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Prevalence and factors associated with calcium disturbances among neonates admitted with nec at Lira regional referral hospital: A cross-sectional study.

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Abstract

Background:

Necrotizing enterocolitis (NEC) is a major cause of neonatal morbidity and mortality, particularly among preterm and low birth weight infants. Calcium disturbances, including hypocalcemia and hypercalcemia, are common complications in critically ill neonates and are associated with poor outcomes. However, there is limited data on calcium disturbances among neonates with NEC in Uganda.

Objective:

To determine the prevalence and factors associated with calcium disturbances among neonates admitted with necrotizing enterocolitis at Lira Regional Referral Hospital.

Methods:

A hospital-based analytical cross-sectional study was conducted among 151 neonates with NEC admitted between February and April 2025. Data were collected using a structured tool and analyzed using STATA version 14. Descriptive statistics were used to summarize variables. Bivariate analysis was performed to identify associated factors, and variables with $p < 0.2$ were included in multivariable logistic regression. Statistical significance was set at $p < 0.05$.

Results:

The prevalence of calcium disturbances was 15.9% (95% CI: 10.8%–22.7%)**.** In multivariable analysis, maternal corticosteroid use (AOR = 5.22, 95% CI: 1.10–24.79, p = 0.04) and neonatal convulsions (AOR = 7.08, 95% CI: 1.19–18.65, p = 0.02) were independently associated with hypocalcemia. For hypercalcemia, urban residence (AOR = 8.99, 95% CI: 1.63–49.53, p = 0.012)**,** maternal gestational hypertension (AOR = 6.90, 95% CI: 1.03–46.13, p = 0.046), and neonatal fever (AOR = 17.49, 95% CI: 2.32–24.89, p < 0.001) were significant predictors.

Conclusion:

Calcium disturbances are common among neonates with NEC and are associated with both maternal and neonatal factors.

Recommendation:

Neonates admitted with NEC should undergo routine serum calcium assessment for early detection and timely correction of calcium disturbances.

Keywords*: Necrotizing enterocolitis, hypocalcemia, hypercalceemia, neonates, electrolyte imbalance, Uganda.*
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BACKGROUND

Necrotizing enterocolitis (NEC) is one of the most serious gastrointestinal emergencies in neonates, predominantly affecting preterm and low birth weight infants. It is characterized by intestinal inflammation, ischemia, and necrosis, and is associated with high morbidity and mortality rates ranging from 20% to 50%. Globally, the incidence of NEC is estimated at 1–3 per 1,000 live births and increases significantly among very low birth weight infants. Electrolyte disturbances are common in neonates with critical illnesses such as NEC due to fluid shifts, intestinal losses, sepsis, and organ dysfunction. Studies report that electrolyte abnormalities such as hyponatremia, hyperkalemia, and hypocalcemia occur frequently and are associated with increased disease severity and poor outcomes. Understanding the prevalence and patterns of these disturbances is essential for improving neonatal survival. (1).

In Africa, neonatal morbidity and mortality remain high, with NEC contributing significantly to neonatal deaths, particularly in resource-limited settings. Studies indicate that electrolyte disturbances are highly prevalent among hospitalized neonates, especially those with sepsis and gastrointestinal conditions. For example, studies in African neonatal units have reported electrolyte abnormalities in up to 40–70% of critically ill neonates. Factors such as prematurity, low birth weight, delayed presentation, infections, and limited access to advanced neonatal care contribute to both NEC and electrolyte imbalance. However, there is limited data specifically focusing on electrolyte disturbances among neonates with NEC in many African settings.(2).

In East Africa, including countries such as Kenya, Tanzania, and Uganda, neonatal intensive care units frequently manage preterm infants at high risk of NEC and metabolic complications. Studies in the region have shown that electrolyte disturbances are common among hospitalized neonates, particularly those with sepsis and prematurity. For instance, research in Tanzania demonstrated a high prevalence of electrolyte abnormalities, including hyponatremia and hyperkalemia, among neonates with severe illness. Identified associated factors include prematurity, low birth weight, perinatal asphyxia, sepsis, and inappropriate fluid management. Despite this, few studies have specifically examined electrolyte disturbances in neonates with NEC, highlighting a significant regional knowledge gap.(3).

In Uganda, neonatal conditions such as prematurity, sepsis, and birth asphyxia remain leading causes of neonatal admissions and mortality. NEC is increasingly recognized in neonatal units, particularly among preterm infants, though it is often underreported. Studies in Ugandan hospitals have documented a high burden of electrolyte disturbances among neonates, especially those with severe infections and critical illness. Common abnormalities include hyponatremia, hyperkalemia, and hypocalcemia, which are associated with poor clinical outcomes. Factors such as low birth weight, sepsis, inadequate monitoring, and limited laboratory support contribute to these disturbances. However, there is a lack of specific data on the prevalence, patterns, and associated factors of calcium disturbances among neonates with NEC in Uganda, including Lira Regional Referral Hospital. This gap limits evidence-based management and underscores the need for this study.(4).

