RESEARCH REPORT

Health Psychology

Editor
André Luiz Monezi de Andrade

Conflict of interest
The authors declare that there is no conflict of interest.

Received
October 11, 2022

Final version
April 27, 2023

Approved
July 31, 2023

Self-care in adults with type 1 diabetes *Mellitus*: analysis of glycemic control

Autocuidado em adultos com diabetes Mellitus tipo 1: análise do controle glicêmico

Gracielie da Silva Campos[1,2], Priscila Goergen Brust-Renck[2], Tonantzin Ribeiro Gonçalves[3]

[1] Universidade Regional Integrada do Alto Uruguai e das Missões, Escola de Educação Básica. Santiago, RS, Brasil.
[2] Universidade do Vale do Rio dos Sinos, Escola de Saúde, Programa de Pós-Graduação em Psicologia. São Leopoldo, RS, Brasil.
[3] Universidade do Vale do Rio dos Sinos, Escola de Saúde, Programa de Pós-Graduação em Saúde Coletiva. São Leopoldo, RS, Brasil. Correspondence to: T. R. GONÇALVES. E-mail: <tonanrib@yahoo.com.br>.

Article based on the thesis by G. S. CAMPOS, entitled "*Autocuidado, percepção da doença e distress em adultos com diabetes mellitus tipo 1*". Universidade do Vale do Rio dos Sinos, 2022.

How to cite ithis article: Campos, G. S., Brust-Renck, P. G., & Gonçalves, T. R. (2024). Self-care in adults with type 1 diabetes *Mellitus*: analysis of glycemic control. *Estudos de Psicologia* (Campinas), *41*, e220120. https://doi.org/10.1590/1982-0275202441e220120

Abstract

Objective

Glycemic control is essential for reducing the risks of long-term complications in individuals living with type 1 diabetes mellitus. The study aimed to evaluate the relationship between glycemic control and demographic, economic, and clinical characteristics, and self-care behaviors for diabetes.

Method

A total of 107 people living with diabetes participated in the study. The participants completed an online self-report questionnaire containing clinical indicators and health care measures.

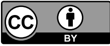
Results

The results showed that most participants did not have adequate glycemic control (based on glycated hemoglobin evaluation), especially due to difficulties in monitoring the disease and a lack of daily testing, as well as an increase in tobacco use. Low income, high body mass index, and low social class also predicted inadequate glycemic control.

Conclusion

It is recommended that health strategies sensitive to social inequalities and individual difficulties related to glycemic control be implemented to promote health.

Keywords: Blood glucose self-monitoring; Diabetes mellitus, type 1; Health promotion; Self-care skills.



Resumo

Objetivo

O controle glicêmico é essencial para diminuir os riscos de complicações em longo prazo de pessoas vivendo com diabetes mellitus tipo 1. O objetivo do estudo foi avaliar a relação entre controle glicêmico e características demográficas, econômicas, clínicas, e comportamentos de autocuidado para a diabetes.

Método

Participaram da pesquisa 107 pessoas vivendo com diabetes. Os participantes responderam um questionário de autorrelato online com indicadores clínicos e de cuidado com a saúde.

Resultados

Os resultados mostraram que a maioria dos participantes não possuía controle glicêmico adequado (baseado na avaliação de hemoglobina glicada), especialmente aqueles com dificuldade de monitorar a doença e pelas falhas em realizar a testagem diária e aumento do uso de tabaco. O controle glicêmico inadequado também foi predito pela baixa renda, índice de massa corporal elevado e baixa classe social.

Conclusão

Recomenda-se implementar estratégias em saúde sensíveis às desigualdades sociais e dificuldades individuais relacionadas ao controle glicêmico para promover a saúde.

Palavras-chave: *Automonitorização da glicemia; Diabetes mellitus tipo 1; Promoção da saúde; Habilidades para autocuidado.*

Type 1 Diabetes *Mellitus* (T1DM) is a chronic disease that most often begins in childhood or adolescence. Since individuals with T1DM live with the disease from an early age, the way their family perceives the condition tends to influence judgments and behaviors throughout life (Sand et al., 2018). Children, adolescents, and adults with T1DM require daily care, such as a healthy diet, physical exercise, glycemic control, and lifelong insulin use. Individuals living with T1DM must adhere to medical recommendations every day to achieve good disease control. However, difficulties in adopting these self-care measures can lead to disease progression, early death, or severe complications such as limb amputation, blindness, nephropathy, and retinopathy, in addition to compromising the quality of life (American Diabetes Association [ADA], 2022).

In addition to daily care, individuals with T1DM must constantly monitor their blood glucose levels to prevent complications. In this context, the glycated hemoglobin (HbA1c) test, which indicates the concentration of blood glucose levels, has been described as an important biological marker. This test reflects glycemic levels for the past 2-3 months and serves both diagnostic and treatment monitoring purposes. HbA1c levels > 7% are associated with a progressively higher risk of chronic complications among individuals with diabetes (Sociedade Brasileira de Diabetes [SBD], 2021), making glycemic control essential for reducing risks of long-term complications (ADA, 2022).

Regardless of the type of diabetes, evidence suggests that most people living with diabetes do not achieve glycemic control goals. Although most studies predominantly focus on samples composed of individuals with type 2 diabetes (T2DM) – or fail to stratify the results by diabetes type –, various factors have been investigated as associated with glycemic control: longer disease duration, lower educational and income levels, lack of knowledge about the disease, greater difficulties in adhering to medication and diet, sedentary lifestyle, overweight, and obesity (Alramadan et al., 2018). Considering that individuals with T1DM generally live with the disease since childhood, it is important to understand specific aspects related to glycemic control in this population.

