Endocrinología, Diabetes y Nutrición 71 (2024) 253–262

Endocrinología, Diabetes y Nutrición

www.elsevier.es/endo

ORIGINAL ARTICLE

Influence of socioeconomic factors on glycemic control, therapeutic adherence and quality of life in children and adolescents with type 1 diabetes

Carmen Yoldi-Vergara[a,*], **Ignacio Conget-Donlo**[b,c,d], **Roque Cardona-Hernandez**[a], **Marta Ramon-Krauel**[a,e]

[a] *Servicio de Endocrinología Pediátrica, Hospital Sant Joan de Déu, Barcelona, Spain*
[b] *Servicio de Endocrinología y Nutrición, Hospital Clinic i Universitari, Barcelona, Spain*
[c] *Centro de Investigación Biomédica en Red de Diabetes y Enfermedades Metabólicas Asociadas (CIBERDEM), Madrid, Spain*
[d] *Institut d'investigacions biomèdiques August Pi i Sunyer (IDIBAPS), Barcelona, Spain*
[e] *Institut de Recerca Sant Joan de Déu, Barcelona, Spain*

Received 5 February 2024; accepted 7 April 2024
Available online 27 June 2024

KEYWORDS
Type 1 diabetes;
Pediatrics;
Socioeconomic status;
Adherence;
Quality of life;
Glycemic control

Abstract
Objective: To stablish the relationship between socioeconomic status of a cohort of children and adolescents with type 1 diabetes (T1D) with glycemic control, therapeutic adherence and diabetes quality of life (DQoL).
Patients y methods: A cross-sectional, observational study with consecutive inclusion was carried out. Participants aged 8–18 years with T1D duration >1 year. Data on family structure, family income, parents' educational level and parental role on primary diabetes care supervision were registered. Adherence (DMQ-Sp) and DQoL (PedsQl) were analyzed. Linear and logistic regression models adjusted for demographics, family structure and parental role on primary diabetes care responsibility were applied.
Results: A total of 323 patients (T1D duration 5,3 ± 3,3 years; HbA1c 7,7 ± 1,0%; age 13,3 ± 2,8 years; 49,8% females) were included. Patients living in a nuclear family and those whose main diabetes care supervision was shared by both parents showed lower HbA1c [adjusted for demographics and family structure (7,06; CI 95% 6,52–7,59); adjusted for demographics and role on primary diabetes care supervision (7,43; CI 95% 6,57–8,28)]. DMQ-Sp score (adjusted for demographics and role on main supervision) was higher in patients whose parents shared the diabetes care supervision (84,56; CI 95% 73,93–95,19). Parents sharing diabetes care supervision showed a significantly higher PedsQl score (both 74,63 ± 12,70 vs mother 68,53 ± 14,59; p = 0,001).

* Corresponding author.
E-mail address: carmen.yoldi@sjd.es (C. Yoldi-Vergara).

Conclusions: Children and adolescents with T1D had lower HbA1c, better therapeutic adherence and better DQoL when lived in a nuclear family, with higher socioeconomic status and the responsibility for supervising diabetes care was shared by both parents.

PALABRAS CLAVE
Diabetes tipo 1;
Pediatría;
Nivel socioeconómico;
Adherencia;
Calidad de vida;
Control glucémico

Influencia de factores socioeconómicos sobre el control glucémico, la adherencia terapéutica y la calidad de vida en niños y adolescentes con diabetes mellitus tipo 1

Resumen
Objetivo: Analizar la relación entre los factores socioeconómicos en que conviven una cohorte de niños y adolescentes con diabetes tipo 1 (DT1) con el grado de control glucémico, adherencia terapéutica y calidad de vida (CVRD).
Pacientes y métodos: Estudio transversal, observacional de inclusión consecutiva. Participaron pacientes (edad 8–18 años) con DT1 > 1 año de evolución. Se registró el tipo de estructura familiar, ingresos económicos familiares, nivel de estudios de los progenitores y progenitor responsable primario de la supervisión del cuidado de la diabetes. Se analizó el grado de adherencia (DMQ-Sp) y CVRD (PedsQl). Se aplicaron modelos de regresión lineal ajustados por datos demográficos, estructura familiar y responsable primario.
Resultados: 323 participantes con DT1 (edad 13,3 ± 2,8 años; evolución 5,3 ± 3,3 años; HbA1c 7,7 ± 1,0%; 49,8% mujeres). La HbA1c (ajustada por demográficos y estructura familiar) fue menor en los pacientes que convivieron en una familia nuclear (7,06; IC 95% 6,52–7,59), y menor (ajustada por demográficos y progenitor responsable primario) en aquellos cuyos progenitores compartían esa responsabilidad (7,43; IC 95% 6,57–8,28). La puntuación DMQ-Sp (ajustada por demográficos y responsabilidad) fue mayor en los pacientes cuyos progenitores compartían la supervisión (84,56; IC 95% 73,93–95,19). Los progenitores mostraron mayor ponderación PedsQl en el grupo que compartían la supervisión (ambos 74,63 ± 12,70; madre 68,53 ± 14,59; p = 0,001).
Conclusiones: Los niños y adolescentes con DT1 presentaron una HbA1c más baja, mejor adherencia terapéutica y CVRD cuando convivieron en una familia con estructura nuclear, con nivel socioeconómico elevado y la responsabilidad de la supervisión del cuidado de la diabetes fue compartida por ambos progenitores.

