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Nutritional Status and Associated Factors Among Children with Type 1 Diabetes Mellitus at Ayder Comprehensive Specialized Hospital, Northern Ethiopia

Salem Hagos
Mekelle University
Hailemariam Gebrearegay Haileeyesus
Mekelle University
Gebretsadikan Gebremedihin
Mekelle University
Zeray Welegebrieal Marru
Mekelle University
Atsede Gebrekidan
atsede.gebrekidan@mu.edu.et
Mekelle University

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Abstract

Type 1 diabetes mellitus (T1DM) is a chronic endocrine disorder affecting children and adolescents, with increasing concern regarding its impact on growth and nutritional status. Children with T1DM are particularly vulnerable to malnutrition due to increased metabolic demands, dietary challenges, and difficulties in maintaining optimal glycemic control, especially in low-resource and conflict-affected settings. This study assessed the prevalence and predictors of malnutrition among children with T1DM attending follow-up care at Ayder Comprehensive Specialized Hospital in northern Ethiopia. An institution-based cross-sectional study was conducted from February to April 2024 among 142 participants using caregiver interviews, anthropometric measurements, and clinical data. The prevalence of malnutrition was 26.1%, with severe acute malnutrition being the most common form. Most participants had suboptimal glycemic control. Although glucometer ownership was high, frequent monitoring was limited. Multivariable analysis identified preschool age, large family size, and low blood glucose levels as independent predictors of malnutrition, while glycemic control was not statistically significant. These findings highlight a substantial burden of malnutrition among children with T1DM in this setting. Integrating nutritional assessment into routine diabetes care and strengthening caregiver support and access to essential resources are critical to improving outcomes.

Introduction

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune disorder resulting from immune-mediated destruction of pancreatic beta cells, leading to absolute insulin deficiency. Although its exact cause is not fully understood, T1DM is believed to arise from a complex interaction between genetic susceptibility and environmental triggers, including infections and nutritional factors (1, 2).

T1DM is the predominant form of diabetes among children and adolescents, with a growing global burden. In 2021, approximately 108,300 children under 15 years were newly diagnosed worldwide, and about 651,700 were living with the condition (3). The burden is expected to increase significantly, particularly in low- and middle-income countries. In Ethiopia, although available data are limited, T1DM remains an important and under-recognized pediatric health problem (4).

At the same time, malnutrition, especially undernutrition, continues to be highly prevalent in sub-Saharan Africa, affecting over one-third of children under five years of age. Malnutrition negatively impacts physical growth, immune competence, and cognitive development, and increases vulnerability to infections (5). Emerging evidence suggests a bidirectional relationship between T1DM and malnutrition. Chronic undernutrition may impair pancreatic function and glucose metabolism, potentially contributing to the development or progression of diabetes. Conversely, T1DM may increase the risk of malnutrition due to altered metabolism, increased energy demands, and challenges in dietary management (6).

Maintaining optimal nutritional status is essential for children with T1DM, as nutrition directly influences glycemic control, growth, and overall health. However, dietary management in T1DM is complex, requiring careful coordination between insulin therapy and food intake. Despite its importance,

nutritional assessment is often underemphasized, and there is limited evidence regarding dietary practices, nutritional status, and growth outcomes among pediatric T1DM patients, particularly in low-resource settings (7, 8).

Poor glycemic control in children with T1DM is associated with serious long-term complications, including organ damage and failure. Malnutrition may further exacerbate these risks, making disease management more challenging. Although intensive insulin therapy improves outcomes, achieving optimal control remains difficult in the presence of nutritional deficiencies (1).

In sub-Saharan Africa, including Ethiopia, there is a paucity of data on the prevalence and determinants of malnutrition among children with T1DM. Furthermore, existing studies have largely focused on glycemic control and complications, with limited attention to comprehensive nutritional evaluation and its impact on growth and development.

Therefore, this study aims to assess the prevalence and predictors of malnutrition among children with T1DM attending follow-up care at Ayder Comprehensive Specialized Hospital. By examining the relationship between nutritional status and growth parameters, the study seeks to generate evidence that can inform clinical practice, guide targeted interventions, and support the development of context-specific strategies to improve health outcomes. In addition, the findings will contribute to raising awareness, informing policy decisions, and providing baseline data for future research in pediatric diabetes care.

Materials and Methods

Study Design, Area, and Period

An institution-based cross-sectional study was conducted from February to April 2024 at Ayder Comprehensive Specialized Hospital (ACSH), a tertiary referral hospital located in Mekelle, northern Ethiopia. ACSH is a major referral hospital providing comprehensive healthcare services for patients from the Tigray region and surrounding areas. The pediatric endocrinology clinic operates twice weekly and delivers specialized pediatric diabetes follow-up care, diabetes education, and counseling for children with diabetes, staffed by one pediatrician, pediatric residents, and nurses.