In Venezuela, a study involving 4,075 adults living with diabetes mellitus who attended healthcare centers found that the prevalence of inadequate glycemic control was 76% (3,100/4,075),

being more common in individuals with T1DM (87%) than those with T2DM (75%). In line with this, another study conducted in Ethiopia with 330 individuals living with diabetes (128 of them with T1DM) indicated that those with T1DM were three times more likely to have poor glycemic control compared to those with T2DM. Such results can be understood from both the perspective of the body's reduced response to externally administered insulin (T1DM) and the challenges of managing and chronically administering insulin (Sheleme et al., 2020).

Among studies conducted exclusively with the T1DM population, a study in the United States involving 31,430 adults living with T1DM showed that only 20% had glycated hemoglobin < 7% (Pettus et al., 2019). The percentage of individuals with adequate glycemic control increased substantially with age: from 12% in individuals aged 18-25 years to 29% in individuals aged ≥ 65 years. Furthermore, a lower proportion of African Americans compared to Caucasians had HbA1c < 7% (15% vs. 21%), and a lower proportion of obese individuals compared to those with normal weight (18% vs. 21%) (Pettus et al., 2019). A study in Brazil indicated that among individuals living with T1DM, nearly 90% do not achieve the glycemic control goal, with 42.9% of people living with diabetes having HbA1c levels of 9% (Coutinho & Silva Junior, 2016).

In Tanzania, a study followed 150 participants for six months to determine factors associated with poor glycemic control in children (1-10 years of age), adolescents (11-18 years of age), and young adults (19-40 years of age) living with T1DM (McLarty et al., 2021). The results indicated that most participants presented a glycemic control of HbA1c > 7.5%, with an overall HbA1c mean of 12.3%, indicating a very high prevalence of glycemic imbalance. Children under 10 years of age had a higher likelihood of having adequate control compared to adolescents and young adults, while adolescents had a higher risk of inadequate control with the highest mean HbA1c (12.8%).

In Brazil, studies on glycemic control in individuals living with T1DM are also scarce and focus on exploring but a few associated factors, generally of a clinical nature. One of the first studies found in the current research, which approached this subject in the Brazilian context, evaluated the annual glycemic control of 175 adults living with T1DM monitored by a multidisciplinary team, as well as 30 individuals assisted at a general endocrinology outpatient clinic (Mourão-Júnior et al., 2006). The results revealed a higher proportion of individuals with good glycemic control in the specialized service compared to those followed at the general outpatient clinic, respectively, 51.4% versus 16.7% with glycated hemoglobin < 7%, and 26.9% versus 46.7% with glycated hemoglobin > 8% (Mourão-Júnior et al., 2006). Among individuals with HbA1c > 7%, the proportion of those receiving two daily insulin injections was higher, and all reports of ketoacidosis occurred in these individuals. Aspects such as age, time at DM diagnosis, daily insulin dose, and number of injections were not associated with glycemic control. Another study with 3,180 Brazilians living with T1DM, with a mean age of 22 years (*SD* = 11.8), revealed an association between poorer glycemic control and higher Body Mass Index (BMI) (Davison et al., 2014). Furthermore, a recent Brazilian study evaluated predictive factors of glycemic control in 120 children and adolescents with T1DM, with a mean age of 11.74 years and HbA1c of 8.13% (Fortins et al., 2019). The results indicated that disease duration and insulin dose were directly associated with higher HbA1c levels, while the use of carbohydrate counting was associated with a reduction in HbA1c.

Although studies on factors associated with glycemic control in individuals with T1DM are rare, especially in Brazil, the reviewed data emphasize the importance of adequate control for preventing disease complications. Furthermore, in our context, it is necessary to further investigate both social inequalities and self-care behaviors as influential aspects in disease management. Therefore, the present study aims to provide an evaluation of individual characteristics

(sociodemographic, clinical, and self-care) associated with levels of glycemic control in T1DM, as well as identify individuals at higher risk of developing complications of the disease.

Method

Participants

This is a quantitative cross-sectional study with a non-probabilistic convenience sample. Initially, 125 adults with T1DM aged 18 years or older at the time of the study were selected for participation. Eighteen participants were excluded for not meeting the inclusion criteria, specifically: 10 did not provide the most recent HbA1c test result (study outcome), five were identified as duplicates, two for having their surveys answered by parents or guardians (not answered by individuals with T1DM), and one declined to participate in the study.

The sociodemographic characteristics of the final sample of 107 participants is described in Table 1. Most participants were female (84.1%), white (76.6%), childless (70.2%), employed (60.7%), who had complete or incomplete higher education or post-graduate studies (78.5%). Most of the sample (59.8%) belonged to the middle-class category B. The mean age was 30.7 years (*SD* = 8.53), the mean BMI was 24.73 (*SD* = 3.83), and the mean age at diagnosis of T1DM was 15 years (*SD* = 7.65). Analyses comparing participants with adequate (*N* = 63) and inadequate (*N* = 44) HbA1c control revealed differences in terms of sex, income ranges, and social class.

Table 1
Comparison of sociodemographic characteristics of people living with t1dm with adequate and Inadequate Glycemic Control

Variables	Total	Adequate	Inadequate	*p*-value[a]
	Median (P25-P75)			
BMI	24.0 (21.4-24.0)	23.0 (20.9-27.6)	25.1 (22.8-28.2)	0.113
Age	30.00 (24-36)	30.00 (2-36)	29.5 (23-36)	0.840
Age at diagnosis	14.00 (9-20)	14.0 (8-19)	15.5 (11-21.7)	0.188
	n (%)			*p*-value[b]
Sex (female)	90 (84.1)	49 (77.8)	41 (93.2)	0.035
Marital status (married/common-law marriage)	54 (50.5)	33 (52.4)	21 (47.7)	0.696
Have children (yes)	33 (30.8)	20 (31.7)	13 (29.5)	0.835
Skin color (white)	82 (76.6)	49 (77.8)	33 (75.0)	0.818
Education (higher education and above)	84 (78.5)	49 (77.8)	35 (79.5)	1.000
Employed (yes)	65 (60.7)	43 (68.3)	22 (50.0)	0.071
Average personal income in minimum-wage salaries				0.002
No income	28 (26.2)	13 (20.6)	15 (34.1)	
Less than 1 MG to 2 MG	41 (38.3)	19 (30.2)	22 (50.0)	
3 MG or more	38 (35.5)	31 (49.2)	7 (15.9)	
Social class				0.001
A	11 (10.3)	10 (15.9)	1 (2.3)	
B	64 (59.8)	42 (66.7)	22 (50)	
C	31 (29.9)	11 (17.5)	21 (47.7)	