Study Objectives

1. To determine the prevalence of calcium disturbances among neonates admitted with necrotizing enterocolitis at Lira Regional Referral Hospital.
2. To identify factors associated with calcium disturbances among neonates with NEC

METHODOLOGY

Study design

This study was a hospital-based cross-sectional analytical study.

Study setting and study duration

The study was conducted at Lira Regional Referral Hospital, located in Lira City in the Northern Region of Uganda. The hospital is one of the regional referral hospitals in the country and serves as a major referral center for an estimated population of over 2 million people in the Lango sub-region, covering districts such as Lira, Apac, Oyam, Kole, Kwania, Otuke, Alebtong, Amolatar, and Dokolo**.**

The hospital provides a wide range of general and specialized healthcare services, including pediatrics, obstetrics and gynecology, internal medicine, surgery, and neonatal care. The study specifically focused on the Neonatal Unit of Lira Regional Referral Hospital, which admits a high number of critically ill neonates with conditions such as prematurity, birth asphyxia, neonatal sepsis, and necrotizing enterocolitis (NEC). The unit receives a substantial number of neonatal admissions annually, providing an appropriate setting for studying electrolyte disturbances among neonates with NEC.

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The study utilized a hospital-based analytical cross-sectional design and was conducted among neonates admitted between 1/Febuary/ 2025 TO 1/MAY/2025.

Operational Definitions

1. **Necrotizing Enterocolitis (NEC)**

Neonates diagnosed with NEC based on clinical features (abdominal distension, feeding intolerance, bloody stools) and/or radiological findings **(**e.g., pneumatosis intestinalis, intestinal perforation) as documented in the patient file, using modified Bell's staging criteria.

2. **Calcium Disturbance**

Any abnormal serum sodium level measured during admission, defined as:
Hypocalcemia**:** Serum calcium < 2.0 mmol/L (8 mg/dL And
Hypercalcemia**:** Serum calcium > 2.75 mmol/L (11 mg/dL)

Consecutive Sampling

was used, where all eligible neonates admitted during the study period were enrolled until the required sample size was achieved. Information bias was minimized through the use of a standardized, structured data collection tool and trained research assistants. Data quality was enhanced through daily supervision, cross-checking for completeness, and the use of routinely generated laboratory results from accredited hospital laboratories. Confounding was addressed during multivariable logistic regression analysis.

Study population

The study population consisted of all neonates aged 0–28 completed days admitted with necrotizing enterocolitis (NEC) to the neonatal unit of Lira Regional Referral Hospital during the study period. Neonates will be included if the diagnosis of NEC is based on clinical features such as abdominal distension, feeding intolerance, or bloody stools and/or supported by radiological findings as documented in the patient's medical records.

Exclusion Criteria

Neonates with incomplete medical records, those without documented serum calcium results, and neonates whose parents or guardians declined consent were excluded from the study.

Sample size

For objective one, Daniel's formula has been used to determine the sample size.

$$n = \frac{z^2 pq}{d^2}$$

Using findings by (5) who reported that hypocalcemia was found in 19 (11.0%) of the neonates diagnosed with NEC, P=0.11, d=0.05, and Z=1.96 for 95% level of significance. Substituting, n=151.
Taking the bigger sample size, the sample size required was 151.

Statistical Analysis

Data were entered into EpiData version 3.1 and exported to STATA version 14.0 for analysis. Data cleaning was performed to check for completeness, consistency, and outliers.
Descriptive statistics were used to summarize the data. Continuous variables such as age and serum calcium levels were summarized using means (± standard deviation) or medians (interquartile range**),** depending on data distribution. Categorical variables such as sex, prematurity, and calcium disturbances were summarized using frequencies and percentages**.**
The prevalence of calcium disturbances was calculated as the proportion of neonates with either hypocalcemia or hypercalcemia among all neonates with necrotizing enterocolitis.
Bivariate analysis was performed using the Chi-square test for variables. Variables with a p-value < 0.2 at bivariate analysis were considered for multivariable analysis.
Multivariable analysis was conducted using logistic regression to identify factors independently associated with calcium disturbances. Results were presented as crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI)**. A** p-value < 0.05 was considered statistically significant.

Model Building

Variables with a p-value < 0.2 at bivariate analysis were selected as candidates for multivariable analysis. These variables were entered into a multivariable logistic regression model to identify factors independently associated with calcium disturbances.
A stepwise backward elimination approach was used, where variables were sequentially removed based on statistical significance while assessing their effect on the model. Variables with a **p-value < 0.05** were retained in the final model.
Confounding was assessed by observing changes in the estimates of the main associations; a variable was considered a confounder if its removal caused a ≥10% change in the odds ratio of other variables. Potential interaction between variables was assessed by including interaction terms where biologically plausible.

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Model fitness was assessed using the Hosmer–Lemeshow goodness-of-fit test, and multicollinearity was checked using the variance inflation factor (VIF). Only variables meeting model assumptions were retained in the final model.

Sampling technique and Recruitment procedure

A consecutive sampling technique was used to recruit study participants. All eligible neonates aged 0–28 days admitted with necrotizing enterocolitis (NEC) to the neonatal unit of Lira Regional Referral Hospital during the study period were consecutively enrolled until the required sample size was attained.