Study Population and Eligibility

The study included children and adolescents aged 0–18 years diagnosed with type 1 diabetes mellitus and attending follow-up care at the pediatric diabetic clinic during the study period. Patients with incomplete clinical records or severe acute illness preventing anthropometric measurement were excluded.

Sample Size and Sampling Technique

The sample size was calculated using a single population proportion formula, assuming a prevalence of undernutrition of 19.7% among children with T1DM based on a study from Basrah (9), a 95% confidence level, and a 5% margin of error. After applying a finite population correction and adding a 5% non-response rate, the final sample size was 142.

A systematic random sampling technique was employed. The sampling interval (k) was calculated as 2, and eligible participants were selected at every second patient on the follow-up visit.

Study Variables

The dependent variable was malnutrition. Independent variables included socio-demographic characteristics, anthropometric measurements, biochemical measurements, disease-related factors, and dietary intake characteristics.

Data Collection Methods

Data was collected using a structured questionnaire administered to caregivers, along with review of medical records. The questionnaire was translated into local language, Tigrinya.Anthropometric measurements were taken on the day of data collection according to WHO standards (10). Venous blood samples were collected on the date of data collection after at least eight hours of overnight fasting. Postprandial blood glucose levels were measured two hours after meal consumption. The most recent HbA1c result, obtained within two months prior to the date of data collection, was extracted from the patients' medical records.

Data Quality Assurance

The questionnaire was pretested on 5% of the sample prior to data collection. Data collectors were supervised daily, questionnaires were checked for completeness, and regular meetings were held to address inconsistencies and ensure data quality.

Data Processing and Analysis

Data was entered and analyzed using SPSS version 27. Descriptive statistics were used to summarize variables. Binary logistic regression was performed to identify candidate variables, and those with $p < 0.25$ were included in multivariable logistic regression. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated, and statistical significance was set at $p < 0.05$.

Operational Definitions

Malnutrition was defined according to World Health Organization (WHO) criteria as the presence of severe or moderate acute malnutrition, stunting, or overweight, determined using mid–upper arm circumference (MUAC), weight-for-height/length, body mass index (BMI)-for-age, and height-for-age Z-scores (10).

Blood glucose levels (BGL) were categorized according to ISPAD and ADA guidelines as low (< 70 mg/dL), optimal (70–180 mg/dL), and high (> 180 mg/dL). Glycated hemoglobin (HbA1c) levels were classified as good metabolic control (< 7%) and poor metabolic control (> 7%). (2, 6)

Family size was categorized as **large** (≥ 3 children) or **small** (< 3 children) ; Monthly family income was classified into four categories: **≤1000 ETB**, **1001–2500 ETB**, **2501–5000 ETB**, and **≥ 5000 ETB** (11).

Results

Sociodemographic, Clinical, and Nutritional Characteristics

A total of 142 children and adolescents with T1DM were enrolled, with adolescents (13–18 years) comprising just over half of the study population (51%). Females represented 54.2% of participants. Most children resided in urban areas (73.9%) and belonged to large families (73.2%). More than one-third of mothers (35.9%) had no formal education (Table 1).

Table 1
Sociodemographic characteristics of children with T1DM at ACSH, 2024 (N = 142)

Characteristic	Frequency (N = 142)	Percentage (%)
Sex		
Male	65	45.8
Female	77	54.2
Mother's education		
No formal education	51	35.9
Primary	30	21.1
Secondary	38	26.8
College/University	23	16.2
Father's education		
No formal education	21	14.8
Primary	42	29.6
Secondary	38	26.8
College/University	41	28.9
Residency		
Urban	105	73.9
Rural	37	26.1
Family size		
Large (≥ 3 children)	104	73.2
Small (< 3 children)	38	26.8
Family income (ETB)		
1000–2500	3	2.1
2501–5000	38	26.8
> 5000	101	71.1

Nutritional status

Nutritional assessment showed that 26.1% of participants were malnourished. Severe acute malnutrition was the predominant form (14.8%), followed by moderate acute malnutrition (4.2%) and stunting (5%).

Only 2.1% of participants were overweight (Table 2).

