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Health Literacy, Mental Health, and Clinical Factors as Predictors of Medication Adherence in Iranian Adolescents with Type 1 Diabetes: A Cross-Sectional Study

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Background and Objective: Type 1 diabetes (T1D) remains one of the most important global public health burdens, particularly for adolescents. The successful management of T1D is dependent on several factors, one of which is adherence to prescribed medications (in addition to health literacy (HL) and mental health), areas that are significantly underexplored in Iranian adolescents.

Material and Methods: This cross-sectional study was conducted from December 2023 to May 2024 in Tehran, Iran. Using convenience sampling, 379 literate adolescents aged 10–18 years with type 1 diabetes (without psychiatric disorders or related medications) were recruited through diabetes associations, pediatric endocrinologists, diabetologists, social media groups, online channels, physician referrals, and diabetes organizations. Data were collected via a web-based questionnaire using validated Persian versions of the following instruments: the 8-item Morisky Medication Adherence Scale (MMAS-8) for medication adherence, the Health Literacy Measure for Adolescents (HELMA) for health literacy, and the 12-item General Health Questionnaire (GHQ-12) for mental health.

Results: Adolescents with comorbidities showed higher medication adherence. Higher health literacy was significantly associated with better adherence (B = 0.012, OR = 1.012, P = 0.001). Use of insulin pens (P = 0.001) and experiencing medication side effects (P = 0.014) were also linked to improved adherence. GHQ-12 scores indicated that better mental health (P = 0.012), presence of positive mental health symptoms (P = 0.001), and fewer symptoms of mental disorders (P = 0.002) correlated with higher adherence, although mental health variables did not remain significant in stepwise logistic regression. Demographic factors (age, sex, parental education, income), diabetes duration, and insulin injection frequency showed no association with nonadherence (all P > 0.05).

Conclusion: In Iranian adolescents with T1D, higher health literacy and certain clinical factors (comorbidities and insulin pen use) were significantly associated with better medication adherence. These findings highlight the need for targeted interventions, including educational programs to enhance health literacy, routine mental health screening and support, and improved

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access to user-friendly insulin delivery devices (e.g., pens), which could be integrated into clinical practice and health policy in Iran.

Keywords: Type 1 Diabetes, Medication Adherence, Health Literacy, Mental Health, Adolescents, Iran

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Introduction

Diabetes ranks among the most serious global public health challenges, placing a heavy medical burden on the health system and restraining socioeconomic development (1). The WHO report in 2019 also characterizes diabetes as one of the ten leading causes of death worldwide (2). There are an estimated 8.4 million individuals with T1D globally, including 1.5 million children and youth (ages 0–20) (18% of all living with T1D) 5 who have had T1D for 15 years or longer (3). Due to a report by the International Diabetes Federation (IDF), published in 2021, 8.2 per 1000 Iranians under the age of 19 years have T1D (4). The rising pattern of T1D among adolescents and young adults has become a major global healthcare challenge because of the chronicity of the disease

and long-term complications, including renal failure, cardiovascular issues, and neuropathy, which require effective management to boost well-being and the quality of life and decrease mortality (5). The increasing rates of T1D in children and young adults underscore the importance of minimizing obstacles to quality care in this age group, particularly in low-resource settings.

Medication adherence, which refers to the degree to which a patient follows agreed-upon treatment recommendations, is a crucial factor influencing treatment response and patient outcomes. Adherence is a complex, multifactorial phenomenon that varies with the disease and therapy, as well as with physician- and patient-related factors such as the quality of the interaction, the complexity of the therapy, and patient motivation. Children and adolescents with T1D frequently do not take their insulin as prescribed; 48% of them do not take their medication as prescribed because of poor caregiver supervision and a lack of knowledge about diabetes (6). Nonadherence, common in chronic conditions, affects individuals by worsening complications, increasing side effects, and reducing quality of life. It also burdens families and society through frequent hospitalizations, prolonged stays, and lost productivity (7, 8). Such consequences underscore the importance of targeted interventions to increase adherence and minimize their far-reaching effects, which include decreasing medical expenditures and improving patients' well-being (9).

Depression, anxiety, and psychological stress can make children and adolescents with T1D struggle with functioning and their quality of life (10). This is especially true for adolescents with T1D, who have reported prevalence rates of anxiety and depression in the range of 20%, which negatively affects their endurance in commitment and their ability to maintain self-care and other complex aspects of disease management. When anxiety is prevalent, adolescents with T1D often struggle with disease management and glycemic control, resulting in diminished self-care practices, including insulin injection and blood glucose testing (11, 12). Health literacy (HL) is the ability to acquire, process, and comprehend health data and services for making appropriate decisions. Limited HL is related to negative self-management and greater psychological distress in adolescents with nonadherence (13). Poor HL limits the capacity to seek, comprehend, analyze, and develop health-related information, leading to poor decision-making, sometimes resulting in misunderstandings about care protocols and poor disease control(14). It also decreases the ability and skills regarding following healthy behaviors, which may lead to poor mental health, as adolescents are unable to address the requirements of the disease (15). Moreover, adolescents with lower health literacy report more psychological distress, further complicating and compromising their ability to adhere to demanding treatments (16). Higher health literacy in adolescents with T2D has been shown to promote better self-care (17) and benefits in increasing

awareness and understanding of T1D, especially for insulin therapy and dietary management (18).

In addition to health literacy and mental health, clinical factors such as comorbid conditions, medication side effects (19), and the method of insulin administration (pen vs. vial) may also influence adherence (20), particularly within the Iranian context, where access to more convenient delivery devices can be limited. A clear rationale for examining the role of insurance and financial factors in medication adherence is warranted. Evidence from a recent systematic review indicates that “individuals’ insurance status” is one of the socioeconomic factors most frequently associated with antidiabetic medication adherence (21). Similarly, findings from a cross-sectional study in Iran demonstrate that income is a significant predictor of treatment adherence, with higher income levels associated with markedly better adherence (22) . Moreover, U.S. data show that “lack of insurance, low income, and financial hardship from medical bills” are independently associated with cost-related medication nonadherence among adults with diabetes (23). Together, these studies highlight the importance of considering insurance coverage and financial status when investigating factors influencing adherence to diabetes medications, providing a strong justification for their inclusion in the present study on Iranian adolescents with type 1 diabetes.

Growing evidence shows that medication adherence in adolescents—particularly those managing chronic conditions such as diabetes—is strongly shaped by mental health and health-literacy–related factors, as studies highlight the role of adolescents’ subjective treatment attitudes in determining adherence (24), widespread deficits in mental health literacy and high stigma that can hinder help-seeking in low- and middle-income settings (25), and the positive impact of school-based mental health literacy interventions (26). Research in diabetes populations further demonstrates that health literacy plays a meaningful role in diabetes treatment adherence (27), medication self-efficacy contributes to both adherence and glycemic outcomes (28), and cognitive challenges such as learning disabilities can impair adolescents’ ability to follow diabetes medication regimens, independent of their health literacy level (29).

Despite global evidence linking health literacy, mental health, and medication adherence in adolescents with T1D, studies in Iran are scarce. Few have examined these factors together in this population, particularly in resource-limited settings like Tehran. This gap limits the development of culturally tailored interventions. The present study addresses this important gap by investigating the associations between health literacy, mental health, and medication adherence in Iranian adolescents with T1D. It provides preliminary evidence to guide targeted educational, psychological, and clinical strategies in Iran.

