Original Article

# Predictors of hypocalcemia among children admitted in the Emergency Pediatric Unit of the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria

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## ABSTRACT

**الأهداف**: تحديد مدى انتشار ونمط نقص السكر في الدم بين الأطفال في وحدة طوارئ الأطفال (EPU) في مستشفى جامعة مايدوجوري التعليمي، مايدوجوري، نيجيريا.

**المنهجية**: أجريت دراسة مقطعية خلال الفترة من فبراير وسبتمبر 2020م. وقياس نسبة الجلوكوز في الدم، إلى جانب الاختبارات الأخرى ذات الصلة، لكل مريض عند دخوله إلى وحدة EPU باستخدام مقياس السكر في الدم في نقطة الرعاية (ACCU-CHEK مع شرائط).

**النتائج**: من بين 340 طفلاً تم اختيارهم للدراسة، كان 54 مريضاً يعانون من نقص السكر في الدم (أقل من 2.2 مليمول/لتر)، مما أعطى معدل انتشار قدره 15.9%. كان ستة وثلاثون (66.7%) من الأطفال الذين يعانون من نقص السكر في الدم تحت سن 5 سنوات (نسبة الأرجحية: 6.218 [1.077–35.912]، قيمة الاحتمال=0.041) و26 (48.1%) كانوا يعانون من نقص الوزن الشديد (نسبة الأرجحية: 3.692 [1.266–10.971]، p=0.017). عوامل مثل عدم تناول الطعام لمدة 16 ساعة على الأقل، والضعف، والغيبوبة في العرض، كلها عوامل متوقعة بشكل مستقل لنقص السكر في الدم (نسبة الأرجحية: 5.696 [1.768–18.352]، 6.556 [1.730–24.850]، 9.479 [3.092–29.059]، 0.001>، 0.006 and p=0.004، على التوالي. وارتبطت الملاريا الوخيمة أيضًا بشكل مستقل بنقص السكر في الدم (نسبة الأرجحية: 2.720 [0.554–13.365]، قيمة الاحتمال = 0.021).

**الخلاصة**: نقص السكر في الدم هو أمر شائع بين الأطفال المقبولين في وحدة EPU. قمنا بتحديد عوامل مثل العمر أقل من خمس سنوات، في غيبوبة، والضعف، والملاريا الشديدة، والصيام لفترات طويلة، جميعها تنبئ مستقل بنقص السكر في الدم. ولذلك، يوصى بالمراقبة الروتينية لمستوى السكر في الدم لدى الأطفال المقبولين في وحدة EPU، وخاصة أولئك الأكثر عرضة للخطر.

**Objectives:** To determine the prevalence and pattern of hypoglycemia among children admitted to the Emergency Pediatric Unit (EPU) at the University of Maiduguri Teaching Hospital, Maiduguri, Nigeria.

**Methods:** A cross-sectional study was conducted between February and September 2020. Blood glucose, along with other relevant laboratory investigations, was measured for each patient upon admission to the EPU using a point-of-care test glucometer (ACCU-CHEK with strips).

**Results:** Of the 340 children recruited for the study, 54 patients had hypoglycemia (<2.2 mmol/L), giving a prevalence rate of 15.9%. Thirty-six (66.7%) of the children with hypoglycemia were under the age of 5 years (odds ratio [OR]: 6.218 [1.077–35.912], *p*=0.041) and 26 (48.1%) were severely underweight (OR: 3.692 [1.266–10.971], *p*=0.017). Factors such as not having eaten for at least 16 h, weakness, and coma at presentation all independently predicted hypoglycemia (OR: 5.696 [1.768–18.352], 6.556 [1.730–24.850], 9.479 [3.092–29.059], *p*=0.004, 0.006 and <0.001) respectively. Severe malaria was also independently related to hypoglycemia (OR: 2.720 [0.554–13.365], *p*=0.021).

**Conclusion:** Hypoglycemia is a common occurrence among children admitted to the EPU. Factors such as being under five years old, in a coma, weakness, severe malaria, and prolonged fasting were all identified as independent predictors of hypoglycemia. Therefore, routine blood glucose monitoring of children admitted to the EPU, specifically those at higher risk, is recommended.

