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CORRELATION OF FASTING BLOOD SUGAR LEVEL AND POST PRANDIEL BSL IN CHILDREN OF DIABETES MELLITUS TYPE-1 BELOW AGE OF 16 YEARS IN SOUTHERN PUNJAB

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ABSTRACT

Background: Type 1 Diabetes Mellitus affects children and demands close glycemic control to avoid detrimental effects in the long run. FBSL and PPBSL are two indicators of glycemic control, but the association between the variables in children and adolescents with T1DM has not been adequately investigated, especially in Southern Punjab, Pakistan.

Objective: The purpose of the present work is to evaluate the relationship between FBSL and PPBSL in children and adolescents with T1DM from Southern Punjab, taking into account the demographic and clinical characteristics.

Methods: This study was a cross-sectional study on 50 T1DM children and adolescents aged between 5 and 16 years. FBSL and PPBSL were determined using calibrated glucometers in the fasting state and two hours after eating. Additional information included patient age, gender, ethnicity, insulin therapies, and patients' SES. Pearson or Spearman correlation analyses were used to compare the correlation of FBSL and PPBSL with HbA1c levels.

Results: The observations made from this study show that FBSL is highly and positively correlated with PPBSL with a coefficient of 0.68 at $p < 0.001$ suggesting that high fasting blood levels predict postprandial hyperglycemia. FBSL and PPBSL were moderately and positively correlated with HbA1c, $r = 0.55$, $r = 0.60$, respectively $p < 0.01$, indicating that both values has an impact in long term glycemic control. Overall FBSL and PPBSL were slightly lower in the insulin pump groups compared with those receiving insulin injections indicating the advantage of continuous insulin delivery.

Conclusion: This study also shows that FBSL and PPBSL have a strong positive relationship in patients with T1DM, lending further credibility to the importance of the measurement of both variables to attain optimum glycemic control in children. Socio demographic variables may influence glycemic control, thus the need for targeted diabetes self-management/education interventions in Southern Punjab.

Keywords: Type 1 Diabetes Mellitus; Fasting Blood Sugar; Postprandial Blood Sugar; Pediatric Diabetes; Glycemic Control; Southern Punjab.

Introduction

Type 1 Diabetes Mellitus (T1DM) is an autoimmune disease which results from the autoimmune destruction of pancreatic β-cells and resulting absolute insulin deficiency and persistent hyperglycemia[1]. This condition needs long-term care, especially in children for whom it is crucial to achieve and maintain the best glycemic control possible. In children, inadequately controlled T1DM has the potential of severe and often life-threatening complications like diabetic ketoacidosis, growth failure, and early development of microvascular and macrovascular comorbidities[2]. As for glycemic control, the two most common tests are fasting blood sugar level (FBSL) and postprandial blood sugar level (PPBSL), which gives information of basal glucose level and the response of the body to food respectively[3]

Self-monitoring of FBSL and PPBSL is important in the management of pediatric T1DM because these measures represent diverse features of glycemic control. Fasting blood sugar level, carried out in the morning after the participant has had no breakfast, is useful in determining long-acting insulin and general glycemic control[4]. On the other hand, PPBSL which is usually measured two hours postprandially stands for the carbohydrate loading capacity as well as the efficiency of rapid acting insulin. Research has also demonstrated that high within-subject SD of PPBSL is usually accompanied by poor glycemic control and leads to long-term glycemic variability that is an independent risk factor for diabetes complications[5].

If there is a tight coupling the FBSL with PPBSL one can guess that the patient has a more stable glycemic curve, on the other hand if the deviation between these two measurements exists certain modification in the regime and specifically insulin regimen or diet should be considered[6]. In pediatric patients, this relationship depends on factors such as growth and development, hormones and activity level, which result in unpredictable insulin needs and blood sugar fluctuations[7]. Furthermore, management of T1DM in developing regions including Southern Punjab, Pakistan is a difficult endeavor because of several factors such as restricted access to forms of diabetes education, and a number of cultural and socioeconomic barriers.

The social-economic setting of Southern Punjab has a bearing on the diabetes self-management. The literature shows that children in low-resource environment situations experience access constraints to proper diabetes care, as evidenced by restricted CGM use, fewer available insulin types, and scarce structured diabetes education programs[8]. In addition, other food habits prevailing in this part of the world which include carbohydrate-rich diet and low protein intake may also be responsible for postprandial hyperglycemia and alter association of FBSL and PPBSL[9,10].