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Materials and Methods

Study Design and Participants

This cross-sectional study sought to examine medication adherence, health literacy, and mental health among Iranian adolescents with T1D. Participants were literate adolescents aged 10–18 years with type 1 diabetes (T1D), free from psychiatric disorders and not receiving psychiatric medication. The age range was applied as an inclusion criterion during recruitment to align with the adolescent developmental stage and study objectives focused on this age group. Convenience sampling was employed. Recruitment occurred through multiple channels: social media platforms (online channels and groups for T1D families), physician referrals, and diabetes scientific organizations.

A web-based questionnaire, including both numeric and descriptive questions, was employed to gather data via social media platforms (online channels and groups), online sources, physician referrals, and diabetes scientific organizations. Each participant completed the questionnaire once collected between December 2023 and May 2024. The sample size of 379 was calculated using Cochran's formula for cross-sectional studies estimating proportions in an infinite population: $n = (Z^2 \times p \times (1-p)) / d^2$, where Z = 1.96 (for 95% confidence level), p = 0.50 (assumed maximum variability/prevalence for conservative estimate, as no prior adherence rate was available for Iranian T1D adolescents), and d = 0.05 (margin of error 5%). This yielded a minimum sample of approximately 385, adjusted slightly downward after accounting for feasibility.

Study Tools

The participants completed a four-part questionnaire. The first section pertained to sociodemographic (age, sex, education, parents' employment, family income, insurance status) and disease-related data (time since diagnosis of DM, brand and name of insulin, frequency of insulin shots, complications associated with treatment activities (such as Hypoglycemia), and comorbid diseases).

The second stage employed the validated 12-item General Health Questionnaire (GHQ-12), a popular self-assessment tool designed to screen for nonpsychotic psychological morbidity in community populations. It evaluates recent symptoms or behaviors on a 4-point Likert scale and provides a total score between 0 and 12. A higher value indicates greater severity of mental health symptoms, and a score of ≥3 was used to detect common mental disorders. In addition, the Persian validated version of this tool was used in this study (30, 31).

The third section used the Persian version of the 8-item Morisky Medication Adherence Scale (MMAS-8), a validated self-reported survey tool for evaluating medication adherence in

individuals with chronic conditions, such as diabetes. The Persian version employed in this study is supported by published psychometric evaluations conducted among Iranian diabetic adults, demonstrating acceptable reliability and validity, including Cronbach's alpha values of 0.75–0.83 and intraclass correlation coefficients of 0.87–0.88 (32, 33). The MMAS-8 consists of seven yes–no items and one 5-point Likert item assessing participants' medication-taking behavior. The scoring system ranges from 0 to 8; a score of 8 indicates high adherence, scores of 6–7 indicate moderate adherence, and scores <6 indicate low adherence(34).

The last section used the Health Literacy Measure for Adolescents (HELMA) includes 44-item port of entry is scoped in eight health literacy domains: access (5 items), reading (5 items), comprehension (10 items), evaluation (5 items), use (4 items), communication (8 items), self-efficacy (4 items), and computation (3 items) (35). Respondents assessed items on a 5-point Likert scale (never to always = 5); three items were reverse-scored. Total scores range from 0-100: inadequate (0-50), less adequate (50.1--66), desirable (66.1--84), and excellent (84.1--100). The HELMA has acceptable reliability (Cronbach's alpha >=.70) and validity (face validity, content validity, and construct validity). Although HELMA was originally validated for adolescents aged 15–18 years, its content reflects general health-literacy competencies relevant across early to late adolescence; therefore, with researcher-assisted administration for younger participants, its use in the 10–18 age range is methodologically justified.

Data collection and analysis

The analysis was performed with SPSS 26. Continuous variables (e.g., age, duration of diabetes, frequency of daily insulin intake) are presented as the means ± standard deviations and ranges. Categorical data (for example, sex, parents' education, employment status, insurance coverage, and drug side effects) are presented as numbers (%). Differences between adherents were assessed with the chi-square test and/or Fisher's test for categorical variables (such as demographic characteristics, insurance status, comorbidities, drug side effects, and type of route of drug administration). Univariate comparisons between quantitative variables (i.e., duration of diabetes, number of insulin injections, health literacy, mental health scores) were done using one-way ANOVA and Tukey's post hoc test for medication adherence. The relationship between independent variables (i.e., health literacy, mental health, and their components) and medication adherence was examined using the cumulative logistic regression method, expressed as odds ratios (ORs) with 95% confidence intervals (CIs). The normality of the quantitative variables was tested with the Shapiro–Wilk test and skewness/kurtosis ratios ($P > 0.05$). Levene's test was used to test variance homogeneity ($P > 0.05$). A value of 0.05 was considered statistically significant.

Ethical considerations

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The study was conducted under the ethical code IR.IAU.PS.REC.1402.268. For participants under 15 years of age, written informed consent was obtained from their parents or legal guardians. Additionally, all adolescents, including those under 15, provided written assent to confirm their voluntary participation and understanding of the study procedures. Data confidentiality was strictly maintained throughout the study.

Results

Demographic and descriptive data

This study included 379 adolescents with T1D (57% female, 43% male), aged 10–18 years (M = 14.25, SD = 2.84), with 54.4% aged 10–14 and 45.6% aged 15–19, alongside their parents. Patterns of medication adherence across varying levels of health literacy, mental health status, and demographic characteristics are summarized below, with key associations detailed in Table 1. **Table 1** shows the relationships between the demographic characteristics of the adolescents and their parents with drug compliance.

Table 1. Relationships between Medication Adherence and Demographic Characteristics (n=379)

Variable	level	Medication adherence			Statistic	P value
		Low (n=20)	Moderate (n=169)	High (n=190)		
		n (%)	n (%)	n (%)		
Age group (years)	10-14	11 (3.5)	98 (47.6)	97 (47.1)	1.738^{ns} (A)	0.419
	15-18	9 (5.2)	71 (41.0)	93 (53.8)		
Gender	Female	11 (5.1)	90 (41.7)	115 (53.2)	1.964^{ns} (A)	0.375
	Male	9 (5.5)	79 (48.5)	75 (46.0)		
Father's education level	Primary	9 (6.5)	64 (46.4)	65 (47.1)	10.068^{ns} (B)	0.220
	Diploma	7 (5.3)	70 (52.6)	56 (42.1)		
	Bachelor's degree	1 (1.9)	24 (46.2)	27 (51.9)		
	Master's degree	2 (9.1)	10 (45.5)	10 (45.5)		
	PhD and above	1 (14.3)	1 (14.3)	5 (71.4)		
Father's job	Employee	6 (6.0)	47 (47.0)	47 (47.0)	9.228^{ns} (B)	0.450
	Business	9 (4.7)	85 (44.3)	98 (51.0)		
	Retired	1 (3.0)	14 (42.4)	18 (54.5)		
	Worker	2 (6.3)	14 (43.8)	16 (50.0)		
	Unemployed	2 (25.0)	5 (62.5)	1 (12.5)		
	Deceased	0 (0.0)	4 (40.0)	6 (60.0)		
Mother's education level	Primary	6 (7.3)	31 (37.8)	45 (54.9)	6.698^{ns} (B)	0.535
	Diploma	10 (5.4)	80 (43.2)	95 (51.4)		
	Bachelor's degree	3 (3.7)	46 (56.8)	32 (39.5)		
	Master's degree	0 (0.0)	10 (50.0)	10 (50.0)		
	PhD and above	1 (20.0)	2 (40.0)	2 (40.0)		
Mother's job	Housewife	18 (5.7)	138 (43.7)	158 (50.0)	2.589^{ns} (B)	0.620
	Employee	0 (0.0)	14 (43.8)	18 (56.3)		