Introduction

Type 1 diabetes mellitus (T1DM) is one of the most prevalent chronic diseases in pediatric age. Achieving glycemic control targets reduces the risk of morbidity and mortality and improves the quality of life of people with diabetes. Clinical guidelines from reference scientific societies indicate a glycated hemoglobin (HbA1c) level <7% as a glycemic control target.[1,2] With the development of continuous glucose monitoring (CGM) for all interstitial glucose measurement systems, other target metrics have been described, such as maintaining a time in range (70 mg/dL up to 180 mg/dL) >70%.[3]

The management of diabetes is challenging. It requires insulin administration, along with a series of self-care behaviors that diabetic patients must follow in their daily lives.[4] These behaviors involve making numerous daily decisions in everyday activities such as eating, exercising, or enjoying social relationships. A high degree of adherence to self-management of treatment is key to achieving good glycemic control[5] and can be a predictor of HbA1c progression in adolescence and young adulthood.[6]

Health-related quality of life is a holistic, multidimensional, and comprehensive concept that measures the individuals' perception of well-being regarding general health, physical and mental health, health concerns, and the impact of a disease or condition on physical, social, or emotional functioning. Currently, health-related quality of life is a health indicator within the framework of Patient-Reported Outcome Measures (PROM)[7] and is considered an aspect that should be regularly evaluated in the follow-up of diabetic people.[2] Numerous studies have positively related quality of life and glycemic control.[8] Moreover, quality of life and adherence to self-management, along with the prevention of chronic complications, are considered variables for evaluating therapeutic education.[9]

According to the World Health Organization (WHO),[10] the social and economic factors that have an impact on health are the family environment, the community where the person is born and grows up, gender, education, financial resources, and social protection, among others.

A recent review highlights the impact of socioeconomic factors on diabetes control.[11] It emphasizes the importance of the level of education received and financial income earned, which are associated with the place of residence. It also associated family and close environment support with the management of T1DM in everyday life. In the field of pediatric diabetes, the impact of the role of family involvement on adherence to diabetes self-management in the United States population has been described.[12–14] Similarly, a few studies conducted in neighboring countries report the role family support plays in children and adolescents on the daily management of diabetes, as well as other socioeconomic factors, which can favor or hinder the achievement of glycemic targets.[15–18] Having good support and low family conflict is associated with a higher perception of well-being in Spanish adolescents with T1DM.[19] However, the impact that other socioeconomic factors may have on health outcomes in the pediatric population with T1DM has not been extensively studyed in Spain.

The objective of this study was to analyze the relationship among the socioeconomic level in which a cohort of patients treated in a tertiary pediatric hospital live, glycemic control, the degree of adherence to self-management, and quality of life in children and adolescents with T1DM in Catalonia, Spain.

Patients and methods

Design

We designed a cross-sectional, observational study of consecutive inclusion. This is a sub-analysis of the data collected in the validation study of the Spanish version of the Diabetes Management Questionnaire (DMQ-Sp).[20] Patients and their parents were included through consecutive non-probabilistic sampling during regular follow-up visits at the diabetes unit from 2018 through 2019.

Ethical considerations

The study was approved by Sant Joan de Déu Hospital Clinical Research Committee (PIC-22-16). Parental consent and child and adolescent assent were obtained.

Population and study setting

The study included children and adolescents (hereinafter referred to as children) aged 8–18 years with a more than 1-year history of T1DM on multiple daily injection (MDI) insulin therapy or continuous subcutaneous insulin infusion (CSII) and their parents. All were treated at a tertiary referral center in Spain. Exclusion criteria were unwillingness to participate or failure to sign the informed consent/assent, as well as individuals with comprehension difficulties. The clinical and sociodemographic characteristics were described in the publication of the validation study of the DMQ-Sp scale[20] (Appendix A in Supplementary material).

Variables and measurement instruments

Patients and their parents completed all questionnaires during the regular follow-up visit with their diabetes team, during which the HbA1c value was obtained as part of routine control. HbA1c was analyzed using high-resolution chromatography (Afinion™ 2 Device; Abbott Diagnostics Technologies AS, Oslo, Norway; reference range, 4.0% up to 6.0% [20—42 mmol/mol]). The type of treatment followed by the patients, the way they measured their own glucose levels, and clinical data were collected from the individual's electronic health record.

The degree of adherence to diabetes self-management was measured using the DMQ-Sp scale.[20] This questionnaire has been validated for the pediatric population with T1DM from 8 years of age with a Cronbach's alpha value of 0.757. It is self-administered and takes 5-to-8 min to complete. It includes a total of 20 items with responses on 5-option Likert scales related to exercise (3 items), diet (8 items), hypoglycemia (3 items), hyperglycemia (3 items), insulin management, and glucose monitoring (3 items) (Appendix B in Supplementary material). Higher scores (range, 0–100) indicate better adherence. It is applicable to both MDI and CSII therapies and patients using CGM.