This study will compare FBSL and PPBSL in pediatric T1DM patients below 16 years of age in Southern Punjab. This research aims to provide findings about how such measurements are related in the given local socioeconomic and cultural setting so that it could serve as information that would aid in the formulation of region-based diabetes management guidelines.

Material and methods

The current study was a cross-sectional study implemented from September, 2023 to end month of July, 2024 at Ibne Siena Hospital & Research Institute, Multan in Southern Punjab, Pakistan after obtaining approval letter from Institutional Review Board/Independent Ethical Committee

(Reference No. C-90-1044, dated: Nov 12, 2024). For this study, 50 pediatric patients diagnosed with T1DM were selected.

The inclusion criteria were: (1) confirmed diagnosis of T1DM for at least 6 months before the enrollment, (2) insulin use, (3) age 5 to 16 years. Patients with other chronic diseases such as celiac disease and those on drugs that affect glucose metabolism were excluded from the study. Verbal consent was sought from the parents or guardians, and the child's written consent was also sought from children aged 10 years and older. Data collection involved both demographic and clinical information. Demographic details included age, gender, socioeconomic status (categorized as low, medium, or high), and residential location (urban or rural).

Clinical data covered the duration of diabetes, type of insulin regimen (multiple daily injections or insulin pump), and daily insulin dose. Fasting Blood Sugar Levels (FBSL) was measured after a minimum of 8 hours of fasting. Patients and caregivers were instructed to avoid food or beverages other than water overnight. Blood samples were obtained via finger stick using a calibrated glucometer, and results were recorded in mg/dL. Postprandial Blood Sugar Levels (PPBSL) was measured two hours after a standardized breakfast meal, which was provided according to requirements of their ages, tailored to regional dietary habits. Blood samples were taken using the same finger stick glucometer method as FBSL measurements. Patients were categorized based on their insulin regimen into those on multiple daily injections (MDI) and those using insulin pumps. Information on insulin types (e.g., rapid-acting, long-acting, or mixed) and daily dose adjustments within two days before the measurements were documented.

Statistical analysis was performed using SPSS software (Version 26.0). Descriptive statistics summarized demographic and clinical characteristics of the participants. FBSL and PPBSL values were analyzed for normality using the Shapiro-Wilk test. Correlation between FBSL and PPBSL was assessed using Pearson's or Spearman's correlation, depending on the normality of the data distribution. Subgroup analysis was conducted by age (5-10 years, 11-16 years), socioeconomic status, and insulin regimen. Comparisons between subgroups (e.g., mean FBSL, mean PPBSL, correlation coefficients) were made using independent t-tests or Mann-Whitney U tests as applicable. Statistical significance was set at $p < 0.05$.

Results

Of the 50 subjects, 26% were male and 48% were female. More respondents 58% lived in urban and 42% in rural areas. There were some discrepancies in socioeconomic status, with 34% in low, 30% in medium, and 36% in high categories. Regarding years since diabetes diagnosed, 24% for 2–3 years, 50% for 4–5 years, and 26% for six or more years. (Table-1)

The average FBSL was 128 mg/dL with the pump regimen, 130 mg/dL with three injections, and 132 mg/dL with four injections. The mean postprandial blood sugar level (PPBSL) was 195, 198, and 202 mg/dL in the pump, three injections, and four injection groups, respectively. The mean HbA1c was 8.6% in the pump, 8.7% for three injections, and 8.8% for four injections. (Table-2)

The highest number 10 of fasting blood sugar levels (110-145 mg/dL) of patients with CCF is in the range of 120-125 mg/dL, followed by 4 in 130-135 mg/dL. There are two each in 110-115 mg/dL and 140-145 mg/dL, but none in 115-120 mg/dL and 135-140 mg/dL. (Fig-1)

In graph 2 compares mean postprandial blood sugar levels (mg/dL) for various types of insulin, together with rapid-acting at postprandial blood sugar levels of 0-100 mg/dL, covering, though not showing all data points. (Fig-2)

The X-axis represents the duration of diabetes in years, and the Y-axis represents the HbA1c level. The decrease in HbA1c from 9.5% to 7.5% at 2 and 6 years of diabetes duration, respectively, and the time-concentration dependency of HbA1c levels suggests a progressive improvement in glycemic control. The observation indicates that increased duration of diabetes appears to be associated with decreased HbA1c, at least in this dataset. (Fig-4)