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	Business	2 (6.1)	17 (51.5)	14 (42.4)		
Monthly family income (Million Tomans)	Less than 5	2 (5.9)	14 (41.2)	18 (52.9)	5.724[ns] (B)	0.676
	5-10	7 (5.4)	54 (41.5)	69 (53.1)		
	10-15	5 (5.6)	44 (49.4)	40 (44.9)		
	15-20	3 (4.2)	29 (40.8)	39 (54.9)		
	More than 20	3 (6.0)	28 (56.0)	19 (38.0)		

(A) Chi-square statistic, (B) Fisher's exact test, ns: nonsignificant

Chi-square and Fisher's exact tests showed no significant associations between medication adherence and demographic factors (all P>0.05). For example: age group (χ^2=1.738, df=2, P= .419), gender (χ^2=1.964, df=1, P=0.375), father's education level (χ^2=10.068, df=8, P=0.220), and family income (χ^2=5.724, df=6, P=0.676). Similar non-significant results were observed for parental employment and mother's education (all P>0.05; Table 1). Adherence levels (low, moderate, high) were similarly distributed across groups, with 5% of women and men exhibiting low adherence, 47% of women and 48% of men showing moderate adherence, and 53% of women and 46% of men demonstrating high adherence (P=0.375). No other demographic variables significantly influenced medication adherence. Descriptive analysis showed that adolescents with low, moderate, and high medication adherence did not differ significantly across adherence groups (14.15 ± 2.83, 14.14 ± 2.86, and 14.35 ± 2.83 years, respectively). One-way ANOVA indicated no statistically marked differences in mean age across adherence groups (P=0.783), suggesting age does not influence adherence. Many participants reported adverse drug events, but their impact on treatment compliance was not statistically analyzed, warranting further investigation in future studies.

Factors Related to Medication Adherence

We investigated the relationship between medication adherence in adolescents with T1D and factors including insurance status, comorbidities, medication side effects, and insulin dosage form, with results detailed in **Table 2**.

Table 2. Relationships between Medication Adherence and Insurance Status, Comorbidities, Side Effects, and Insulin Dosage Forms (n=379)

Variable	level	Medication adherence			Chi-Square	P value
		Low (n=20)	Moderate(n=169)	High (n=190)		
		N (%)	N (%)	N (%)		
Under insurance coverage	Yes	18 (4.8)	153 (40.4)	161 (42.5)	2.878[ns]	0.237
	No	2 (4.3)	16 (34.0)	29 (61.7)		
Covered by supplementary insurance	Yes	6 (4.8)	58 (46.8)	55 (44.4)	1.218[ns]	0.544
	No	14 (5.3)	111 (42.2)	135 (51.3)		
Having a disease other than diabetes	Yes	5 (7.7)	19 (29.2)	41 (63.1)	7.641*	0.022
	No	15 (4.8)	150 (47.8)	149 (47.5)		
Experiencing medication side effects	Yes	12 (3.8)	140 (44.4)	163 (51.7)	8.591*	0.014

	No	8 (12.5)	29 (45.3)	27 (42.2)		
The dosage form of insulin used	Pen	17 (4.6)	168 (45.2)	180 (48.4)	13.073**	0.001
	Vial	3 (21.4)	1 (7.1)	10 (71.4)		

Chi-square statistic: * significant at the 0.05 level, ** significant at the 0.01 level, ns nonsignificant

Insurance Status

Chi-square tests showed no significant association between medication adherence and insurance status (P=0.237 for general insurance; P=0.544 for complementary insurance). Adherence levels were similar across insured (4.8% low, 40.4% moderate, 42.5% high) and uninsured (4.3% low, 34.0% moderate, 61.7% high) adolescents, indicating insurance status does not significantly affect adherence.

Comorbidities

A significant association was found between comorbidities and medication adherence (P=0.022). Adolescents with comorbidities exhibited higher adherence (63.1%) compared to those without (47.5%). Women with comorbidities showed lower moderate adherence (29.2%) than those without (47.8%), suggesting comorbidities may enhance adherence due to increased health awareness.

Medication Side Effects

A significant relationship was observed between medication side effects and adherence (P=0.014). Adolescents experiencing side effects (e.g., hypoglycemia) had lower poor adherence (3.8%) compared to those without (12.5%), and higher adherence (51.7% vs. 42.2%), indicating side effects may be associated with higher adherence.

Insulin Dosage Form

Insulin dosage form was significantly associated with adherence (P=0.001). Use of an insulin pen was significantly associated with adherence (χ^2=13.073, df =2, P=0.001). High adherence was 48.4% in pen users (n=365) versus 71.4% in vial users (n=14), although the small vial group limits interpretation. Only 7.1% of vial users had moderate adherence compared to 45.2% of pen users, suggesting insulin pens may improve adherence due to ease of use.

Relationships among Medication Adherence, Diabetes Duration, and Insulin Injection Frequency

The following analysis evaluated the associations between medication adherence and diabetes duration, and daily insulin injection frequency among adolescents with T1D in Tehran in 2024, as presented in **Table 3**, to determine their impact on adherence levels.

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Table 3. The connections between medication adherence in adolescents with T1D and factors such as diabetes duration and daily insulin doses (n=379)

Variable	Medication adherence			F	P value
	Low (n = 20)	Moderate (n = 169)	High (n = 190)		
	Mean ± SD	Mean ± SD	Mean ± SD		
Duration of diabetes (years)	6.28 ± 4.31	5.12 ± 4.00	5.79 ± 3.65	1.802^{ns}	0.166
Number of times insulin is taken per day	3.30 ± 1.81	3.36 ± 1.90	3.92 ± 2.08	1.851^{ns}	0.152

F Statistics: ns nonsignificant

One-way ANOVA revealed no significant differences in diabetes duration across medication adherence groups (F=1.802, P=0.166). Mean diabetes duration was 6.28 ± 4.31 years for low adherence, 5.12 ± 4.00 years for moderate adherence, and 5.79 ± 3.65 years for high adherence, indicating that time since diabetes diagnosis does not significantly affect adherence.

Similarly, no significant link was found between insulin injection frequency and medication adherence (F=1.851, P=0.152). The average number of daily injections was 3.30 ± 1.81 for low adherence, 3.36 ± 1.90 for moderate adherence, and 3.92 ± 2.08 for high adherence, suggesting that injection frequency does not significantly influence adherence levels.

Relationships among Medication Adherence, Health Literacy, and Mental Health in Adolescents

Table 4 shows the relationships between medication adherence and mental health, health literacy, and its components among adolescents with T1D in Tehran.

Table 4. Relationships among Medication Adherence, Health Literacy, and Mental Health Components (n=379)

Variable	Medication adherence			F value	P value
	Low (n = 20)	Moderate (n = 169)	High (n = 190)		
	Mean ± SD	Mean ± SD	Mean ± SD		
Health literacy score	146.01 ± 31.69	157.02 ± 28.66	161.21 ± 30.49	6.905**	0.001
Mental health score	12.17 ± 4.31	12.14 ± 3.76	10.16 ± 3.47	5.219*	0.012
Positive mental health symptom score	7.28 ± 2.30	6.10 ± 2.60	6.00 ± 2.91	7.789**	0.001
Mental disorder symptom score	5.90 ± 4.21	4.84 ± 3.77	3.16 ± 2.27	6.118**	0.002

F statistic, * Significant at the 0.05 level, ** Significant at the 0.01 level

One-way ANOVA indicated a significant association between health literacy and medication adherence (F=6.905, P=0.001). Adolescents with high adherence exhibited a higher mean health literacy score (161.21 ± 30.49) compared to those with moderate (157.02 ± 28.66) or low adherence (146.01 ± 31.69), suggesting that greater health literacy is associated with improved adherence.