Recruitment was conducted by the principal investigator and trained research assistants. Neonates were screened daily in the neonatal unit to identify those who met the inclusion criteria. Parents or legal guardians of eligible neonates were approached, and the study was explained to them in detail. Written informed consent was obtained before enrollment.

After obtaining consent, relevant clinical and laboratory information, including serum calcium levels, was collected from the patient's medical records and through direct assessment where necessary.

Study procedure

Neonates admitted to the neonatal unit of Lira Regional Referral Hospital were screened daily for eligibility based on the diagnosis of necrotizing enterocolitis (NEC). Eligible neonates were identified using clinical and/or radiological findings as documented in the patient's medical records.

Parents or legal guardians of eligible neonates were approached, and the purpose, procedures, risks, and benefits of the study were explained. Written informed consent was obtained before enrollment.

Following enrollment, data were collected using a structured data collection tool. Sociodemographic and clinical information, including gestational age, birth weight, feeding history, presence of sepsis, and other relevant variables, were obtained from patient medical records and caregiver interviews where necessary.

Blood samples for serum calcium measurement were obtained as part of routine clinical care. The calcium levels were recorded from laboratory results and categorized as normal, hypocalcemia, or hypercalcemia based on predefined criteria.

Participants were followed during their hospital stay to ensure complete data collection. All collected data were checked daily for completeness and accuracy before entry into the database.

Validity of data collection instruments

The data collection tool was developed after an extensive review of relevant literature and similar studies on neonatal electrolyte disturbances and necrotizing enterocolitis. To ensure content validity, the tool was reviewed by supervisors and experts in pediatrics and research methodology to assess its relevance, clarity, and completeness in capturing all study variables.

The tool was then pretested (piloted) on a small sample of neonates with similar characteristics at a health facility comparable to Lira Regional Referral Hospital but not included in the study. Feedback from the pretest was used to refine the tool by correcting ambiguities, improving wording, and ensuring all necessary variables were included.

Additionally, standard definitions and measurement criteria (e.g., sodium levels, NEC diagnosis) were used to ensure consistency and accuracy of data collected. Only routinely generated laboratory results from accredited hospital laboratories were used, which further enhanced the validity of measurements.

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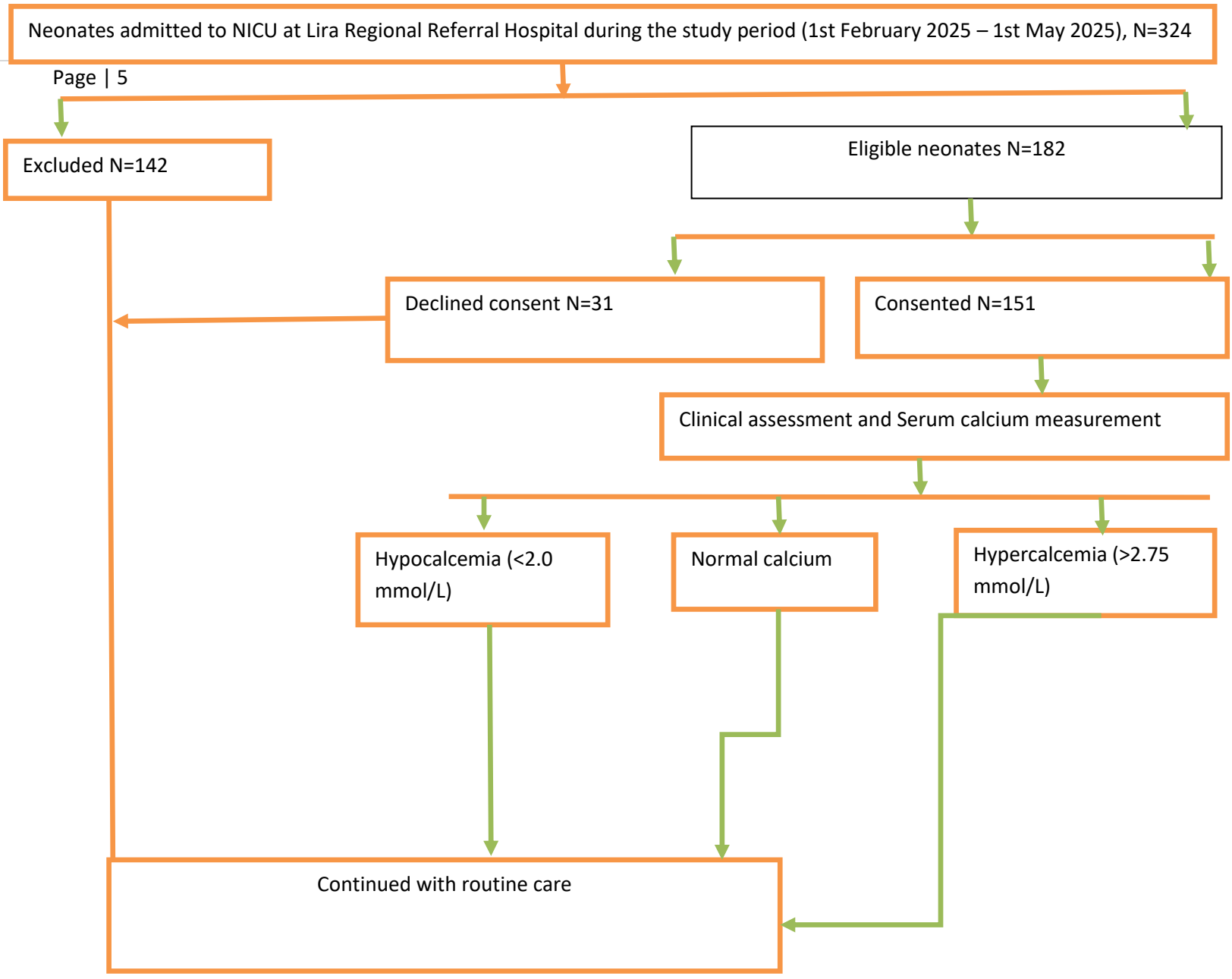
RESULT PRESENTATION