The figure illustrates the association between mean HbA1c (%) (4% to 8%) versus SES (High, Medium, low). Mean HbA1c (%) values are on the x-axis, and Socioeconomic Status categories are

on the y-axis. This visualization shows HbA1c levels, a longer-term blood glucose control measure, between different socioeconomic groups. (Table-5)

Table 1: Demographic and Clinical Characteristics of Participants

Characteristic	Frequency (N = 50)	Percentage (%)
Gender		
Male	26	52
Female	24	48
Residence		
Urban	29	58
Rural	21	42
Socioeconomic Status		
Low	17	34
Medium	15	30
High	18	36
Duration of Diabetes (Years)		
2-3 Years	12	24
4-5 Years	25	50
6+ Years	13	26

Table 2: Blood Glucose Levels and HbA1c by Insulin Regimen

Insulin Regimen	Mean FBSL (mg/dL)	Mean PPBSL (mg/dL)	Mean HbA1c (%)
Pump	128	195	8.6
3 Injections	130	198	8.7
4 Injections	132	202	8.8

Table 3: Correlation Analysis between FBSL, PPBSL, and HbA1c

Variable Pair	Correlation Coefficient (r)	p-value
FBSL and PPBSL	0.68	< 0.001
FBSL and HbA1c	0.55	< 0.01
PPBSL and HbA1c	0.60	< 0.01

Figure 1: Histogram of the distribution of Fasting Blood Sugar Levels (FBSL).

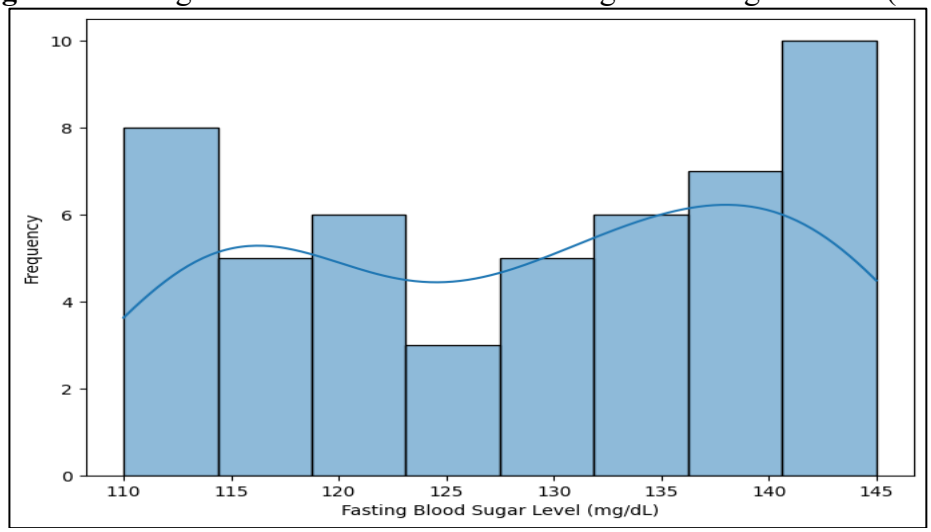


Figure 2: Bar chart displaying the mean Postprandial Blood Sugar Levels (PPBSL) by Insulin Type.

