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Severity, Factors, and Short-Term Outcomes of Neonatal Hypoxic-Ischemic Encephalopathy Due to Birth Asphyxia at a Tertiary Hospital in Tanzania

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Abstract

Background: Hypoxic-Ischemic Encephalopathy (HIE), with a prevalence of 10.7% - 25.4% in Sub-Saharan Africa, including Tanzania, is a leading cause of neonatal mortality and long-term neurological impairment. **Methodology:** This prospective cohort study was conducted from October 2023-May 2024, at a tertiary care hospital, enroling all eligible neonates with birth asphyxia who developed HIE. These neonates were consecutively admitted neonatal unit and followed from admission until discharge or death within 28days of life. Maternal, delivery, and neonatal factors were collected via questionnaires, and HIE severity was assessed daily using the Thompson score. Short-term outcomes were defined as survival during hospitalization with hospital stay being less or more than 7days. Data were analysed with STATA 15, with variables categorized as baseline (maternal and perinatal) and post admission. Baseline variables were interpreted as a potential factors for HIE and post admission variables interpreted as indicators of health care access and condition progression. Bivariable logistic regression analysis was performed first, variables with stastical significance ($p < 0.05$) and clinical relevance were included in multivariable logistic regression model with adjusted relative risk (ARR) and with 95% confidence intervals used to identify independent factors associated with HIE. **Results:** Out of 1619 deliveries, 121 neonates had birth asphyxia, of whom 88 (72.7%) developed HIE (49% moderate, 35% severe, 16% mild). HIE mortality was 20%, with 72.2% occurring in severe cases. Key ne-

onatal factors for HIE included low birth weight (<2500 g), gestational age of 37 - 39.9 weeks, and admission age >25 hours. Maternal factors associated with HIE included age 21 - 34 years (75.0%), cesarean delivery (47.7%), multiparity (51.1%), anemia (26.1%), maternal fever (12.5%), twin pregnancy (5.7%) while antenatal care (ANC) visits were protective. Moderate HIE had a 55.7% recovery, with most cases hospitalized for over seven days. **Conclusion:** HIE prevalence among neonates with birth asphyxia is high at 72.7%, with significant high mortality in severe cases. Early identification of high-risk pregnancies and improved antepartum, intrapartum, and neonatal care can reduce HIE burden, neonatal mortality and future sequelae.

Keywords

Severity, Short-Term, Hypoxic Ischemic, Encephalopathy, Infants, Birth Asphyxia

1. Background

Birth asphyxia occurs when a newborn fails to start and maintain breathing at birth, leading to poor oxygenation, high carbon dioxide levels, and metabolic acidosis. Clinical signs include low consciousness, seizures, breathing difficulties, and abnormal muscle tone and reflexes. The Apgar score assesses the newborn's condition at 1 and 5 minutes, but it cannot alone confirm birth asphyxia because it does not reliably distinguish hypoxia from other causes of neonatal depression [1]-[4]. HIE is a condition observed in neonates characterized by a combination of clinical and biochemical indicators that signify immediate or sub-acute brain injury and it is closely associated with asphyxia. It can be classified as mild, moderate, and severe based on the neurological presentation [1]. Accurate identification and grading of birth asphyxia severity are crucial for predicting outcomes and planning long-term care. Hypoxic-ischemic encephalopathy (HIE) following birth asphyxia can result from many causes, including maternal factors (older age, high parity, low socioeconomic status, preeclampsia, bleeding), labor complications (shoulder dystocia, placental abruption, uterine rupture, abnormal CTG), delivery-related factors (gestational age, mode of delivery, abnormal placental histology), and neonatal conditions such as meconium aspiration syndrome [5] [6]. In low-resource settings, treatment for birth asphyxia and HIE mainly involves supportive care, including stabilization, oxygenation, hydration, nutrition, and seizure management. Birth asphyxia is a leading cause of HIE, which has a global prevalence of about 1 to 8 cases per 1000 live births [1] [2] [7]-[9]. In developed countries HIE occurrence is reported to be 1.5cases per 1000 live births while in developing countries found to be 2.3 to 26.5 cases per 1000 live birth. In Sub-Saharan Africa data collected from few centers found HIE to be ranging from 2.3 - 30.6cases per 1000 live births [2] [8] [10].

