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RESEARCH ARTICLE

Factors Associated With Glycaemic Control Among Indian Children With Type 1 Diabetes Attending A Tertiary Care Centre.

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Abstract: ***Background***: Type-1 Diabetes mellitus (T1DM) is a widespread chronic diseases affecting individuals irrespective of childhood or adulthood. Achieving optimal glycaemic control in T1DM is challenging but essential to prevent long-term microvascular and macrovascular complications. For the wellbeing of health, ISPAD: The International Society for Pediatric and Adolescent Diabetes, 2022 recommends an ideal target of HbA1c <7.0%. ***Methods:*** A cross sectional study was conducted at a tertiary care center in Kerala, India, involving 122 children diagnosed with T1DM aged between 8–18 years . All were on regular treatment for at least six months. A quantitative data in the form of set of standard questions related to diabetes and Socio-demography were collected. HbA1c was measured using HPLC. Based on ISPAD 2022 criteria, children were classified as having good (HbA1c < 7%) or poor (HbA1c >7%) glycaemic control. ***Results:*** Of the 122 participants, the mean age was 13.08 ± 2.40 yrs, having a male:female ratio of 1:1.4. Good glycaemic control was observed in 42.6%, while 57.4% had poor controlling issues. Factors including age, duration of diabetes, family history of T1DM, frequency of blood glucose monitoring, and dietary adherence were notably responsible for the glycaemic management. Multivariate logistic regression identified independent predictors: duration of diabetes (aOR = 3.85, p=0.003), frequency of glucose monitoring (aOR = 0.381, p = 0.04), and dietary adherence (aOR = 6.519, p = 0.003). ***Conclusion:*** Glycaemic control in children with T1DM is influenced largely by modifiable factors. Focused interventions targeting these areas through individualized, multidisciplinary care can improve outcomes.

Keywords: T1DM; HbA1c; Glycemic control; HPLC; blood glucose monitoring; dietary adherence.

INTRODUCTION

The loss of insulin-producing cells in the pancreas results in a decrease in insulin levels. This condition is classified as Type 1 Diabetes Mellitus (T1DM), an autoimmune disorder. This autoimmune response results in the body's incapacity to regulate glucose metabolism, leading to disturbances in carbohydrate, fat, and protein metabolism due to insufficient insulin action on target tissues. [1,2].

Worldwide, the incidence of T1DM among children and adolescents has been consistently increasing. The 2021 version of the International Diabetes Federation(IDF), indicates that children or teen between 0 to 19 yrs of age are more prone to T1DM in India, with a prevalence of 229,400 cases and around 24,000 new cases annually. This positions India at the top among all IDF member nations concerning disease burden [3]. The rising prevalence is particularly alarming given the lifelong nature of the condition and the difficulties involved in managing it during childhood and adolescence.

Managing T1DM is complicated and necessitates a structured and personalized self-care approach, which includes periodic glucose tracking in blood, a number of insulin injections per day, continuous insulin infusion therapy, routine physical movements, and adherence to a balanced, carbohydrate-controlled diet [4]. These requirements can be especially challenging during the early stages of life, as psychological, emotional, and behavioral factors significantly impact adherence and glycemic control [5].

Diabetes managing education plays an essential role in providing children and their caregivers with the awareness needed to achieve desirable glycemic control and to prevent both immediate and future complications, such as cardiovascular complications, retinopathy, neuropathy, etc. [6]. Establishing glycemic targets early in life has been demonstrated to offer long-term advantages, including a decreased risk of further hurdles and enhanced wellbeing life throughout. [7].

Diverse studies on T1DM have pinpointed important factors that affect the children or adolescents suffering with it. These factors include the age at which diabetes is diagnosed, the length of time since diagnosis, the type of insulin regimen used (whether basal-bolus or fixed-dose), how frequently blood glucose is self-monitored

(SMBG), adherence to dietary guidelines, levels of physical activity, psycho-social support, and family participation in diabetes management [8-10]. Furthermore, the application of contemporary methods like continuous tracking of glucose and insulin pumps has been linked to better metabolic results [11].