**Keywords:** hypoglycemia, pediatrics, emergency, predictors

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Glucose plays a pivotal role in energy generation, serving as the immediate energy source. It can be reversibly stored as glycogen and can also be synthesized de novo from fat and protein. The concentration of glucose in plasma is maintained within a narrow range under varied conditions, regulated by hormones such as insulin, glucagon, cortisol, and epinephrine.[1,2] However, this delicate balance can be disrupted in children suffering from acute illnesses, potentially leading to hypoglycemia with harmful consequences.[3,1]

Hypoglycemia may result from decreased intake or increased utilization of glucose due to an increase in metabolic demand or disordered glucose homeostasis associated with ill health.[2] It is known to complicate common emergency room diseases in children such as severe malaria, febrile convulsion, meningitis, diarrheal disease, and acute poisoning, leading to increased morbidity and mortality.[5] Studies from different parts of Nigeria have shown a marked variation in the incidence of hypoglycemia; the lowest incidence of 0.3% was reported from Ekiti by Oluwayemi et al in 2018,[6] while the highest was 22.1%, from a study carried out in Gusau by Musa et al in 2019.[7] The wide variation in incidence from these previous studies underscores the need for local data. In Maiduguri, the incidence of hypoglycemia among children admitted into the Emergency Pediatric Unit (EPU) has not been documented in the past, nor have the specific factors associated with hypoglycemia. Hypoglycemia may present with symptoms, but the absence of symptoms does not exclude hypoglycemia. It has been shown that even asymptomatic hypoglycemia can potentially result in adverse neurologic damage.[1,8] This fact emphasizes the need for a high index of suspicion, prompt recognition, and treatment of this metabolic problem.[9]

Currently, random blood glucose testing among children admitted to the EPU at the University of Maiduguri Teaching Hospital (UMTH) is at the discretion of the attending physician, with no standardized criteria. This approach has led to variations in practice; on one hand, causing potential over-testing and resource wastage, and on the other under-testing with the risk of overlooking cases of hypoglycemia. The standard laboratory determination of blood glucose is time-consuming and requires a well-trained expert, delaying potentially necessary action. Additionally, point-of-care glucose testing devices often have a limited number of strips, particularly in resource-poor settings like ours. This study aims to describe the prevalence and pattern of hypoglycemia among children admitted to the EPU. This information will assist physicians in making informed decisions, prioritizing patients who most require testing in the face of limited resources, and those who may require presumptive treatment in the absence of a point-of-care testing device.

**Disclosure.** Authors have no conflict of interests, and the work was not supported or funded by any drug company.

**Methods.** This is a cross-sectional descriptive study conducted between February and September 2020, among children admitted into the EPU of UMTH. The UMTH is a tertiary health facility located in Maiduguri, Borno State, Nigeria, and serves as a referral centre for patients from Borno, Yobe, Adamawa, and Bauchi States. The EPU of UMTH has a capacity of 28 beds with an annual patient turnover of 3979 children aged 15 years and below.

Previous related research articles were assessed from the internet through Google search engine. The key words of 'hypoglycemia in children, hypoglycemia in Pediatric Emergency' were keyed in and all the displayed articles were downloaded and reviewed.

The sample size was determined using the Cochran Formula,[10] considering the finite population of <10,000.

$$n0=Z^2pq/e^2$$

where *P* is the prevalence of hypoglycemia in a previous study conducted in Enugu is 20.7%.[11] The minimum calculated sample size was 233. However, to enhance the observational power, a total of 340 children were studied, as resources permitted. Study subjects were recruited consecutively until the minimum sample size was reached. Children, whose caregivers declined consent, were excluded. Patients who had received intravenous glucose before recruitment or from the referral health facility within 8 hours (h) were also excluded.