Prevalence of HIE in Tanzania ranges from 10.7% to 25.4% [11]. Mortality rate

of HIE ranges between 10% - 60%. Mortality due HIE claim the lives of around 814,000 children under the age of five annually making it the fifth leading cause of mortality in this age group. Long term neurodevelopmental outcomes occurred in 25% of survivors [2] [10]. Short term and long-term consequences developed from HIE includes need of supportive care during the perinatal period, severe and long-lasting neurological sequel, cerebral palsy, epilepsy and cognitive impairments [10]. HIE can have significant impact on individual, family, community, health system and national at large. It can also lead to death and for the survivors, it found to contribute to about 42 million disability adjusted life years among affected neonates [12]. Prevention of hypoxic-ischemic encephalopathy relies primarily on skilled intrapartum care, timely recognition of fetal distress, effective neonatal resuscitation, and early postnatal stabilization [1].

Tanzanian studies indicate that mild HIE is most common (50% - 56%), followed by moderate HIE (20% - 39%) and severe HIE (10% - 23.5%). While mild cases generally have better outcomes, the increasing proportion of severe HIE is concerning because of its poor prognosis. Overall, nearly 45% of affected neonates experience poor outcomes, including a 27.1% mortality rate and 17.6% long-term neurological deficits, highlighting the need for stronger prevention and treatment measures [8]. The study highlighted that severe HIE, history of aspiration, and abnormal heart rate at admission are major predictors of poor outcomes, emphasizing the need to improve obstetric and neonatal care. The study aimed to assess the severity, associated maternal and neonatal factors, and short-term outcomes of HIE among neonates with birth asphyxia admitted to a tertiary hospital in Northern Tanzania.

2. Materials and Methods

This prospective cohort study, conducted from October 2023 to May 2024 in the neonatal ward at KCMC Zonal Referral Hospital, Northern Tanzania, analyzed quantitative data on asphyxiated neonates who developed HIE. Neonates with congenital malformations affecting breathing or delivered via C-section under general anesthesia were excluded. Independent variables included maternal demographics (age, residency, socioeconomic status, education, occupation, and marital status), neonatal characteristics (gender, birth weight, gestational age, and age on admission), maternal comorbidities (e.g., diabetes, preeclampsia, eclampsia), pregnancy complications, antenatal care attendance, hemoglobin levels, fever, and parity. Outcomes were assessed using the Thompson HIE score and survival status. Severity of hypoxic-ischemic encephalopathy was assessed daily using the Thompson score, which classifies HIE as mild (1 - 10), moderate (11 - 14), or severe (≥15), based on clinical neurological findings [13].

2.1. Data Collection Methods

Data collection at KCMC Hospital involved interviews with parents of neonates with birth asphyxia, using a structured Kiswahili questionnaire covering maternal,

delivery, and neonatal details. HIE severity was classified using the Thompson score, while neonatal data, including random blood glucose and vital signs, were collected during admission and hospital stays. Hypoglycemia (≤47 mg/dL) and hyperglycemia (>150 - 180 mg/dL) were assessed using an Accu-Chek glucose meter. Birth weight was measured with a calibrated SECA digital scale, averaging two readings for accuracy. Delivery details were verified from medical staff, referral letters, or referring hospitals for unclear cases.

2.2. Data Analysis

Data were analyzed using STATA version 15. Descriptive statistics summarized categorical and continuous variables, and Chi-square and t-tests assessed associations. Logistic regression models evaluated the impact of maternal and neonatal factors on HIE risk, with adjusted relative risks and statistical significance determined by $p < 0.05$ and 95% confidence intervals.