It's a rationale that even though T1DM is becoming increasingly prevalent in India, particularly among children, there is a lack of regional data regarding glycaemic control and its influencing factors. Kerala, recognized for its high literacy rates and relatively advanced healthcare system, provides a distinctive setting to investigate these relationships in a tertiary care environment. Grasping the factors that govern glycaemic control within this population is crucial for developing targeted interventions and fostering early and ongoing metabolic regulation.

Aim and Objectives

The primary intent is to estimate the proportion of children achieving optimal glycaemic control as per ISPAD guidelines among those diagnosed with T1DM attending a diabetic clinic at a tertiary care hospital in Kerala, India. A secondary objective is to identify the sociodemographic, clinical, and behavioral factors connected with its controlling in this population.

MATERIALS AND METHODS

A descriptive analytical study design was utilized to identify factors linked to glycaemic regulation in children. The research involved at a tertiary care center in Kerala with 122 children aged 8 to 18 years who attended the diabetic clinic, which acts as a referral hub for T1DM management across three districts—Thiruvananthapuram, Kollam, and Pathanamthitta. The sample size was determined based on a previously reported prevalence of inadequate glycaemic control (HbA1c >7.0%) of 77.6% [3].

The Institutional Ethics Committee (Ref No: IEC-NI/19/NOV/71/87 dtd 09/12/2019) has granted ethical approval for the study. From the parents and their children in the centre a written consent and assent were taken after providing information sheets. Children eligible for the study were confirmed to have T1DM, were aged between 8 and 18 years, and had undergone regular treatment for at least six months. Those with secondary diabetes or Type 2 Diabetes mellitus were excluded.

Participants were selected consecutively based on the established eligibility criteria. Data collection utilized a structured questionnaire that included both socio-demographic details (such as age, gender, place of residence, family type, parents' ages and education levels, parental occupations, and family income) and diabetes-related information (family history of T1DM, age, history of thyroid issues, period of diabetes, type and frequency of insulin administration, weekly blood glucose monitoring frequency, dietary adherence, weekly physical activity, and regularity of follow-up visits).

Glycaemic control was measured through high-performance liquid chromatography(HPLC), it is an analytical method. It evaluated the most recent HbA1c values. According to ISPAD 2022 guidelines, participants were categorized into two groups: those achieving optimal glycaemic control (HbA1c <7.0%) and those with suboptimal control (HbA1c >7%). The collected data were analyzed with IBM SPSS V.20 which depicts the relations between the variables. Continuous variables and categorical variables were displayed by it. The relationship among glycaemic control and numerous socio-demography elements and clinical factors was explored using the Pearson's Chi-square test, as applicable. Variables demonstrating a statistically significant association in the univariate analysis ($p<0.01$) were further investigated using multivariate logistic regression to recognize independent predictors of glycaemic control. A p-value of <0.05 was considered statistically important.

RESULTS AND OBSERVATIONS:

The socio-demography profile of all the participants indicates that a significant portion of them fell within the early adolescent age group of 11–14 years, had an average age(13.08 ± 2.40) yrs comprising 53.3%, and a higher number of female participants (59.0%). A large majority of the participants lived in rural settings (76.2%) and were part of nuclear family units (66.4%), highlighting traditional family structures and representation from rural communities. Most fathers were under the age of 45 (49.2%), while 6.6% had passed away.

The educational level of the fathers was mostly confined to higher secondary education (79.5%), with many employed as daily wage laborers (58.2%), whereas only a small fraction held government or professional occupations (4.9%). Most mothers were under 40 years of age (55.7%), with 73% having achieved higher secondary education. Despite 39.3% of mothers being employed, the predominant role remained that of a homemaker (60.7%). The income levels exhibited a relatively even distribution, with 49.2% of families earning less than ₹10,000 and 50.8% earning above this amount, reflecting socioeconomic diversity within the cohort, as depicted in Table 4.1.