Ethical clearance was obtained from the Research and Ethics Committee of the UMTH. Study subjects were only recruited after receiving informed consent from their caregivers. The study procedure was explained to the caregivers in the language they could understand, with the freedom to participate or decline without any consequences whatsoever. Children who were found to be hypoglycemic received an intravenous glucose bolus at 200 mg/kg and were subsequently fed or maintained on glucose-containing intravenous fluid. The study procedure was totally in line with the principle of Helsinki Declaration.

For each participant, a questionnaire administered by an interviewer was completed on the day of enrollment. The information sought and obtained included sociodemographic and clinical characteristics such as age, gender, symptoms presented, duration since the last meal, anthropometric indices, and clinical diagnosis.

Random blood glucose (RBG) testing was performed on all patients using an ACCU-CHECK® (Roche, F. Hoffman-La Roche Ltd, 4070 Basel, Switzerland) point-of-care glucometer and strip, following the manufacturer's instructions. The researcher or an assistant collected 2 ml of venous blood into a fluoride oxalate container from either the cannula insertion point or the antecubital fossa. We avoided finger prick capillary blood to minimize false positive hypoglycemia due to tissue fluid dilution.

The performance of the Accu-Check glucometer, previously validated in Nigeria, correlates significantly with standard laboratory blood glucose measurement, boasting a sensitivity and specificity of 96% and 96.1% respectively.[12] The test strip features arrows indicating the direction of use and is inserted into the strip chamber on the ACCU-CHECK® device until it fits snugly and the device powers on. A blood drop is then applied at the designated sample area (after mixing the sample by rolling the specimen bottle), triggered by a prompt on the device screen indicating readiness.

Results were subsequently read and interpreted. Hypoglycemia was defined as a blood glucose level of less than 2.2 mmol/L, in line with WHO guidelines on malaria and emergency intervention recommendations.[13,14]

The glucometer was recalibrated at the chemical pathology laboratory of UMTH after every 50 patients. Additionally, for every 20th patient recruited, the blood sample was sent to the laboratory for glucose determination. The final diagnosis, made by the managing team based either on discharge or demise, was upheld based on clinical symptoms and available investigations.

The data obtained were entered and analyzed using IBM SPSS Statistics for windows, version 25 (IBM Corp., Armonk, N.Y., USA). Frequency tables and charts were employed to summarize categorical variables. The blood glucose level was classified into hypoglycemia and 'no hypoglycemia'. The relationship of hypoglycemia with various factors was tested using the Chi-square/Fisher's exact test, with further analysis conducted through logistic regression. A level of significance was established at $p<0.05$.

**Results.** A total of 340 patients were recruited, of which 206 (60.6%) were males, yielding a male-to-female ratio of 1.5:1. The age range was between 1 month and 15 years (180 months) with a modal age of 24 months; 226 (66.5%) were under 5 years old. The majority, 222 (65.3%), of the subjects were of low socioeconomic status, while 116 (34.1%) were severely underweight and 85 (25%) exhibited moderate to severe stunting. Regarding the duration since their last meal, 127 (37.4%) had eaten less than 8 h before presentation, while 95 (27.9%), 93 (27.4%), and 25 (7.3%) subjects had eaten within 8–16 h, 16–24 h, and over 24 h respectively. Hypoglycemia was present in 54 of the subjects, giving a prevalence of 15.9% (**Figure 1**).

**Table 1** depicts the relationship between hypoglycemia and the socio-demographics, nutritional status, and timing of the last meal of the participants. Factors such as age, socioeconomic class, weight-for-age ratio, and the duration since the last meal were all significantly associated with the pattern of blood glucose levels, with *p*-values of 0.046, 0.017, 0.039, and 0.001, respectively.

All study subjects exhibited more than one symptom in various combinations. The most common symptoms were fever (85%), refusal to feed or loss of appetite (anorexia) (71.8%), weakness (57.6%), vomiting (56.8%), diarrhea (50.9%), cough (47.1%), and difficulty breathing (37.9%). The least common symptoms included polyuria (2.1%), neck stiffness (3.5%), and sore throat (4.1%).

