancy-induced hypertension, and infants of diabetic mothers were significantly associated with neonatal hypoglycemia.

In the current study, one out of four (27.8%) neonates admitted to the NICU developed hypoglycemia. The findings of this study are consistent with the results of the studies conducted in Addis Ababa, Ethiopia (25%) (Fantahun and Nurussen, 2020), and Turkey (30.4%) (Yuce and Anukince, 2020). However, this is higher than the findings of the studies from Nigeria (11.1%) (Ochoga *et al.,* 2018), Iran (15.15%) (Dashti *et al*., 2007), and Bangladesh (17.2%) (Hassan et al., 2020). This difference could be due to the lower RBS cutoff point of less than 45 mg/dl they used to define hypoglycemia. This finding is lower than the findings of the studies from Nigeria (Dedeke *et al*., 2011; Efe *et al*., 2019). This discrepancy might be difference in the ages of study participants, sample size, laboratory methods. Neonatal hypoglycemia causes neonatal morbidity, mortality, or other complications due to the following mechanisms: insufficient glucose supply with low glycogen or fat stores causing cell starvation or inadequate glucose production mechanisms; increased glucose utilization caused by excessive insulin production (Yang et al., 2016).

Hypothermia increases the risk of hypoglycemia in neonates (Efe et al., 2019). In this study, hypothermic babies were more likely to develop hypoglycemia than non-hypothermic babies. This finding is supported by studies from Bangladesh (Hassan *et al*., 2020), Nigeria (Abramowski *et al*., 2021; Dedeke *et al*., 2011), India (Sasidharan *et al*., 2010), and Ethiopia (Fantahun and Nurussen, 2020). This could be because the glucose requirement increases in neonates who have hypothermia, which increases the risk of hypoglycemia (Sharma et al., 2017).

Perinatal birth asphyxia increases the risk of hyperinsulinism in neonates because of anaerobic metabolism to maintain blood glucose concentration (Hassan *et al*., 2020; Sasidharan *et al*., 2010). In the current study, neonates with perinatal birth asphyxia were more likely to have NHs than non-asphyxic neonates. This finding is similar to the studies conducted in Bangladesh (Hassan et al., 2020), India (Sasidharan *et al*., 2010), and Macedonia (Stomnaroska *et al*., 2017).

In this study, neonates with very low birth weights were more likely to get NHs compared to neonates with normal birth weights. This finding is in line with the studies conducted in Addis Ababa, Ethiopia (Fantahun and Nurussen, 2020), and Nigeria (Ochoga et al., 2018). This could be due to inadequate glucose storage and a delayed response to counter regulatory hormones due to premature enzymes for this hormone (Chappe *et al*., 2020). Neonates with LBW also have a limited reserve of glycogen, which predisposes them to develop hypoglycemia (Uettwiller *et al*., 2015).

The findings of this study showed that macrosomic neonates were more likely to develop NHs than neonates with normal birth weights. This finding is in line with the studies from Nigeria (Efe et al., 2019) and Southeast Michigan, USA (Ogunyemi et al., 2017). Macrosomic babies of non-diabetic mothers might have hyperplasia of the islet of the pancreas and hyperinsulinemia, which are not connected to exposure to abnormally elevated levels of glucose in utero as seen in infants of diabetic mothers (Hoegsberg *et al*., 1993; Pinar *et al*., 2000).

In the current study, preterm babies were more at risk of obtaining NHs than term babies. This finding is in line with the studies conducted in Nigeria (Ochoga et al., 2018), India (Sasidharan *et al*., 2010), and Bangladesh (Hassan *et al*., 2020). Preterm neonates are uniquely predisposed to hypoglycemia and its associated complications due to their limited glycogen and fat stores, inability to generate glucose using gluconeogenesis pathways, higher metabolic demands due to relatively larger brain size, and inability to mount a counter-regulatory response to hypoglycemia (Dhananjaya and Kiran, 2011). In addition, preterm neonates are at high risk of developing hypothermia, which increases glucose consumption to maintain body temperature (Chappe et al., 2020).