Diabetes-related quality of life (DQoL) was measured using the Pediatric Quality of Life Inventory [PedsQL] 3.2 Diabetes Module.[21] It is self-administered and validated for children and parents alike. It consists of 33 questions with Likert-type responses. Higher scores (range 0–100) indicate better DQoL.

Socioeconomic characteristics were obtained through a self-administered questionnaire developed ad hoc. It included both the children's school level and their parents' education level, the type of family structure, the primary caregiver for diabetes supervision, the parents' employment status, and the annual family income. Family structure was classified as: 1) nuclear (both parents living with their children), separated parents, single-parent, blended, and others (Appendix C in Supplementary material). The questionnaire was completed by one of the parents who accompanied the child to the visit.

Statistical analysis

Statistical analysis was performed using SPSS 19.0 (IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.).

Descriptive analysis of the sample was performed using frequency distribution. Data were expressed as mean ± standard deviation and percentage. The Student *t*-test was used for the analysis of unpaired data, the Mann–Whitney *U* test for variables that did not show nor-

Table 1 Description of the participants' metabolic control, adherence level, and quality of life.

Variable	Overall sample	Female	Male	p Value	8–12 years	13–18 years	p Value[b]
n (%)	323 (100)	161 (49.8)	162 (50.2)		155 (47.98)	168 (52.02)	
HbA1c (%)[a]	7.7 ± 0.97	7.7 ± 1.1	7.7 ± 0.9	0.53	7.6 ± 0.9	7.8 ± 1.0	0.055
DMQ-Sp[a]	73.30 ± 13.1	73.5 ± 13.8	73.2 ± 12.4	0.818	82.5 ± 9.2	75.0 ± 10.3	<0.001
PedsQl[a] patients	73.10 ± 12.67	70.56 ± 13.05	75.61 ± 11.78	<0.001	73.10 ± 12.80	73.14 ± 12.60	0.971
PedsQl[a] patients	72.56 ± 13.78	70.18 ± 14.14	74.78 ± 13.08	<0.001	72.57 ± 13.30	72.53 ± 14.24	0.983

HbA1c, glycosylated hemoglobin; DMQ-Sp, Diabetes Management Questionnaire — Spanish version; PedsQl, Pediatric Quality of Life Inventory.
DMQ-Sp and PedsQl range: 0–100 (higher scores indicate greater adherence and better quality of life).
[a] Values are expressed as mean ± standard deviation.
[b] p Values < 0.05 were considered statistically significant.

mality, and the ANOVA test was used to compare the degree of DQoL based on the type of family in which they lived, the primary caregiver for diabetes, and the parents' education level. Spearman's Rho coefficient was used to analyze the correlation among family income, adherence, HbA1c, and DQoL. Bonferroni correction for multiple tests was applied in the detailed analysis of the relationship among income level and parents' education level with DQoL. The Pearson correlation coefficient was used to analyze the correlation among quality of life, HbA1c, and adherence. p Values < 0.05 were considered statistically significant. HbA1c and DMQ-Sp (continuous variables) were adjusted using linear regression models. The following models were used: Model #1 was adjusted for age, sex, type of treatment, and type of glucose measurement; model #2 was additionally adjusted for type of family structure; model #3 was further adjusted for the primary caregiver for diabetes supervision. Regression comparisons were performed using the ANOVA test with a 95% confidence interval (CI).

Results

Unadjusted results

The study included a total of 323 patients with a 5.3 ± 3.3 year-history of T1DM. A complete description of their clinical data is detailed in Appendix A in Supplementary material. When analyzing the characteristics by age, the group aged 13–18 scored lower on the DMQ-Sp adherence scale vs the group aged 8–12 (75.0 ± 10.3 vs 82.5 ± 9.2; p < 0.001). Between genders, lower scores were reported on the PedsQL scale in females (70.56 ± 13.05 vs 75.61 ± 11.78; p < 0.001) and their parents (70.18 ± 14.14 vs 74.78 ± 13.08; p = 0.003) (Table 1).

A total of 71.7% of all children and adolescents lived in a nuclear family structure, 60.1% of the parents reported sharing the primary responsibility for supervising diabetes care, and approximately half reported having a higher education level (54.9% mothers and 47.6% fathers). The education levels reported by fathers and mothers were highly correlated. A total of 31.8% of the families had annual incomes over 40,000 euros (Table 2).

Patients on CSII had lower HbA1c values vs those on MDI (7.4 ± 0.9% vs 7.8 ± 1.0%; p < 0.01). Additionally, children using CGM had lower HbA1c values than those measuring capillary blood glucose (7.5 ± 0.9% vs 7.8 ± 1.0%; p < 0.01). A total of 91.1% of children with CGM used the flash glucose monitoring system. Both the use of CSII treatment and CGM were significantly associated with higher maternal education levels (p < 0.05 and p = 0.001, respectively) and higher family incomes (p = 0.001 and p < 0.0001, respectively).

