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Determinants of Poor Glucose Monitoring Among Type 1 Diabetic patients aged 15-39 years in India: Role of Psychological Well-Being and Treatment Costs

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Background: Self-monitoring of blood glucose is central to effective management of type 1 diabetes, yet adherence remains suboptimal among adolescents and young adults. Psychological well-being and treatment-related costs may influence glucose monitoring behaviour, particularly in low- and middle-income settings such as India. **Objectives:** To assess glucose monitoring behaviour among type 1 diabetic patients aged (15–39 years) and to examine the association of psychological quality of life and treatment-related costs with glucose monitoring practices. **Methods:** A hospital-based cross-sectional analytical study was conducted among 80 type 1 diabetic patients attending a tertiary care endocrinology outpatient department in northern India. Glucose monitoring behaviour was assessed using the glucose monitoring subscale of the Diabetes Self-Management Questionnaire–Revised (DSMQ-R). Psychological quality of life was measured using the psychological domain of the WHOQOL-BREF. Direct and indirect treatment costs were recorded. Hierarchical multiple linear regression analysis was performed after adjusting for sociodemographic variables. **Results:** Participants demonstrated low glucose monitoring scores, indicating suboptimal monitoring behaviour. Psychological quality of life was positively associated with glucose monitoring behaviour ($\beta = 0.398$, $p<0.01$), while higher indirect treatment costs were associated with poorer monitoring ($\beta = -0.242$, $p < 0.05$). Increasing age was negatively associated with glucose monitoring, whereas higher caregiver education showed a positive association. The final regression model explained 51.0% of the variance in glucose monitoring behaviour. **Conclusion:** Glucose monitoring behaviour among type 1 diabetic patients in India is influenced by psychological well-being and economic burden. Interventions addressing mental health and reducing treatment-related costs may improve glucose monitoring adherence in this population.

Keywords: Type 1 diabetes, Glucose Monitoring, Psychological quality of life, Treatment Costs, India

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Introduction

Type 1 diabetes (T1D) is a lifelong autoimmune condition that places substantial self-management demands on affected individuals, particularly adolescents and young adults who must regularly monitor blood glucose levels and administer insulin to prevent acute and long-term complications. Self-monitoring of blood glucose (SMBG) is a cornerstone of effective T1D management, enabling timely insulin dose adjustments and reducing the risk of hypoglycaemia and hyperglycaemia. Despite its clinical importance, adherence to recommended glucose monitoring practices remains suboptimal among adolescents and young adults with T1D, contributing to poor glycaemic control and increased risk of complications. [1,3,4]

Psychological well-being plays a critical role in diabetes self-management. Emotional distress, reduced motivation, diabetes-related burnout, and impaired quality of life have been shown to negatively influence engagement in daily self-care behaviours, including glucose monitoring.[2,4,5] International studies have consistently demonstrated that poorer psychological functioning is associated with lower adherence to SMBG and other self-management tasks among young people with T1D.[4,5] Evidence from India similarly indicates that children, adolescents, and adults (15-39 years) with T1D experience significant psychological burden, which adversely affects their quality of life and diabetes management behaviours. [6,9]

In addition to psychological factors, the economic burden of T1D care is a major determinant of glucose monitoring behaviour, particularly in low- and middle-income countries. In India, diabetes care is largely financed through out-of-pocket expenditure, and the recurring costs of insulin, glucose testing strips, glucometers, clinic visits, transportation, and caregiver time place a substantial financial strain on families.[7,8] Indian studies have documented high direct and indirect costs associated with T1D care, with glucose monitoring supplies constituting a significant proportion of total expenditure[7,8]. Financial constraints may therefore directly limit the frequency of SMBG, especially among adolescents and young adults who are dependent on family resources.

Although psychological well-being and economic burden have been independently examined in relation to diabetes outcomes, there is limited empirical evidence from India assessing their combined influence on specific self-management behaviours such as glucose monitoring among T1D patients. Most Indian studies have focused separately on quality of life, cost burden, or general adherence patterns,[6–9] leaving a gap in understanding how psychological quality of life and treatment-related costs jointly shape glucose monitoring behaviour in this vulnerable age group.

The present hospital-based cross-sectional study therefore investigated glucose monitoring behaviour among patients with T1D attending a tertiary endocrinology outpatient clinic in India, with a focus on the role of psychological quality of life and treatment-related costs. By using validated instruments for self-management (DSMQ-R) and quality of life (WHOQOL-BREF), and by controlling for sociodemographic and clinical covariates, the study examined modifiable psychological and economic determinants of glucose monitoring behaviour.