Similarly, the most commonly identified physical signs included pyrexia (70.9%), tachycardia (69.5%), and tachypnea (70.4%), whereas hepatomegaly (5.3%) was the least common. Other signs included edema (8.4%), dehydration (12.9%), (17.6%), unarousable coma (19.3%), dyspnea (26.2%), and others.

Severe acute malnutrition (15.6%), pneumonia (15%), and severe malaria (12.4%) were the most frequently observed diagnoses. Other common diagnoses included surgical cases (8.8%), diarrhea disease (7.6%), sickle cell crises (6.2%), febrile convulsion (5.6%), enteric fever (5.3%), acute pharyngotonsillitis (5%), and urinary tract infection (4.4%). Less frequent diagnoses included severe sepsis (2.6%), meningitis (2.6%) and others (8.8%).

**Table 2** illustrates the relationship between hypoglycemia and clinical features among the study subjects. A significantly higher proportion of hypoglycemic children presented with diarrhoea, vomiting, abdominal distension, anorexia, convulsion, tachypnea, coma, and dehydration compared to non-hypoglycemic children exhibiting the same features.

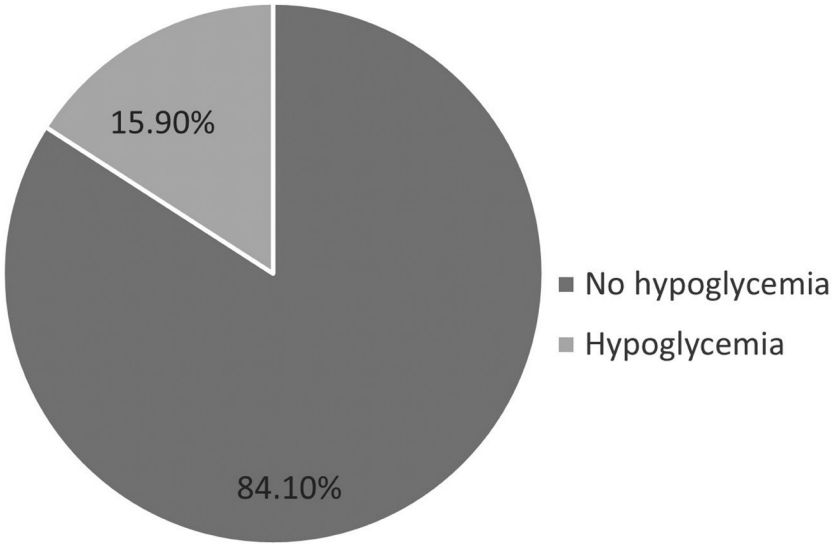


**Figure 1 -** Blood glucose category of the study subjects.

**Table 1 -** Association between hypoglycemia and sociodemographic factors, nutritional status, and duration since last meal.

| Variable | n | Hypoglycemia | | $X^2$ | *P*-value |
|---|---|---|---|---|---|
| | | Absent n (%) | Present n (%) | | |
| ***Age*** | | | | | |
| <5 years | 226 | 190 (84.1) | 36 (15.9) | 6.161 | 0.046* |
| 5-<10 | 58 | 44 (75.9) | 14 (24.1) | | |
| 10-15 | 56 | 52 (92.9) | 4 (7.1) | | |
| ***Gender*** | | | | | |
| Male | 206 | 179(86.9) | 27(13.1) | 3.014 | 0.083 |
| Female | 134 | 107 (79.9) | 27(20.1) | | |
| ***Socioeconomic class*** | | | | | |
| Low | 222 | 178 (80.2) | 44 (19.8) | 7.899 | 0.017^ |
| Middle | 93 | 84 (90.3) | 9 (9.7) | | |
| High | 25 | 24 (96.0) | 1 (4.0) | | |
| ***Weight-for-age*** | | | | | |
| Normal | 175 | 151 (86.3) | 24 (13.7) | 6.505 | 0.039* |
| Moderate underweight | 49 | 45 (91.8) | 4 (8.2) | | |
| Severe underweight | 116 | 90 (77.6) | 26 (22.4) | | |
| ***Height-for-age*** | | | | | |
| Normal | 255 | 213 (83.5) | 42 (16.5) | 3.998 | 0.136 |
| Moderate stunting | 37 | 35 (94.6) | 2 (5.4) | | |
| Severe stunting | 48 | 38 (79.2) | 10 (19.8) | | |
| ***Duration since last meal*** | | | | | |
| <8 hours (h) | 127 | 120 (94.5) | 7 (5.5) | 72.30 | 0.001 |
| 8- <16 h | 95 | 90 (94.7) | 5 (5.3) | | |
| 16-24 h | 96 | 67 (72.0) | 26 (28.0) | | |
| >24 h | 25 | 9 (36.0) | 16 (64.0) | | |