3. Results

A total of 126 neonates with birth asphyxia were admitted to KCMC Zonal Referral Hospital, but five were excluded for not meeting the inclusion criteria. Of the remaining 121 neonates, 88 (72.7%) had HIE and were included in the analysis. Most of the neonates with HIE were male (73.9%), with 80.7% born at 37 - 39.9 weeks gestation, and a mean gestational age of 37 weeks. Additionally, 75% of the neonates had a birth weight between 2501 - 3999 grams (Table 1).

Table 1. Socio-demographic and clinical characteristics of neonates with HIE at KCMC (N = 88).

Variable	Frequency	Percentage
Age in admission in hours		
<6	47	53.4
7 - 24	18	20.5
≥25	23	26.1
Median, (IQR)	**6, (1 - 24)**	
Gender		
Male	65	73.9
Female	23	26.1
Gestational age (weeks)		
37 - 39.9	71	80.7
≥40	17	19.3
Mean ± SD	37 ± 5.4	

Continued

Birth weight(gram)		
≤2500	17	19.3
2501 - 3999	66	75.0
≥4000	5	5.7

*IQR: Interquartile range, *SD: Standard deviation.

The socio-demographic and clinical characteristics of mothers with neonates diagnosed with HIE revealed a mean maternal age of 21 - 34 years, comprising 75% of the sample, with 12.5% each for those aged ≤20 and ≥35 years. Regarding body mass index (BMI), 59.1% had a BMI >25, while 5.7% had a BMI <18.5, and 35.2% were in the normal range (18.5 - 24.9). Most mothers resided in urban areas (51.1%) compared to rural areas (48.9%). Income levels were varied, with 25% earning <200,000 Tanzanian shillings, 36.4% earning between 200,001 - 500,000 shillings, and 22.7% earning more than 500,000 shillings. Educationally, 45.5% had primary education, 44.3% had secondary education, and a smaller proportion had higher education. In terms of marital status, 78.4% were married, while the remaining were single or cohabiting. Regarding occupation, 35.2% were farmers, 26.2% were self-employed, 18.2% were unemployed, and 10.2% were employed. The majority (73.9%) had attended at least four antenatal care (ANC) visits, with 26.1% attending ≤3 visits. Household size was balanced between ≤2 members (47.7%) and >2 members (52.3%) (Table 2).

Table 2. Socio-demographic and clinical characteristics of maternal with HIE neonates at KCMC (N = 88).

Variables	Frequency	Percentage
Maternal age (years)		
≤20	11	12.5
21 - 34	66	75.0
≥35	11	12.5
Mean ± SD		
Body mass index (kg/m²)		
<18.5	5	5.7
18.5 -2 4.9	31	35.2
>25	52	59.1
Maternal residency		
Rural	43	48.9
Urban	45	51.1

Continued

Maternal income level (Tshs)		
<200,000/=	22	25.0
200,001-500,000/=	32	36.4
>500,000/=	20	22.7
Don't know	14	15.9
Maternal education level		
Primary	40	45.5
Secondary	39	44.3
Higher education level	9	10.2
Maternal marital status		
Married	69	78.4
Single	16	18.2
Cohabiting	3	3.4
Maternal occupation		
Employed	22	25.0
Farmer	12	13.6
Unemployed	23	26.2
Self-employed	31	35.2
Number of households		
≤2	42	47.7
>2	46	52.3
Number of ANC attendance		
≤3	23	26.1
≥4	65	73.9

*SD: Standard deviation, *Tshs: Tanzanian shilling.

A total of 121 neonates with birth asphyxia were included in the study. Of these, the majority, 88 (72.7%), were diagnosed with hypoxic-ischemic encephalopathy (HIE), while 33 (27.3%) did not have HIE. According to the Thompson score for HIE classification, nearly half (43 or 49%) had moderate HIE, 31 (35%) had severe HIE, and 14 (16%) had mild HIE (Figure 1).

Clinical characteristics of neonates with HIE

Among neonates with HIE, over half, 65 (73.86%) were male with 33 (50.8%) of them having moderate HIE. Overall, nearly two third 53 (60.2%) were referral

cases among which 24 (45.3%) had severe HIE (Table 3).