The primary aim of this study was to identify determinants of poor glucose monitoring among type 1 diabetic patients aged 15-39 years in India.

Methods

Study design and setting: A hospital-based cross-sectional analytical study was conducted among type 1 diabetes patients aged 15-39 years attending the Endocrinology Outpatient Department (OPD) of the Institute of Medical Sciences, Banaras Hindu University (IMS-BHU), Varanasi, India. The study aimed to examine psychological and economic determinants of glucose monitoring behaviour among patients receiving routine diabetes care.

Study participants: Individuals aged 15–39 years with a confirmed diagnosis of type 1 diabetes for at least one year were eligible to participate. Patients with acute medical illness at the time of data collection or those unable to provide informed consent were excluded. For participants below 18 years of age, written informed consent was obtained from parents or guardians along with assent from the participant.

Ethical considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of the Institute of Medical Sciences, Banaras Hindu University, Varanasi (IEC No.: Dean/2022/EC/4085). Participation was voluntary, and confidentiality of participant information was strictly maintained.

Sampling and sample size: Given the relatively low prevalence of type 1 diabetes, all eligible patients aged 15–39 years attending the outpatient department were consecutively recruited until either a six-month period was completed or the required sample size was achieved.

The sample size was determined a priori as part of the broader doctoral research, which included development and testing of structural models examining relationships among psychosocial constructs. The minimum required sample size was estimated using the inverse square root method proposed by Kock and Hadaya, which is recommended for structural equation modelling and provides a conservative estimate of sample adequacy.

Assuming a medium-sized standardized effect (β = 0.25), a two-tailed significance level of 0.05, and a corresponding Z value of 1.96, the minimum required sample size was calculated as:

$$N \geq \left(\frac{1.96}{0.25}\right)^2 \approx 62$$

This assumption is consistent with psychosocial and health-behaviour research, where small-to-medium effects are considered meaningful. A total of 80 participants were recruited, exceeding the minimum required sample size. The achieved sample was therefore considered adequate for the present secondary analysis, including hierarchical multiple linear regression.

Data collection: Data were collected using a structured interviewer-administered questionnaire covering socio-demographic characteristics, clinical details, diabetes self-management behaviour, quality of life, and treatment-related costs. Interviews were conducted in the participant's preferred language after explaining the study objectives and ensuring confidentiality.

Measures: Glucose monitoring behaviour was assessed using the glucose monitoring subscale of the Diabetes Self-Management Questionnaire–Revised (DSMQ-R). This subscale evaluates adherence to recommended blood glucose monitoring practices, with scores ranging from 0 to 10, where higher scores indicate better glucose monitoring behaviour. The DSMQ-R is a validated instrument widely used in diabetes self-management research.

Psychological well-being was assessed using the psychological domain of the World Health Organization Quality of Life–BREF (WHOQOL-BREF) instrument. Domain scores were transformed to a 0–100 scale, with higher scores representing better psychological quality of life. The WHOQOL-BREF has demonstrated good validity and cross-cultural applicability, including in Indian populations.

Treatment-related costs were assessed through patient self-report and categorized into: Direct costs, including expenses related to insulin, glucose monitoring supplies (glucometers, strips, lancets), outpatient consultations, and investigations and Indirect costs, including travel expenses, loss of wages of patients or caregivers, and other non-medical expenditures related to diabetes care. Costs were recorded in Indian Rupees (INR) and calculated on a monthly basis.

Information on age, sex, educational status of participants, caregiver education, and duration of diabetes was collected. Socioeconomic status was assessed using the Modified Kuppuswamy Socioeconomic Scale, which incorporates education, occupation, and monthly family income. Although originally developed for urban populations, the scale has been widely used in hospital-based studies in India, including those with mixed rural–urban participants, and was therefore considered appropriate for the present study.

Statistical analysis*:* Data were analysed using SPSS 26 trial version. Descriptive statistics were used to summarize socio-demographic characteristics, glucose monitoring behaviour, psychological quality of life, and treatment costs. Continuous variables were expressed as mean ± standard deviation or median, as appropriate, while categorical variables were presented as frequencies and percentages.

Prior to conducting hierarchical multiple linear regression analysis, key assumptions were systematically evaluated. A correlation matrix was generated to assess relationships among independent variables, and variables with very weak correlations ($|r|<0.30$) or problematic intercorrelations were evaluated and excluded where appropriate. The normality of residuals was assessed using the Shapiro–Wilk test, supported by visual inspection of Q–Q plots of standardized residuals. Linearity and homoscedasticity were examined using residuals versus fitted values plots. Standardized and studentized residuals were inspected and found to fall within the acceptable range of ±3, indicating the absence of extreme outliers.