This pattern was statistically significant, with $p<0.05$ in all these features.

Among the diagnoses observed in the study subjects, only severe malaria exhibited a significant relationship with hypoglycemia. The proportion of hypoglycemic children diagnosed with severe malaria was 18 (33.3%), a significantly larger percentage compared to non-hypoglycemic children with severe malaria, where the figure stood at 24 (8.4%). This difference was significant, with $p=0.001$.

A multiple logistic regression model of all factors showing a significant association with hypoglycemia

**Table 2 -** Relationship between clinical features and hypoglycemia.

| Variable | | Hypoglycemia | | | |
|---|---|---|---|---|---|
| Clinical features | n | Absent n (%) | Present n (%) | $X^2$ | *P*-value |
| Fever | 289 | 239 (82.7) | 50 (17.3) | 2.903 | 0.888 |
| Cough | 160 | 135 (84.4) | 25 (15.6) | 0.015 | 0.903 |
| Difficulty in breathing | 129 | 103 (79.8) | 26 (20.2) | 2.840 | 0.092 |
| Diarrhoea | 173 | 138 (79.8) | 35 (20.2) | 4.986 | 0.026* |
| Vomiting | 193 | 160 (82.9) | 33 (17.1) | 0.494 | 0.482 |
| Abdominal distention | 65 | 45 (69.2) | 20 (30.8) | 13.331 | 0.001* |
| Anorexia | 244 | 196 (80.3) | 48 (19.7) | 9.290 | 0.002* |
| Convulsions | 92 | 65 (70.7) | 27 (29.3) | 17.118 | 0.001* |
| Weakness | 196 | 146 (74.5) | 50 (25.5) | 32.109 | 0.001* |
| Dysuria | 70 | 61 (87.1) | 9 (12.9) | 0.604 | 0.437 |
| Frequency | 28 | 26 (92.9) | 2 (7.1) | 1.744 | 0.187 |
| Tachypnea | 226 | 183 (81.0) | 43 (19.0) | 4.988 | 0.026* |
| Tachycardia | 223 | 182 (81.6) | 41 (18.4) | 3.040 | 0.081 |
| Hypertension | 51 | 40 (78.4) | 11 (21.6) | 1.452 | 0.228 |
| Unarousable coma | 62 | 28 (45.2) | 34 (54.8) | 86.135 | 0.001* |
| Oedema | 27 | 21 (77.8) | 6 (22.2) | 0.882 | 0.348 |
| Dehydration | 44 | 29 (65.9) | 15 (34.1) | 12.543 | 0.001* |
| Pallor | 60 | 52 (86.7) | 8 (13.3) | 0.354 | 0.552 |
| Hepatomegaly | 18 | 14 (77.8) | 4 (22.2) | 0.572 | 0.450 |
| Dyspnea | 74 | 62 (83.8) | 12 (16.2) | 0.008 | 0.929 |
| Crepitation | 66 | 54 (81.8) | 12 (18.2) | 0.324 | 0.569 |

