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ORIGINAL RESEARCH

Glycemic Control and Associated Factors Among Children and Adolescents with Type 1 Diabetes Mellitus, Southwest Ethiopia

Aneso Mohammed Abrahim[1], Tsion Tilahun[1], Beshea Gelana[2]

[1]Department of Pediatrics and Child Health, Jimma University, Jimma, Ethiopia; [2]Department of Health Policy and Management, Jimma University, Jimma, Ethiopia

Correspondence: Beshea Gelana, Department of health policy and management, Jimma University, Jimma, Ethiopia, Tel +251 921833996, Email tuniriyabesha@gmail.com

Purpose: Type 1 diabetes mellitus is the most common endocrine disorder among children and adolescents worldwide. Glycemic control is the ultimate goal of management of diabetes. Poor glycemic control is shown to be associated with complications of diabetes. Only a few studies have addressed the problem in Ethiopia, and this study aimed to determine the level of glycemic control and factors associated among children and adolescents with type 1 diabetes mellitus on follow up.

Methods: Institution based cross sectional study design was conducted on a total of 158 children and adolescents with type 1 diabetes on follow up at Jimma Medical Center from July to October 2022. Data were collected using structured questionnaire and entered into Epi Data 3.1 then exported to SPSS for analysis. Glycemic control was assessed based on glycosylated hemoglobin (HbA1c) level. Descriptive and inferential statistics were employed, and a p-value <0.05 was considered to declare statistical significance.

Results: The mean glycosylated hemoglobin of the participants was 9.67 ± 2.28%. Of the total study participants, 121 (76.6%) had poor glycemic control. In multivariable logistic regression, guardian or father as a primary caregiver [guardian (AOR=4.45, 95%, p=0.045), father (AOR=6.02, 95%, p=0.023)], minimal involvement of caregiver in insulin injection (AOR=5.39, 95%, p=0.002), poor blood glucose monitoring adherence (AOR=4.42, 95%, p=0.026), faced problems at health facility (AOR=4.42, 95%, p=0.018) and being admitted to hospital in the past 6 months (AOR=7.94, 95%, p=0.004) were the variables significantly associated with poor glycemic control.

Conclusion: Majority of children and adolescents with diabetes had poor glycemic control. Whereas, primary caregiver other than mother, minimal involvement of caregiver in insulin injection, and poor adherence to glucose monitoring were among the contributing factors for poor glycemic control. Therefore, adherence counseling and the participation of caregivers in diabetes management is recommended.

Keywords: adolescents, children, diabetes, Ethiopia, glycemic control, Jimma

Introduction

Type 1 diabetes mellitus is one of the most common endocrine disorders among children and adolescents, having significant consequences on physical and emotional development. It is an autoimmune disease characterized by low or absent level of endogenously produced insulin and by dependence on exogenous insulin to prevent development of ketoacidosis, an acute life-threatening complication of T1DM. Although most symptoms of T1DM are non-specific, the most important clue is an inappropriate polyuria and poor weight gain. T1DM in children and adolescents are diagnosed in the presence of random blood glucose ≥200mg/dL (11.1mmol/L) with typical symptoms like polyuria, polydipsia, and unexplained weight loss with glucosuria and ketonuria.[1]

According to the International Diabetes Federation (IDF) estimation, there were an estimated 1.1 million children 0–14 years in 2021 globally. In Ethiopia, the estimated prevalence of T1DM among children and adolescents of 0–19 years old is 2.4 per 100,000 per year.[2]

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In patients with diabetes the morbidity and mortality are usually due to the acute metabolic derangements and chronic complications such as nephropathy, retinopathy, ischemic heart disease, neuropathy, and arterial occlusion with gangrene of the extremities.[1] Glycemic control is an important part of management of diabetes. It is the strongest modifiable predictor of chronic complications of diabetes. It was shown that strict glycemic control delayed the onset and also slowed the progression of chronic complications of diabetes.[3]

Glycemic control can reliably be determined by measuring level of glycosylated hemoglobin (HbA1c) which reflects the level glycaemia over the preceding two to three months. As a result, measurement of HbA1c is often recommended to be done every three months.[1] According to the recommendations of the ADA and the International Society for Pediatric and Adolescent Diabetes (ISPAD), children and adolescents who have access to comprehensive diabetes care should aim to achieve a target of HbA1c <7.0% (53mmol/mol). However, a higher HbA1c target (<7.5%[58mmol/mol]) is appropriate in settings where there is lack of access to analog insulins, advanced insulin delivery technology, ability to regularly check blood glucose and continuous glucose monitoring.[4,5]