Multicollinearity was assessed using the variance inflation factor (VIF)**,** with all predictors demonstrating acceptable values ($VIF<5$). Heteroskedasticity and model specification were further evaluated using the Breusch–Pagan/Cook–Weisberg test**,** Cameron and Trivedi's decomposition of the information matrix (IM) test**,** and the Ramsey RESET test. Detailed diagnostic outputs are provided in the Supplementary Material.

Hierarchical multiple linear regression analysis was then performed using a block wise entry approach. Demographic and clinical variables were entered in the first block, treatment-related cost variables in the second block, and psychological quality of life in the final block. Statistical significance was set at p<0.05. The study was approved by the Institutional Ethics Committee, IMS, BHU. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study.

Results

A total of 80 adolescents and young adults with type 1 diabetes were included in the analysis. The mean age of the participants was 21.3 ± 6.1 years, and the mean duration of diabetes was 5.3 ± 4.9 years (Table 1). With respect to educational attainment, the largest proportion of participants had completed middle school education (41.25%), followed by intermediate/diploma (21.25%), graduate or higher education (17.5%), and high school education (16.25%). Only small proportions of participants were illiterate or had primary education (3.75%). Regarding caregivers' education, 30% were illiterate, while 18.75% had completed graduate or professional education. Most participants belonged to the upper-lower socioeconomic class (47.5%), followed by the lower-middle class (32.5%). A minority belonged to the upper-middle or upper socioeconomic classes (Table 1).

Table-1: Socio-demographic and Clinical Characteristics of the Type 1 diabetic patients

Characteristic	Category	No.	%
Age (years)	21.3± 6		
Education level of respondents	Graduate or Higher	14	17.5
	High School	13	16.25
	Intermediate/Diploma	17	21.25
	Middle School	33	41.25
	Illiterate or Primary Education	3	3.75
Duration of diabetes	5.3 ± 4		
Caregivers' education status	Illiterate	24	30.00
	Primary school certificate	10	12.50
	Middle school certificate	12	15.00
	High school certificate	10	12.50
	Intermediate or diploma	9	11.25
	Graduate	12	15.00
	Professional/ Honours	3	3.75
Socio-economic status	Lower (V)	4	5
	Upper Lower (IV)	38	47.5
	Lower Middle (III)	26	32.5
	Upper Middle (II)	10	12.5
	Upper (I)	2	2.5

Descriptive statistics for glucose monitoring behaviour, psychological quality of life, and treatment-related costs are presented in Table 2. The mean glucose monitoring score assessed using the DSMQ-R subscale was 3.98 ± 2.99 (median = 3.33) on a scale ranging from 0 to 10, indicating suboptimal glucose monitoring behaviour among the study participants. The mean score for the psychological domain of quality of life was 47.86 ± 24.44 (median = 45.83) on a 0–100 scale, reflecting relatively low psychological well-being with considerable inter-individual variability.

The mean direct treatment cost was INR 9,355 ± 5,438, while the mean indirect treatment cost was INR 713 ± 877. Both cost variables demonstrated positive skewness, indicating that a subset of participants experienced a disproportionately higher financial burden related to diabetes care.

Responses to individual items of the DSMQ-R glucose monitoring subscale are presented in Supplementary Table S1. Based on these items, a composite glucose monitoring score was computed according to the DSMQ-R scoring guidelines, with higher scores indicating better glucose monitoring behaviour. Similarly, item-wise response distributions for the psychological domain of the WHOQOL-BREF are provided in Supplementary Table S2, and domain scores were calculated following the standard WHOQOL-BREF scoring procedure, with higher scores reflecting better psychological quality of life.

Table-2: Descriptive Statistics of Glucose Monitoring Behaviour, Psychological Health, and Treatment Costs

Domain	Mean ± SD	Median	Skewness / SE	Kurtosis / SE
Glucose monitoring score (DSMQ-R)	3.98 ± 2.99	3.33	0.415/0.269	-1.06/0.532
Psychological QoL (WHO-QOL)	47.86 ± 24.44	45.83	0.033/0.269	-1.000/0.532
Direct treatment cost (INR)	9355 ± 5438	8125	1.31 / 0.269	1.59 / 0.532
Indirect treatment cost (INR)	713 ± 877	400	1.45 / 0.269	2.04 / 0.532

Determinants of glucose monitoring behaviour: After confirming that the assumptions of multiple linear regression were reasonably satisfied (normality of residuals, linearity, homoscedasticity, absence of multicollinearity, and correct model specification), a hierarchical multiple regression analysis was conducted to identify the predictors of the glucose monitoring behaviour. The results are presented in Table 3.