Follow chart



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Socio-demographic characteristics of study participants

The majority of the study participants, 42.4% (64/151), were aged 12-24 years, 58.3% (88/151) were female, and 81.5% (123/151) resided in rural areas. Additionally, 88.7% (134/151) of the mothers stopped in primary or below, and 66.2% (100/151) are unemployed. Furthermore, 58.9% (89/151) had a birth weight of 1600g to 2500g

Medical characteristics of study participants

Medical characteristics of the neonates

Regarding the medical characteristics of neonates admitted with necrotizing enterocolitis, 3.3% (5/151) had an altered level of consciousness, and 4.0% (6/151) presented with convulsions**.** Additionally, 29.3% (44/151) had a 5th-minute Apgar score of less than 7, while 6.6% (10/151) had excessive sweating**.** Among preterm neonates, 13.2% (20/151) had hypothermia**,** and 11.9% (18/151) were irritable**.** The majority, 87.4% (132/151)**,** presented with difficulty in breathing. Furthermore, 37.8% (57/151) had a gestational age of less than 28 weeks, and 7.9% (12/151) had neonatal fever**.**

Medical characteristics of the mothers

Regarding the maternal medical characteristics of neonates admitted with necrotizing enterocolitis, 7.3% (11/151) of the mothers reported having received corticosteroids during pregnancy**,** 56.3% (85/151) had maternal diabetes, and 28.5% (43/151) had gestational hypertension or higher. Additionally, 7.3% (11/151) of the deliveries were conducted by cesarean section**.**

Prevalence of dyscalcemia among neonates admitted to the NEC in NICU at Lira Regional Referral Hospital.

Prevalence of dyscalcemia was 15.9% with a 95% confidence interval of 10.8%-22.7% (Figure 1).

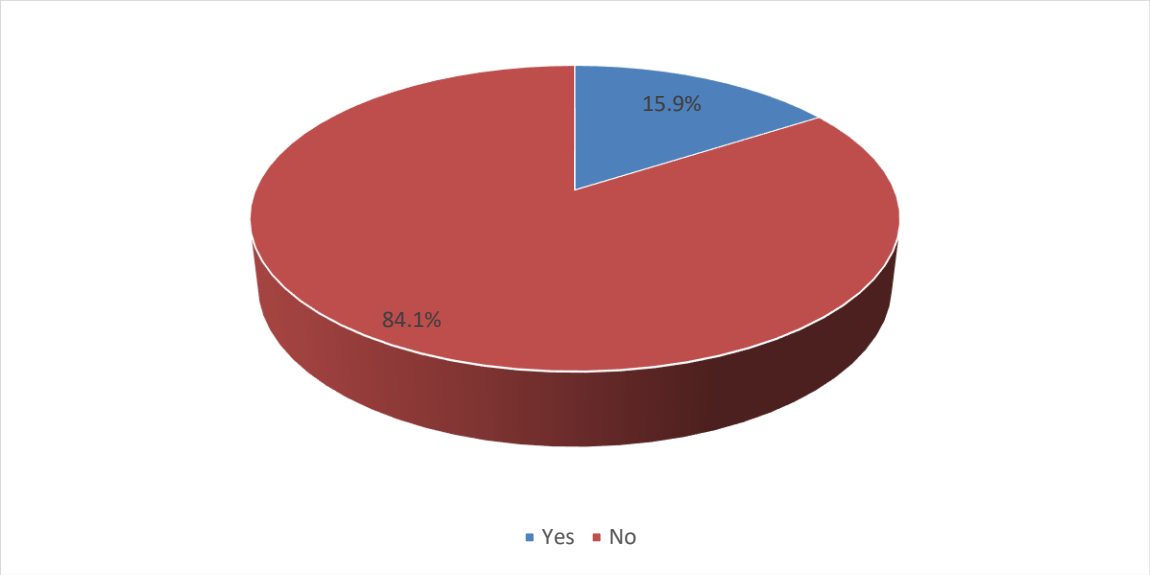

Figure 1: Prevalence of dyscalcemia among neonates admitted to the NEC in the NICU

Bivariate Analysis of Neonatal Factors Associated with Hypocalcemia among Neonates with Necrotizing Enterocolitis

Regarding the bivariate analysis of neonatal factors, convulsions were strongly associated with hypocalcemia, with affected neonates having a markedly higher likelihood of hypocalcemia **(**COR = 10.15, 95% CI: 1.86–55.51, p = 0.007**)**. Neonates who had hypothermia were also more likely to experience hypocalcemia **(**COR = 3.64, 95% CI: 1.11–11.90, p = 0.03**).** Neonatal irritability showed a borderline association with hypocalcemia **(**COR = 2.88, 95% CI: 0.82–10.15, p = 0.10**)** (Table 1).