Despite continuous improvement means and development of supported protocols, majority of children and adolescents with T1DM failed to achieve optimal glycemic control. According to ADA only 21% of adolescents with T1DM achieved optimal glycemic goals. This situation is even alarming in low income countries due to lack of adequate financial human resources. This failure to meet optimal glycemic control can have significant consequences on health outcomes and can contribute to early development of chronic complications of diabetes.[6]

Various factors and challenges have been identified that are associated with the level of glycemic control. Some of these factors include socio-demographic variables like age of the child, family structure and socioeconomic status. Other diabetes related factors that were found to affect glycemic control includes duration of diabetes, adherence and involvement of caregiver in the diabetes management.[7–11]

In a study done in Ethiopia it was found that more than fifty percent of children and adolescents with diabetes had poor glycemic control. However, in that study the HbA1c cutoff used for defining poor glycemic control was >10% (86mmol/mol) which is higher than the recommended target HbA1c; and the study did not identify factors associated with glycemic control.[12] Another recent study in Ethiopia also documented that the mean HbA1c was 9.6 ± 2.4% and concluded that the majority of children and adolescents had poor glycemic control. However, in that study the HbA1c measurement was not uniformly done at the time of data collection, rather it was taken from the medical records of patients. Therefore, this study aimed to determine the level of glycemic control and identify factors associated among children and adolescents with T1DM on follow-up at a pediatric chronic follow up clinic in Jimma Medical Center, Jimma, Ethiopia.

Materials and Methods

Study Area and Period

The study was conducted at pediatric chronic follow up clinic of Jimma Medical Center, Jimma, South-west Ethiopia. Jimma Medical Center is located in Jimma town which is located in southwestern part of Ethiopia, Oromia region, 352km from Addis Ababa. It serves as a referral hospital for southwestern part of the country. It gives service in different specialty and subspecialty fields, among these pediatrics and child health is one of them. The service given at pediatrics and child health include inpatient treatment and outpatient treatment including emergency, ambulatory and follow up service. Children and adolescents with T1DM attend their regular follow up at pediatrics follow up clinic and the care given include evaluation by pediatrics residents, medication refill, diabetes education etc. The study was conducted from July 10 to October 10, 2022.

Study Design and Population

An institution-based cross-sectional study was conducted among children and adolescents with type 1 diabetes mellitus on follow up at pediatric follow-up clinic at Jimma Medical Center.

Sampling and Eligibility Criteria

There were a total of 173 children and adolescents with type 1 diabetes mellitus on regular visits at pediatrics follow-up clinic of Jimma Medical Center. The calculated final sample size before performance the study become 107 by using single population proportion formula. However, as the sample size is manageable and also to increase the precision, we decided to include all sample fulfilling the inclusion criteria as the final sample size.

All children and adolescents ≤ 18 years of age, diagnosed with type 1 diabetes mellitus, on medication for at least 3 months, and on follow up at pediatric follow up clinic were consecutively included. Those children and adolescents who are on treatment for less than 3 months and those who refuse to participate in the study were excluded.

Study Variables

The dependent variable is the level of glycemic control. The independent variables in this study were divided into two categories. They were: a) socio-demographic- this category included variables such as age, gender and educational status of child/adolescent, age, gender, educational status, marital status of primary caregivers, average family monthly income, place of residence and relationship of primary caregivers with the child and adolescent; and b) diabetes, medication and health facility related factors-this category included variables such as Age at diagnosis, Duration of diabetes, Anthropometric parameters, Insulin Storage, Missed Insulin doses, Frequency of blood glucose monitoring, Caregiver involvement in Insulin injections and supervision and blood glucose monitoring (BGM), presence of comorbidity, Caregiver's diabetes knowledge status, health education given during visit, problems faced during follow up visit and frequency of hospital admission in the past 6 month.