Table-3: Hierarchical Regression Models Showing Standardized Beta Coefficients for Predictors of Glucose monitoring among type 1 diabetic adolescent and adult

Variables	Model 1	Model 2	Model 3
Demographic & Socioeconomics factors			
Age	-0.315**	-0.309**	-0.185*
Respondent's Education Level			
Graduate/Professional/ Honours	Ref.		
High School	-0.148	-0.184	-0.185
Illiterate/Primary Education/Middle School	-0.169	-0.196	-0.195*
Intermediate/Diploma	-0.187	-0.201	-0.146
Duration of diabetes	-0.159	-0.130	-0.116
Socio Economic Class			
Lower (V)	Ref.		
Upper Lower (IV)	-0.124	-0.141	-0.161
Lower Middle (III)	-0.134	-0.186	-0.236
Upper Middle (II)	-0.029	-0.161	-0.228
Upper (I)	-0.056	-0.128	-0.133
Care Giver's Education Level			
Illiterate	Ref.		
Primary School Certificate	0.197	0.184	0.203*
Middle School Certificate	0.068	0.059	0.080
High School Certificate	0.086	0.134	0.140
Intermediate or Diploma	0.179	0.175	0.124
Graduate/Professional/ Honours	0.346*	0.395*	0.309*
Direct cost		0.107	0.145
Indirect cost		-0.215*	-0.242*
Psychological Health			0.398***
R^2	0.365	0.392	0.51
Adjusted R^2	0.228	0.237	0.380
Change in Adjusted R^2		0.009	0.143
Significance of F change (p-value)		0.258	0.000
Note: β = Standardized Regression Coefficient. Ref. = Reference Category. ***p < 0.001, **p <0.01, *p < 0.05.			

In **Model 1**, which included demographic and clinical variables, age was significantly and negatively associated with glucose monitoring behaviour (β=−0.315, *p*<0.01), indicating poorer glucose monitoring with increasing age. Caregiver education at the graduate or professional level was positively associated with glucose monitoring behaviour ($\beta = 0.346$, $p < 0.05$). This model explained 36.5% of the variance in glucose monitoring behaviour.

In **Model 2**, after the inclusion of socioeconomic variables and treatment-related costs, age remained a significant negative predictor ($\beta = -0.309$, $p < 0.01$). Indirect treatment cost emerged as a significant negative determinant of glucose monitoring behaviour ($\beta = -0.215$, $p < 0.05$). The positive association between caregiver education and glucose monitoring behaviour persisted ($\beta = 0.395$, $p < 0.05$). The explained variance increased modestly ($R^2 = 0.392$).

In the final model **(Model 3)**, psychological health demonstrated a strong and significant positive association with glucose monitoring behaviour ($\beta = 0.398$, $p < 0.01$). Indirect treatment cost remained independently associated with poorer glucose monitoring behaviour ($\beta = -0.242$, $p < 0.05$), even after adjusting for demographic, socioeconomic, and clinical factors. Age continued to show a significant negative association ($\beta = -0.185$, $p < 0.05$), while caregiver education at the graduate or professional level remained a significant positive predictor ($\beta = 0.309$, $p < 0.05$). Direct treatment cost was not significantly associated with glucose monitoring behaviour in the fully adjusted model.

The final model explained 51.0% of the variance in glucose monitoring behaviour and demonstrated a statistically significant improvement in model fit compared with earlier models ($p < 0.001$).

Discussion

This study examined the determinants of glucose monitoring behaviour among adolescents and young adults with type 1 diabetes in India, with a particular focus on psychological quality of life and treatment costs. The results indicate that psychological well-being, economic burden, caregiver education, and age are important predictors of glucose monitoring practices, underscoring the multifactorial nature of self-management in this population.

Consistent with international evidence, psychological health emerged as a strong positive determinant of glucose monitoring behaviour in the fully adjusted model. This finding aligns with research demonstrating that poorer psychological functioning, including elevated diabetes-related distress and reduced quality of life, is associated with suboptimal engagement in self-management behaviours among individuals with type 1 diabetes. Psychological distress has been shown to adversely affect adherence to self-management tasks, including monitoring behaviours, by undermining motivation and self-efficacy and contributing to avoidance coping strategies.[10, 11]

The role of psychological quality of life in diabetes management is also supported by Indian research indicating that individuals with diabetes experience poorer quality of life compared with those without diabetes, and that psychosocial factors significantly contribute to this burden.[9] Studies among children and adolescents with type 1 diabetes in India have similarly highlighted compromised emotional well-being and behavioural challenges that are closely linked to daily management tasks.[6,12] These findings underscore the need for routine screening and targeted psychosocial interventions to enhance mental well-being alongside traditional clinical care.