Table 2
Nutritional status of children with T1DM, ACSH, 2024 (N = 142)

Nutritional status	Frequency	Percentage (%)
Severe acute malnutrition	21	14.8
Moderate acute malnutrition	6	4.2
Stunted	7	5
Overweight	3	2.1
Well-nourished	105	73.9

Disease characteristics and dietary assessment

Clinically, the mean age at diagnosis was 7 years, and the mean duration of diabetes was 4 years. Nearly half (49.3%) had lived with the disease for 1–5 years. High blood glucose levels were observed in 59.2% of participants. Although 72.5% owned a glucometer, fewer than one-third monitored blood glucose more than four times per day. Regarding dietary practices, 54.2% consumed three meals daily, and 42.3% reported regular snack intake (Table 3).

HbA1c results were available for 68 (47.9%) of the study participants. Using the ISPAD-recommended cutoff, 57 (83.8%) children had poor glycemic control (HbA1c ≥ 7%), while 11 (16.2%) had good glycemic control (HbA1c < 7%). The prevalence of malnutrition among children with poor glycemic control was 31.6%, compared to 18.2% among those with good glycemic control.

Table 3
Disease characteristics and dietary assessment of children with T1DM, ACSH, 2024 (N = 142)

Characteristic	Frequency (%)
Blood glucose level	
Low	12 (8.5)
Optimal	46 (32.4)
High	84 (59.2)
Self-monitoring glucose	
Yes	103 (72.5)
No	39 (27.5)
Meals per day	
2	4 (2.8)
3	77 (54.2)
> 4	61 (43)
Snacks between meals	
Yes	60 (42.3)
No	82 (57.7)

Predictors of Malnutrition

A multivariable logistic regression model fitted including HbA1c category, blood glucose level, age category, and family size. Variables with a p-value < 0.25 in the bivariate analysis were entered into the final model. In the multivariable analysis, preschool age, larger family size, and low blood glucose levels remained independently associated with malnutrition. Although the prevalence of malnutrition was higher among children with poor glycemic control (31.6%) compared with those with good control (18.2%), this difference was not statistically significant. Other sociodemographic and clinical factors did not retain statistical significance in the final model. (Table 4).

Table 4
Multivariable predictors of malnutrition among children with T1DM (N = 142)

Variable	AOR	95% CI	P-value
Preschool age (< 6 years)	0.22	0.05–0.91	0.038
Large family size (≥ 3 children)	0.46	0.29–0.92	0.044
Low blood glucose level	4.38	2.21–8.67	0.008
Poor glycemic control (HbA1c ≥ 7%)	1.94	0.38–9.85	0.42

Discussion

This study demonstrated a substantial burden of malnutrition among children and adolescents with T1DM, with a prevalence of 26.1%. This is higher than findings from other studies (8–10), suggesting that children with T1DM in this setting face compounded risks related to both chronic disease and environmental factors. This aligns with the concept of the “double burden” of malnutrition and chronic disease in low-resource settings (4).

The high prevalence of malnutrition may be partly explained by the broader socioeconomic and healthcare context. In particular, the recent conflict in northern Ethiopia has had a profound impact on chronic disease management. Evidence from Ayder Comprehensive Specialized Hospital indicates a marked increase in diabetes-related complications during the war period, including a rise in diabetic ketoacidosis and mortality. Malnutrition, interruption of insulin supply, and limited healthcare access were identified as major contributing factors (12).

Similarly, large-scale studies have documented severe disruption of healthcare services in the region, including a dramatic reduction in follow-up care for patients with chronic illnesses such as T1DM (13) The destruction of health infrastructure, shortages of essential medicines, and widespread food insecurity have further exacerbated health risks among children (14). These findings support the hypothesis that the observed burden of malnutrition is not solely disease-related but is strongly influenced by the humanitarian crisis.

The predominance of female participants aligns with findings from Turkey (15), although sex was not an independent predictor of malnutrition. Nevertheless, the higher proportion of malnourished females observed in this study may reflect gender-related differences in dietary intake, caregiving attention, or metabolic requirements, as suggested by previous studies (8, 9). Cultural feeding practices may also contribute to this disparity.

Age was a significant predictor of malnutrition, with younger children being more vulnerable. This finding contrasts with studies reporting higher malnutrition among adolescents (16). This difference may be explained by the increased nutritional vulnerability of younger children, who have higher growth demands

and depend entirely on caregivers for feeding and diabetes management. Caregiver-related factors, including limited knowledge and fear of hypoglycemia, may contribute to inadequate feeding practices (11).

Large family size emerged as an independent predictor of malnutrition, consistent with findings from Egypt (17). In larger households, limited financial and caregiving resources may be distributed among many children, reducing individual attention to dietary quality and diabetes management. Additionally, caregivers in large families may experience difficulty maintaining individualized meal planning and glucose monitoring.