Table1: Socio-demography features of the parents and their children

Variables	Features	Frequency	Percentage
Age in years	8-10	23	18.9
	11-14	65	53.3
	15-18	34	27.9
Gender	Female	72	59.0
	male	50	41.0
Resident area	Urban	29	23.8
	Rural	93	76.2
Type of Family	Nuclear	81	66.4
	Joint family	41	33.6
Age of father(in years)	Not alive	8	6.6
	<45	60	49.2
	>45	54	44.3
Education of father	NA	8	6.6
	Higher Secondary	97	79.5
	Degree and above	17	13.9
Occupation of father	NA	8	6.6
	Daily wager	71	58.2
	Self employed or private job	37	30.3
	Govt or professional	6	4.9
Age of mother(in years)	<40	68	55.7
	>40	54	44.3
Education of mother	Higher Secondary	89	73.0
	Degree and above	33	27.0
Occupational status of mother	Home maker	74	60.7
	Employed	48	39.3
Monthly Family Income(in Rs)	<10000	60	49.2
	>10000	62	50.8

Table 4.2 illustrates the clinical profile of the pediatric group diagnosed with T!DM, indicating that the largest proportion was diagnosed between the ages of 7–10 years (52.5%), followed by those aged 11–14 years (23.0%), with only 4.9% diagnosed before the age of 3. The average duration of the illness was 3 years, and more than half (54.1%) had been living with diabetes for 1–3 years. A family history of T1DM was reported by 9.0% of the participants, while 4.9% had concurrent thyroid disorders. The majority of the children (82.8%) were on a regimen of both long-acting and short-acting insulin, with nearly half (48.4%) needing five injections each day. However, most individuals monitored their blood glucose

infrequently, with 67.2% indicating they checked it less than three days a week. Dietary adherence was noted in 76.2% of the group, and 64.8% participated in physical activity on more than three days per week, while 21.3% did not engage in any physical activity. Importantly, all participants (100%) were under regular clinical supervision, highlighting their consistent access to healthcare and ongoing diabetes management.

Table2: Diabetes related characteristics of study participants

Variables		Frequency	Percentage
Age of Diagnosis of T1DM(yrs)	<3	6	4.9
	3-6	24	19.7
	7-10	64	52.5
	11-14	28	23.0
Duration of Diabetes in years	1-3	66	54.1
	4-6	18	14.8
	7-9	22	18.0
	≥10	16	13.1
Family History of TIDM	Yes	11	9.0
	No	111	91.0
H/O Thyroid Disorder	Yes	6	4.9
	No	116	95.1
Type of Insulin	Long acting+short acting	101	82.8
	Short acting+Intermediate acting	21	17.2
Insulin frequency/day	3	16	13.1
	4	47	38.5
	5	59	48.4
Self monitoring of blood glucose per week	≤3 days	82	67.2
	>3 days	40	32.8
Dietary Adherence	Yes	93	76.2
	No	29	23.8
Physical activity per week(in days)	No activity	26	21.3
	< 3 days	17	13.9
	> 3 days	79	64.8
Regular follow up	Yes	122	100.0

Glycaemic control, assessed by HbA1c levels, indicated that only 52 out of 122 children (42.6%) achieved good control (HbA1c <7%), while 70 (57.4%) showed poor control (HbA1c >7%). The average HbA1c for the group was significantly high at 8.89% (SD ± 2.13), indicating insufficient glycaemic management for a large portion of the participants. This

disparity—almost 2 out of 4 children with uncontrolled diabetes—highlights the urgent need for focused interventions to improve glycaemic results through better adherence, education, and enhanced access to comprehensive diabetes care, as illustrated in Table 4.3.