Note: [a]Mann-Whitney test for equality of means. [b]Fisher's Exact test for qualitative comparison. P25: 25% percentile; P75: 75% percentile. BMI: Body Mass Index; MG: Minimum-Wage. Adequate Control: Glycated Hemoglobin ≤ 7%. Inadequate Control: Glycated Hemoglobin ≥ 8%.

Data Collection Procedures

All participants were recruited through online social media platforms (e.g., Instagram, Facebook, WhatsApp, email). Those who expressed interest accessed the online survey form

developed for this study and responded to a questionnaire consisting of closed- and open-ended questions containing sociodemographic and medical history information. The survey form had an approximate duration of 20 minutes and was open from January 21, 2020, to December 1, 2020.

The study was approved by the Research Ethics Committee of the Universidade do Vale do Rio dos Sinos – Unisinos (CAAE: 22487719.0.0000.5344). Before initiating the study, detailed information about the research was provided, and participants agreed to the terms of the informed consent.

Dependent Variable

The assessment of glycemic control was done based on the question: "What is the most recent result of the glycated hemoglobin test?" and the participants described their responses in percentage using whole numbers. The responses were classified dichotomously, considering the presence (HbA1c ≤ 7% = 0) and absence (HbA1c ≥ 8% = 1) of glycemic control. Glycated hemoglobin (HbA1c) is used for the diagnosis of diabetes by estimating the average concentration of glucose in the blood over the past 60 to 90 days (World Health Organization [WHO], 2011). In Brazil, the range considered as adequate glycemic control in adults is HbA1c 6.5 to 7.0% (SBD, 2021).

Independent Variables

The demographic variables were as follows: age (in years), sex (male and female), marital status (single/widowed/divorced; married/with a partner), have children (yes/no), skin color (white; black/mixed race/yellow/indigenous), education level (up to high school; incomplete higher education or above), and currently employed (yes/no). In addition, the average individual income in minimum wages was classified as no income, less than one to two minimum wages, and 3 or more minimum wages. Social class was evaluated according to categories A, B, and C/D/E, following the classification of the *Associação Brasileira de Empresas de Pesquisa* (ABEP, Brazilian Association of Research Companies) which considers the possession of certain material goods and the educational level of the head of the family (Associação Brasileira de Empresas de Pesquisa, 2019).

The variables related to self-care for T1DM were developed for this study in an attempt to represent the entirety and comprehensiveness of the health of individuals living with diabetes: glucose testing in the last week (6 days or fewer/7 days), daily frequency of glucose testing (never test or tests up to 3 times a day/test 4 times or more a day), smoking in the last seven days (yes/no), HbA1c test in the last 12 months (yes/no), medical check-up for T1DM control in the last 12 months (yes/no), carries a T1DM medical identification (yes/no), use of insulin exceeding the prescribed amount in the last 30 days (used the prescribed amount; used more than the prescribed amount), delay in applying insulin dose in the last 30 days (never delayed; delayed a few times), perception of T1DM control level in the last 12 months (poor/bad/fair; good/excellent), carrying food for glucose control (yes/no), presence of other health problems (yes/no), experienced hypoglycemic episodes in the last 12 months (yes/no), presence of other chronic diseases (yes/no), hospitalization due to diabetic ketoacidosis in the last 12 months (yes/no), current or previous participation in a T1DM group or association (never participated; participated or currently participating), and support for T1DM care in childhood/adolescence (yes/no). The participant`s body mass index was also evaluated [weight/(height*height) – weight (in kg) divided by height squared (in meters)]. Finally, participants indicated their age at T1DM diagnosis (in years), and health problems related to T1DM (yes/no).

Data Analysis Procedures

Data analysis was carried out using the IBM®SPSS® (version 21) (New York, United States). First, descriptive analyses of the sample were conducted. The normality of the data was verified using the Kolmogorov-Smirnov test. The relationship between the outcome and continuous variables was examined using the Mann-Whitney test, while categorical variables were analyzed using the Chi-square test, as several variables did not have a normal distribution.

For the clinical and self-care independent variables, an exploratory factor analysis extraction was conducted using the Principal Component Analysis method to reduce the dimensionality of large datasets and transform them into latent variables (or factors) that can parsimoniously explain the observed covariance between observed behaviors, such as glycemic control. Varimax rotation and Kaiser normalization were employed to avoid collinearity among predictors and extract the maximum common variance from the variables that make up a factor and share a common order and structure with each other (Watkins, 2018). Factor loadings > 0.40 were considered in the composition of the factors, and some variables were reversed to ensure coherence in factor interpretation. Finally, two logistic regression models were conducted: one to examine the joint relationship between relevant sociodemographic aspects and glycemic control, and another to investigate the association of clinical and self-care aspects with the assessed outcome. Separation was necessary due to the regression assumptions for the sample size of the present study (Peduzzi et al., 1996). Variables that achieved a *p*-value equal to or less than 0.20 in the bivariate analyses were included in the regression models. A significance level of 5% was adopted for the statistical tests.