Regarding glycemic control, lower HbA1c values were observed in patients living in a nuclear family vs those living in other family structures (7.6 ± 0.9% vs 7.9 ± 0.9%, respectively; p < 0.05). Patients whose parents shared the primary responsibility for supervising diabetes care had significantly lower HbA1c values vs those whose parents did not share such responsibility (7.6 ± 0.9% vs 7.8 ± 1.0%, respectively; p < 0.05). Family income held a negative correlation with HbA1c value (Rho = −0.181; p < 0.05). No differences were seen in HbA1c values among children based on the level of maternal education (higher 7.7 ± 1.0% vs other levels 7.7 ± 0.9%).

Based on the degree of adherence, children living in a nuclear family scored 74.1 ± 12.1 on the DMQ-Sp scale, which is similar to the scores obtained from children from separated parents and those living in a single-parent family (73.8 ± 15.3; p = 0.87 and 72.9 ± 12.5; p = 0.76, respectively). However, significantly lower DMQ-Sp scores were observed in subjects living in a blended family and other family structures (63.9 ± 14.9; p < 0.05 and 65.3 ± 13.4; p < 0.05, respectively) vs those living in a nuclear family. Patients whose parents shared the primary responsibility for supervising diabetes care had significantly higher DMQ-Sp adherence scores vs those whose primary responsibility only fell on the mother or the father (both 74.9 ± 12.7; the mother 71.3 ± 12.9; p < 0.05; the father 65.9 ± 19.1; p < 0.05). Children whose mothers reported having a higher education level had significantly higher DMQ-Sp scores vs those whose mothers had other education levels (74.9 ± 13.2 vs 71.4 ± 12.7, respectively; p < 0.05). Family income held a positive correlation with DMQ-Sp score (Rho = 0.169; p < 0.003).

Table 2 Socioeconomic characteristics of participant patients and their families (n = 323).[20]

Level of education of children and adolescents		
Primary	118 (36.4)	
Secondary	144 (44.4)	
High School	43 (13.6)	
Vocational training	18 (5.6)	
Family structure		
Nuclear (both parents living with children)	229 (71.7)	
Separated parents	60 (18.5)	
Single parent	13 (4)	
Reconstituted family	11 (3.4)	
Others	8 (2.4)	
Primary person responsible for diabetes care supervision		
Mother and father	194 (60.1)	
Mother	118 (36.5)	
Father	10 (3.1)	
Others	1 (0.3)	
Educational level	*Fathers*	*Mothers*
Higher education	148 (47.6)	175 (54.9)
Secondary education	111 (35.7)	105 (32.9)
Primary education	49 (15.8)	36 (11.3)
No Education	3 (1.0)	3 (0.9)
No Response	12 (3.7)	12 (3.7)
Annual Income[b]		
<€10,000	25 (8.4)	
€10,000–€20,000	76 (25.4)	
€20,000–€30,000	59 (19.7)	
€30,000–€40,000	44 (14.7)	
>€40,000	95 (31.8)	
No response	8.0)	

[a]Values are expressed as number (%).
[b] Income is expressed in euros (€).

DMQ-Sp and DQoL scores were positively correlated in both children (r = 0.184; p = 0.001) and parents (r = 0.210; p < 0.001).

Regarding quality of life, no differences were observed in DQoL reported by children according to the type of family they lived in. Parents showed significantly higher PedsQL scores in the group sharing primary supervision of care (Table 3) vs the group in which the mother was the primary supervisor (both 74.63 ± 12.70; mother 68.53 ± 14.59; p = 0.001). Family income and PedsQL scores held a positive correlation for both patients (Rho = 0.186; p = 0.002) and parents (Rho = 0.251; p < 0.001). A detailed analysis of this relationship shows significantly lower DQoL scores in the group of children and parents whose annual income was <10,000 euros vs those whose income was >40,000 euros annually (p < 0.05). The children's DQoL was not associated with maternal education level (r = 0.66; p = 0.245). However, both held a positive and significant correlation in parents (r = 0.124; p < 0.05). DQoL held a negative correlation with the children's HbA1c values (r = −0.269; p = 0.000) and their parents (r = −0.245; p = 0.000).

Adjusted results

The results of the linear regression model are shown in Table 4. Adjusted for demographic data and family structure type (Model #2), HbA1c was significantly lower in patients living in a nuclear family. Also adjusted according to Model #2, those living in a blended family structure showed significantly lower DMQ-Sp scores. Additionally, adjusted for demographic data and primary caregiver of diabetes supervision (Model #3), DMQ-Sp scores were significantly higher when shared by both parents.

Discussion

This is one of the first real-life studies analyzing the association of socioeconomic factors with glycemic control, adherence, and quality of life in the pediatric population with T1DM in Spain. The study shows the association of some socioeconomic factors, such as the type of family in which patients live, the primary caregiver responsible for diabetes supervision, the mother's education level, and economic income, with educational and health outcomes in a large sample of children and adolescents with T1DM.

Several studies relate maintaining good glycemic control and a high degree of adherence with a better perception of quality of life.[22–25] Our results showed similar data, associating lower HbA1c levels and a higher adherence to diabetes self-management with better DQoL. This finding was confirmed in both children and parents.