Data Collection and Measurements

Data Collection Instruments

Diabetes knowledge of the caregiver was assessed using validated structured questionnaire of diabetes knowledge test adapted from Michigan University tools for health professionals and modified to the context of Ethiopian diet.[13,14] It contains 23 items, correct answer to the question was given a score of 1 and incorrect or I do not know answer was given score of 0. Additionally, to capture important information about the sociodemographic information of the child and caregiver, duration of diabetes, anthropometric assessments, insulin dose, regimen, storage and missed doses, frequency of blood glucose monitoring, caregiver involvement in insulin injections and BGM, level of HbA1c, comorbidity and health facility/service related factors were prepared after reviewing literatures.

Data Collection Procedures

Participants and their caregivers were interviewed using structured questionnaires. The anthropometric assessment was done and standardized using WHO curve for nutritional assessment. Chart of the patient reviewed to capture duration of DM, insulin regimen and dosage. Blood sample for HgbA1c determination collected by trained nurses, the code written on the sample collection tube (EDTA), and then it was given to the assigned laboratory technician at the main laboratory. Results were collected and documented on questionnaire. HgbA1C was done using Roche HITACHI (Cobas 6000) machine at the main laboratory. The questionnaire was prepared in English and translated to Afaan Oromo and Amharic language which are most commonly used by the study population. Data quality was assured during data collection, coding, entry and analysis. To increase the quality of data internal consistency, reliability test was done for the tool used. The Cronbach's alpha for Diabetes knowledge test was (α=0.79). The completeness and consistency of collected data was checked on daily basis.

Operational Definition

Missed insulin doses: this was determined by the number of insulin doses missed in the past 1 week.

Insulin storage: this the place where the family or caregiver regularly keep the Insulin after using this can be refrigeration, storage in a pot of cold water, storage at room temperature or others.

Blood glucose monitoring (BGM) adherence: This was determined by the frequency of blood glucose measurement in a week. It was graded as, Good: ≥3 times per week, Average: 1–2 times per week and Poor: none.[7,15]

Caregiver involvement in diabetes management: includes involvement in insulin injections and involvement in BGM. This was assessed by using a scale graded as minimal, moderate or optimal involvement. This was adapted from study done in Tanzania on glycemic control and associated factors.[7]

Involvement in insulin injection was determined by the number of insulin doses injected or supervised by caregiver in the last 24hr:

Minimal: none

Moderate: 1 injection

Optimal: all injections

Involvement in BGM was determined by the degree of participation of caregiver in the task of blood glucose determination:

Minimal: No participation

Moderate: Reminds the child to check blood glucose, Enters glucose level in the diary or Asks the child about the blood glucose level

Optimal: Sets up the glucometer, Does the finger prick or Supervises the task

Level of Glycemic control: In this study, Good glycemic control: HbA1c <7.5% and Poor Glycemic control: HbA1c ≥7.5%.

Caregiver: an individual, such as a family member or guardian who takes care of a child or adolescent.

Guardian: an individual other than the parents who takes care of a child or adolescent.

Adolescents: from 12 to 18 years old

Children: up to 12 years old

Overweight: defined as BMI b/n 2SD and 3SD or WFA b/n 2SD and 3SD

Obese: defined as BMI > 3SD or WFA >3SD.

Wasting: Moderate wasting = defined by WHO curve as WFH/L b/n −2SD and −3SD, BMI b/n −2SD and −3SD and Severe wasting: defined by WFH/L <-3SD, BMI < −3SD.

Stunting: Severe stunting= defined by using WHO curve as L/HFA less than −3SD and Moderate stunting= Defined as L/HFA b/n −2SD and −3SD.

Comorbidities: are a problem identified after onset of diabetes and usually related to as complication either due to disease progression or treatment related complication or chronic illnesses like epilepsy, RVI.

Diabetes Knowledge: includes components like knowledge of diabetic diet, diabetic test, general diabetes knowledge, physical exercise and diabetes and about diabetic complication.

From the 23 knowledge test questions

Poor Knowledge: participants who scored below the mean value were considered as having poor knowledge towards T1DM.

Good Knowledge: participants who scored above the mean value were considered as having good knowledge or knowledgeable towards T1DM.