Results

Regarding the clinical and self-care aspects of participants living with T1DM, 43% experienced hypoglycemic episodes in the last year, and 13% required hospitalization due to diabetic ketoacidosis during the same period. These data were presented in Table 2. Nearly a quarter (23.4%) reported having another chronic disease in addition to T1DM, and 66.4% indicated having other health problems. More than half (52.3%) had a perception of control that was considered poor/fair/average in the last year, although the vast majority had undergone medical consultations for T1DM control (96.3%) and underwent HbA1c testing (95.3%) during the same period. A significant number of participants had performed four or more blood glucose tests a day in the past week and reported using only the prescribed amount of insulin in the last thirty days, with 35.5% never experiencing any delays in doses during the same period.

Half of the participants wore or carried something with them that identified them as having T1DM, and 86% carried some food or beverage in case of low blood glucose levels. There were very few smokers (Table 2). Around 50.5% had never participated in groups or associations related to the disease, and 72.9% reported having received support from someone for T1DM care during childhood and adolescence. Table 2 also indicates comparisons between response proportions of clinical and self-care indicators among people living with T1DM with Adequate (≤ 7%) and Inadequate (≥ 8%) control of HbA1c. The analyses indicated that participants with adequate glycemic control (HbA1c ≤ 7%) were more likely to never delay insulin doses and to perform blood glucose testing at a frequency of more than 4 times per day compared to participants with inadequate glycemic control (HbA1c ≥ 8%). In contrast, those with inadequate control perceived their T1DM control as inferior to those who had achieved adequate control (HbA1c ≤ 7%).

A factor analysis was conducted with the clinical and self-care variables to aggregate variability and avoid collinearity among the variables (Table 3). An initial assessment of the factor analysis revealed

that two items ("Carries food for diabetes control" and "Did you smoke a cigarette?") had factor loadings lower than 0.40. Additionally, one item ("Did you need to be hospitalized or go to the emergency room due to diabetic ketoacidosis in the last 12 months?") had factor loadings higher than 0.40 in two factors. Therefore, a new analysis was implemented excluding these items. Table 3 presents the factor loadings of each evaluated variable and the polarization of the factor loadings. Initially, the model was observed with seven factors, but the scree plot indicated an inflection point in the descending curve at the fifth factor, used as a parameter (Ledesma et al., 2015).

Table 2

Comparison of the proportion (%) of agreement of clinical and self-care indicators through glycemic control

Self-care indicators	Total	Adequate	Inadequate	*p*-value[a]
Tested insulin 4 times or more (last week)	73 (68.22)	51 (80.95)	22 (50)	0.001
Tested glucose 4 times or more (last week)	73 (68.22)	51 (80.95)	22 (50)	0.001
Had a hemoglobin A1c test (frequency in the last 12 months)	102 (95.33)	58 (92.06)	44 (100)	0.066
Had a medical check-up for T1DM control (last 12 months)	103 (96.26)	59 (93.65)	44 (100)	0.115
Has not delayed insulin doses (last 30 days)	38 (35.51)	32 (50.79)	6 (13.64)	0.000
Has a positive perception of T1DM control (12 months)	51 (47.66)	42 (66.67)	9 (20.45)	0.000
Used insulin as prescribed, not exceeding dosage (last 30 days)	65 (60.75)	41 (65.08)	24 (54.55)	0.185
Has other health problems	39 (36.45)	17 (26.98)	22 (50)	0.013
Experienced a hypoglycemic episode (12 months)	46 (42.99)	25 (39.68)	21 (47.73)	0.265
Has other chronic diseases (in addition to T1DM)	25 (23.36)	15 (23.81)	10 (22.73)	0.543
Participates/participated in a T1DM group or association	53 (49.53)	33 (52.38)	20 (45.45)	0.306
Received support in T1DM care during childhood	78 (72.9)	45 (71.43)	33 (75)	0.428
Consulted other doctors (last 12 months)	18 (16.82)	8 (12.7)	10 (22.73)	0.136
Carries a T1DM medical identification	54 (50.47)	35 (55.56)	19 (43.18)	0.144
Carries food in case blood glucose levels gets too low	92 (85.98)	57 (90.48)	35 (79.55)	0.094
Smoked cigarettes (last week)	5 (4.67)	2 (3.17)	3 (6.82)	0.667
Was hospitalized or went to the emergency room due to diabetic ketoacidosis	14 (13.08)	5 (7.94)	9 (20.45)	0.056

Note: [a]Fisher's Exact test for qualitative comparison. Adequate Control: Glycated Hemoglobin ≤ 7%. Inadequate Control: Glycated Hemoglobin ≥ 8%. T1DM: Type 1 diabetes *Mellitus*.

Table 3

Exploratory factor analysis of the medical history of individuals living with type 1 diabetes Mellitus

Variables	Factors				
	1	2	3	4	5
Tested insulin 4 times or more in the last week	**0.95**	0.01	0.14	0.06	0.04
Tested glucose 4 times or more in the last week	**0.95**	0.01	0.14	0.06	0.04
Had a hemoglobin A1c test (frequency in the last 12 months)	0.07	**0.88**	-0.06	0.04	0.00
Had a medical check-up for T1DM control (last 12 months)	-0.04	**0.84**	-0.06	0.13	-0.04
Has not delayed insulin doses (last 30 days)	0.16	-0.05	**0.75**	-0.10	0.15
Has a positive perception of T1DM control (12 months)	0.29	0.04	**0.68**	-0.19	-0.04
Used insulin as prescribed, not exceeding dosage (last 30 days)	-0.17	-0.13	**0.67**	0.33	-0.13
Has other health problems	0.11	0.14	-0.22	**0.70**	-0.04
Experienced a hypoglycemic episode (12 months)	-0.13	-0.13	0.02	**0.68**	0.10
Has other chronic diseases (in addition to T1DM)	0.18	0.21	0.12	**0.48**	-0.10
Participates/participated in a T1DM group or association	0.02	0.15	0.03	-0.08	**0.75**
Received support in T1DM care during childhood	0.03	-0.21	-0.01	-0.07	**0.63**
Consulted other doctors in the last 12 months	-0.34	0.19	0.04	0.31	**0.48**
Carries a T1DM medical identification	0.26	-0.35	-0.05	0.19	**0.44**
% Explained Variance	17.62	13.90	11.08	9.49	9.14

Note: Factor loadings > 0.40 are in bold. Factor 1: Daily testing; Factor 2: Medical care; Factor 3: T1DM Control; Factor 4: Other health problems; Factor 5: Support from others. T1DM: Type 1 diabetes *Mellitus*.