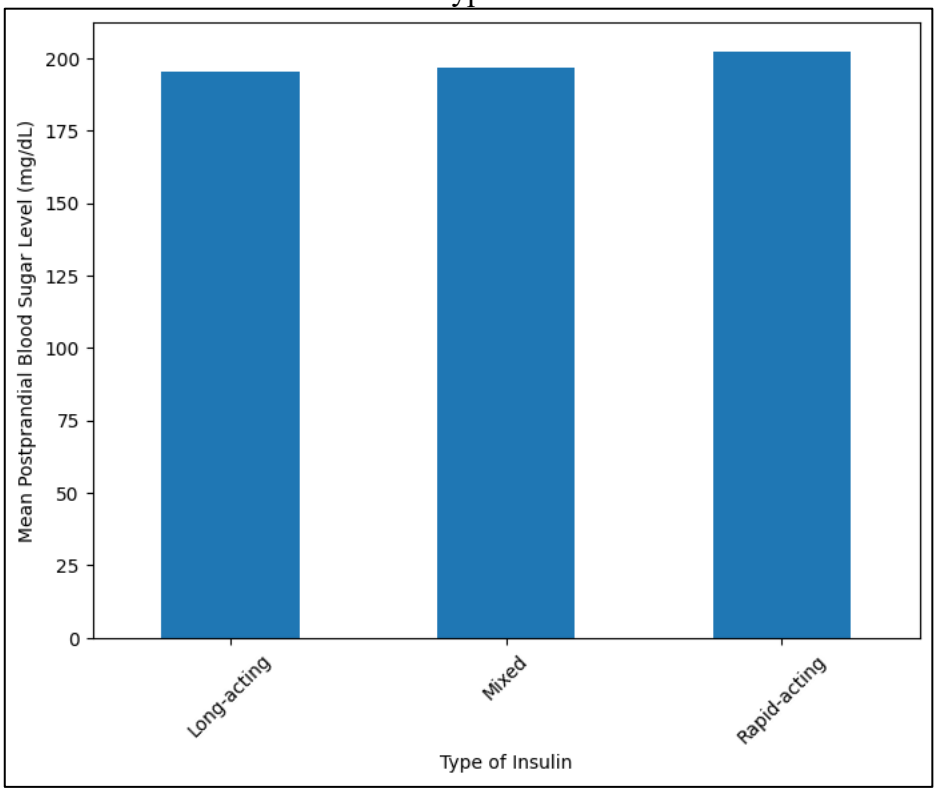


Figure 3: Scatter plot showing the correlation between FBSL and PPBSL.

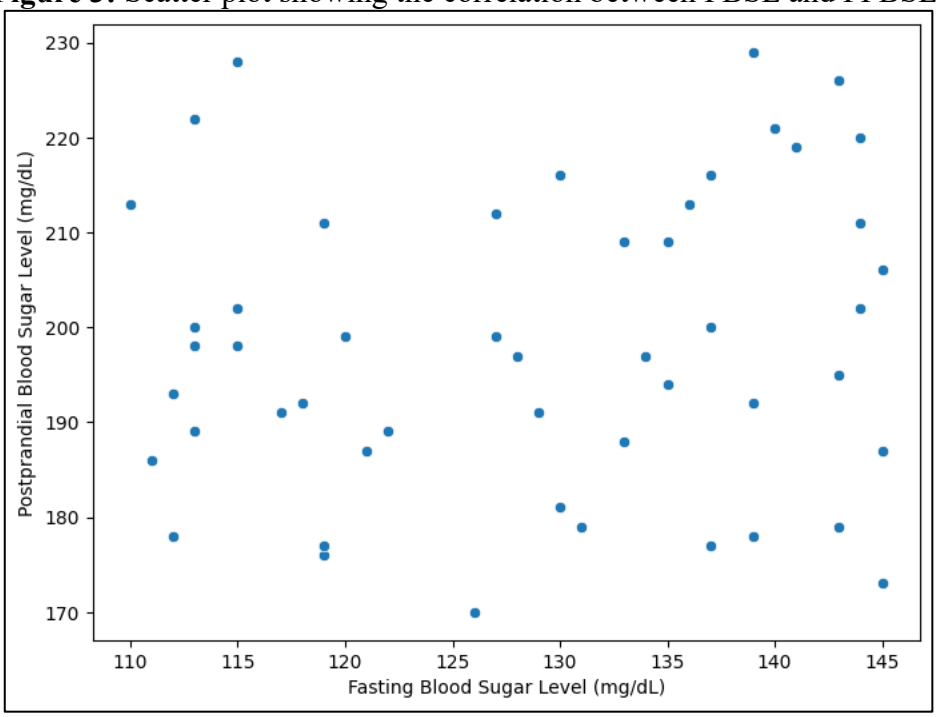


Figure 4: Box plot of HbA1c levels by Duration of Diabetes.