A significant relationship was observed between mental health scores and medication adherence (F=5.219, P=0.012). Adolescents with high adherence had a lower mean mental health score (10.16 ± 3.47), indicating fewer mental health symptoms, compared to those with moderate (12.14 ± 3.76) or low adherence (12.17 ± 4.31), highlighting that better mental health correlates with higher adherence.

A significant association was found between positive mental health symptoms and adherence (F=7.789, P=0.001). Adolescents with low adherence had a higher mean positive symptom score (7.28 ± 2.30) compared to those with moderate (6.10 ± 2.60) or high adherence (6.00 ± 2.91), indicating that fewer positive symptoms are linked to greater adherence.

A significant difference was observed between mental disorder symptom scores and adherence (F=6.118, P=0.002). Adolescents with high adherence showed a lower mean symptom score (3.16 ± 2.27) compared to those with moderate (4.84 ± 3.77) or low adherence (5.90 ± 4.21), suggesting that fewer mental disorder symptoms are associated with better adherence.

Differences in Health Literacy and Mental Health Scores across Medication Adherence Groups

Table 5 presents the results of Tukey's multiple comparisons test, which examines significant differences in mean health literacy, mental health, and mental health component scores across low, moderate, and high medication adherence groups among adolescents with T1D in Tehran in 2024.

Table 5. Comparison of Mean Health Literacy, Mental Health, and Component Scores across Medication Adherence Groups (n=379)

Variable	Low vs. Moderate	Low vs. High	Moderate vs. High
	Mean Diff. (P value)	Mean Diff. (P value)	Mean Diff. (P value)
Health literacy score	-11.013* (P = 0.038)	-15.205** (P = 0.001)	-4.193^{ns} (P = 0.568)
Mental health score	0.031^{ns} (P = 0.943)	2.015* (P = 0.039)	1.984* (P = 0.043)
Positive mental health symptom score	1.174** (P < 0.001)	1.283** (P < 0.001)	0.101^{ns} (P = 0.614)
Mental disorder symptom score	1.055* (P = 0.012)	2.737** (P = 0.004)	1.682^{ns} (P = 0.079)

Mean difference: * Significant at the 0.05 level, ** significant at the 0.01 level, ns nonsignificant

Tukey's test identified significant differences in health literacy scores, with the low-adherence group showing a lower mean score compared to the moderate (mean difference=-11.013, P=0.038) and high-adherence groups (mean difference = -15.205, P = 0.001), but no difference between moderate and high-adherence groups (P=0.568), indicating lower health literacy is associated with reduced adherence.

Significant differences were observed in mental health scores, with low (mean difference=2.015, P=0.039) and moderate-adherence groups (mean difference=1.984, P=0.043) exhibiting higher scores (more symptoms) compared to the high-adherence group, while no difference was found between low and moderate groups (P=0.943), suggesting better mental health correlates with higher adherence.

Low-adherence adolescents had significantly higher positive mental health symptom scores than moderate (mean difference=1.174, P<0.001) and high-adherence groups (mean difference=1.283, P<0.001), with no marked difference between moderate and high-adherence groups (P=0.614), indicating that higher positive symptom scores are linked to lower adherence.

Mental disorder symptom scores differed significantly, with the low-adherence group showing higher scores than the moderate (mean difference=1.055, P=0.012) and high-adherence groups (mean difference=2.737, P=0.004), and no noticeable difference between moderate and high-adherence groups (P=0.079), suggesting fewer mental disorder symptoms are associated with higher adherence.

Predictors of medication adherence: health literacy, mental health, and clinical factors

The next step is to carry out a cumulative logistic regression analysis in which the health literacy, mental health, and clinical factor intensities of the drug (low/moderate/high) in adolescents with T1D in Tehran in 2024 will help clarify some of the strengths and directions of health literacy, mental health, and clinical factors related to medication adherence **(Tables 6, 7 and 8)** among adolescents with T1D in Tehran in 2024 and identify the key predictor parameters of adherence.

Table 6. Omnibus tests of the model coefficient

		Chi-square	df	Sig.
Step 1	Step	14.009	2	0.001
	Block	14.009	2	0.001
	Model	14.009	2	0.001

Table 7. Classification table

Observed	Predicted		Percentage Correct
	Low Adherence	Moderate or High Adherence	
Step 1			

Low Adherence	109	82	57.1
Moderate or High Adherence	81	107	56.9
Overall Percentage			57

Table 8. Impact of Health Literacy, Mental Health, and Its Components on Medication Adherence

Variable	B	S.E.	Wald	df	EXP(B)	95% Confidence Interval	P value
Case 'a'							
Health literacy score	.013	0.004	12.994**	1	1.013	1.006 – 1.020	0.001
Mental health score	-.021	.026	0.644^{ns}	1	0.979	0.930 – 1.031	0.422
Constant	-1.698	0.613	7.663**	1	0.183	---	0.006
Case 'b'							
Health literacy score	0.009	0.004	5.241*	1	1.009	1.001 – 1.016	0.022
Positive mental health symptom score	0.109	0.049	4.881^{ns}	1	0.815	0.792 – 1.055	0.097
Mental disorder symptom score	-0.051	0.028	2.234^{ns}	1	0.951	0.899 – 1.005	0.072
Constant	-1.797	0.628	8.180**	1	0.166	---	0.004
Case 'c'							
Health literacy score	0.012	0.004	11.781**	1	1.012	1.005 – 1.019	0.001
Mental health score	-0.022	0.027	0.699^{ns}	1	0.978	0.928 – 1.030	0.403
Having a disease other than diabetes	0.618	0.287	4.649*	1	1.855	1.058 – 3.252	0.031*
Experiencing medication side effects	0.389	0.289	1.900^{ns}	1	1.489	0.845 – 2.622	0.168
Dosage form of insulin used (vial vs. pen)	0.882	0.621	2.016^{ns}	1	2.417	0.715 – 8.169	0.156
Constant	-4.060	1.069	14.439**	1	0.017	----	0.000

Wald statistics: * Significant at the 0.05 level, ** Significant at the 0.01 level, ns not significant

Model performance

The omnibus test of the model coefficient (chi-square = 14.009, P = 0.001) found good performance of cumulative logistic regression model in predicting medication adherence using health literacy, mental health, and clinical factors. The classification table demonstrated the model classified 57% of respondents correctly, 57.1% of respondents with low adherence and 56.9% respondents with moderate or high adherence.

Case 'a': Health literacy and mental health scores

Results from the first model based purely on health literacy and mental health scores show that health literacy had a significant effect using logistic regression (B = 0.013, EXP(B) = 1.013, P = 0.001). That is, for every one-point increase in health literacy score, there is a 1.3 percent increase in being in the high medication adherence category. On the other hand, mental health score had no statistically significant effect (P = 0.422), revealing that health literacy is a better predictor of medication adherence.

Case 'b': Health literacy and mental health components

When the second model was tested with both health literacy and mental health—a measure made up of positive mental health and symptom scores—health literacy was still an important determinant of adherence (B=0.009, EXP(B)=1.009, P=0.022), suggesting that an additional one-point increase in health literacy would add approximately 0.9% to the probability of high adherence. Neither the positive mental health symptom score (P=0.097) nor the symptom score of mental disorder demonstrated a significant relationship to adherence (P=0.072).