Therefore, a new analysis was generated with five factors explaining 61.23% of the variance. The first factor was named "Daily Testing" and included variables related to insulin and glucose testing, and the second factor was named "Medical Care" because it included variables related to consultations and examinations carried out by people living with diabetes. In each of these factors, only two variables had factor loadings equal to or greater than 0.40, but as they were highly intercorrelated (above 0.80), the factors can be considered reliable (Knekta et al., 2019). The third factor was named "T1DM Control" as it included variables related to a positive perception of T1DM control, not delaying insulin doses, and not using more than what is prescribed; the fourth factor was named "Other Health Problems", with variables related to the presence of other diseases or health problems; and finally, the fifth factor was named "Support from Others" because it included variables related to family, medical, and social support.

The factor loadings of the model were saved and included as predictors in logistic regression models of clinical and self-care indicators to predict glycemic control in T1DM (Table 4). The independent variables were the standardized scores on the five factors obtained through principal component analysis. The outcome considered was the glycemic control of people living with T1DM, evaluated as 0 = Adequate (HbA1c ≤ 7%) and 1 = Inadequate (HbA1c ≥ 8%). The results indicated that the factors "Daily Testing" and "T1DM Control" were responsible for predicting the odds ratio of having adequate glycemic control, while "Other Health Problems" was responsible for predicting the odds of having inadequate glycemic control. These variables were identified as protective and risk factors for T1DM management and self-care.

Table 4

Logistic regression analysis of clinical indicators and self-care for the prediction of inadequate glycemic control

Variables	B	*SE*	Wald	OR	95% CI
Intercept	-0.58	0.26	5.16	0.56	
Factor 1: Daily testing	-0.85	0.25	11.30*	0.43	0.26 - 0.70
Factor 2: Medical care	0.64	0.39	2.70	1.90	0.88 - 4.08
Factor 3: T1DM Control	-1.16	0.28	17.52**	0.31	0.18 - 0.54
Factor 4: Other health problems	0.55	0.25	4.88*	1.73	1.06 - 2.82
Factor 5: Support from others	-0.09	0.24	0.12	0.92	0.57 - 1.48

Note: $^{*}p < 0.05$. $^{**}p < 0.001$. Inadequate Control: Glycated Hemoglobin ≤ 8%. SE: Standard Error; OR: Odds Ratio; CI: Confidence Interval. T1DM: Type 1 diabetes *Mellitus*.

To assess the effects of demographic and economic characteristics on glycemic control, a logistic regression analysis was performed, with sex, education level, employment, personal income, BMI, social class, and age at diagnosis as explanatory variables. The results described in Table 5 indicate that individuals without income were 5.12 times more likely to have inadequate glycemic control compared to those with an income of three or more minimum wages. Those with an income between one and two minimum wages had 4.61 times higher odds of having the outcome compared to those with higher income. Furthermore, it can be observed that a one-unit increase in BMI represented 1.22 times higher odds of having inadequate glycemic control. Finally, it was observed that belonging to social classes A and B were protective factors, as they represented 0.04- and 0.25-times lower odds of having HbA1c > 8% compared to participants in social classes C/D/E (Table 5).

Table 5

Logistic regression analysis of sociodemographic indicators for the prediction of inadequate glycemic control

Variables	B	SE	Wald	OR	95% CI
Intercept	-6.50	2.11	9.45**	0.002	
Sex (male)	-0.01	0.84	0.0001	0.99	0.19 -5.09
Education (incomplete higher education and above)	1.09	0.62	3.07†	2.96	0.88 -9.99
Employed (yes)	-0.79	0.72	1.22	0.45	0.11 -1.85
Personal income (> = 3MW)					
No income	1.63	0.89	3.40†	5.12	0.90-28.97
Less than 1 MW to 2 MW	1.53	0.63	5.88*	4.61	1.34-15.88
BMI	0.20	0.07	8.16**	1.22	1.07-1.41
Social class (C/D/E)					
A	-3.18	1.33	5.72*	0.04	0.003-0.56
B	-1.40	0.55	6.58**	0.25	0.08-0.72
Age at diagnosis	0.05	0.03	2.11	1.05	0.98-1.12

Note: †$p < 0.10$. *$p < 0.05$. **$p < 0.001$. Inadequate Control: Glycated Hemoglobin ≤ 8%. BMI: Body Mass Index; CI: Confidence Interval; OR: Odds Ratio; SE: Standard Error; MW: Minimum-Wage.

Discussion

Glycemic control is an important health parameter for people living with T1DM, who require continuous monitoring of the disease throughout their lives (SBD, 2021). The factors associated with adequate glycemic control in this population are still poorly studied in Brazil. The results of the present study showed that a significant percentage of our sample did not have adequate glycemic control, corroborating international and national data (Coutinho & Silva Júnior, 2016; Fortins et al., 2019; Moreira et al., 2010; Sheleme et al., 2020).

It was also noted that inadequate glycemic control was higher among individuals with lower levels of education, income, and social class, and among those with higher BMI, in agreement with previous findings (Alramadan et al., 2018; Davison et al., 2014; McLarty et al., 2021; Pettus et al., 2019). The precarious health of a significant portion of the global population is related to poverty, as individuals with lower income and fewer individual resources have worse access to health services or preventive measures (WHO, 2018), such as adequate quantity and quality of food or regularly monitored physical activity.