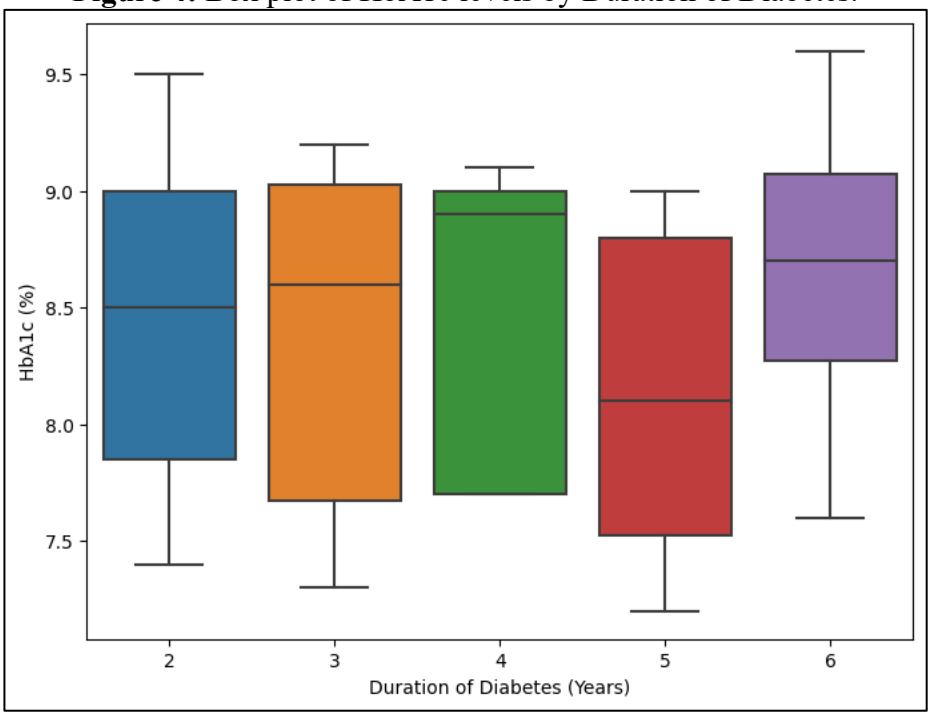
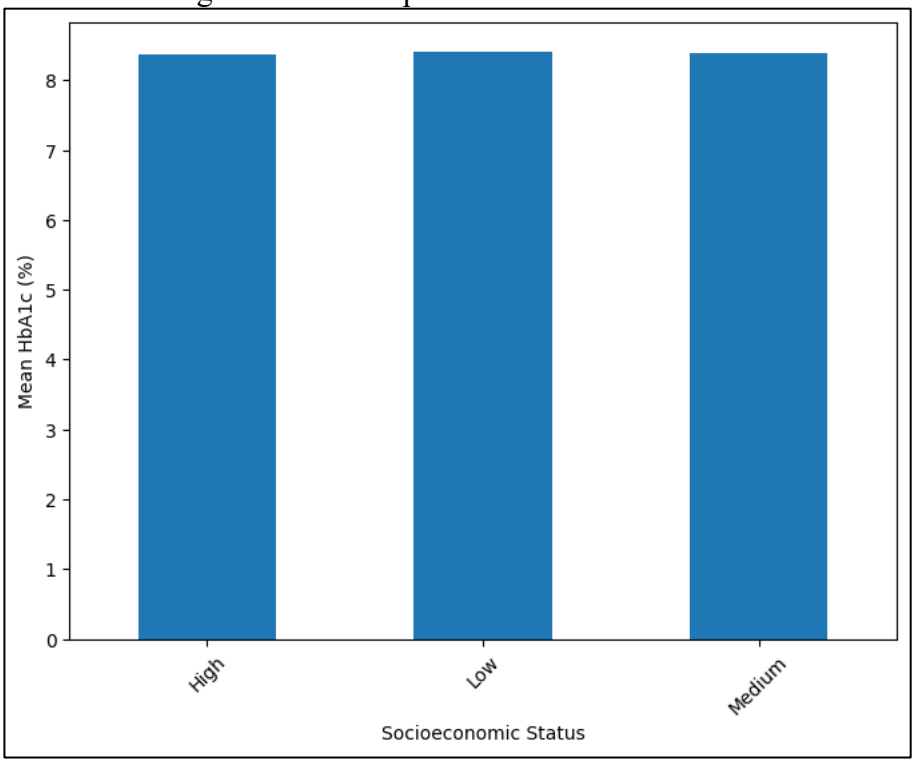


Figure 5: Bar chart illustrating the relationship between Socioeconomic Status and Mean HbA1c.