Case 'c': Comprehensive Model

The comprehensive model, which accounted for health literacy, mental health score, comorbidities, medication side effects, and insulin dosage form, also supported the findings that health literacy significantly predicted adherence (B=0.012, EXP(B)=1.012, P=0.001), with 1.2% increased odds of high adherence for every one-point score increase. Comorbid adolescents were significantly more likely to report higher adherence (B=0.618, EXP(B)=1.855, P=0.031), with 85.5% higher odds. There was no effect of mental health score (P = 0.403), medication side effects (P=0.168), or insulin delivery device (vial vs pen, P=0.156) on adherence.

Discussion

This cross-sectional study of 379 adolescents with type 1 diabetes in Tehran, Iran, found significant associations of medication adherence with health literacy, mental health, comorbidities, medication side effects, and insulin delivery method, but not with demographics, diabetes duration, or injection frequency (5, 36). In multivariate analyses, health literacy remained the strongest independent predictor, with higher scores linked to greater odds of high adherence, while comorbidities also independently predicted higher adherence; mental health,

side effects, and insulin pen use showed bivariate significance but attenuated after adjustment, highlighting health literacy's mediating potential (37, 38) . Overall adherence was notably favorable, with only 5.3% low adherence, contrasting typical reports of suboptimal adherence in youth with T1D and suggesting protective urban/family factors in this context (39).

These results highlight health literacy's central role in overriding other influences in this urban Iranian sample, as it likely mediates indirect effects from mental health and clinical factors, enabling adolescents to better navigate complex regimens despite developmental challenges (40). Health literacy emerged as the strongest predictor of medication adherence across all statistical models (41), with higher health literacy levels significantly enhancing adherence, underscoring the role of health knowledge in effective self-management behavior (42). This robust association suggests that health literacy equips adolescents to navigate complex regimens amid developmental transitions, often superseding psychosocial barriers in supportive contexts(43).

This aligns with prior research linking health literacy to better adherence in chronic conditions like diabetes, where understanding complex care regimens is critical, supporting the critical need for targeted educational strategies to enhance adherence and reduce complications in this population care (44, 45, 46). Recent scoping reviews confirm that in T1D adolescents, health literacy dimensions like numeracy and self-efficacy strongly support insulin regimen adherence, often overriding other clinical influences in urban settings (37). Targeted interventions improving health literacy have been shown to enhance engagement and reduce numeracy-related barriers in diabetes management (38). Integrating digital tools tailored to adolescents could further amplify this, as recent interventions have shown sustained improvements in self-efficacy and adherence (47).

The importance of mental health and its specific domains in drug adherence was further analyzed. The mental health state highly affected adherence, and it was shown that adolescents who reported fewer mental health symptoms (i.e., less positive and mental disorder symptoms, e.g., optimism, negative response, sensitivity, less depression, and less anxiety) had better adherence. Moderate adherers had improved mental health and health literacy and were less likely to report symptoms of mental disorder, which might impede usual diabetes self-care (42). Higher adherence was associated with lower mental health scores (indicating fewer symptoms), suggesting better mental health reduces psychological barriers to adherence.

However, the attenuation in multivariate models implies indirect pathways, where mental health influences adherence primarily through self-management behaviors or health literacy mediation

(48). Although adherence to diabetes self-care is important, it has not been consistently associated with mental health (49). For instance, 30% of children and adolescents with diabetes are symptomatic for depression and anxiety, which is related to low adherence and glycemic regulation (50). This vulnerability may be amplified during adolescence, but family-supported settings could buffer effects, aligning with recent psychosocial reviews emphasizing integrated care (51).

Higher positive mental health symptom scores were linked to lower adherence, indicating that emotional well-being may sometimes conflict with strict compliance needs. Non-adherent adolescents report negative peer and family influence, more frustration, anger, and low self-esteem (52). Low self-efficacy and negative social support are some of the psychosocial factors that contribute to non-adherence and poor mental status (49). These findings are in line with prior research, which demonstrates that emotional factors, such as depression and anxiety, are inhibitory barriers for achieving A1C control and adherence to diabetes care (36, 53). However, the mental health scores and their components were not significantly correlated in the multivariate regression models, and the association might be explained by health literacy or clinical conditions (54). This complex issue indicates the critical role of routine mental health screening and interventions to address mental health barriers to adherence (55).

Recent studies suggest mental health effects on adherence in T1D adolescents are often indirect, mediated by self-management behaviors or health literacy, aligning with the attenuation seen here in adjusted models (48, 51). Narrative reviews highlight adolescence-specific psychological challenges in T1D, including elevated anxiety/depression risks that exacerbate non-adherence during developmental transitions (51). These findings indicate that several clinical variables are statistically correlated with adherence. The greater adherence of adolescents with comorbidities could also be related to greater attention and awareness of health (among peers, families, and even the referring clinician) and an increased frequency of contact with medical professionals, as studies have described patients with multiple morbidities as prioritizing treatment adherence (46).

This independent prediction may reflect heightened monitoring and clinician involvement, driving engagement despite complexity, as seen in multimorbid youth, where added oversight counters treatment burden (56). This pattern may reflect heightened monitoring and family/clinician involvement in multimorbid cases, potentially driving better engagement despite added complexity (48). Side effects such as hypoglycemia and the need to contact healthcare providers (HCPs) are also associated with better adherence, probably because side effects and

the need to contact HCPs in cases of adverse reactions increase the perception of important treatment (45).

Insulin pens, rather than vials, are associated with better adherence, possibly because of their simplicity and convenience, which confirms previous observations regarding insulin delivery devices (44, 57). Despite significant bivariate associations, medication side effects and insulin dosage form (pen vs. vial) were not robust predictors of adherence in the regression models, suggesting that their influence may be mediated by other factors, such as health literacy. Such mediation underscores the need for convenience-focused interventions, though small vial subgroups here warrant caution in interpretations(43). Prospective studies in youth with T1D show insulin pens improve preference, ease, and adherence over vials due to reduced pain and convenience, though small subgroups like vial users here limit strong conclusions (58).

In this study, demographic factors including age, sex, parental education, occupation, and family income showed no correlation with medication adherence, contrasting with prior research that identified a notable association between socioeconomic status and adherence (59). This null finding may stem from equitable urban healthcare access and strong family support in Tehran, mitigating typical SES barriers observed elsewhere (60). This lack of association may be due to relatively good access to healthcare services and family support systems in urban Tehran, though further research in diverse Iranian settings is needed to confirm contextual influences (61).

No significant associations were observed between diabetes duration or daily insulin injections and medication adherence, contrasting with prior studies that linked longer duration or increased injection frequency to treatment fatigue or burnout (23, 62). The wider background and issues surrounding medication adherence are also considerable. While medication adherence among youth with T1D is often suboptimal, with common barriers including prescription access, cost, limited physician availability, injection fatigue, injection site reactions, and parental nonadherence (43, 63).

This study found a more encouraging pattern. Only 5.3% of participants exhibited low adherence, with the majority demonstrating moderate to high adherence. Notably, greater social support, particularly familial collaborations in disease management, was associated with improved compliance. These findings suggest that family-centered interventions aimed at strengthening social support may enhance adherence in this population (64, 65). In Middle Eastern contexts like Saudi Arabia, strong family support correlates with better glycemic control and adherence in T1D adolescents, potentially explaining the low non-adherence rate observed in urban Tehran (39).