In Brazil, as in other countries, the association between higher diabetes prevalence and low education has been identified as an important socioeconomic indicator and suggests risks for the health-disease process, as access to health services is less frequent, and the adoption of dietary care, physical activity, and disease prevention is not consistent with the opportunities and life context of the poor (Azharuddin et al., 2021; Malta et al., 2014). People with low income face more challenging demands to achieve glycemic control in T1DM, as access to medications and modern supplies is more difficult, as is the continuous support to help them manage the disease and educate them on diabetes (Huo et al., 2020; Nguyen et al., 2015). Thus, poorer glycemic control and treatment difficulties are associated with the financial condition and low socioeconomic status of people living with T1DM (Gomes et al., 2012; Rodrigues et al., 2010).

Nutritional status has also been associated with glycemic uncontrol, which corroborates the findings of the present study. In this regard, a study showed that participants who were overweight or obese had lower adherence to the prescribed diet, and smoking was more frequent (Davison et al., 2014). Other studies with Brazilian samples of adults (Moraes et al., 2003; Nunes et al., 2009) and adolescents (Marques et al., 2011) living with T1DM also found higher proportions

of inadequate glycemic control among those with higher BMI, obesity, overweight, and/or at risk of overweight.

The present study explored a series of daily self-care indicators related to T1DM and overall health, finding sets of aspects that were most influential in the risk of high HbA1c. It was possible to observe that adequate glycemic control was predicted by good T1DM management (not delaying insulin use or exceeding doses, adequate perception of disease control) and daily testing (frequency of glucose and insulin testing). Conversely, individuals who reported having other health problems had a higher probability of having poorer glycemic control.

In this regard, routine care such as glucose monitoring has the primary purpose of determining the level of glycemic control for people living with diabetes, being the best option over time in preventing chronic and acute complications (Okido et al., 2017). A study conducted in Germany and Austria between 1995 and 2006 with over 27,000 children and adolescents living with T1DM observed that the concentration of HbA1c was proportional to the number of daily glucose monitoring (Ziegler et al., 2011). Another study also found that the higher the number of daily glucose checks through monitoring, the better glycemic control of HbA1c in people living with T1DM (Šoupal et al., 2020). People undergoing multiple daily insulin injections should monitor their blood glucose levels before and occasionally after meals, before bed and physical exercise, in cases of suspected hypoglycemia or hyperglycemia, and after their normalization, as a strict monitoring behavior (approximately six to eight times a day) is an indicator of reduced concentration of HbA1c in adults (ADA, 2022).

Furthermore, in another study, individuals living with T1DM who regularly performed glucose monitoring had fewer chances of omitting insulin treatment compared to those who monitored glucose levels occasionally (Peyrot et al., 2012). In addition to individual and social factors, a recent meta-analysis of 43 studies conducted in low- and middle-income countries like Brazil, indicated factors associated with low adherence to insulin treatment, including variability in disease expression and treatment, complexity of therapeutic regimens, and difficulties in the transportation of insulin (Azharuddin et al., 2021). In this regard, the presence of other health problems, whether diabetes-related or not, adds complexity to disease management and should be considered by healthcare teams and services.

The use of insulin is indispensable for the survival of individuals living with T1DM, and appropriate treatment is crucial for achieving prolonged glycemic control (ADA, 2022). However, it is important to emphasize the need to strengthen behavioral strategies and expand the use of resources and devices that facilitate insulin monitoring in daily life. Thus, it is believed that new technologies that enable the monitoring of these indicators and alert individuals living with diabetes and healthcare services can assist in care and prevent complications, sequelae, and premature deaths related to glycemic no control (Johnston et al., 2021). Nevertheless, it is important to keep in mind that such technological advancements should be available and accessible to all individuals in an equitable manner, considering the different profiles of individual and social vulnerability among those living with T1DM.

Our study has some limitations to be considered. Being a cross-sectional study, we cannot determine the direction of causality between the variables included in the analyses and glycemic control over time, as participants self-selected the group to participate in based on their monitoring abilities. Additionally, due to restrictions imposed by the Ministry of Health for non-essential activities during the COVID-19 pandemic period, the glucose monitoring results were obtained through self-reporting. Therefore, there is a possibility of overestimation of levels of glycemic

control due to memory bias and social desirability. Future studies still need to assess the extent to which self-report measures underestimate the evaluation of glycated hemoglobin. However, it is worth noting that even though the study was based on a convenience sample that was more educated than the general Brazilian population, it was able to detect differences related to social inequalities; therefore, it emphasizes the importance of investigating the topic in more diverse and representative samples. In any case, our study investigated the influence of various self-care indicators on glycemic control in individuals living with T1DM using a robust analytical approach.

Conclusion

The process of glycemic control in T1DM is complex, and its mastery depends on several elements, including commitment to daily care, family support, a bond with the medical team, financial situation, cultural influences, and other factors directly related to the health of individuals living with diabetes. Particularly, diabetes education is recommended as a fundamental part of effective care of people living with diabetes to promote better disease management outcomes. Diabetes education should always be supported by an understanding of the psychological, social, and cultural needs of individuals living with T1DM, especially regarding difficulties in accessing and adhering to healthy eating and guided physical activity.

It is worth noting that the widespread availability of new technologies and treatment options that facilitate T1DM management is still limited in Brazil, which hinders aspects of disease management for a significant portion of the population. Therefore, our study highlights the importance of implementing health strategies that are sensitive to social inequalities and individual characteristics and difficulties related to T1DM control in everyday life. Additionally, these strategies can promote treatment adherence and maintenance.