Table 3 Description of diabetes-related quality of life (PedsQl scale), according to the type of family in which children and adolescents with T1DM lived and the primary responsible parent for supervising diabetes care.

Variable	PedsQl patients	PedsQl parents
Family structure		
Nuclear		
n	225	220
Mean ± SD	73.78 ± 12.10	73.37 ± 13.18
25th percentile	66.93	64.06
50th percentile	75.00	75.75
75th percentile	82.57	82.75
Separated parents		
n	56	58
Mean ± SD	73.45 ± 12.15	72.42 ± 14.41
25th percentile	61.72	60.49
50th percentile	72.26	73.43
75th percentile	84.73	84.16
Single parent		
n	10	11
Mean ± SD	70.95 ± 15.57	69.12 ± 20.12
25th percentile	56.25	56.82
50th percentile	71.48	69.10
75th percentile	82.51	87.88
Reconstituted		
n	11	11
Mean ± SD	63.62 ± 20.46	61.19 ± 13.17
25th percentile	50.78	50.00
50th percentile	61.72	62.50
75th percentile	75.78	70.45
Others		
n	9	9
Mean ± SD	73.16 ± 8.70	72.96 ± 11.64
25th percentile	65.15	63.01
50th percentile	74.24	71.97
75th percentile	81.64	83.20
ANOVA test between groups[a]	p = 0.124	p = 0.061
Primary caregiver for diabetes		
Father and mother		
n	189	190
Mean ± SD	74.44 ± 12.28	74.63 ± 12.69
25th percentile	67.42	65.62
50th percentile	75.76	76.51
75th percentile	82.81	83.72
Mother		
n	110	109
Mean ± SD	71.25 ± 12.89	68.54 ± 14.59
25th percentile	61.17	58.46
50th percentile	71.54	69.53
75th percentile	82.03	79.92
Father		
n	9	8
Mean ± SD	72.60 ± 12.06	79.80 ± 14.39
25th percentile	63.26	69.89
50th percentile	68.18	82.20
75th percentile	80.68	91.51
ANOVA test between groups[a]	p = 0.105	p < 0.0001

T1DM, type 1 diabetes mellitus; SD, standard deviation.
PedsQl Range: 0–100 (higher scores indicate better quality of life).
[a] p Values <0.05 were considered statistically significant.

Table 4 Linear regression model for HbA1c and DMQ-Sp in children and adolescents with T1DM (n = 323).

Variable	HbA1c			DMQ-Sp		
	Mean (%)	95%CI	p Value[a]	Mean (%)	95%CI	p Value[a]
Unstandardized	7.7	5.4–11.2	–	73.30	–	–
Model #1	7.18	6.63–7.72	NS	92.16	85.4–98.86	NS
Model #2	7.06	6.52–7.59	$p < 0.05$[b]	93.52	86.82–100	$p < 0.05$[b]
Model #3	7.43	6.57–8.28	NS	84.56	73.93–95.19	$p < 0.05$[c]

Data are expressed as mean with a 95% confidence interval (CI) (lower limit–upper limit).
Description of the models:
Model #1: Age, gender, type of therapy (MDI/CSII), and type of monitoring (CBG/CGM).
Model #2: Model 1 + family structure.
Model #3: Model 1 + primary caregiver responsible for T1DM supervision.
T1DM, type 1 diabetes mellitus; HbA1c, glycosylated hemoglobin; DMQ-Sp: Diabetes Management Questionnaire — Spanish version; MDI, multiple daily injection insulin therapy; CSII, continuous subcutaneous insulin infusion; CBG, capillary blood glucose monitoring; CGM, continuous glucose monitoring; CI, confidence interval.
DMQ-Sp Range: 0–100 (higher scores indicate greater adherence).
[a] Statistical significance value $p < 0.05$.
[b] Lower HbA1c levels and higher adherence if living in a nuclear family structure.
[c] Higher adherence scores when the responsibility for primary T1DM care supervision is shared by both parents.

A recent study[6] reports that adherence, living in a single-parent family, and having a low education level are predictors of the progression of glycemic control in diabetic patients. Our study showed lower HbA1c levels in minors living in a nuclear family structure. Although the degree of adherence did not differ among subjects living in a nuclear, single-parent, or separated family, the adjusted analysis showed higher adherence in patients living in a nuclear family. These results are consistent with those described in an American study in which children living in a single-parent family with the mother were at a higher risk for having higher HbA1c levels.[26] No differences were seen in the DQoL of children or parents based on the family structure in which they lived.

Regarding the importance of sharing primary responsibility for parental diabetes care supervision, adolescents whose parents reported sharing it had lower HbA1c levels and higher adherence to diabetes self-management. Some studies relate good support and low family conflict with good glycemic control and better adherence.[12,17] Considering that questionnaires were answered only by one parent who reported the type of family supervision, the high response ''shared responsibility for diabetes care supervision'' would be indicative of good cohesion and lower family conflict. Additionally, sharing this care supervision was associated with better DQoL in parents, without differences in the patients' DQoL.