Data Processing and Analysis

Collected data were checked for completeness and clarity and variables were categorized then cleaned, coded, and entered into Epi-Data 3.1, exported to SPSS version 25.0 for analysis. Frequencies, percentage, mean and standard deviation were used to summarize descriptive statistics. Univariate, bivariate, and multivariate analyses were also done. Candidate variables on binary logistic regression (p-value ≤0.25) were analyzed by multivariable logistic regression to identify significant predictor for poor glycemic control. Variables having p-value <0.05 in the multivariate logistic regression model were considered as statistically significant. The odds ratio was also used to determine the strength of association between independent variables and the outcome variable.

Results

Socio-Demographic Characteristics

A total of 158 children and adolescents with T1DM on follow up at pediatrics follow up clinic of JMC fulfilling the inclusion criteria were included in the study during the study period. This study revealed that the mean and standard deviation of the age of the participants were 12.05 ± 3.74 years with minimum and maximum age of 1 and half year and 18 years old respectively. More than half 86 (54.4%) of the study participants were males. Regarding educational status of the study participants 68 (43.0%) were attending elementary school. This study also revealed that the mean and standard deviation age of primary caregiver was 39.33± 10.25 years. About 93 (58.9%) of the primary caregivers were females and 86 (54.4%) of caregivers were children's mother. Additionally, the majority 93 (58.9%) participants were from rural. One-fourth of the primary caregivers ha attended primary education. Based on this study 55 (34.8%) of the study participants were having ≤1500 ETB of family monthly income (See Table 1).

Table 1 Socio-Demographic Characteristics of Children and Adolescents with Type 1 DM at Pediatric Follow Up Clinic, JMC, Southwest Ethiopia, 2022

Variables	Category	Frequency	Percentage
Age of the child	<6 years	13	8.2
	6–12 years	64	40.5
	12–18 years	81	51.3
Sex of the child	Male	86	54.4
	Female	72	45.6
Educational status of the child	Pre-school (including KG)	24	15.2
	Elementary (1–4)	68	43.0
	Junior school (5–8)	47	29.7
	Secondary school (9–12)	19	12.0
Age of the primary caregiver	<20 years	3	1.9
	20–30 years	35	22.2
	31–40 years	64	40.5
	>40 years	56	35.4
Sex of caregiver	Male	65	41.1
	Female	93	58.9
Relationship of the caregiver with the child	Mother	86	54.4
	Father	47	29.7
	Guardian	25	15.8
Marital status of caregiver	Married	128	81.0
	Unmarried	11	7.0
	Divorced	8	5.1
	Widowed	11	7.0

(*Continued*)

Table 1 (Continued).

Variables	Category	Frequency	Percentage
Place of residence	Urban	65	41.1
	Rural	93	58.9
Caregiver educational status	Cannot read and write	59	37.3
	Primary (1–8)	40	25.3
	Secondary school (9–12)	39	24.7
	College/above	20	12.7
Current occupational status of caregiver	House wife	60	38.0
	Farmer	60	38.0
	Employed	19	12.0
	Merchant	5	3.2
	Daily laborer	11	7.0
	Others	3	1.9
Family monthly income	≤1500ETB	55	34.8
	1500–3500 ETB	51	32.3
	>3500 ETB	52	32.9

Diabetes and Medications Related Factors

This study revealed that the mean and standard deviation age in years at diagnosis was 8.62 ±3.56 years. About 71 (44.9%) participants age at diagnosis was between 5 and 10 years of age. The mean and standard deviation of duration of diabetes in years was 3.43±2.76 years. Similarly, about 79 (50%) respondents duration of diabetes was between 1 and 5 years. This study revealed that all children and adolescents with type 1 diabetes were using an intermediate-acting NPH insulin mixed with regular insulin administered twice daily. This study revealed that half 79 (50.0%) of the patients stored the medication in pot of cold water followed by 59 (37.3%) of them stored insulin in refrigerator. Regarding caregiver involvement in insulin injection, only 40 (25.3%) of them had optimal and 14 (8.9%) of them were having moderate caregiver involvement in the tasks. Whereas 41 (25.9%) of participants were having optimal caregiver involvement with regard to insulin injection supervision. Sixty (38.0%) study participants had good adherence to blood glucose monitoring. Regarding the role/involvement of caregivers in measurement of blood glucose, only 47 (29.7%) caregivers had optimal involvement in the task (See Table 2).