This pattern likely benefits from protective cultural factors, where familial involvement buffers adolescence-specific challenges, as evidenced in regional qualitative studies (66, 67). These findings highlight the interconnected roles of health literacy, mental health, and select clinical factors (e.g., comorbidities and insulin delivery method) in medication adherence. Family-centered interventions that build on observed family support patterns, along with HL education and mental health screening, could help improve adherence in this population.

Educational activities for a better understanding of optimal diabetes control and support for mental health screening and management are needed to enhance adherence and decrease complications. While not directly measured in this study, broader barriers such as medication costs and access could influence adherence in resource-limited settings; future research and policy efforts should explore ways to improve affordability and availability of insulin devices alongside individual-level interventions like HL education and mental health support. Integrating digital health tools to boost health literacy and address mental health holds promise for T1D adolescent care, particularly in supporting family involvement (37). Such integrated approaches could address mediation pathways and cultural strengths in urban settings like Tehran (47).

Study Limitations and Strengths: This study has some limitations, notably its cross-sectional design and dependence on self-reported adherence data, which preclude causal inferences. The online survey methodology may have introduced selection bias by excluding individuals with limited internet access, potentially reducing the generalizability of the findings. Additionally, self-reported measures are susceptible to information bias, such as recall bias or social desirability, which could compromise the validity of self-reports. Some subgroups, such as insulin vial users or specific parental education/job levels, included very few participants, which may limit the statistical reliability of these comparisons. Future research should adopt longitudinal designs and objective adherence measures (e.g., electronic monitoring or clinical records) to enhance validity. Further exploration of psychological factors influencing adherence and cross-national comparisons would also provide deeper insights into the interplay between demographic, health-related variables, and adherence behaviors.

Conclusion

This study revealed that health literacy and comorbid conditions have a significant influence on medication adherence in adolescents with type 1 diabetes (T1D). While other factors—including mental health, insulin delivery methods, and medication side effects—also contribute, the limited impact of demographic and disease-specific variables suggests that tailored adherence interventions are essential for this high-risk group. Policymakers should consider implementing school- and community-based programs to enhance health literacy and support adherence

among adolescents with T1D. Additionally, integrating routine monitoring and counseling into clinical care can help identify adolescents at risk and provide targeted interventions.

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Consent for publication: Not applicable.

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References

1. Liu J, Ren ZH, Qiang H, Wu J, Shen M, Zhang L, et al. Trends in the incidence of diabetes mellitus: results from the Global Burden of Disease Study 2017 and implications for diabetes mellitus prevention. BMC Public Health. 2020;20(1):1415. https://doi.org/10.1186/s12889-020-09502-x PMid:32943028 PMCid:PMC7500018

2. TW. B. World Bank Country and Lending Groups (Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.; 2025.

3. Oboza P, Ogarek N, Olszanecka-Glinianowicz M, Kocelak P. Can type 1 diabetes be an unexpected complication of obesity? Front Endocrinol (Lausanne). 2023;14:1121303. https://doi.org/10.3389/fendo.2023.1121303 PMid:37065759 PMCid:PMC10102381

4. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119. https://doi.org/10.1016/j.diabres.2021.109119 PMid:34879977 PMCid:PMC11057359

5. Gong B, Yang W, Xing Y, Lai Y, Shan Z. Global, regional, and national burden of type 1 diabetes in adolescents and young adults. Pediatr Res. 2025;97(2):568-76. https://doi.org/10.1038/s41390-024-03107-5 PMid:38443523 PMCid:PMC12015108

6. Kyokunzire C, Matovu N, Mayega RW. Factors associated with adherence to diabetes care recommendations among children and adolescents with type 1 diabetes: a facility-based study in two urban diabetes clinics in Uganda. Diabetes Metab Syndr Obes. 2018;11:93-104. https://doi.org/10.2147/DMSO.S179015

7. Valaei Sharif N, Ghasemzadeh P, Ghasemzadeh S. A Scoping Review on Strategies that Enhance Medication Adherence in Children and Adolescents with Attention Deficit Hyperactivity Disorder and Associated Outcomes. Current Developmental Disorders Reports. 2024;11:113 - 24. https://doi.org/10.1007/s40474-024-00299-7

8. Coskun S, Bagcivan G. Associated factors with treatment adherence of patients diagnosed with chronic disease: Relationship with health literacy. Appl Nurs Res. 2021;57:151368. https://doi.org/10.1016/j.apnr.2020.151368 PMid:33092934

9. Religioni U, Barrios-Rodríguez R, Requena P, Borowska M, Ostrowski J. Enhancing Therapy Adherence: Impact on Clinical Outcomes, Healthcare Costs, and Patient Quality of Life. Medicina (Kaunas). 2025;61(1). https://doi.org/10.3390/medicina61010153 PMid:39859135 PMCid:PMC11766829

10. Tremolada M, Cusinato M, Bonichini S, Fabris A, Gabrielli C, Moretti C. Health-Related Quality of Life, Family Conflicts and Fear of Injecting: Perception Differences between Preadolescents and Adolescents with Type 1 Diabetes and Their Mothers. Behav Sci (Basel). 2021;11(7). https://doi.org/10.3390/bs11070098 PMid:34356715 PMCid:PMC8301019

11. ghasemzadeh s, naghsh z, Gholami Fesharaki M, shafiee e. The Effectiveness of Transdiagnostic Treatment Program on Improving the Quality of Life and Reducing Depression in Children with Type 1 Diabetes: An Experimental Study. The Neuroscience Journal of Shefaye Khatam. 2021;9(4):71-80. https://doi.org/10.52547/shefa.9.4.71

12. Bernstein CM, Stockwell MS, Gallagher MP, Rosenthal SL, Soren K. Mental health issues in adolescents and young adults with type 1 diabetes: prevalence and impact on glycemic control. Clin Pediatr (Phila). 2013;52(1):10-5. https://doi.org/10.1177/0009922812459950 PMid:22988007

13. Aygun O, Topcu M. The relationship between parental health literacy levels and anthropometric measurements of children in Turkey. BMC Pediatrics. 2023;23(1):559 https://doi.org/10.1186/s12887-023-04385-4PMid:37946149 PMCid:PMC10636928

14. Haeri-Mehrizi A, Mohammadi S, Rafifar S, Sadighi J, Kermani RM, Rostami R, et al. Health literacy and mental health: a national cross-sectional inquiry. Sci Rep. 2024;14(1):13639.https://doi.org/10.1038/s41598-024-64656-7PMid:38871848 PMCid:PMC11176292

15. Tehrani H, Vali M, Nejatian M, Moshki M, Charoghchian Khorasani E, Jafari A. The status of depression literacy and its relationship with quality of life among Iranian public population: a cross sectional study. BMC Psychiatry. 2022;22(1)

16. Pourhabibi N, Sadeghi R, Mohebbi B, Shakibazadeh E, Sanjari M, Tol A, et al. Factors affecting nonadherence to treatment among type 2 diabetic patients with limited health literacy: Perspectives of patients, their families, and healthcare providers. J Educ Health Promot. 2022;11:388. https://doi.org/10.4103/jehp.jehp_804_22 PMid:36618458 PMCid:PMC9818700

17. Lee EH, Lee YW, Chae D, Lee KW, Hong S, Kim SH, et al. Pathways Linking Health Literacy to Self-Management in People with Type 2 Diabetes. Healthcare (Basel). 2021;9(12). https://doi.org/10.3390/healthcare9121734 PMid:34946460 PMCid:PMC8701917