Table3: Proportion of glycaemic control among children with T1DM

Glycemic Control(HBA1c)	Frequency	Percentage	Mean	SD
< 7% (Good Control)	**52**	**42.6**	**8.89**	**2.13**
>7 % (Poor Control)	**70**	**57.4**		

As indicated in Table 4.4, various factors revealed statistically significant correlations with glycaemic control in children with T1DM. Children under 10 years of age were more likely to attain good glycaemic control compared to those over 10 years ($\chi^2 = 3.85$, $p = 0.04$). The duration of diabetes was identified as a significant factor, with those diagnosed in the last three years exhibiting notably better control than those with a longer history of the disease ($\chi^2 = 13.14$, $p < 0.001$). A family history of T1DM correlated with poorer control ($\chi^2 = 4.15$, $p = 0.04$), indicating possible genetic or behavioral challenges in managing the disease. The frequency of blood glucose self-monitoring also had a significant effect; children who monitored more than three days weekly demonstrated improved glycaemic results ($\chi^2 = 5.38$, $p = 0.02$). Dietary compliance emerged as one of the most impactful factors, with participants who did not adhere to dietary guidelines exhibiting a much higher rate of poor control ($\chi^2 = 10.02$, $p < 0.001$). Conversely, factors such as gender, place of residence, type of family, maternal age, parental educational background, occupational status, insulin treatment, levels of physical activity, and family income did not exhibit significant links to glycaemic management ($p > 0.05$). These results highlight the crucial role of early diagnosis, organized diabetes education, adherence to dietary recommendations, and consistent glucose monitoring in achieving optimal metabolic results in managing pediatric diabetes.

Table4: Association of sociodemographic and diabetes related characteristics with glycaemic control

Variables	Category	Glycemic control <7 (Good)	Glycemic control >7 (Poor)	X^2	P
Age in years	<10	14	09	3.85	0.04*
	>10	38	61		
Gender	Male	17	33	2.57	0.10
	Female	35	37		
Area of Residence	Rural	41	52	0.34	0.55
	Urban	11	18		
Type of Family	Nuclear	36	45	0.32	0.56
	Joint family	16	25		
Age of mother	<40	30	38	0.14	0.70
	>40	22	32		
Education of mother	Higher Secondary	39	50	0.19	0.66
	Degree and above	13	20		
Occupational status of mother	Home maker	33	41	0.29	0.58
	Employed	19	29		
Family Income	<10000	23	37	0.88	0.34
	>10000	29	33		
Duration of Diabetes in years	<3	38	28	13.14	0.00*
	>3	14	42		
Family History of T1D	Yes	01	10	4.15	0.04*
	No	51	60		
Insulin frequency/day	3	06	10	1.09	0.57
	4	18	29		
	5	28	31		
Self monitoring of blood glucose per week	<3 days	29	53	5.38	0.02*
	>3 days	23	17		
Dietary Adherence	Yes	47	46	10.02	0.00*
	No	05	24		
Physical activity per week (in days)	No activity	13	13	1.79	0.40
	<3 days	5	12		
	>3 days	34	45		

A multivariate logistic regression analysis indicated that children with a long period of history of type 1 had markedly higher chances of experiencing unhealthy glycaemic management. Additionally, not adhering to dietary guidelines was strongly linked to inadequate control. On the other hand, regularly monitoring blood glucose >3 days per week seemed to provide a protective effect, correlating with significantly improved glycaemic control. While there was a tendency for children with a family record of type 1 to have better glycaemic outcomes, this association had not achieved significance statistically . Other variables such as age and gender were not mainly correlated with glycaemic control, as detailed in Table 4.5.

Table5: Significant variation among factors associated with glycemic control

Variables	aOR	95% CI		P
		Lower	Upper	
Age in years	1.458	0.498	4.266	0.491
Gender	0.499	0.203	1.224	0.129
Duration of Diabetes in years	3.855	1.598	9.298	0.003*
Family History of TIDM	0.128	0.014	1.203	0.072
Self monitoring of blood glucose per week	0.381	0.151	0.963	0.041*
Dietary Adherence	6.519	1.915	22.186	0.003*

DISCUSSION

The study revealed that 57.4% of children exhibited poor glycaemic control (HbA1c >7.0%), while 42.6% maintained good control (HbA1c <7.0%). These results align with prior studies indicating poor glycaemic control in the range of 45.8% to 76% among children with T1DM [4–7]. The differences in prevalence reported across various studies may stem from variations in healthcare systems, diabetes education, glycaemic objectives, and the age distribution of participants [12].