References

Alramadan, M. J., Afroz, A., Hussain, S. M., Batais, M. A., Almigbal, T. H., Al-Humrani, H. A., Albaloshi, A., Romero L., Magliano, D. J., & Billah, B. (2018). Patient-related determinants of glycemic control in people with type 2 diabetes in the gulf cooperation council countries: a systematic review. *Journal of Diabetes Research, 2018*, 9389265. https://doi.org/10.1155/2018/9389265

American Diabetes Association. (2022). Standards of medical care in diabetes-2022 abridged for primary care providers. *Clinical Diabetes, 40*(1), 10-38. https://doi.org/10.2337/cd22-as01

Associação Brasileira de Empresas de Pesquisa. (2019). *Critério Brasil-2019*. www.abep.org/criterioBr/01_cceb_2019.pdf

Azharuddin, M., Adil, M., Sharma, M., & Gyawali, B. (2021). A systematic review and meta-analysis of non-adherence to anti-diabetic medication: Evidence from low- and middle-income countries. *International Journal of Clinical Practice, 75*(11), e14717. https://doi.org/10.1111/ijcp.14717

Coutinho, W. F., & Silva Júnior, W. S. (2016). Diabetes Care in Brazil. *Annals of Global Health, 81*(6), 735-741. https://doi.org/10.1016/j.aogh.2015.12.010

Davison, K. A, Negrato, C. A, Cobas, R., Matheus, A., Tannus, L., Palma, C. S., Japiassu, L., Carneiro, J. R. I., Rodacki, M., Zajdenverg, L., Araújo, N. B. C., Cordeiro, M. M., Luescher, J. L., Berardo, R. S., Nery, M., Cani, C., Marques, M. C. A., Calliari, L. E., Noronha, R. M., … Gomes, M. B. (2014). Relationship between adherence to diet, glycemic control and cardiovascular risk factors in patients with type 1 diabetes: a nationwide survey in Brazil. *Nutrition Journal, 13*(1), 1-11. https://doi.org/10.1186/1475-2891-13-19

Fortins, R. F., Lacerda, E. M. A., Silverio, R. N. C., Carmo, C. N., Ferreira, A. A., Felizardo, C., Nascimento, B. F., & Luescher, J. L., & Padilha, P. C. (2019). Predictor factors of glycemic control in children and adolescents with type 1 diabetes mellitus treated at a referral service in Rio de Janeiro, Brazil. *Diabetes Research and Clinical Practice, 154*, 138-145. https://doi.org/10.1016/j.diabres.2019.05.027

Gomes, M. B., Coral, M., Cobas, R. A., Dib, S. A., Canani, L. H., Nery, M., Freitas, M. C., Faria, M., Felício, J. S., Silva, S. C., Pedrosa, H., Costa e Forti, A., Rea, R. R., Pires, A. C., Montenegro Junior, R., Oliveira, J. E., Rassi, N., & Negrato, C. A. (2012). Prevalence of adults with type 1 diabetes who meet the goals of care in daily clinical practice: a nationwide multicenter study in Brazil. *Diabetes Research and Clinical Practice, 97*(1), 63-70. https://doi.org/10.1016/j.diabres.2012.02.008

Huo, L., Deng, W., Shaw, J. E., Magliano, D. J., Zhang, P., McGuire, H. C., Kissimova-Skarbek, K., Whiting, D., & Ji, L. (2020). Factors associated with glycemic control in type 1 diabetes patients in China: A cross-sectional study. *Journal of diabetes investigation, 11*(6), 1575–1582. https://doi.org/10.1111/jdi.13282

Johnston, L., Wang, G., Hu, K., Qian, C., & Liu, G. (2021). Advances in biosensors for continuous glucose monitoring towards wearables. *Frontiers in Bioengineering and Biotechnology, 9*, 1-17. https://doi.org/10.3389/fbioe.2021.733810

Knekta, E., Runyon, C., & Eddy, S. (2019). One size doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research. *Life Sciences Education, 18*(rm1), 1-17. https://doi.org/10.1187%2Fcbe.18-04-0064

Ledesma, R. D., Valero-Mora, P., & Macbeth, G. (2015). The scree test and the number of factors: A dynamic graphics approach. *Spanish Journal of Psychology, 18*(e11), 1-10. http://dx.doi.org/10.1017/sjp.2015.13

Malta, D. C., Andrade, S. C., Claro, R. M., Bernal, R. T. I., & Monteiro, C. A. (2014). Evolução anual da prevalência de excesso de peso e obesidade em adultos nas capitais dos 26 estados brasileiros e no Distrito Federal entre 2006 e 2012. *Revista Brasileira de Epidemiologia, 17*(1), 267-276. https://doi.org/10.1590/1809-4503201400050021

Marques, R. D. M. B., Fornés, N. S., & Stringhini, M. L. F. (2011). Fatores socioeconômicos, demográficos, nutricionais e de atividade física no controle glicêmico de adolescentes portadores de diabetes melito tipo 1. *Arquivos Brasileiros de Endocrinologia & Metabologia, 55*, 194-202. https://doi.org/10.1590/S0004-27302011000300004

McLarty, R. P., Alloyce, J. P., Chitema, G. G., & Msuya, L. J. (2021). Glycemic control, associated factors, acute complications of Type 1 Diabetes Mellitus in children, adolescents and young adults in Tanzania. *Endocrinology, Diabetes & Metabolism, 4*, e00200. https://doi.org/10.1002/edm2.200

Moraes, C. M., Portella, R. B., Pinheiro, V. S., Oliveira, M. M. S., Fuks, A. G., Cunha, E. F., & Gomes, M. B. (2003). Prevalência de sobrepeso e obesidade em pacientes com diabetes tipo 1. *Arquivos Brasileiros de Endocrinologia & Metabologia, 47*(6), 677-683. https://doi.org/10.1590/S0004-27302003000600009

Moreira, E. D., Jr, Neves, R. C. S., Nunes, Z. O., Almeida, M. C. C., Mendes, A. B. V., Fittipaldi, J. A. S., & Ablan, F. (2010). Glycemic control and its correlates in patients with diabetes in Venezuela: Results from a nationwide survey. *Diabetes Research and Clinical Practice, 87*(3), 407-414. https://doi.org/10.1016/j.diabres.2009.12.014