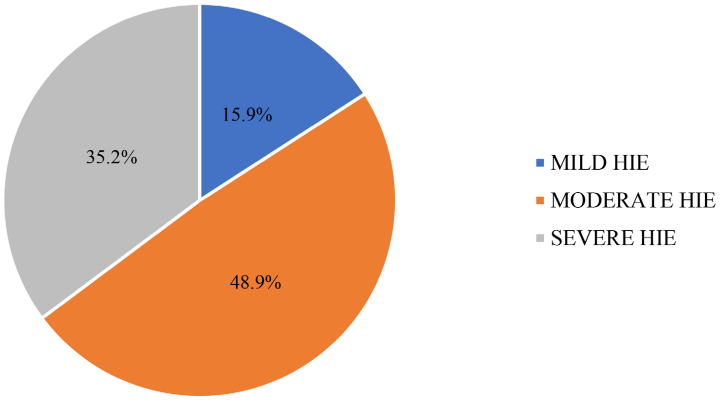

Figure 1. HIE severity classification by Thompson score (N = 88).

Table 3. Logistic regression analysis of characteristics of neonates with HIE in relation to HIE severity at KCMC (N = 88).

Variable	Mild HIE n (%)	Moderate HIE n (%)	Severe HIE n (%)	p-value
Gender				
Male	10 (15.4)	33 (50.8)	22 (33.8)	0.905
Female	4 (17.4)	10 (43.5)	9 (39.1)	
Referral				
Yes	7 (13.2)	22 (41.5)	24 (45.3)	0.104
No	7 (20.0)	21 (60.0)	7 (20.0)	
APGAR score at 5th				
≤3	0 (0.0)	0 (0.0)	1 (0.0)	0.395
4 - 7	14 (16.1)	43 (49.4)	30 (34.5)	
Mode of delivery				
Spontaneous vaginal delivery	10 (21.7)	21 (45.7)	15 (32.6)	0.294
Cesarean section	4 (9.5)	22 (52.4)	16 (38.1)	

*APGAR score: Activity, Pulse, Grimace, Activity and Respiration score.

The study included 88 neonates with HIE and examined their short-term outcomes (alive or dead) during the follow-up period. Approximately 20% (18 neonates) of those with HIE died. Additionally, 19 neonates with birth asphyxia died during the study, with 18 (94.7%) diagnosed with HIE, and 13 (72.2%) having severe HIE. The majority of deaths (83.3%) occurred within the first 7 days of life. Neonates with moderate HIE (28, or 54.9%) experienced longer hospital stays, exceeding 7 days (Table 4).

The study involved 88 neonates diagnosed with HIE. The majority, 66 (75%), had a birth weight between 2500 g and 3999 g, and 71 (80.7%) had a gestational

age between 37 and 39.9 weeks. In bivariate analysis, neonates with a birth weight between 2500 g and 3999g had a 30% lower risk of HIE compared to those weighing over 4000 g (CRR: 0.8; 95% CI: 0.31, 3.0). Neonates weighing less than 2500 g had a 20% higher risk of HIE compared to those over 4000 g (CRR: 1.2; 95% CI: 1.04, 3.76). Neonates admitted after 25 hours had an 80% higher risk of HIE compared to those admitted within six hours (CRR: 1.8; 95% CI: 1.23, 2.31). Neonates with a gestational age of 37 - 39.9 weeks had a 10% higher risk of HIE compared to those with a gestational age of ≥40 weeks (CRR: 1.1; 95% CI: 1.01, 3.95).

Table 4. Logistic regression analysis of the outcomes of HIE and length of hospital stay among neonates with HIE according to HIE classification (N = 88).