Nutritional Status of Children and Adolescents

This study showed that 8 (5.1%) participants were reported as being underweight. Similarly, moderate stunting was reported among 27 (17.1%) children and severe stunting was reported among 8 (5.1%) children. Based on the BMI for age result 13 (8.2%) children had moderate wasting and 2 (1.3%) children were reported as having severe wasting. Additionally, 20 (12.7%) respondents had moderate wasting based on MUAC for age value (See Table 3).

Health Facility/Service Related Factors

This study revealed that 145 (91.8%) study participants have received health education and/or advice about diabetes during any of their visits to health facility. This study also revealed that half 81 (51.3%) of study participants faced problems in the hospital during health care delivery. Among problems faced during health care delivery shortage of

Table 2 Diabetes and Medication Related Characteristics of Children and Adolescents with Type 1 DM at Pediatric Follow Up Clinic, JMC, Southwest Ethiopia, 2022

Variables	Category	Frequency	Percentage
Age at diagnosis of DM	<5 years	31	19.6
	5–10 years	71	44.9
	≥10 years	56	35.4
Duration of diabetes	<1 year	44	27.8
	1–5 years	79	50
	≥5 years	35	22.2
Insulin regimen	NPH/Regular	158	100.0
Place in which insulin stored	Refrigerator	59	37.3
	Pot	79	50.0
	Room temperature	14	8.9
	Other	6	3.8
Caregiver involvement in insulin injection	Minimal	104	65.8
	Moderate	14	8.9
	Optimal	40	25.3
Caregiver involvement in insulin injection supervision	Minimal	95	60.1
	Moderate	22	13.9
	Optimal	41	25.9
Having Glucometer	Yes	124	78.5
	No	34	21.5
Blood glucose monitoring adherence	Good	60	38.0
	Average	45	28.5
	Poor	53	33.5
Role of caregiver in blood glucose determination (n=142)	Minimal	50	35.2
	Moderate	45	31.7
	Optimal	47	33.1
No- of missed insulin doses in the past 1 week	No missed dose	153	96.8
	1 missed dose	5	3.2

insulin was reported among 79 (50.0%) children. Similarly, 42 (26.6%) of children with Type 1 DM attending their follow up at Pediatric clinic of JUMC have been admitted to hospital in the past 6 months. Among admitted children 36 (85.7%) of them were admitted for 1 time and the rest 6 (14.3%) of children were admitted to hospital 2 times in the last 6 months (See Table 4).

Table 3 Anthropometric Parameters of Children and Adolescents with Type 1 DM at Pediatric Follow Up Clinic, JMC, Southwest Ethiopia, 2022

Variables	Category	Frequency	Percent
WFA (n=48)	Normal	40	83.3
	Underweight	8	16.7
L/HFA	Normal	123	77.8
	Moderate stunting	27	17.1
	Severe stunting	8	5.1
WFH/L (n=14)	Normal	13	92.9
	Moderate wasting	1	7.1
BMI for age (n=153)	Normal	138	90.2
	Moderate wasting	13	8.5
	Severe wasting	2	1.3
MUAC for age	Normal	138	87.3
	Moderate wasting	20	16.7

Table 4 Health Facility Related Characteristics of Children and Adolescents with Type 1 DM at Pediatric Follow Up Clinic, JMC, Southwest Ethiopia, 2022

Variables		Category	Frequency	Percentage
Have you got health education/advice		Yes	145	91.8
		No	13	8.2
Type of health education/advice you got (n=145)	Importance of insulin	Yes	90	62.1
		No	55	37.9
	Method of insulin administration	Yes	115	79.3
		No	30	20.7
	Compilations of DM	Yes	92	63.4
		No	53	36.6
	Not to miss doses and appointments	Yes	118	81.4
		No	27	18.6
	Dietary counseling	Yes	96	66.2
		No	49	33.8
Ever faced problems in the health facility		Yes	81	51.3
		No	77	48.7

(*Continued*)

Table 4 (Continued).

Variables		Category	Frequency	Percentage
Type of problems faced in health facility (n=81)	Shortage of insulin	Yes	79	97.5
		No	2	2.5
	Long waiting time	Yes	24	29.6
		No	57	70.4
	Poor communication	Yes	1	1.2
		No	80	98.8
Have you been admitted previously in last 6 months		Yes	42	26.6
		No	116	73.4
For how many time did you admit to hospital (n=42)		1 Time	36	85.7
		2 times	6	14.3

Caregivers' Diabetes Knowledge Status

This study revealed that the mean and standard deviation of diabetes knowledge score among caregivers towards diabetic knowledge was 8.48 ±3.58 with minimum and maximum knowledge score of 2 to 17 out of 23 knowledge items.