In addition to psychological determinants, our results highlight the independent negative impact of indirect treatment costs on glucose monitoring behaviour. This finding resonates with broader evidence from India demonstrating the high out-of-pocket expenditure associated with type 1 diabetes care, which includes the costs of insulin, testing supplies, travel, and caregiver time.[13] A recent qualitative study in Karnataka reported that financial barriers-such as erratic insulin supply and high cost of diabetes care-disproportionately burden households, leading to rationing of essential resources and compromised self-care practices.[14]

The significance of economic burden as a barrier to optimal self-management has also been recognized in international guidelines. For example, consensus recommendations emphasize that self-monitoring of blood glucose (SMBG) is a practical tool for improving glycemic outcomes but must be supported through accessible and affordable resources to ensure consistent use.[15] In resource-limited settings, indirect costs such as lost wages and travel expenses may be particularly relevant for young people who are dependent on caregivers, highlighting the importance of integrating financial protection mechanisms within diabetes care programs.

The observed negative association between age and glucose monitoring behaviour suggests that older adolescents and young adults may face unique challenges in maintaining consistent self-monitoring. This pattern may reflect transitional care issues as young people move from family-supported management to greater autonomy, a period marked by competing academic, social, and occupational demands. Previous literature has identified adolescence and young adulthood as critical periods for lapses in self-management, partly due to psychosocial stressors and changing life roles.[16,17] This emphasizes the need for age-appropriate education and support strategies that facilitate sustained engagement in glucose monitoring.

Caregiver education also demonstrated a positive association with glucose monitoring behaviour, consistent with studies indicating that higher caregiver knowledge and support improve diabetes management outcomes. Family involvement and health literacy are key determinants of adolescent adherence, particularly in contexts where caregivers play a central role in daily care and decision-making.[18,19,20]

Collectively, these findings reinforce that glucose monitoring behaviour in type 1 diabetes cannot be attributed solely to individual motivation or clinical factors but is shaped by a complex interplay of psychological, economic, and social determinants. Interventions that address mental health, enhance caregiver support, and reduce financial barriers may be more effective than narrowly focused clinical strategies.

Strengths and limitations

An important strength of this study is its focus on a relatively understudied population—adolescents and young adults with type 1 diabetes in India using validated measures of self-management and quality of life. By incorporating both psychological and economic determinants, the study provides a comprehensive perspective on the real-world factors influencing glucose monitoring behaviour. The use of well-validated instruments to assess glucose monitoring behaviour and quality of life enhances the methodological rigor and comparability of the findings. In addition, the systematic evaluation of regression assumptions and the use of hierarchical modelling strengthened the robustness of the analytical approach and supported the internal validity of the results.

However, several limitations merit consideration. Although the final regression model explained a moderate proportion of variance in glucose monitoring behaviour, additional determinants not assessed in this study may have contributed to the unexplained variability. These include diabetes-related distress, mental health symptoms, health literacy, family and peer support, access to glucose monitoring supplies, use of advanced monitoring technologies, and health-system factors such as continuity of care.

The cross-sectional design further limits causal inference and the hospital-based setting may restrict generalizability to individuals with type 1 diabetes not engaged in tertiary care. Future longitudinal and mixed-methods studies incorporating psychosocial, behavioral, and health-system variables are warranted to more comprehensively explain variations in glucose monitoring behaviour. Additionally, Self-reported measures, while widely used in diabetes research, may be subject to recall bias.

Conclusion

In conclusion, psychological quality of life and indirect treatment costs are important determinants of glucose monitoring behaviour among adolescents and young adults with type 1 diabetes in India. Interventions that address mental health challenges and lower the economic barriers to self-monitoring may improve adherence and, ultimately, diabetes outcomes. Future longitudinal and intervention studies are needed to confirm these associations and assess the effectiveness of targeted strategies in this vulnerable population.

Implications for practice and policy

The study’s findings have important implications for clinical practice and health policy. First, routine assessment of psychological well-being should be integrated into diabetes care protocols, with referral pathways for counselling and psychosocial support where needed. Second, strategies to alleviate economic burden such as subsidized blood glucose testing supplies, travel support, and inclusion of CGM technologies where feasible may enhance consistent glucose monitoring, especially for economically vulnerable families.

In India, where type 1 diabetes care infrastructure is evolving, these findings support the development of comprehensive care models that combine clinical management with psychological counselling, caregiver education, and financial support systems to improve overall outcomes.[9]

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