Mourão-Júnior, C. A., Sá, J. R. D., Guedes, O. M. S., & Dib, S. A. (2006). Glycemic control in adult type 1 diabetes patients from a brazilian country city: Comparison between a multidisciplinary and a routine endocrinological approach. *Arquivos Brasileiros de Endocrinologia & Metabologia, 50*(5), 944-950. https://doi.org/10.1590/S0004-27302006000500018

Nguyen, A. L., Green, J., & Enguidanos, S. (2015). The relationship between depressive symptoms, diabetes symptoms, and self-management among an urban, low-income Latino population. *Journal of Diabetes and its Complications, 29*(8), 1003-1008. https://doi.org/10.1016/j.jdiacomp.2015.09.004

Nunes, R. R., Clemente, E. L. D. S., Pandini, J. A., Cobas, R. A., Dias, V. M., Sperandei, S., & Gomes, M. D. B. (2009). Confiabilidade da classificação do estado nutricional obtida através do IMC e três diferentes métodos de percentual de gordura corporal em pacientes com diabetes melitus tipo 1. *Arquivos Brasileiros de Endocrinologia & Metabologia, 53*(3), 360-367. https://doi.org/10.1590/S0004-27302009000300011

Okido, A. C. C., Almeida, A. D., Vieira, M. M., Neves, E. T., Mello, D. F. D., & Lima, R. A. G. (2017). As demandas de cuidado das crianças com Diabetes Mellitus tipo 1. *Escola Anna Nery, 21*(2), e20170034. https://doi.org/10.5935/1414-8145.20170034

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology, 49*(12), 1373-1379. https://doi.org/10.1016/s0895-4356(96)00236-3

Pettus, J. H., Zhou, F. L., Shepherd, L., Preblick, R., Hunt, P. R., Paranjape, S., Miller K. M., & Edelman, S. V. (2019). Incidences of severe hypoglycemia and diabetic ketoacidosis and prevalence of microvascular complications stratified by age and glycemic control in U.S. adult patients with type 1 diabetes: A real-world study. *Diabetes Care, 42*(12), 2220-2227. https://doi.org/10.2337/dc19-0830

Peyrot, M., Barnett, A. H., Meneghini, L. F., & Schumm-Draeger, P. M. (2012). Factors associated with injection omission/non-adherence in the Global Attitudes of Patients and Physicians in Insulin Therapy study. *Diabetes, Obesity and Metabolism, 14*, 1081-1087. https://doi.org/10.1111/j.1463-1326.2012.01636.x

Rodrigues, T. C., Pecis, M., Canani, L. H., Schreiner, L., Kramer, C. K., Biavatti, K., Macedo, B., Esteves, J. F., & Azevedo, M. J. (2010). Caracterização de pacientes com diabetes mellitus tipo 1 do sul do Brasil: complicações crônicas e fatores associados. *Revista da Associação Médica Brasileira, 56*(1), 67-73. https://doi.org/10.1590/S0104-42302010000100019

Sand, P., Blom, M. D., Forsander, G., & Lundin, C. S. (2018). Family dynamics when a child becomes chronically ill: impact of type 1 diabetes onset in children and adolescents. *Nordic Psychology, 70*(2), 97-114. https://doi.org/10.1080/19012276.2017.1362990

Sheleme, T., Mamo, G., Melaku, T., & Sahilu, T. (2020). Glycemic control and its predictors among adult diabetic patients attending Mettu Karl referral hospital, southwest Ethiopia: A prospective observational study. *Diabetes Therapy, 11*, 1775-1794. https://doi.org/10.1007/s13300-020-00861-7

Sociedade Brasileira de Diabetes. (2021). *Diretrizes da Sociedade Brasileira de Diabetes - 2021*. https://diretriz.diabetes.org.br/data/2021/

Šoupal, J., Petruželková, L., Grunberger, G., Hásková, A., Flekač, M., Matoulek, M., Mikeš, O., Pelcl, T., Škrha, J., Jr, Horová, E., Škrha, J., Parkin, C. G., Svačina, Š., & Prázný, M. (2020). Glycemic outcomes in adults with T1D are impacted more by continuous glucose monitoring than by insulin delivery method: 3 years of follow-up from the COMISAIR study. *Diabetes Care, 43*(1), 37-43. https://doi.org/10.2337/dc19-0888

Watkins, M. W. (2018). Exploratory factor analysis: a guide to best practice. *Journal of Black Psychology, 44*(3), 219-246. https://doi.org/10.1177/0095798418771807

World Health Organization. (2018). *Health inequities and their causes*. https://www.who.int/news-room/facts-in-pictures/detail/health-inequities-and-their-causes

World Health Organization. (2011). *Use of glycated haemoglobin (HbA1c) in the diagnosis of diabetes mellitus*. http://www.who.int/diabetes/publications/report-hba1c_2011.pdf

Ziegler, R., Heidtmann, B., Hilgard, D., Hofer, S., Rosenbauer, J., Holl, R., & DPV-Wiss-Initiative. (2011). Frequency of SMBG correlates with HbA1c and acute complications in children and adolescents with type 1 diabetes. *Pediatric Diabetes, 12*(1), 11-17. https://doi.org/10.1111/j.1399-5448.2010.00650.x

Contributors

Conceptualization: G. S. CAMPOS and T. R. GONÇALVES. Formal analysis: P.G. BRUST-RENCK and G. S. CAMPOS. Investigation: G. S. CAMPOS. Project administration: G. S. CAMPOS. Supervision: P. G. BRUST-RENCK and T. R. GONÇALVES. Writing – original draft: G. S. CAMPOS. Writing – review & editing: P. G. BRUST-RENCK and T. R. GONÇALVES.