Univariate analysis highlighted significant correlations between glycaemic control and factors such as the child's age, duration of diabetes, family history of T1DM, frequency of self-monitoring of blood glucose (SMBG), and adherence to dietary recommendations. Among these factors, age proved to be highly significant. Children under 10 years old demonstrated better glycaemic control compared to those aged 10 and older, which is consistent with other research findings [4–6, 9–11, 13].

This may be influenced by greater parental involvement and stricter monitoring for younger children, while hormonal changes during puberty in older children can lead to increased insulin resistance and poorer control. The duration of diabetes also showed a significant relationship with glycaemic control. Children who had been diagnosed for more than three years exhibited poorer control, aligning with literature that indicates that managing glycaemic levels becomes more challenging over time due to progressive beta-cell loss, declining adherence, and less parental oversight [4, 8, 14]. Children who followed self-monitoring of their glucose levels more than three days weekly showed significantly improved glycaemic control.

This finding is supported by multiple studies that emphasize the crucial role of SMBG in managing T1DM, facilitating insulin dose adjustments, dietary planning, and hypoglycemia prevention [4, 5, 7, 9, 15]. Likewise, adherence to a dietary regimen consisting of three main meals and three snacks daily was linked to better control, reflecting results from a Kerala-based study that found significant improvements in outcomes with dietary compliance ($p = 0.005$) [5, 16].

In the multivariate logistic regression analysis, duration of diabetes (aOR = 3.85, $p = 0.003$), frequency of SMBG (aOR = 0.381, $p = 0.04$), and dietary adherence (aOR = 6.519, $p = 0.003$) emerged as independent predictors of glycaemic control. Children having diabetes more than three years of duration were nearly four times more likely to encounter poor control, which is stable with findings from an Egyptian study that identified a threefold increased risk for those with diabetes lasting five years or more (aOR = 3.0, $p = 0.000$) [4, 14]. Moreover, children who engaged in SMBG greater than three days/week were likely to achieve 2.6 times good glycaemic control, corresponding with a Tanzanian study that reported better control associated with higher adherence to SMBG ($\beta = -0.234$, $p = 0.03$) [9, 17]..

CONCLUSION

In summary, this research emphasizes the complex factors contributing to glycaemic management in children with T1DM, highlighting the notable effect of modifiable clinical factors over fixed sociodemographic elements. A longer duration of the disease and inadequate dietary adherence were closely linked to unfavorable glycaemic results, while consistent self-monitoring of blood glucose acted as a protective factor. Although sociodemographic factors like age, gender, parental education, and income did not reveal significant

correlations, early diagnosis, regular dietary habits, and frequent glucose monitoring were crucial for achieving better metabolic regulation. These results suggest the necessity for targeted, behavior-oriented interventions—especially in the areas of dietary guidance and self-monitoring practices—to enhance diabetes outcomes in pediatric groups, particularly those in rural and socioeconomically varied environments.

Study limitations:

Regardless of limitations, this research gives valuable insights into the factors affecting glycaemic management in children with T1DM. The prevalence nature of the study restricts causal conclusions; however, the identified associations offer a solid basis for hypothesis development and upcoming longitudinal studies. While the research took place in a single tertiary care facility, it reflects the real-life difficulties encountered by a mainly rural and socioeconomically diverse community, thus delivering significant context-specific evidence. Self-disclosed data can be bias regarding glucose tracking frequency and diet consistency, yet they are crucial metrics of the behavioral trends affecting glycaemic results. Although psycho-social and environmental factors were not included in the assessment, the study underscores essential modifiable aspects—specifically dietary adherence, self-monitoring frequency, and illness duration—that can guide targeted interventions. The absence of continuous glucose monitoring data and small subgroup sizes are noted; nonetheless, the consistent trends observed across both bivariate and multivariate analyses strengthen the credibility of the findings. Overall, the study advocates for the development of behavior-focused diabetes management approaches, particularly within under-resourced adolescents.

Conflicts of Interest:

No conflicts of interest.

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