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Table 1 Bivariate Analysis of Neonatal Factors Associated with Hypocalcemia among Neonates with Necrotizing Enterocolitis

Variable	Hypocalcemia		COR(95% CI)	P-value
	No 135(89.4%)	Yes 16(10.6%)		
Age (hrs)				
<12	41(87.2)	6(12.8)	1.41(0.43-4.69)	0.57
12-24	58(90.6)	6(9.4)	Ref	
>24	36(90.0)	4(10.0)	1.07(0.28-4.07)	0.92
Sex				
Female	77(87.5)	11(12.5)	1.66(0.55-5.03)	0.37
Male	58(92.1)	5(7.9)	Ref	
Neonatal birth weight				
<1.0kg	19(79.2)	5(20.8)	4.42(0.54-9.21)	0.51
1.0-1.5kg	32(84.2)	6(15.8)	3.15(0.61-7.69)	0.28
1.6-2.5kg	84(94.4)	5(5.6)	Ref	
Neonatal altered consciousness				
No	131(89.7)	15(10.3)		
Yes	4(80.0)	1(20.0)	2.18(0.23-20.83)	0.50
Neonatal convulsions				
No	132(91.0)	13(9.0)		
Yes	3(50.0)	3(50.0)	10.15(1.86-55.51)	0.007*
Neonatal 5th minute APGAR				
<7	39(88.6)	5(11.4)	1.12(0.36-3.43)	0.84
≥7	96(89.7)	11(10.3)	Ref	
Excessive sweating				
No	127(90.1)	14(9.9)		
Yes	8(80.0)	2(20.0)	2.27(0.44-11.75)	0.33
Neonatal hypothermia				
No	120(91.6)	11(8.4)		
Yes	15(75.0)	5(25.0)	3.64(1.11-11.90)	0.03*
Baby irritable				
No	121(91.0)	12(9.0)		
Yes	14(77.8)	4(22.2)	2.88(0.82-10.15)	0.10*
Gestational age at delivery				
<28 weeks	47(82.5)	10(17.5)	3.78(0.62-9.17)	0.29
28-33	17(89.5)	2(10.5)	2.09(0.54-7.63)	0.37
34-36 weeks	71(94.7)	4(5.3)	Ref	
Neonatal fever				
No	125(89.9)	14(10.1)	Ref	
Yes	10(83.3)	2(16.7)	1.79(0.35-8.98)	0.48

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Regarding the bivariate analysis of maternal factors, maternal factors showed an association with hypocalcemia among neonates with necrotizing enterocolitis**.** Neonates whose mothers received corticosteroids during pregnancy were significantly more likely to have hypocalcemia (COR = 6.10, 95% CI: 1.56–23.83, p = 0.009) compared to those whose mothers did not. Maternal gestational diabetes also demonstrated a weak association with hypocalcemia (COR = 3.45, 95% CI: 0.79–8.42, p = 0.12) (Table 2).

Table 2: Bivariate Analysis of Maternal Factors Associated with Hypocalcemia in Neonates with NEC

Variable	Hypocalcemia		COR(95% CI)	P-value
	No 135(89.4%)	Yes 16(10.6%)		
Residence				
Rural	111(90.2)	12(9.8)	Ref	
Urban	24(85.7)	4(14.3)	1.54(0.46-5.19)	0.49
Mother's education level				
≤ Primary	119(88.9)	15(11.1)	2.02(0.24-5.53)	0.87
≥Secondary	16(94.1)	1(5.9)	Ref	
Occupation				
Unemployment	89(89.0)	11(11.0)	1.14(0.37-3.47)	0.82
Employment	46(90.2)	5(9.8)	Ref	
Received corticosteroids in pregnancy				
No	128(91.4)	12(8.6)		
Yes	7(63.6)	4(36.4)	6.10(1.56-23.83)	0.009*
Maternal gestational diabetes				
No	115(92.0)	10(8.0)	Ref	
Yes	20(76.9)	6(23.1)	3.45(0.79-8.42)	0.12*
Gestational hypertension				
No	97(89.8)	11(10.2)	Ref	
Yes	38(88.4)	5(11.6)	1.16(0.38-3.56)	0.79
Type of delivery				
CS	9(81.8)	2(18.2)	2.17(0.39-10.19)	0.40
Vaginal	126(90.0)	14(10.0)	Ref	

Bivariate Analysis of Neonatal Factors Associated with Hypercalcemia among Neonates with Necrotizing Enterocolitis

Regarding the bivariate analysis, neonates aged more than 24 hours had a higher likelihood of developing hypercalcemia compared to those aged 12–24 hours **(**COR = 3.44; 95% CI: 0.60–19.74, p = 0.17**).** Additionally, neonatal fever was significantly associated with increased odds of hypercalcemia (COR = 8.93; 95% CI: 1.84–43.48, p = 0.007) (Table 3).