Low blood glucose levels were strongly associated with malnutrition, underscoring the close relationship between poor nutritional status and glycemic instability. Malnourished children may have reduced glycogen stores and inadequate caloric intake, increasing their susceptibility to hypoglycemia. Conversely, fear of hypoglycemia may result in irregular insulin dosing or meal skipping, further exacerbating undernutrition (2, 17). Similar associations have been reported in previous studies (9, 17).

Although malnutrition was more common among children with poor glycemic control, this association was not statistically significant. This may reflect limited HbA1c data or the multifactorial nature of malnutrition. Nevertheless, poor glycemic control remains an important clinical concern (2).

Despite relatively high ownership of glucometers, frequent self-monitoring was suboptimal. This may reflect limited availability of test strips, financial constraints, or inadequate education regarding optimal monitoring frequency. Inconsistent glucose monitoring may delay recognition of hypoglycemia or poor glycemic control, indirectly contributing to malnutrition (11).

The low prevalence of overweight in this study contrasts with reports from higher-income settings (7, 8) and may be explained by lower caloric intake, higher physical activity levels, and limited exposure to energy-dense diets. This pattern suggests that undernutrition remains a more pressing concern than overnutrition in this population.

Overall, these findings highlight the need for integrated diabetes and nutrition care, particularly in fragile and conflict-affected settings and with special attention to younger children, households with many members, and those experiencing hypoglycemia. Interventions should focus on strengthening caregiver education, improving food security, restoring healthcare services, and ensuring uninterrupted access to insulin and monitoring tools.

Conclusion

The prevalence of malnutrition among children and adolescents with type 1 diabetes mellitus (T1DM) in this study was 26.1%, higher than reported in previous studies. Preschool age, large family size, and low blood glucose levels were identified as significant predictors of malnutrition. These findings underscore

that malnutrition is a considerable health concern in pediatric T1DM. Integrated and context-specific interventions are essential to improve nutritional and clinical outcomes in this vulnerable population.

Recommendations

The findings of this study highlight the need for an integrated approach to the management of children with type 1 diabetes mellitus (T1DM), particularly in resource-limited and conflict-affected settings. Routine nutritional assessment should be incorporated into diabetes follow-up care to enable early identification and management of malnutrition. Special attention should be given to high-risk groups, including younger children, those from large families, and those experiencing hypoglycemia. Strengthening caregiver education on appropriate feeding practices, insulin use, and blood glucose monitoring is essential to improve both nutritional and glycemic outcomes. In addition, efforts should focus on improving access to adequate nutrition through community and policy-level interventions, especially in areas affected by food insecurity. Ensuring uninterrupted availability of insulin, glucometers, and test strips, along with restoring and strengthening healthcare services disrupted by conflict, is critical. Policymakers and stakeholders should prioritize integrated diabetes and nutrition programs and support further research to better understand long-term outcomes and develop context-specific interventions for children with T1DM.

Abbreviations

ACSH
Ayder Comprehensive Specialized Hospital
AOR
Adjusted Odds Ratio
BMI
Body Mass Index
CI
Confidence Interval
DM
Diabetes Mellitus
DKA
Diabetic Ketoacidosis
FBG
Fasting Blood Glucose
HbA1c
Glycated Hemoglobin
IDF
International Diabetes Federation
IRB
Institutional Review Board

ISPAD
International Society for Pediatrics and Adolescent Diabetes
MAM
Moderate Acute Malnutrition
MU
Mekelle University
MUAC
Mid-Upper Arm Circumference
RBS
Random Blood Sugar
SAM
Severe Acute Malnutrition
SD
Standard Deviation
SPSS
Statistical Package for the Social Sciences
T1DM
Type 1 Diabetes Mellitus
and WHO
World Health Organization.

Declarations

Ethical consideration

Ethical approval was obtained from the Institutional Review Board of Mekelle University, College of Health Sciences (Ref. No. IRB 2163/2024). Permission from Ayder Comprehensive Specialized Hospital clinical director offices and a support letter from the chief clinical director were obtained before the commencement of the study. Written informed consent was obtained from parents or legal guardians, and confidentiality was maintained throughout the study. All methods were performed in accordance with the relevant guidelines and regulations.

Competing interests

No conflict of interest.

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Availability of data and material

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

Authors' contribution

SH, HGH, and AG contributed to the conception of the study and the initial drafting of the manuscript. AG led to the critical review, editing, and finalization of the manuscript. SH, HGH, GG, ZWM and AG were involved in data analysis as well as the critical review and revision of the manuscript. All authors reviewed and approved the final version of the manuscript.

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