The mother's education level has been positively related to diabetes knowledge and glycemic control.[27] It has also been associated with better adherence to treatment and better glycemic control.[28] This relationship was observed in the psychometric analysis of the DMQ-Sp scale.[20] However, it was not reflected in the glycemic control of the group of patients whose mothers reported higher education levels. Our results differ from data described by other studies in our region,[15,16] which report better glycemic control in patients whose mothers have a higher education level. In our study, a positive correlation was seen between the mothers' education level and the use of technology for diabetes treatment, as well as with higher economic income.

The use of technology regardin treatment—both CSII and CGM—also held a positive correlation to family income. Although we could expect that access to CSII treatment should not be impacted by the family economic level since it is publicly funded in Spain, this relationship could perhaps be explained by its association with the mothers' higher education level. The use of CGM was low vs the current situation. At the time the study was conducted, CGM systems were not yet publicly funded, so families bore their cost. Greater access to CGM use was observed in patients whose families had higher purchasing power. In turn, these patients showed better HbA1c values. Some studies have shown that access to diabetes-related technology is lower in people with low socioeconomic status,[29] even when this technology is funded. This could partly explain some of the differences seen in the results of this study. We should say that there is an association between the families' purchasing power and achieving glycemic targets, especially when the devices required for treatment are not publicly funded. These results are consistent with the WHO statements; universal access to health services improves equity among social groups[10] and, therefore, provides the same opportunities to all children and adolescents with diabetes. Currently, in Spain, access to CGM systems is universal for all people living with T1DM. However, the relationship between sociodemographic factors is not resolved solely in the issue of access to technological means but transcends beyond them. A recently published study has described the impact of socioeconomic level as a determinant in chronic control and complications of T1DM, even in users of CGM systems in the context of a universal health system.[30]

The economic situation can have an impact in the health outcomes of people living with diabetes.[31] In our study, children from families with higher income levels had better glycemic control and higher adherence, which is consistent with previously published data. Additionally, the socioeco-

nomic situation can also affect the individuals' perceived quality of health. However, a recent review[32] concludes that the impact of inequality on the general health perception of adolescents remains unclear. This study related having lower family income with worse perceived DQoL in patients and their parents whose family income was <10,000 €/year.

The results of our study are representative of a population with different socioeconomic realities, as the hospital belongs to the public health system and serves a diverse population from a broad health area. However, it has some limitations. The sample size was estimated for the adaptation and validation of the DMQ-Sp scale, but not for this analysis. Although it is a large sample of more than 300 patients, it may not have sufficient statistical power to confirm some of the observed associations. Conversely, one of the strengths of our study is that we were able to adjust HbA1c values and the DMQ-Sp questionnaire score based on demographic data, family structure, and the parent who primarily supervises diabetes care.

We have reported on the impact family conflict and the adolescents' executive function have on the level of control of the pediatric population living diabetes.[17] These aspects were not considered in our study and could bias the obtained results. All patients willing to participate who could understand Spanish were included. However, we did not analyze if there were any differences based on whether participants were of immigrant origin or not. The participants' type of social relationships was not analyzed either.

The size of the group of patients living in a nuclear family structure was much larger than the other groups of patients with different family structures. This aspect could explain why no differences were found in adherence to diabetes self-management or DQoL between patients living in a nuclear family structure and those living in a family with separated parents. However, a difference in DMQ-Sp score was indeed found in the linear regression model. Another limitation was the small size of the group of patients whose mothers reported a low education level and the group whose fathers were primarily responsible for supervising diabetes care. Therefore, the comparative analysis of these aspects might be less representative.

We can conclude that in the studied cohort, an association was found between lower HbA1c levels and greater adherence to diabetes self-management when participants lived in a nuclear family, both parents were responsible for primary diabetes care supervision, and purchasing power was higher. The parents' DQoL benefited when they shared primary diabetes care supervision and had a higher education level. Additionally, better glycemic control and better adherence to diabetes self-management were related to better DQoL for both patients and their parents. More studies are needed to delve into the impact socioeconomic factors have on all aspects related to diabetes care and control. Also, in the current context in which technological devices for the pediatric population with T1DM are funded, new studies are needed to assess the impact socioeconomic factors, therapeutic adherence, and quality of life have on more informative glucose metrics than HbA1c, such as time in range, time below range, or glycemic variability. Identifying these factors that impact T1DM self-care would help us better design educational strategies and follow-up for children and adolescents with T1DM living in less favorable socioeconomic environments.

Funding

The primary study (validation of the DMQ-Sp scale) in which the data analyzed in this work were collected was funded by the Spanish Diabetes Society (SED) with the Guido Rufino 2017 grant. The primary study was also funded by the Intensification of Research Activity of Nursing Professionals from the Sant Joan de Déu Research Institute in Barcelona, Catalonia, Spain.

Conflicts of interest

None declared.

Acknowledgements

The authors wish to thank all patients and their families for their voluntary and selfless participation in this study. We also wish to thank María Teresa Rouco Gómez, Irune Goicoechea Manterola, and Marina Llobet Garcés for their contribution to data collection, as well as Sol Balcells Mejía and Daniel Cuadras Palleja for their contribution to the statistical analysis. Last but not least, we wish to thank Mapy Research for giving us permission to use the PedsQL questionnaire.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.endien.2024.04.003.