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Table 3 Bivariate Analysis of Neonatal Factors Associated with Hypercalcemia among Neonates with Necrotizing Enterocolitis

Variable	Hypercalcemia		COR(95% CI)	P-value
	No 143(94.7%)	Yes 8(5.3%)		
Age (hrs)				
<12	45(95.7)	2(4.3)	1.38(0.19-10.15)	0.75
12-24	62(96.9)	2(3.1)	Ref	
>24	36(90.0)	4(10.0)	3.44(0.60-19.74)	0.17*
Sex				
Female	83(94.3)	5(5.7)	Ref	
Male	60(95.2)	3(4.8)	1.20(0.28-5.24)	0.80
Neonatal birthweight				
<1.0kg	20(83.3)	4(16.7)	8.70(0.74-13.76)	0.54
1.0-1.5kg	36(94.7)	2(5.3)	2.42(0.28-7.10)	0.29
1.6-2.5kg	87(97.8)	2(2.2)	Ref	
Neonatal altered consciousness				
No	138(95.2)	7(4.8)	Ref	
Yes	5(83.3)	1(16.7)	3.94(0.40-38.45)	0.24
Neonatal convulsions				
No	137(95.1)	7(4.9)	Ref	
Yes	6(85.7)	1(14.3)	3.26(0.34-30.92)	0.30
Neonatal 5th minute APGAR				
<7	42(95.5)	2(4.5)	Ref	
≥7	101(94.4)	6(5.6)	1.25(0.24-6.43)	0.79
Excessive sweating				
No	133(95.0)	7(5.0)	Ref	
Yes	10(90.9)	1(9.1)	1.90(0.21-17.00)	0.57
Neonatal hypothermia				
No	123(94.6)	7(5.4)	1.14(0.13-9.75)	0.91
Yes	20(95.2)	1(4.8)	Ref	
Baby irritable				
No	126(94.7)	7(5.3)	Ref	
Yes	17(94.4)	1(5.6)	1.06(0.12-9.14)	0.96
Maternal gestational diabetes				
No	119(95.2)	6(4.8)	Ref	
Yes	24(92.3)	2(7.7)	1.65(0.47-12.45)	0.29
Gestational age at delivery				
<28 weeks	53(93.0)	4(7.0)	2.75(0.51-5.91)	0.29
28-33	17(89.5)	2(10.5)	4.29(0.65-8.80)	0.58
34-36 weeks	73(97.3)	2(2.7)	Ref	
Neonatal fever				
No	134(96.4)	5(3.6)	Ref	
Yes	9(75.0)	3(25.0)	8.93(1.84-43.48)	0.007*

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Regarding the bivariate analysis of maternal factors, residence was significantly associated with hypercalcemia**,** with neonates whose mothers resided in urban areas having higher odds of hypercalcemia compared to those from rural areas **(**COR = 8.70; 95% CI: 1.94–38.94, p = 0.005**).** Additionally, neonates born to mothers with hypertension had higher odds of hypernatremia compared to those born to normotensive mothers **(**COR = 4.61; 95% CI: 1.05–20.20, p = 0.043**).** Gestational hypertension also showed a borderline association with hypercalcemia (Table 4).

Table 4: Bivariate Analysis of Maternal Factors Associated with Hypercalcemia among Neonates with Necrotizing Enterocolitis.

Variable	Hypercalcemia		COR(95% CI)	P-value
	No 143(94.7%)	Yes 8(5.3%)		
Residence				
Rural	120(97.6)	3(2.4)	Ref	
Urban	23(82.1)	5(17.9)	8.70(1.94-38.94)	0.005*
Mother's education level				
≤Primary	127(94.8)	7(5.2)	Ref	
≥Secondary	16(94.1)	1(5.9)	1.13(0.76-6.59)	0.46
Occupation				
Unemployment	94(94.0)	6(6.0)	1.56(0.30-8.04)	0.59
Employment	49(96.1)	2(3.9)	Ref	
Experienced corticosteroids in pregnancy				
No	133(95.0)	7(5.0)		
Yes	10(90.9)	1(9.1)	1.90(0.21-17.00)	0.57
Gestational hypertension				
No	105(97.2)	3(2.8)	Ref	
Yes	38(88.4)	5(11.6)	4.61(1.05-20.20)	0.043*
Type of delivery				
CS	11(91.7)	1(8.3)	1.71(0.19-15.22)	0.63
Vaginal	132(95.0)	7(5.0)	Ref	

Multivariate Analysis of Neonatal Factors Associated with Hypocalcemia among Neonates with Necrotizing Enterocolitis

After adjusting for potential confounders, two factors remained significantly associated with hypocalcemia among neonates with necrotizing enterocolitis. Neonates whose mothers received corticosteroids during pregnancy were over five times more likely to have hypocalcemia compared to those whose mothers did not receive corticosteroids (AOR = 5.22, 95% CI: 1.10–24.79, p = 0.04). In addition, neonates who experienced convulsions had a significantly higher likelihood of hypocalcemia, with a sevenfold increase in odds compared to those without convulsions (AOR = 7.08, 95% CI: 1.19–18.65, p = 0.02) (Table 5).