18. Lan YY, Kovinthapillai R, Kędzia A, Niechciał E. Age-based challenges to type 1 diabetes management in the pediatric population. Front Pediatr. 2024;12:1434276. https://doi.org/10.3389/fped.2024.1434276 PMid:39286453 PMCid:PMC11402681

19. Khandehroo M, Peyman N, Gholian-Aval M, Tehrani H. Self-efficacy intervention on health literacy and quality of life in menopausal women of suburban areas. Scientific Reports. 2025;15(1. https://doi.org/10.1038/s41598-025-09347-7 PMid:40610658 PMCid:PMC12229341

20. Ayyagari R, Wei W, Cheng D, Pan C, Signorovitch J, Wu EQ. Effect of Adherence and Insulin Delivery System on Clinical and Economic Outcomes among Patients with Type 2 Diabetes Initiating Insulin Treatment. Value in Health. 2015;18(2):198-205. https://doi.org/10.1016/j.jval.2014.12.016 PMid:25773555

21. Studer CM, Linder M, Pazzagli L. A global systematic overview of socioeconomic factors associated with antidiabetic medication adherence in individuals with type 2 diabetes. Journal of Health, Population and Nutrition. 2023;42(1):122. https://doi.org/10.1186/s41043-023-00459-2 PMid:37936205 PMCid:PMC10631092

22. Pourhabibi N, Mohebbi B, Sadeghi R, Shakibazadeh E, Sanjari M, Tol A, et al. Factors associated with treatment adherence to treatment among in patients with type 2 diabetes in Iran: A cross-sectional study. Frontiers in Public Health. 2022;Volume 10 - 2022. https://doi.org/10.3389/fpubh.2022.976888 PMid:36407991 PMCid:PMC9667890

23. Taha MB, Valero-Elizondo J, Yahya T, Caraballo C, Khera R, Patel KV, et al. Cost-Related Medication Nonadherence in Adults With Diabetes in the United States: The National Health Interview Survey 2013-2018. Diabetes Care. 2022;45(3):594-603. https://doi.org/10.2337/dc21-1757 PMid:35015860

24. Both C, Mechler K, Niemeyer L, Jennen-Steinmetz C, Hohmann S, Schumm L, et al. Medication Adherence in Adolescents with Psychiatric Disorders: Hogrefe AG; 2021. 295-306 p. https://doi.org/10.1024/1422-4917/a000813 PMid:34240621

25. Renwick L, Pedley R, Johnson I, Bell V, Lovell K, Bee P, et al. Mental health literacy in children and adolescents in low- and middle-income countries: a mixed studies systematic review and narrative synthesis. European Child & Adolescent Psychiatry. 2024;33(4):961-85. https://doi.org/10.1007/s00787-022-01997-6 PMid:35570227 PMCid:PMC11032284

26. Nobre J, Oliveira AP, Monteiro F, Sequeira C, Ferré-Grau C. Promotion of Mental Health Literacy in Adolescents: A Scoping Review. International Journal of Environmental Research and Public Health. 2021;18(18):9500. https://doi.org/10.3390/ijerph18189500 PMid:34574427 PMCid:PMC8470967

27. Ngoatle C, Hlahla LS, Mphasha MH, Mothiba TM, Themane MJ. Does Health Literacy Have an Impact on Adherence to Diabetes Mellitus Treatment? Endocrines. 2023;4(1):82-92. https://doi.org/10.3390/endocrines4010007

28. Huang Y-M, Shiyanbola OO, Smith PD. Association of health literacy and medication self-efficacy with medication adherence and diabetes control. Patient Preference and Adherence. 2018;12(null):793-802. https://doi.org/10.2147/PPA.S153312 PMid:29785094 PMCid:PMC5953319

29. Dharmapuri S, Best D, Kind T, Silber TJ, Simpson P, D'Angelo L. Health Literacy and Medication Adherence in Adolescents. The Journal of Pediatrics. 2015;166(2):378-82. https://doi.org/10.1016/j.jpeds.2014.10.002 PMid:25454933

30. Montazeri A, Harirchi AM, Shariati M, Garmaroudi G, Ebadi M, Fateh A. The 12-item General Health Questionnaire (GHQ-12): translation and validation study of the Iranian version. Health and Quality of Life Outcomes. 2003;1(1):66. https://doi.org/10.1186/1477-7525-1-66

31. Telo GH, Cureau FV, Lopes CS, Schaan BD. Common mental disorders in adolescents with and without type 1 diabetes: Reported occurrence from a countrywide survey. Diabetes Res Clin Pract. 2018;135:192-8. https://doi.org/10.1016/j.diabres.2017.10.027 PMid:29155124

32. Nakhaeizadeh M KA. Psychometric Properties of Persian Version of the 8-item Morisky Medication Adherence Scale in Type 2 Diabetes Patients. J Clin of Diagn Res. 2019;13(8):YC14-YC8. https://doi.org/10.7860/JCDR/2019/41408.13076

33. Laghousi D, Rezaie, F., Alizadeh, M., & Jafarabadi, M. A. The eight-item Morisky Medication Adherence Scale: validation of its Persian version in diabetic adults. Caspian journal of internal medicine. 2021;12(1):77-83.

34. Barati M T-KZ, Bandehelahi K, Yeh VM, Kripalani S. Validation of the Short Form of the Adherence to Refills and Medications Scale in Iranian Elders with Chronic Disease. J Clin of Diagn Res. 2018;12(11):FC05-FC8. https://doi.org/10.7860/JCDR/2018/37584.12305

35. Ghanbari S, Ramezankhani A, Montazeri A, Mehrabi Y. Health Literacy Measure for Adolescents (HELMA): Development and Psychometric Properties. PLoS One. 2016;11(2):e0149202. https://doi.org/10.1371/journal.pone.0149202 PMid:26881933 PMCid:PMC4755574

36. Alves Peres H, Leira Pereira LR, Zangiacomine Martinez E, Viana CM, de Freitas MCF. Elucidating factors associated with non-adherence among Type 1 diabetes patients in primary care setting in Southeastern Brazil. Prim Care Diabetes. 2020;14(1):85-92. https://doi.org/10.1016/j.pcd.2019.06.002 PMid:31262602

37. Milani I, Cipponeri E, Ripa P, Magon A, Terzoni S, Cilluffo S, et al. Health Literacy in People with Type 1 Diabetes: A Scoping Review. International Journal of Environmental Research and Public Health. 2025;22(6):869. https://doi.org/10.3390/ijerph22060869 PMid:40566297 PMCid:PMC12192628

38. Naef AN, Wilhelm C, Tezcan-Güntekin H, Amelung VE. Impact of digital health interventions for adolescents with type 1 diabetes mellitus on health literacy: a systematic review. BMC Endocrine Disorders. 2023;23(1):70. https://doi.org/10.1186/s12902-023-01321-6 PMid:37004000 PMCid:PMC10064727

39. AlHaidar AM, AlShehri NA, AlHussaini MA. Family Support and Its Association with Glycemic Control in Adolescents with Type 1 Diabetes Mellitus in Riyadh, Saudi Arabia. J Diabetes Res. 2020;2020:5151604. https://doi.org/10.1155/2020/5151604 PMid:32280715 PMCid:PMC7125464