Level of Glycemic Control

Regarding the level of HgbA1C; the mean and standard deviation of HgbA1C was 9.67 ± 2.28%. According to this study about 3/4th of the study participants were having poor glycemic control (See Figure 1).

Factors Associated with Poor Glycemic Control

In multivariate logistic regression model caregivers relationship with child, involvement of caregiver in insulin injection supervision, blood glucose monitoring adherence, faced problems at hospital during health care delivery, and having previous admission in last six months were found to be significant variables associated with poor glycemic control at p-value <0.05 with 95% CI of AOR.

So, this study revealed that children having guardian as primary caregiver were 4.4 times more likely to have poor glycemic control compared to mother as primary caregiver for a child (AOR=4.45 95%, p=0.045). Similarly, children having father as primary were 6 times more likely to have poor glycemic control compared to mother as primary caregiver for a child (AOR=6.02, 95%, p=0.023).

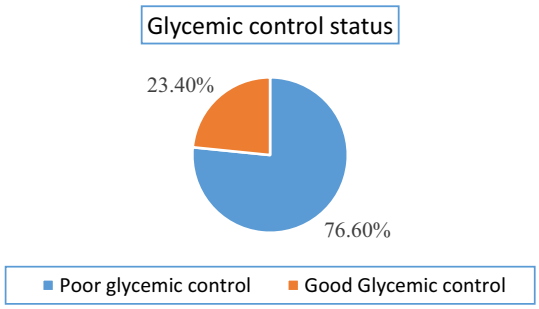

Figure 1 Glycemic control among children and adolescents with type 1 DM at pediatric follow up clinic, JMC, Southwest Ethiopia, 2022.

The odds of having poor glycemic control was 5.4 times higher among participants who had minimal caregiver involvement in insulin injection supervision compared to children who had optimal caregiver involvement (AOR=5.39, 95%, p=0.002). The odds of having poor glycemic control was 4.4 times higher among children who had poor blood glucose monitoring adherence as compared to children who had good adherence (AOR=4.42, 95%, p=0.026).

Participants who had faced problems at hospital while seeking health service was 3.4 times more likely to have poor glycemic control compared to their counterparts (AOR=4.42, 95%, p=0.018). Similarly, this study revealed that the odds of having poor glycemic control was 7.9 times higher among children who had history of previous admission in the last six months as compared to their counterparts (AOR=7.94, 95%, p=0.004) (See Table 5).

Table 5 Binary and Multivariable Logistic Regression Model to Identify Factors Associated with Poor Glycemic Control Among Children and Adolescents with Type 1 DM at Pediatric Follow Up Clinic, JMC, Southwest Ethiopia, 2022

Variables	Category	Glycemic Control		COR 95% CI	AOR 95% CI
		Poor (%)	Good (%)		
Educational status of the child	Preschool	21 (87.5)	3 (12.5)	4.08 (0.88–18.80)	9.83 (0.84–115.4)
	Primary (1–4)	53 (77.9)	15 (22.1)	2.06 (0.69–6.16)	1.10 (0.24–5.00)
	Junior school (5–8)	35 (74.5)	12 (25.5)	1.70 (0.54–5.32)	1.24 (0.25–6.24)
	Secondary	12 (63.2)	7 (36.8)	1	1
Sex of primary caregiver	Male	58 (89.2)	7 (10.8)	3.95 (1.60–9.67)	3.16 (0.16–62.15)
	Female	63 (67.7)	30 (32.3)	1	1
Relationship of caregivers with child	Mother	56 (65.1)	30 (34.9)	1	1
	Father	43 (91.5)	4 (8.5)	5.76 (1.88–17.58)	6.02 (1.58–22.96)*
	Guardian	22 (88.0)	3 (12.0)	3.93 (1.08–14.20)	4.45 (1.03–19.16)*
Place of residence	Urban	42 (64.6)	23 (35.4)	1	1
	Rural	79 (84.9)	14 (15.1)	3.90 (1.44–6.62)	2.60 (0.48–14.06)
Caregivers level of education	Cannot read and write	49 (83.1)	10 (16.9)	3.27 (1.06–10.05)	3.08 (0.52–18.19)
	Primary school	33 (82.5)	7 (17.5)	3.14 (0.93–10.54)	5.25 (0.87–31.70)
	Secondary school	27 (69.2)	12 (30.8)	1.50 (0.48–4.64)	3.46 (0.51–23.42)
	College /university	12 (60.0)	8 (40.0)	1	1
Involvement of caregiver in insulin injection supervision	Minimal	84 (88.4)	11 (11.6)	10.78 (4.45–26.08)	5.39 (1.86–15.60)*
	Moderate	20 (90.9)	2 (9.1)	14.12 (2.90–68.59)	8.97 (1.41–57.12)*
	Optimal	17 (41.5)	24 (59.5)	1	1
Having glucometer	Yes	91 (73.4)	33 (26.6)	1	1
	No	30 (88.2)	4 (11.8)	2.72 (0.89–83.08)	0.18 (0.01–2.29)
Adherence to blood glucose monitoring	Good	34 (56.7)	26 (43.3)	1	1
	Average	38 (84.4)	7 (15.6)	4.15 (1.59–10.78)	1.80 (0.56–5.80)
	Poor	49 (92.5)	4 (7.5)	9.36 (2.99–29.28)	4.42 (1.19–16.47)*