References

1. De Bock M, Codner E, Craig ME, Huynh T, David, Maahs M, et al. ISPAD Clinical Practice Consensus Guidelines 2022: glycemic targets and glucose monitoring for children, adolescents, and young people with diabetes. Pediatr Diabetes. 2022;23:1270–6, http://dx.doi.org/10.1111/pedi.13455.
2. Elsayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. 14. Children and adolescents: standards of care in diabetes–2023. Diabetes Care. 2023;46:S230–53, http://dx.doi.org/10.2337/dc23-s014.
3. Battelino T, Alexander CM, Amiel SA, Arreaza-Rubin G, Beck RW, Bergenstal RM, et al. Continuous glucose monitoring and metrics for clinical trials: an international consensus statement. Lancet Diabetes Endocrinol. 2023;11:42–57, http://dx.doi.org/10.1016/s2213-8587(22)00319-9.

4. Association of Diabetes Care & Education Specialist, Kolb Leslie. An effective model of diabetes care and education: the ADCES7 self-care behaviors™. Sci Diabetes Self Manag Care. 2021;47:30–53, http://dx.doi.org/10.1177/0145721720978154.
5. Shrivastava SRBL, Shrivastava PS, Ramasamy J. Role of self-care in management of diabetes mellitus. J Diabetes Metab Disord. 2013;12:14, http://dx.doi.org/10.1186/2251-6581-12-14.
6. Marks KP, Birkebæk NH, Pouwer F, Ibfelt EH, Thastum M, Jensen MB. Adherence in Diabetes Questionnaire (ADQ) score as predictor of 11-year HbA1c trajectories in children and adolescents with type 1 diabetes: a population-based longitudinal study. Diabetes Res Clin Pract. 2023;197:110558, http://dx.doi.org/10.1016/j.diabres.2023.110558.
7. Martin-Delgado J, Guilabert M, Mira-Solves J. Patient-reported experience and outcome measures in people living with diabetes: a scoping review of instruments. Patient. 2021;14:759–73, http://dx.doi.org/10.1007/s40271-021-00526-y.
8. Lizama Fuentes F, Rojas SO, Liberona FM, Cammell JF, López-Alegría F. [Impact on the quality of life of adolescents with diabetes mellitus type 1]. Rev Chil Pediatr. 2020;91:968–81, http://dx.doi.org/10.32641/rchped.vi91i6.2457.
9. Golay A, Lagger G, Chambouleyron M, Carrard I, Lasserre-Moutet A. Therapeutic education of diabetic patients. Diabetes Metab Res Rev. 2008;24:192–6, http://dx.doi.org/10.1002/dmrr.798.
10. World Health Organization. Action on the social determinants of health : learning from previous experiences, Vol. 50; 2010 [Accessed 15 December 2023]. Available from: https://www.who.int/publications/i/item/9789241500876
11. Hill-Briggs F, Adler NE, Berkowitz SA, Chin MH, Gary-Webb TL, Navas-Acien A, et al. Social determinants of health and diabetes: a scientific review. Diabetes Care. 2020;44:258–79, http://dx.doi.org/10.2337/dci20-0053.
12. Snyder LL, Stafford JM, Dabelea D, Divers J, Imperatore G, Law J, et al. Socio-economic, demographic, and clinical correlates of poor glycaemic control within insulin regimens among children with Type 1 diabetes: the SEARCH for Diabetes in Youth Study. Diabet Med. 2019;36:1028–36, http://dx.doi.org/10.1111/dme.13983.
13. Queen TL, Baucom KJW, Baker AC, Mello D, Berg CA, Wiebe DJ. Neighborhood disorder and glycemic control in late adolescents with Type 1 diabetes. Soc Sci Med. 2017;183:126–9, http://dx.doi.org/10.1016/j.socscimed.2017.04.052.
14. Sutherland MW, Ma X, Reboussin BA, Mendoza JA, Bell BA, Kahkoska AR, et al. Socioeconomic position is associated with glycemic control in youth and young adults with type 1 diabetes. Pediatr Diabetes. 2020;21:1412–20, http://dx.doi.org/10.1111/pedi.13112.
15. Gesuita R, Skrami E, Bonfanti R, Cipriano P, Ferrito L, Frongia P, et al. The role of socio-economic and clinical factors on HbA1c in children and adolescents with type 1 diabetes: an Italian multicentre survey. Pediatr Diabetes. 2017;18:241–8, http://dx.doi.org/10.1111/pedi.12378.
16. Nielsen NF, Gaulke A, Eriksen TM, Svensson J, Skipper N. Socioeconomic inequality in metabolic control among children with type 1 diabetes: a nationwide longitudinal study of 4,079 Danish children. Diabetes Care. 2019;42:1398–405, http://dx.doi.org/10.2337/dc19-0184.
17. Almeida AC, Leandro ME, Pereira MG. Adherence and glycemic control in adolescents with type 1 diabetes: the moderating role of age, gender, and family support. J Clin Psychol Med Settings. 2020;27:247–55, http://dx.doi.org/10.1007/s10880-019-09662-y.