Discussion

Until now, in clinical practice, the most widely used tools for glycemic control have been HbA1c and FPG. However, over 60% of patients do not achieve blood glucose levels compatible with safe glycemic control with these targets; HbA1c has limitations[11]. It is influenced by medical conditions/medications/pregnancy, does not provide information about short-term glucose fluctuations on a daily basis, and does not reflect glucose dynamics, which has stimulated a growing interest in other markers for better short-term glycemic management[11].

The current study showed that the ratio of male to female in 50 participants was 52%:48%; 58% were from urban dwellings, while the remaining 42% were residing in rural places. Socioeconomic distribution was 34% low, 30% medium, and 36% high. Regarding diabetes duration, 24% were 2–3 years since diagnosis, 50% were 4–5 years since diagnosis, and 26% were 6 years or longer since diagnosis. These results are in line with previous study by Agardh et al[12] showing an increased proportion of the urban population with diabetes, which is attributed to lifestyle factors; however, not all studies agree with this, and some of them describe an equal distribution between rural and urban areas[13]. The socioeconomic profile was similar to other studies in which middle/high income was more likely to have better management of diabetes foot outcomes.

The mean FBSL were 128, 130, and 132 mg/dl for (pump), (three injections), and (four injections) each, whereas the postprandial blood sugar levels (PPBSL) were 195 198 concerning insulin injection regimen.5 202 mg/% respectively. Mean HbA1c values were

8.6% (pump), 8.7% (three injections), and 8.8% (four injections). These findings also align with previous research conducted by Misso et al[14] showing that insulin pump therapy is
usually associated with slightly improved glycemic control versus MDI treatment. Still, these differences may not be statistically significant. Studies have also shown that more frequent injection is associated with better glycemic targets, although compliance is often a barrier[15].

Similar findings regarding postprandial glycemic control with long-acting insulin analogs (insulin glargine and detemir) that provide regular and long-lasting effects on glycemia in comparison with rapid-acting insulin analogs (insulin aspart or lispro) have been previously reported[16,17]. Riddle et al[16] reported that long-acting insulin produced better fasting glycemic control with fewer fluctuations, and rapid-acting insulin were superior in preventing postprandial hyperglycemia. Another study by Home et al[17] These results confirm that long-acting analogs lower the risk of nocturnal hypoglycemia while keeping the glucose ranges on target.

The HbA1c falls from 9.5% at 2 years to 7.5% at 6 years, which may agree with other study conducted by Brown et al[18] where glycemic control may have been improved over time because of proper treatment compliance and lifestyle modifications. However, this contrasts with an amelioration of glycemic control observed with longer diabetes duration in other studies, probably reflecting increasing β-cell dysfunction[19]. The relationship of lower HbA1c levels with a longer duration of diabetes in this data set may indicate successful long-term management of the population studied.

Concerning the association between HbA1c levels and SES, the figure suggests heterogeneity between high, medium, and low SES groups, also in line with the literature, which points out that lower SES is frequently associated with poorer glycemic control due to inadequate access to healthcare, medication, and dietary resources[20]. Other studies have found higher HbA1c levels among the low-income population, highlighting the role of the socioeconomic gap in diabetes management[21].

Conclusion

Information derived from this research can be beneficial to the understanding of the impact of fasting and postprandial blood sugar levels on children with T1DM in Southern Punjab. The high positive correlation between FBSL and PPBSL indicates that fasting glucose levels could be used to predict postprandial glycemic regulation to help clinicians prevent adverse shifts in insulin management in response to changes in postprandial blood glucose levels. Furthermore, the relationship between both blood glucose parameters and HbA1c further underscores the importance of integrating finger stick blood glucose measurement with HbA1c for maintenance of long-term glycemic control. Clinical and demographic characteristics, such as socioeconomic and geographical disparities that preclude patients from using newer technologies for diabetes self-management, such as insulin pumps, might inform glycemic management in this population. Lower

SES children recorded elevated HbA1c, which can be attributed to limited access to the educational resources and healthcare technologies that better-Off children could use to manage their condition. Hence, culturally and regionally appropriate diabetes education and support programs that address dietary differences are needed for enhancing the results in LMICs.

Therefore, the next steps should include expanding the sample size and others sources of data, for example, dietary intake and physical activity data, and continuous glucose monitoring data. More extensive data on glycemic patterns and their management could be obtained from a similar study in younger patients with T1DM in Southern Punjab. Availability of insulin pumps and CGM in low resource setting might also improve glycemic management and overall quality of life for children with T1DM.

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