Variable	Mild HIE n (%)	Moderate HIE n (%)	Severe HIE n (%)	p-value
Patient status				
Dead	1 (5.6)	4 (22.2)	13 (72.2)	<0.001
Alive	13 (18.6)	39 (55.7)	18 (25.7)	
Length of hospital stay (days)				
<7	3 (8.1)	15 (40.5)	19 (51.4)	0.018
>7	11 (21.6)	28 (54.9)	12 (23.5)	

In multivariable analysis, after adjusting for other factors, neonates weighing less than 2500 g had a 30% higher risk of HIE compared to those weighing over 4000 g (ARR: 1.3; 95% CI: 1.12, 4.01). Neonates with a gestational age of 37 - 39.9 weeks had a 30% higher risk of HIE compared to those with a gestational age of ≥40 weeks (ARR: 1.3; 95% CI: 1.21, 4.07). Neonates admitted after 25 hours had a 60% higher risk of HIE compared to those admitted within 6 hours (ARR: 1.6; 95% CI: 1.23, 6.78) (Table 5).

Table 5. Associated factors of HIE among neonates at KCMC hospital.

Factors	HIE		CRR (95%CI)	p-value	ARR (95%CI)	p-value
	Yes n (%)	No n (%)				
Gender						
Male	65 (73.9)	23 (26.1)	1.3 (1.10, 3.17)	0.037	1.1 (0.92, 1.83)	0.221
Female	23 (26.1)	10 (73.9)	1		1	
Birth weight (g)						
<2500	17 (19.3)	5 (80.7)	1.2 (1.04, 3.76)	0.041	1.3 (1.12, 4.01)	0.029
2500 - 3999	66 (75.0)	24 (25.0)	0.8 (0.31, 0.94)	0.002	0.7 (0.31, 0.93)	0.001
>4000	5 (5.7)	4 (94.3)	1		1	

Continued

Age on admission (hrs)						
≤6	47 (53.4)	19 (46.6)	1		1	
7 - 24	18 (20.5)	7 (79.5)	1.3 (0.91, 1.43)	0.089	1.1 (1.10, 2.84)	0.039
>25	23 (26.1)	7 (73.9)	1.8 (1.23, 2.31)	0.001	1.6 (1.23, 6.78)	0.021
Gestational age (weeks)						
37 - 39.9	71 (80.7)	24 (19.3)	1.1 (1.01, 3.95)	0.034	1.3 (1.21, 4.07)	0.038
≥40	17 (19.3)	9 (80.7)	1		1	
Resuscitation time (min)						
≤5 - 10	37 (42.0)	16 (58.0)	1		1	
>10 - 30	40 (45.5)	14 (55.5)	1.1 (1.12, 1.97)	0.038	1.1 (0.79, 2.91)	0.281
>30	11 (12.5)	3 (87.5)	1.5 (0.81, 1.86)	0.401	1.4 (1.14, 3.65)	0.024
Referral						
Yes	53 (60.2)	18 (39.8)	1.2 (1.19, 2.74)	0.003	1.1 (0.89, 2.93)	0.623
No	35 (39.8)	15 (60.2)	1		1	

CRR: Crude relative risk, ARR: Adjusted relative risk*Adjusted for male gender, birth weight, age on admission, gestational age, resuscitation time and referral time*hrs-hours *Min-minutes *g-gram.

This study included 88 mothers whose neonates had HIE. Majority 11 (78.6%) of mothers who had neonates with HIE had maternal age ≥35years, 42 (73.7) had cesarean section as mode of delivery. In bivariate analysis factors associated with HIE included; mothers aged 21 - 34 had a 30% higher risk of having neonates with HIE compared to those ≤20 (CRR: 1.3; 95%CI: 1.29, 1.85). Mothers with more than one child had a 30% higher risk of having neonates with HIE compared to those with one child (CRR: 1.3; 95%CI: 1.08, 6.34). Cesarean delivery increased HIE risk by 50% compared to normal delivery (CRR: 1.5; 95%CI: 1.13, 3.22). Twin births had a 2.2 times higher risk of HIE compared to singletons (CRR: 2.2; 95%CI: 1.93, 2.91). Conversely, ≥4 ANC visits reduced HIE risk by 60% compared to <4 visits (CRR: 0.4; 95%CI: 0.05, 0.92). Anemic mothers had 2 times higher risk of HIE compared to non-anemic mothers (CRR: 2.3; 95%CI: 1.03, 2.97).