18. Delagrange M, Dalla-Vale F, Salet R, Asensio-Weiss V, Moulin P, Cabaret B, et al. Impact of deprivation on glycaemic control in youth with type 1 diabetes in the southwestern region of France. Pediatr Diabetes. 2021;22:796–806, http://dx.doi.org/10.1111/pedi.13156.
19. De Dios C, Avedillo C, Palao A, Ortiz A, Agud JL. Factores familiares y sociales asociados al bienestar emocional en adolescentes diabéticos. Eur J Psychiatry. 2003;17:171–82.
20. Yoldi Vergara C, Conget Donlo I, Cardona-Hernandez R, Goicoechea Manterola I, Rouco Gómez MT, Llobet Garcés M, et al. Psychometric analysis of the cross-cultural Spanish version of the diabetes management questionnaire. J Pediatr Nurs. 2023;72:146–52, http://dx.doi.org/10.1016/j.pedn.2022.11.015.
21. Varni JW, Delamater AM, Hood KK, Raymond JK, Chang NT, Driscoll KA, et al. PedsQL 3.2 Diabetes module for children, adolescents, and young adults: reliability and validity in type 1 diabetes. Diabetes Care. 2018;41:2064–71, http://dx.doi.org/10.2337/dc17-2707.
22. Anderson BJ, Laffel LM, Domenger C, Danne T, Phillip M, Mazza C, et al. Factors associated with diabetes-specific health-related quality of life in youth with type 1 diabetes: The Global TEENs Study. Diabetes Care. 2017;40:1002–9, http://dx.doi.org/10.2337/dc16-1990.
23. Murillo M, Bel J, Pérez J, Corripio R, Carreras G, Herrero X, et al. Health-related quality of life (HRQOL) and its associated factors in children with Type 1 Diabetes Mellitus (T1DM). BMC Pediatr. 2017;17:16, http://dx.doi.org/10.1186/s12887-017-0788-x.
24. Álvarez Casaño M, Alonso Montejo M del M, Leiva Gea I, Jiménez Hinojosa JM, Santos Mata MÁ, Macías F, et al. Estudio de calidad de vida y adherencia al tratamiento en pacientes de 2 a 16 años con diabetes mellitus tipo 1 en Andalucía. An Pediatría. 2021;94:75–81.
25. Lacámara-Ormaechea N, Balseiro-Campoamor M, Ruiz-Serrano A, Royuela A, Martínez-Badas I. Relación entre calidad de vida y control metabólico, tipos de tratamiento con insulina y monitorización de glucemia en diabetes mellitus tipo 1. Rev Esp Endocrinol Pediátr. 2019;10:60–8, http://dx.doi.org/10.3266/RevEspEndocrinolPediatr.pre2019.Dec.511.
26. Thompson SJ, Auslander WF, White NH. Comparison of single-mother and two-parent families on metabolic control of children with diabetes. Diabetes Care. 2001;24:234–8, http://dx.doi.org/10.2337/diacare.24.2.234.
27. Tahirovic H, Toromanovic A. Glycemic control in diabetic children: role of mother's knowledge and socioeconomic status. Eur J Pediatr. 2010;169:961–4, http://dx.doi.org/10.1007/s00431-010-1156-0.
28. Prikken S, Raymaekers K, Oris L, Rassart J, Weets I, Moons P, et al. A triadic perspective on control perceptions in youth with type 1 diabetes and their parents: associations with treatment adherence and glycemic control. Diabetes Res Clin Pract. 2019;150:264–73, http://dx.doi.org/10.1016/j.diabres.2019.03.025.
29. Dover AR, Strachan MWJ, McKnight JA, Stimson RH, Mackenzie SD, Lyall MJ, et al. Socioeconomic deprivation, technology use, C-peptide, smoking and other predictors of glycaemic control in adults with type 1 diabetes. Diabet Med. 2021;38:e14445, http://dx.doi.org/10.1111/dme.14445.
30. Sebastian-Valles F, Martínez-Alfonso J, Alfonso Arranz Martin J, Jiménez-Díaz J, Hernando Alday I, Navas-Moreno V, et al. Impact of socioeconomic status on chronic control and complications of type 1 diabetes mellitus in users of glucose flash systems: a follow-up study. BMC Med. 2024;22:37, http://dx.doi.org/10.1186/s12916-024-03254-w.

31. Rechenberg K, Whittemore R, Grey M, Jaser S. Contribution of income to self-management and health outcomes in pediatric type 1 diabetes. Pediatr Diabetes. 2016;17:120, http://dx.doi.org/10.1111/pedi.12240.
32. Macintyre AK, Torrens C, Campbell P, Maxwell M, Pollock A, Biggs H, et al. Socioeconomic inequalities and the equity impact of population-level interventions for adolescent health: an overview of systematic reviews. Public Health. 2020;180:154–62, http://dx.doi.org/10.1016/j.puhe.2019.11.008.