(*Continued*)

Table 5 (Continued).

Variables	Category	Glycemic Control		COR 95% CI	AOR 95% CI
		Poor (%)	Good (%)		
Health education	Yes	109 (75.2)	36 (24.8)	1	1
	No	12 (92.3)	1 (7.7)	3.96 (0.48–31.55)	3.07 (0.19–48.19)
Faced problem in hospital	Yes	66 (81.5)	15 (18.5)	1.76 (0.83–3.72)	3.43 (1.24–9.52)*
	No	55 (71.4)	22 (28.6)	1	1
Previous admission in last 6 months	Yes	39 (92.9)	3 (7.1)	5.39 (1.56–18.63)	7.94 (1.91–32.95)*
	No	82 (70.7)	34 (29.3)	1	1
Caregivers diabetes knowledge	Poor knowledge	76 (14.6)	13 (85.4)	3.12 (1.45–6.73)	0.94 (0.29–2.99)
	Good knowledge	45 (65.2)	24 (34.8)	1	1

Note: *Indicates variable which have statistically significant association with poor glycemic control at $p<0.05$.

Discussion

This study revealed that significant numbers of participants were having poor glycemic control, which accounts about 76.6%. The mean HbA1c in this study was 9.67 ± 2.28%, which is higher than the recommended target [7.5%]. This is alarming because children and adolescents with poor glycemic control are at risk of multiple complications of diabetes. This finding is in line with the studies done in Ethiopia (mean HbA1c was 9.6 ± 2.4%) and other resource-limited settings like Cameroon (mean HbA1c was 9.2% ± 2.5), Tanzania (mean HbA1c 11.1 ± 2.1%), and Southeast Niger (mean HbA1c was 10.5%). It is also consistent with the finding of study done in Sudan which showed the prevalence of poor glycemic control of 76%.[7–9,11,16] This similarity in glycemic control could be due to the same poor socioeconomic status in these countries as poor socioeconomic status contributes to poor glycemic control through its undesired effects on quality of diabetes care, treatment adherence, and provision of adequate and healthy nutrition.[17]

According to this study regarding the nutritional status of children and adolescents with diabetes, about 22.2% were stunted. This finding is lower than study done in Rwanda, which showed the prevalence of stunting was 30.9%. This difference could be due to the sample size difference. This study is also consistent study done in Pune, India. The effect of diabetes on the nutritional status could be explained by the fact that insulin is an important regulator of growth hormone-related factors, specifically insulin-like growth factor (IGF-1) and insulin-like growth factor binding protein (IGFBP-3), disorders of insulin production can result in poor growth. In our study, there is no association between stunting and glycemic control, which is in line with the study done in Rwanda.[18]

This study revealed that more than half of the caregivers (56.3%) had poor level of diabetes knowledge, and this shows that many caregivers may have difficulty in managing their children's diabetes, which might lead to many types of complications. This result is consistent with an Ethiopian study demonstrating the same finding.[14] It is also in line with study from Tanzania, which mentioned that mothers had limited knowledge about diabetes mellitus though they did not mention the exact knowledge level. There is no statistically significant association between diabetes knowledge of caregiver and poor glycemic control, which is in line with the above study.[7]

In the current study, a primary caregiver other than the mother were one of the factors significantly associated with poor glycemic control. This is in line with the study done in Tanzania.[7] This could be explained by the role that parents play in caring for sick children in the African societies, where it is the primary responsibility of the mother to care for sick children.