In multivariable analysis after adjusting for other factors, mothers who delivered twins had two times higher risk of HIE compared to those who delivered singletons (ARR:2.1; 95%CI: 1.03,2.71). Anemic mothers had a two times higher risk of having neonates with HIE compared to non-anemic mothers (ARR: 2.0; 95%CI: 1.12, 2.89). Those with ≥4 ANC visits had a 40% lower risk compared to those with <4 visits (ARR: 0.6; 95%CI: 0.42, 0.94). Mothers with a history of fever had a 90% higher risk compared to those without fever. (ARR: 1.9; 95%CI: 1.12, 3.04) (Table 6).

Table 6. Maternal associated factors of HIE at KCMC hospital.

Factors	HIE		CRR (95%CI)	p-value	ARR (95%CI)	p-value
	Yes n (%)	No n (%)				
Maternal age (years)						
≤20	11 (73.3)	4 (26.7)	1		1	
21 - 34	66 (71.7)	26 (28.3)	1.3 (1.29, 1.85)	0.002	1.1 (1.06, 7.32)	0.041
≥35	11 (78.6)	3 (9.1)	0.9 (0.34, 1.43)	0.297	0.8 (0.31, 0.91)	0.037
Maternal parity						
Primiparity	43 (75.4)	19 (29.6)	1		1	
Multiparity	45 (70.3)	14 (24.6)	1.3 (1.08, 6.34)	0.029	1.3 (1.23, 4.79)	0.023
Mode of delivery						
Spontaneous delivery	46 (72.8)	18 (27.2)	1		1	
Cesarean section	42 (71.4)	15 (28.6)	1.5 (1.13, 3.22)	0.041	1.3 (1.13, 3.53)	0.036
Type of pregnancy						
Singleton	83 (72.8)	31 (27.2)	1		1	
Twin	5 (71.4)	2 (28.6)	2.2 (1.93, 2.91)	<0.001	2.1 (1.03, 2.71)	0.001
Referral case						
Yes	53 (74.7)	18 (25.3)	1			
No	35 (70.0)	15 (30.0)	0.5 (0.42, 4.61)	0.783		
Number of ANC attendance						
≤3	23 (76.7)	7 (23.3)	1		1	
≥4	65 (71.4)	26 (28.6)	0.4 (0.05, 0.92)	0.002	0.6 (0.42, 0.94)	0.030
Maternal Hb level (g/dl)						
<11	23 (67.6)	11 (32.4)	2.3 (1.03, 2.97)	0.021	2.0 (1.12, 2.89)	0.001
≥11	65 (74.7)	22 (25.3)	1		1	
Amniotic fluid						
Stained	14 (70.0)	6 (30.0)	1			
Non stained	74 (73.3)	27 (26.7)	3.1 (0.74, 3.54)	0.632		
Duration of labor (hours)						
<20	82 (71.3)	33 (28.7)	1		1	
>20	6 (100.0)	0 (0.0)	1.6 (1.14, 3.24)	0.032	1.4 (0.39, 1.92)	0.328

Continued

Labor pain						
Augmented	5 (55.6)	4 (44.4)	1		1	
Spontaneous	83 (100.0)	29 (0.0)	1.3 (1.23, 2.61)	0.041	1.1 (0.67, 3.04)	0.327
Body mass index (kg/m²)						
<18.5	5 (100.0)	0 (0.0)	1			
18 - 24.9	31 (77.5)	9 (22.5)	1.3 (0.81, 1.84)	0.062		
>25	52 (68.4)	24 (31.6)	1.2 (0.47, 1.34)	0.085		
Presenting part						
Cephalic	77 (70.6)	32 (29.4)	1		1	
Non cephalic	11 (91.7)	1 (8.3)	1.4 (1.06, 2.84)	0.036	1.2 (0.99, 1.74)	0.059
Maternal fever history						
Yes	11 (78.6)	3 (21.4)	2.1 (1.34, 2.94)	0.023	1.9 (1.12, 3.04)	0.038
No	77 (72.0)	30 (28.0)	1		1	

*CRR: Crude relative risk, *ARR: Adjusted relative risk*Adjusted for maternal age, parity, mode of delivery, type of pregnancy, referral number of ANC attendance, maternal Hb level, amniotic fluid, duration of labor, labor pain, body mass index, presenting part and maternal fever.