**Table 3 -** Relationship between hypoglycemia and clinical diagnosis.

| Diagnoses | n | Absent n (%) | Present n (%) | $X^2$ | *P*-value |
|---|---|---|---|---|---|
| Severe malaria | 42 | 24 (57.1) | 18 (42.9) | 26.099 | 0.001 |
| Pneumonia | 51 | 45 (88.2) | 6 (11.8) | 0.761 | 0.383 |
| Diarrheal disease | 26 | 23 (88.5) | 3 (11.5) | 0.398 | 0.597 |
| Enteric fever | 18 | 18 (100.0) | 0 (0.0) | 3.589 | 0.089 |
| Meningitis | 9 | 7 (77.8) | 2 (22.2) | 0.278 | 0.639 |
| Febrile convulsion | 19 | 18 (94.7) | 1 (5.3) | 1.699 | 0.226 |
| SAM | 53 | 40 (75.5) | 13 (24.5) | 3.513 | 0.061 |
| Surgical cases | 30 | 24 (80.0) | 6 (20.0) | 0.418 | 0.518 |
| Severe sepsis | 9 | 6 (66.7) | 3 (33.3) | 2.107 | 0.158 |
| Sickle cell crisis | 21 | 21 (100.0) | 0 (0.0) | 4.226 | 0.033 |
| UTI | 15 | 15 (100.0) | 0 (0.0) | 2.963 | 0.142 |
| Pharyngotonsilitis | 17 | 15 (88.2) | 2 (11.8) | 0.227 | 0.475 |
| Others | 30 | 30 (100.0) | 0 (0.0) | 6.212 | 0.007 |

UTI: urinary tract infections, SAM: severe acute malnutrition

revealed that children aged less than 5 years were approximately 6 times more likely to develop hypoglycemia than those aged 10 years and above (OR=6.218, 1.077–35.912; *p*=0.041). Likewise, subjects who were significantly underweight were roughly 4 times more prone to developing hypoglycemia than those maintaining a normal weight for their age (OR=3.692, 1.266–10.971; *p*=0.017). Conversely, subjects who last ate between 16–24 h and more than 24 h before were about 6 and 30 times more likely to develop hypoglycemia than those who ate less than 8 h prior (OR=5.696, 1.768–18.352, and 30.279, 5.569–164.633; *p*=0.004 and <0.001 respectively). Among the clinical features, children who presented with coma or weakness were 9 and 6 times more likely to be hypoglycemic than those without these symptoms (OR=9.479, 3.092–29.059 and OR=6.556, 1.730–24.850; *p*<0.001 and 0.004 respectively). Notably, severe malaria had a significant association with hypoglycemia, with children suffering from severe

**Table 4 -** Multiple regression for factors associated with hypoglycemia.

| Variables | | Total enrolled | Hypoglycemia n=58 | Odds ratio (95% CI) | *P*-value |
|---|---|---|---|---|---|
| ***Age*** | | | | | |
| <5 years | | 226 | 36 (15.9) | 6.218 (1.077-35.912) | 0.041* |
| 5-<10 year | | 58 | 14 (24.1) | 5.730 (0.889-34.702) | 0.057 |
| 10-15 years | | 56 | 4 (7.1) | 1 | |
| ***Social status*** | | | | | |
| Low | | 222 | 44 (19.8) | 3.191 (0.226-44.967) | 0.390 |
| Middle | | 93 | 9 (9.7) | 3.179 (0.198-50.996) | 0.414 |
| High | | 25 | 1 (4.0) | 1 | |
| ***Weight-for-age*** | | | | | |
| Normal | | 175 | 24 (13.7) | 1 | |
| Moderate underweight | | 49 | 4 (8.2) | 0.530 (0.100-2.811) | 0.456 |
| Severe underweight | | 116 | 26 (22.4) | 3.692 (1.266-10.971) | 0.017* |
| ***Duration since last meal*** | | | | | |
| <8 h | | 127 | 7 (5.1) | 1 | |
| 8- <16 h | | 95 | 5 (5.3) | 0.668 (0.152-2.945) | 0.594 |
| 16-24 h | | 93 | 26 (28.3) | 5.696 (1.768-18.352) | 0.004* |
| >24 h | | 25 | 16 (64.0) | 30.279(5.569164.633) | <0.001* |
| Abdominal distension | Yes | 65 | 20 (30.8) | 2.863 (0.948—8.649) | 0.062 |
| | no | 275 | 34 (12.4) | 1 | |
| Anorexia | Yes | 244 | 48 (19.7) | 1.096 (0.338-3.560) | 0.876 |
| | no | 96 | 6 (6.3) | 1 | |
| Diarrhea | yes | 173 | 35 (64.8) | 1.303 (0.492-3.451) | 0.594 |
| | no | 167 | 19 (11.4) | 1 | |
| Convulsions | Yes | 92 | 27 (29.3) | 1.472 (0.505-4.288) | 0.478 |
| | no | 248 | 27 (10.7) | 1 | |
| Weakness | yes | 196 | 50 (25.5) | 6.556 (1.730-24.850) | 0.006* |
| | no | 144 | 4 (2.8) | 1 | |
| Coma | yes | 62 | 34 (54.8) | 9.479 (3.092-29.059) | <0.001* |
| | no | 278 | 20 (7.2) | 1 | |
| Dehydration | yes | 44 | 15 (34.1) | 0.483 (0.113-2.070) | 0.327 |
| | no | 296 | 39(13.2) | 1 | |
| Tachypnea | yes | 226 | 43 (19.0) | 1.294 (0.469--3.570) | 0.619 |
| | no | 114 | 11 (9.6) | 1 | |
| Severe malaria | yes | 42 | 18 (42.9) | 2.720 (0.554-13.365) | 0.021* |
| | no | 298 | 36 (12.1) | 1 | |