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Table 5 Multivariate Analysis of Neonatal Factors Associated with Hypocalcemia among Neonates with Necrotizing Enterocolitis

Variable	COR(95% CI)	P-value	AOR(95%CI)	P-value
Received corticosteroids in pregnancy				
No	Ref		Ref	
Yes	6.10(1.56-23.83)	0.009*	5.22(1.10-24.79)	0.04*
Neonatal convulsions				
No	Ref		Ref	
Yes	10.15(1.86-55.51)	0.007*	7.08(1.19-18.65)	0.02*
Neonatal hypothermia				
No	Ref		Ref	
Yes	3.64(1.11-11.90)	0.03*	1.33(0.25-7.11)	0.74
Baby irritable				
No	Ref		Ref	
Yes	2.88(0.82-10.15)	0.10*	1.07(0.19-6.20)	0.94
Maternal gestational diabetes				
No	Ref		Ref	
Yes	3.45(0.79-8.42)	0.12*	2.08(0.60-7.21)	0.25

**Statistically significant, p<0.05*

Multivariate Analysis of Factors Associated with Hypercalcemia among Neonates with Necrotizing Enterocolitis

In the multivariate analysis, three factors remained independently associated with hypercalcemia among neonates with necrotizing enterocolitis. Neonates whose parents resided in urban areas had significantly higher odds of developing hypercalcemia compared to those from rural residences (AOR = 8.99, 95% CI: 1.63–49.53, p = 0.012). Similarly, neonates born to mothers with gestational hypertension were more likely to experience hypercalcemia than those born to normotensive mothers (AOR = 6.90, 95% CI: 1.03–46.13, p = 0.046). Additionally, neonatal fever emerged as a strong independent predictor, with febrile neonates having a markedly increased likelihood of hypercalcemia (AOR = 17.49, 95% CI: 2.32–24.89, p < 0.001) (Table 6).

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Table 6: Multivariate Analysis of Factors Associated with Hypercalcemia among Neonates with Necrotizing Enterocolitis

Variable	COR(95% CI)	P-value	AOR(95% CI)	P-value
Age (hrs)				
<12	1.38(0.19-10.15)	0.75	2.02(0.23-17.87)	0.53
12-24	Ref		Ref	
>24	3.44(0.60-19.74)	0.17*	5.30(0.68-41.12)	0.11
Residence				
Rural	Ref		Ref	
Urban	8.70(1.94-38.94)	0.005*	8.99(1.63-49.53)	0.012*
Gestational hypertension				
No	Ref		Ref	
Yes	4.61(1.05-20.20)	0.043*	6.90(1.03-46.13)	0.046*
Neonatal fever				
No	Ref			
Yes	8.93(1.84-43.48)	0.007*	17.49(2.32-24.89)	<0.001*

Statistically significant, P<0.05

Discussion

Overview of the Study

This study determined the prevalence and factors associated with calcium disturbances (hypocalcemia and hypercalcemia**)** among neonates admitted with necrotizing enterocolitis (NEC) at Lira Regional Referral Hospital. The findings demonstrate that calcium disturbances are common in neonates with NEC and are associated with both neonatal and maternal factors.

Prevalence of Sodium Disturbances

The study found a substantial prevalence of calcium disturbances among neonates with NEC, indicating that electrolyte imbalance is a frequent complication in this population. This finding is consistent with global evidence showing that critically ill neonates, particularly those with gastrointestinal pathology such as NEC, are highly prone to electrolyte abnormalities due to intestinal inflammation, third spacing of fluids, and systemic illness. Similar findings have been reported in studies where hypocalcemia was the most common electrolyte disturbance among neonates with severe illness.(6).

The high prevalence observed in this study may be attributed to the severity of illness among neonates with NEC, delayed presentation, and challenges in fluid and electrolyte monitoring in resource-limited settings. In addition, ongoing intestinal losses and sepsis-related fluid shifts may further contribute to calcium imbalance.

Factors Associated with Hypocalcemia

This study found that maternal corticosteroid use during pregnancy and neonatal convulsions were independently associated with hypocalcemia.

Neonates whose mothers received corticosteroids were more likely to develop hypocalcemia. This may be explained by the effects of corticosteroids on fetal fluid and electrolyte balance, as well as their association with prematurity, which itself predisposes neonates to electrolyte instability. Similar associations have been suggested in studies evaluating metabolic complications in preterm neonates.(7).

Neonatal convulsions were also significantly associated with hypocalcemia. This relationship may be bidirectional, as hypocalcemia can precipitate seizures, while severe illness associated with convulsions can disrupt sodium balance. This finding aligns with established pediatric evidence that electrolyte disturbances, particularly hypocalcemia, are a known cause of neonatal seizures. (8).