4. Discussion

This study reported a 72.7% prevalence of HIE among neonates with birth asphyxia, with significant factors such as maternal age, fever, multiparity, ANC attendance, anemia, twin delivery, mode of delivery, gestational age of 37 - 39.9 weeks, birth weight less than 2500 g, and delayed admission (after 25 hours) identified as associated with HIE. The prevalence was lower than studies at Dodoma Regional Referral Hospital (96.05%) and KCMC Hospital in 2017 (93%), likely due to improved neonatal care interventions [8]. However, it was higher than the 5.1% prevalence observed in Latin America, reflecting differences in neonatal care practices, such as therapeutic hypothermia [2] [14].

This study highlights the need for improved preventive measures, particularly better antenatal care in low-resource settings, to reduce the risk of HIE. HIE severity was assessed using the Thompson score, classifying cases as mild, moderate, or severe. About 72.7% of neonates had HIE, with nearly half (49%) having moderate HIE, likely due to persistent hypoxia and acidosis that inhibit the respiratory center. These findings are consistent with a study from King Abdullah Children

Specialist Hospital, Saudi Arabia, but differ from studies at Dodoma Regional Referral Hospital and KCMC Hospital in Tanzania [8] [9].

This study highlights the need for early intervention to reduce HIE risk, with a 20% neonatal mortality rate, mainly due to severe HIE. The high mortality is linked to brain injury causing multi-organ failure. This contrasts with lower mortality rates in other studies, which used therapeutic cooling and advanced monitoring not available in this study [5] [7] [15]. Our mortality was 20% exceeded the 9.1% reported by earlier study done by Simiyu *et al*. at KCMC. Hospital, Tanzania [8], possibly due to extended follow-up time (28 days vs. 1 week) compared to Simiyu and colleagues. The study highlights the importance of advanced interventions, like cooling therapy, in reducing HIE-related mortality. It also found that severe HIE often leads to short hospital stays and poor long-term outcomes, with 7% of neonates showing poor suckling reflex at follow-up, emphasizing the need for ongoing care [11], male neonates in this study had a higher risk of HIE though it was not significant, this may be attributed to gender-specific variations in anti-inflammatory responses and neurogenesis. This finding was in consistent with findings at Dodoma Regional Referral Hospital, Tanzania, and St. Francis Hospital Nsambya, Uganda. However, this contrasts with results the earlier study conducted at KCMC Hospital, Tanzania [2] [8]. This difference can be explained by number of male neonates in this study being almost three times higher compared to female neonates (72.7% vs 27.3%) compared to the earlier study done in the same setting which had more female compared to male neonates [8]. Understanding gender-specific risks in HIE can help tailor interventions and improve outcomes for male neonates. The observed male predominance is likely influenced by the disproportionately higher number of male neonates in the present study (72.7%), in addition to possible sex-related biological differences in inflammatory response and neuroprotection. Additionally, neonates weighing less than 2500g were found to have a higher risk of HIE, consistent with findings from Henan Children Hospital, China [4]. This is in contrasts with, Dodoma RRH [11], Tanzania potentially due to presence of maternal illness and complications and hence higher risk of HIE. This findings emphasis on the importance of maintaining of good maternal health and hence better neonatal outcome. Neonates with a gestational age of 37 - 39.9 weeks had a higher risk of HIE, consistent with findings from King Abdullah Children Specialist Hospital, Riyadh, Saudi Arabia [9]. However, this contrasts with results from Henan Children Hospital, China [4]. This can be explained by the fact the lower the gestational age the higher the chance of incomplete formation of blood brain barrier hence more prone to ischemia and the immaturity of organ especially lungs hence increase the like hood of respiratory failure. Promoting full-term pregnancies and timely prenatal care can reduce HIE risk. Delayed admission (after 25 hours) was associated with a higher likelihood of HIE, possibly reflecting delays in accessing care and greater severity at presentation rather than causal effect, this emphasizing the need for early admis-