Values are presented as number and percentages (%). *Significant *p*-value. OR: odds ratio, CI: confidence interval
h: hours

malaria being 3 times more likely to have hypoglycemia than those diagnosed with other conditions (OR = 2.720, 0.554–13.365; *p*=0.021).

**Discussion.** Hypoglycemia is a significant metabolic complication of acute illness in non-diabetic children. Early recognition and initiation of suitable therapy are crucial to prevent harmful outcomes. The high prevalence of 15.9% reported in this study underscores the burden of hypoglycemia among children visiting the emergency unit, reinforcing the need for active screening in this patient group. This prevalence exceeds the 3.1% reported by Sambany et al[15] from Madagascar in 2013, even though the same hypoglycemia definition of RBG <2.2 mmol/l was used. This discrepancy might be due to differing malaria endemicity in the study areas. The current study was conducted in a malaria holoendemic region, where severe malaria made up 12.4% of all diagnoses and 33.3% of hypoglycemia cases, in contrast to the non-malaria setting of the Madagascar study. However, the prevalence of hypoglycemia in this study was lower than the 20.7% reported by Uleanya et al[11] in Enugu in 2017 for children aged 1 month to <10 years, and the 22.1% reported by Musa et al[7] in Gusau in 2019 for children 1 month to <13 years old. The reduced prevalence in the current study compared to the Uleanya et al[11] and Musa et al[7] studies may stem from differences in hypoglycemia definitions. While this study deemed hypoglycemia to be an RBG of <2.2 mmol/l, studies by Musa et al[7] and Uleanya et al[11] used RBG cut-offs of <2.8 mmol/l and <3.6 mmol/l, respectively, thus providing these studies with a broader range of possible RBG levels for inclusion as hypoglycemia.

Age was significantly associated with hypoglycemia at the bivariate level in this study. This mirrors the findings of other studies from Ekiti by Oluwayemi et al[6] and Nnewi by Azuka et al[16] both in Nigeria. Conversely, Oyenusi et al[17] from Lagos in 2014 found no significant link between age and hypoglycemia and did not explain this finding. At the multivariate level, children <5 years old had significantly higher odds of developing hypoglycemia in this study. While other quoted studies only evaluated the relationship at the bivariate level, Azuka et al[16] could not demonstrate an independent connection between age and hypoglycemia at the multivariate level. This could be because the study included a small number of older children (≥10 years old), which could have clouded the results. The higher prevalence of hypoglycemia in children under 5 can be attributed to their unique glucose metabolism. They have smaller glycogen reserves in the liver, along with higher rates of glucose consumption due to their larger brain-to-body mass ratio.[18]