Factors Associated with Hypercalcemia

The study also identified urban residence, maternal gestational hypertension, and neonatal fever as independent factors associated with hypercalcemia.

Neonates from urban settings were more likely to develop hypercalcemia, possibly reflecting differences in feeding practices, delayed healthcare seeking, or variations in fluid management. Although this finding is not consistently

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reported in the literature, it may reflect contextual factors specific to the study setting.

Maternal gestational hypertension was significantly associated with hypercalcemia. This may be due to placental insufficiency and intrauterine stress, which can affect neonatal fluid balance and renal function. Similar associations between maternal hypertensive disorders and neonatal complications have been documented in previous studies. (9).

Neonatal fever was a strong predictor of hypercalcemia, likely due to increased insensible fluid loss and dehydration. This is consistent with existing evidence that febrile neonates are at higher risk of developing hypercalcemia due to fluid imbalance.(10).

Conclusion

Calcium disturbances are common among neonates admitted with necrotizing enterocolitis and represent an important clinical problem in this population. Both hypocalcemia and hypercalcemia were identified, reflecting the complex fluid and electrolyte imbalances associated with severe neonatal illness.

This study found that maternal corticosteroid use and neonatal convulsions were independently associated with hypocalcemia, while urban residence, maternal gestational hypertension, and neonatal fever were significantly associated with hypercalcemia. These findings highlight the multifactorial nature of Calcium disturbances involving both maternal and neonatal factors.

Early identification and appropriate management of sodium disturbances are essential to improve outcomes among neonates with necrotizing enterocolitis. Strengthening routine electrolyte monitoring and targeted clinical interventions is therefore critical in neonatal care settings.

Limitation of the study

This study had several limitations. First, the cross-sectional design limited the ability to establish a causal relationship between identified factors and calcium disturbances; only associations could be determined. Second, the study relied on routine clinical and laboratory records, which may have been subject to incomplete documentation or measurement variability, potentially affecting data accuracy. Third, serum calcium measurements were taken as part of routine care, and variations in the timing of sample collection could have influenced the results.

Additionally, the study was conducted in a single hospital setting (Lira Regional Referral Hospital), which may limit the generalizability of the findings to other settings. Some potential confounders, such as detailed fluid management practices and nutritional intake, may not have been fully captured. Finally, the sample size may have limited the statistical power to detect associations for some variables, especially those with low frequency.

Recommendations

At the clinical practice level, routine monitoring of serum calcium levels should be implemented for all neonates admitted with necrotizing enterocolitis to enable early detection of hypocalcemia and hypercalcemia. Healthcare providers should ensure appropriate fluid and electrolyte management tailored to the clinical condition of each neonate. Neonates presenting with risk factors such as convulsions, fever, or maternal corticosteroid exposure should be closely monitored for calcium disturbances. In addition, continuous training of healthcare workers in neonatal electrolyte management should be strengthened to improve early recognition and timely intervention.

At the health system level, health facilities should be equipped with reliable laboratory services to ensure timely and accurate electrolyte testing. There is a need to strengthen neonatal care units through adequate staffing, essential equipment, and the availability of supplies to support proper monitoring and management of critically ill neonates. Standardized clinical guidelines and protocols for the management of electrolyte disturbances in neonates with necrotizing enterocolitis should be developed and implemented across healthcare facilities. Furthermore, improving record-keeping and data management systems is essential to enhance the completeness and accuracy of clinical and laboratory information.

At the policy level, the Ministry of Health should integrate routine electrolyte monitoring into national neonatal care guidelines, particularly for high-risk conditions such as necrotizing enterocolitis. Policies should also support capacity building and continuous professional development of healthcare workers in neonatal intensive care. Increased resource allocation is needed to strengthen neonatal services, especially in regional referral hospitals. Additionally, further multicenter research should be encouraged to generate broader evidence on calcium disturbances among neonates in Uganda and similar settings.

Declarations

Ethical Approval and Consent to Participate

Ethical clearance for this study was obtained from the Research Ethics Committee of Lira Regional Referral

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Hospital University (Ref No: LRRH-2021-05). Written informed consent was obtained from all participants before enrollment.

Consent For Publication

All participants provided written informed consent for the publication of this study, parents, and any accompanying data.

Data Availability

The datasets generated and analyzed during the study are available from the corresponding author upon reasonable request.

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Authors' Contributions

AHM conceived and designed the study, collected and analyzed data, and drafted the manuscript. DJMM, AAO, MAA, and MOA contributed to data collection and validation. MJ provided supervision, critical revisions, and methodological guidance. MAH assisted with visualization and manuscript editing. ZAA, SAM, NOM, and AHM performed statistical analysis and data visualization. All authors reviewed and approved the final manuscript.

Competing Interests

The authors declare that they have no competing interests.

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List of Abbreviations

Abbreviation	Meaning
NEC	Necrotizing Enterocolitis
NICU	Neonatal Intensive Care Unit
AOR	Adjusted Odds Ratio
COR	Crude Odds Ratio
CI	Confidence Interval
KIU	Kampala International University
REC	Research Ethics Committee
STATA	Statistical Software for Data Analysis

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this study.

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