sion to improve neonatal outcomes [10]. Mothers with four or more ANC visits had a lower risk of neonates with HIE, similar to findings from Chris Hani Baragwaneth Academic Hospital, South Africa, but different from Jalabad Ragib Rabeya Medical Hospital, Bangladesh [6]. This may be due to reduced likelihood of home births and better reproductive health knowledge gained from ANC visits [16]. Adequate ANC visits are essential for improving maternal and neonatal health outcomes, requiring region-specific healthcare strategies. In this study, mothers delivering twins had a higher risk of HIE in their neonates, consistent with findings from Abha Maternity and Children Hospital, Saudi Arabia [4]. This contrasts with results from King Abdullah Children Specialist Hospital, Saudi Arabia [9]. The study emphasizes the need for targeted interventions and monitoring in twin pregnancies and anemic mothers to reduce HIE risk. Anemia leads to reduced oxygen delivery to the fetus, increasing the risk of brain damage and HIE, consistent with findings from Civil Hospital Karachi [16].

The study highlights the need to address low hemoglobin levels and the risks associated with multiparity to reduce HIE. Multiparous mothers face higher risks due to prolonged labor and placental complications, which can reduce oxygen supply to the neonate, contrasting with findings from Henan Children Hospital in China [14]. These findings highlight the need for enhanced prenatal care, labor management, and healthcare system readiness to better prevent and treat HIE, especially in multiparous women. Mothers who underwent cesarean section were at a higher risk of giving birth to neonates with hypoxic-ischemic encephalopathy (HIE), a finding consistent with studies from KCMC Hospital in Tanzania and St. Francis Hospital Nsambya in Uganda [2] [8]. This increased risk can be attributed to the late referrals of high-risk pregnancies and the necessity of performing emergency cesarean sections [6]. These findings highlight the need for vigilant monitoring and specialized care protocols during cesarean section to minimize the risk of HIE in newborns.

Mothers with a history of fever had a higher risk of giving birth to neonates with HIE. This higher risk is due to neonatal brain injury arising from inflammatory pathways triggered by maternal infection [16]. Providing targeted prenatal care and timely interventions may help reduce the negative effects of maternal fever on newborn health, leading to better neonatal outcomes.

5. Study Limitations

Nevertheless, our study does have some limitations. It was conducted in a single tertiary hospital which introduced referral bias and limit generalizability. Some analyzed subgroups had a small sample sizes hence limited statistical power. The existence of residual confounding particularly from emergency obstetric indications. The severity of HIE was assessed solely through clinical evaluation, which does not fully capture the extent of hypoxia, making it difficult to pinpoint the location and severity of brain injury. The absence of portable radiological equip-

ment such as x-rays, echocardiograms, and brain imaging for critically ill neonates with HIE hinders the confirmation of other potential malformations. Moreover, the inconsistency of Apgar scores undermines their reliability, prompting the use of patient history, physical examination, and specific lab investigations for diagnosis of asphyxia.

6. Conclusion

This study, conducted at KCMC, identified key factors associated with HIE, including maternal age, parity, anemia, and neonatal birth weight and gender. It found that 72.7% of neonates with birth asphyxia had HIE, with 20% mortality, mainly due to severe cases. The study recommends improving neonatal outcomes through increased ANC attendance, early anemia detection and treatment, better management of maternal fever, and tailored care for high-risk pregnancies, including early NICU admission for at-risk neonates.

Consent for Publications

Not applicable.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Clearance Number

PG 122/2023.

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Conflicts of Interest

The authors declare that they have no competing interests' in this section.

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