This study revealed a direct relationship between hypoglycemia and severe undernutrition. The odds of experiencing hypoglycemia were 3.6 times higher in severely underweight individuals compared to those of normal weight-for-age. This finding aligns with the evidence from Osier et al[3] in Kenya, which demonstrated a significant association between weight-for-age (<-3 Z-score) and hypoglyemia. In 2017, Kirti et al[9] also reported a significant relationship between malnutrition and hypoglycemia. However, a contrast was found in a 2021 study by Azuka et al[16] from Nigeria, where no association between nutritional status and hypoglycemia was found. Their findings were attributed to the absence of edematous malnutrition among the study subjects. Similarly, an earlier study in 1990 by Bennish et al[19] found no correlation between nutritional status and hypoglycemia among children suffering from diarrhoea. The variations in these findings regarding hypoglycemia and nutritional status may not be immediately clear, but they could be linked to the differing proportions of severely malnourished subjects in these studies. It is known that severe undernutrition is associated with low levels of gluconeogenic substrate and decreased endogenous glucose production.[19,20]

In this study, the duration since the last meal served as an independent predictor of hypoglycemia. It was observed that children who had not eaten for 16 h or more had significantly higher odds of developing hypoglycemia. Similar findings have been consistently reported in previous studies, albeit with varying durations. For instance, Osier et al. 3 in Kenya (2003), Sambany et al[15] in Madagascar (2013), and Oyenusi et al[17] in Lagos (2014) all reported durations of 12 h or more since the last meal as a significant factor associated with hypoglycemia. Meanwhile, Azuka et al[16] reported a duration of 6 h or more.

The variation in the significant duration since the last meal could be attributed to differences in the number and size of the classes used in various studies. This study divided the duration into 4 classes with 8-h intervals, while Azuka et al[16] and Osier et al[3] utilized 2 classes with intervals of 6 h and 12 h, respectively. Our use of 8-h intervals was based on the standard gastric emptying time of 4 h, and the need to determine the closest possible duration since the last meal that independently predicts hypoglycemia. The results would likely have been similar if this study had adopted 2 classes and a class size comparable to those used in prior studies.

Hypoglycemia has been significantly associated with weakness and coma. This finding parallels the report from Osier et al,[3] who also identified an association between coma, weakness, and hypoglycemia. Similarly, Sambany et al[15] found a connection between coma and hypoglycemia. Both coma and weakness are among the features listed by WHO as indicators of hypoglycemia in a child with severe acute malnutrition (SAM).[21] Coma can occur as a result of decreased cerebral glucose concentration, while weakness is often linked to the activation of the autonomic nervous system and the release of epinephrine, usually observed in conjunction with a rapid decline in blood glucose concentration.[22] In a study by Bennish et al,[19] 87% of the hypoglycemic children presented with coma, either convulsing (34.8%) or unconscious (52.2%). Azuka et al[16] found a significant association between the level of consciousness and hypoglycemia during bivariate analysis. Still, this association did not maintain its significance at the multivariate level.

Severe malaria was identified as the only independent predictor of hypoglycemia among the diagnoses, with the odds of having hypoglycemia in those with severe malaria being 2.7 times higher compared to those with other diagnoses. This finding agrees with a study reported by Musa et al[7] from Gusau in 2019. Hypoglycemia in individuals with malaria is explained as a consequence of impaired hepatic gluconeogenesis, sequestration of parasitized red cells in the venules and capillaries of deep tissues, which may impair local circulation. This can lead to anaerobic respiration, increasing glucose consumption.[23-25] However, the current study did not evaluate the relationship between different types of severe malaria and hypoglycemia.

In conclusion, hypoglycemia is a common occurrence among children presenting to the EPU of

UMTH. A young age, prolonged fasting, weakness, loss of consciousness, severe underweight, and severe malaria are independent predictors of hypoglycemia among these children. Routine screening of all children admitted into the EPU for hypoglycemia, particularly those at higher risk, is recommended.

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