Minimal caregiver involvement in insulin injection supervision was also significantly associated with poor glycemic control. This is in line with study done in Southeast Nigeria, on sociodemographic determinants of glycemic control among children with type 1 diabetes, and found caregivers' involvement in diabetes management was the only strong

determinant for optimal glycemic control.[8] This could be explained by some children may not take doses accurately when they take without supervision by the caregiver.

In this study, poor blood glucose monitoring adherence was associated with poor glycemic control. This is consistent with the study done in Tanzania.[7] This might be due to the fact that participants who measure their blood glucose less frequently may not detect episodes of hyperglycemia or hypoglycemia and take necessary measures. In our setting due to limited resources, it could be because of lack of continuous supply of glucometer strips or the fact that most of the participant's glucometer was not functional but this is just the observation of the authors and needs further studies on factors affecting the adherence to blood glucose monitoring.

Problems faced in the health facility were one of the variables that were significantly associated with glycemic control. Children who had faced problems which was mainly lack of insulin medication at hospital while seeking health service were more likely to have poor glycemic control. This might be the lack of insulin supply, which happens sometimes in the hospital because of limited availability of economic resources in our setup and obviously most of the parents in our setting may not afford to buy from the private pharmacies.

Admission to the hospital in the past 6 months were significantly associated with the poor glycemic control. This could be explained by the fact that admission to hospital by itself could be because of poor glycemic control. Children and adolescents should be monitoring their blood glucose level and health professionals and caregivers must work in integrity to support admitted children and adolescents with diabetes.

The strength of this study included that HbA1 measurements were done using the same machine for all participants and used many independent variables to look associations with outcome variable. However, this study does have some limitations. The cross-sectional nature of the study design and being conducted at a single follow-up site limiting the generalizability of these findings to all children and adolescents with diabetes are the main limitations of this study.

Conclusion

In conclusion, this study found that the level of glycemic control is poor in children and adolescents with type 1 diabetes mellitus. Factors associated with poor glycemic control include a caregiver other than the mother, minimal caregiver involvement in insulin injection, poor adherence to blood glucose-monitoring, problems faced during health care seeking and having history of hospital admission in the past 6 months.

Health education and counseling should be sustainable and long lasting; emphasis needs to be given to adherence counseling and active participation of caregiver in diabetes management tasks. Regular monitoring of glycemic control should be strengthened. We also recommend that health care constraints in our setting like lack of continuous supply of the insulin and lack of access to technologies such as continuous glucose monitoring and insulin pumps shall be solved. Additionally, putting strategies to sustain insulin supply shall also be considered. We also recommend more multicenter studies with a large number of participants.

Abbreviations

AOR, adjusted odds ratio; COR, crude odds ratio; CI, confidence interval; JMC, Jimma Medical Center; T1DM, Type 1 diabetes mellitus; HbA1c. Hemoglobin A1C (Glycated hemoglobin); WHO, World Health Organization; BMI, Body Mass Index; MUAC, Mid Upper Arm Circumference; ADA, American Diabetes Association; ETB, Ethiopian Birr; IDF, International Diabetes Federation; SPSS, Statistical Package for the Social Sciences; mg/dL, milligram per deciliter; mmol, millimole; RBS, random blood sugar; BGM, blood glucose monitoring; ISPAD, International Society for Pediatric and Adolescent Diabetes.

Ethics Approval and Informed Consent

Ethical clearance was obtained from Jimma University Institutional Review Board and permission to conduct the study was obtained from administration of Jimma Medical Center. After explaining the purpose of the study, written informed consent was obtained from each study participant's caregiver. Assent was also obtained from adolescent participants. Confidentiality was assured by collecting data anonymously. This study was conducted in accordance with the Declaration of Helsinki.

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Disclosure

The authors report no conflicts of interest in this work.

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