The findings of this study revealed that neonates delivered to pregnancy-induced hypertensive mothers were more likely to have NHs. This finding is supported by studies conducted in Bangladesh (Hassan *et*

al., 2020), Nigeria (Abramowski et al., 2021), and India (Sasidharan *et al*., 2010). However, this finding is different from the studies conducted in Addis Ababa, Ethiopia (Fantahun and Nurussen, 2020), and Nigeria (Ochoga *et al*., 2018). The difference might be due to difference antenatal care (ANC) follow-up and early detection and intervention with anticipatory complications in the studies.

The findings of this study further showed that infants of diabetic mothers were more likely to develop neonatal hypoglycemia compared to infants of non-diabetic mothers. This finding is supported by studies conducted in Macedonia (Stomnaroska *et al*., 2017), China (Zhao *et al*., 2020), and Australia (Thevarajah and Simmons, 2019). However, this finding is inconsistent with the studies conducted in Addis Ababa, Ethiopia (Fantahun and Nurussen, 2020), and Nigeria (Ochoga *et al.,* 2018). Maternal hyperglycemia, which causes the newborn to obtain too much glucose, causing hyperplasia of the pancreatic beta cells and elevating insulin hormone (Schwartz and Teramo, 2000; Chappe *et al*., 2020). There is a need for early detection and monitoring of glucose concentration throughout pregnancy, which are crucial to reduce the effects of diabetes in newborn neonates (Narvey and Marks, 2019). The study provides research-based relevant data on the magnitude of hypoglycemia and its associated factors, which could help health policymakers design evidence-based preventive measures. This study could also help health professionals in the early detection and management of neonatal hypoglycemia. This is a cross-sectional study that did not show a causal relationship between the study variables. The study included only neonates admitted to the NICU, which may not represent the entire population, which was considered another limitation of this study.

Conclusions and Recommendations

One out of four neonates admitted to the NICU of HFCSUH developed hypoglycemia. Gestational age, birth weight, hypothermia, perinatal asphyxia, pregnancy-induced hypertension, and infants of diabetic mothers were predictors of neonatal hypoglycemia. Therefore, early detection and treatment of hypothermia, perinatal asphyxia, and pregnancy-induced hypertension and diabetes, as well as monitoring blood glucose in high-risk neonates, are crucial to minimize the burden of neonatal hypoglycemia. Maintaining a suitable ambient temperature is crucial to prevent hypothermia and subsequent hypoglycemia in neonates. In addition, a study that used venous plasma glucose measurements, the most accurate reading of blood glucose, is recommended in the study area. Moreover, a further study assessing the magnitude of neonatal hypoglycemia and associated factors is recommended to fill the gap in the study.

Acknowledgments

First, we would like to express our gratitude to Haramaya University, College of Health and Medical Sciences for funding, critically reviewing, and providing approval of the ethical protocol of this study. We would also like to forward our kindest regards to the study participants. Finally, we extend our thanks to data collectors and supervisors; they are the backbone of finalizing the reports.

Conflict of Interests

The authors declare that there is no conflict of interest.

Funding Statement

Haramaya University financially supported this study. The authors report that the funding body had no role in the study selection, data collection, analysis, conclusion, and interpretation.

List of Abbreviations /acronyms

AOR: adjusted odds ratio; CI: confidence interval; COR: crude odds ratio; HFCSUH: Hiwot Fana Comprehensive Specialized University Hospital; IDM: infant of a diabetic mother; NH: neonatal hypoglycemia; PIH: pregnancy-induced hypertension; PNA: perinatal asphyxia.

Authors' Contribution

I.S., D.Y., and F.W. conceived and designed the study, acquired data, and analyzed and interpreted the findings. I.K., A.M., Y.B., A.M.H., A.D.W., A.D., and I.M.A. revised and provided critical intellectual feedback. A.M. and I.K. drafted the manuscript. All authors have read and approved the final manuscript for submission.

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