40. Yeşildal M, Tetik A, Siyar A. The Mediating Role of Treatment Adherence in the Relationship Between Health Literacy and Health Maintenance Efficacy Among Adults with Type 1 Diabetes. Patient Preference and Adherence. 2026;20(null):586362. https://doi.org/10.2147/PPA.S586362 PMid:41773094 PMCid:PMC12949969

41. Ayed F, Malak MZ, Shehadeh A, Harazneh L. Self-Care behaviors and their association with self-efficacy and health literacy among adolescents with type 1 diabetes mellitus in palestine: a cross-sectional study. BMC Psychol. 2025;13(1):793. https://doi.org/10.1186/s40359-025-03136-7 PMid:40665435 PMCid:PMC12265322

42. Abbas Q, Latif S, Ayaz Habib H, Shahzad S, Sarwar U, Shahzadi M, et al. Cognitive behavior therapy for diabetes distress, depression, health anxiety, quality of life and treatment adherence among patients with type-II diabetes mellitus: a randomized control trial. BMC Psychiatry. 2023;23(1):86. https://doi.org/10.1186/s12888-023-04546-w

43. Dilek SO, Çömlek FÖ. Evaluating Treatment Adherence in Children and Adolescents with Type 1 Diabetes: The Impact of the Adherence Starts with Knowledge-12 Score on Metabolic Control. Children. 2025;12(4):463. https://doi.org/10.3390/children12040463 PMid:40310133 PMCid:PMC12025722

44. Kamrul-Hasan ABM, Hannan MA, Alam MS, Rahman MM, Asaduzzaman M, Mustari M, et al. Comparison of simplicity, convenience, safety, and cost-effectiveness between use of insulin pen devices and disposable plastic syringes by patients with type 2 diabetes mellitus: a cross-sectional study from Bangladesh. BMC Endocrine Disorders. 2023;23(1):37. https://doi.org/10.1186/s12902-023-01292-8 PMid:36782190 PMCid:PMC9926700

45. Boeder S, Matamoros D, Mansy C. Practical Guidance for Healthcare Providers on Collaborating with People with Type 2 Diabetes: Advancing Treatment and Initiating Injectable Therapy. Diabetes Ther. 2023;14(2):425-46. https://doi.org/10.1007/s13300-022-01330-z PMid:36520406 PMCid:PMC9943835

46. Bąk-Sosnowska M, Gruszczyńska M, Wyszomirska J, Daniel-Sielańczyk A. The Influence of Selected Psychological Factors on Medication Adherence in Patients with Chronic Diseases. Healthcare (Basel). 2022;10(3). https://doi.org/10.3390/healthcare10030426 PMid:35326906 PMCid:PMC8955226

47. Naef AN, Fischbock N, Tezcan-Güntekin H, Amelung VE. Adolescents with type 1 diabetes' perspectives on digital health interventions to enhance health literacy: a qualitative study. Front Public Health. 2024;12:1340196. https://doi.org/10.3389/fpubh.2024.1340196 PMid:38414892 PMCid:PMC10896973

48. Azar S, Maroun Abou Jaoude N, Kędzia A, Niechciał E. Barriers to Type 1 Diabetes Adherence in Adolescents. J Clin Med. 2024;13(19). https://doi.org/10.3390/jcm13195669 PMid:39407728 PMCid:PMC11477045

49. AlBurno H, Mercken L, de Vries H, Al Mohannadi D, Schneider F. Determinants of healthful eating and physical activity among adolescents and young adults with type 1 diabetes in Qatar: A qualitative study. PLoS One. 2022;17(7):e0270984. https://doi.org/10.1371/journal.pone.0270984 PMid:35793375 PMCid:PMC9258857

50. Huhn F, Lange K, Jördening M, Ernst G. Real-World Use of Continuous Glucose Monitoring Systems Among Adolescents and Young Adults With Type 1 Diabetes: Reduced Burden, but Little Interest in Data Analysis. J Diabetes Sci Technol. 2023;17(4):943-50. https://doi.org/10.1177/19322968221081216 PMid:35255729 PMCid:PMC10347979

51. Bombaci B, Torre A, Longo A, Pecoraro M, Papa M, Sorrenti L, et al. Psychological and Clinical Challenges in the Management of Type 1 Diabetes during Adolescence: A Narrative Review. Children (Basel). 2024;11(9). https://doi.org/10.3390/children11091085 PMid:39334618 PMCid:PMC11430186

52. Liu SY, Huang J, Dong QL, Li B, Zhao X, Xu R, et al. Diabetes distress, happiness, and its associated factors among type 2 diabetes mellitus patients with different therapies. Medicine (Baltimore). 2020;99(11):e18831. https://doi.org/10.1097/MD.0000000000018831 PMid:32176027 PMCid:PMC7440060

53. Mostafavi F, Alavijeh FZ, Salahshouri A, Mahaki B. The psychosocial barriers to medication adherence of patients with type 2 diabetes: a qualitative study. Biopsychosoc Med. 2021;15(1):1. https://doi.org/10.1186/s13030-020-00202-x PMid:33461565 PMCid:PMC7812642

54. Albright D, Wardell J, Harrison A, Mizokami-Stout K, Hirschfeld E, Garrity A, et al. Screening for diabetes distress and depression in routine clinical care for youth with type 1 diabetes. J Pediatr Psychol. 2024;49(5):356-64. https://doi.org/10.1093/jpepsy/jsae016 PMid:38647266 PMCid:PMC11098041

55. Gonzalez JS, Hood KK, Esbitt SA, Mukherji S, Kane NS, Jacobson A. Psychiatric and Psychosocial Issues Among Individuals Living With Diabetes. In: Cowie CC, Casagrande SS, Menke A, Cissell MA, Eberhardt MS, Meigs JB, et al., editors. Diabetes in America. Bethesda (MD): National Institute of Diabetes and Digestive and Kidney Diseases (US); 2018.

56. Gómez-Rivera D, Cumba-Avilés E. Comorbid Chronic Physical Illnesses in Type 1 Diabetes Adolescents: Personal, Caregiver, and Family Functioning. Salud Conducta Humana. 2021;8(1):66-81. https://doi.org/10.71332/1zm6jy67 PMid:35855399 PMCid:PMC9291632

57. Huang YM, Shiyanbola OO. Investigation of Barriers and Facilitators to Medication Adherence in Patients With Type 2 Diabetes Across Different Health Literacy Levels: An Explanatory Sequential Mixed Methods Study. Front Pharmacol. 2021;12:745749. https://doi.org/10.3389/fphar.2021.745749 PMid:34690778 PMCid:PMC8527013

58. Al Hayek A, Al Dawish M. Patient-Reported Preference and Clinical Efficacy of Insulin Pen Devices With Safety Needles in Adolescents and Young Adults With Type 1 Diabetes: A Prospective Study. Cureus. 2021;13(4):e14555. https://doi.org/10.7759/cureus.14555

59. Nadia M. Taha, Magda Abd El-Azeaz, Bahia G. Abd El-Razik. Factors Affecting Compliance of Diabetic Patients toward Therapeutic Management. . Med J Cairo Univ,. 2011;79(1):211-8.

60. Fayyaz F, Aghamahdi F, Noorian S, Tabatabaei-Malazy O, Qorbani M. Associated factors to insulin adherence in type 1 diabetes in Tehran and Karaj, Iran. J Diabetes Metab Disord. 2022;21(2):1591-7. https://doi.org/10.1007/s40200-022-01105-0 PMid:36065331 PMCid:PMC9430011

61. Shahsavari A, Estebsari F, Atashzadeh-Shoorideh F, Ilkhani M. Challenges in Access to Support Resources for Diabetic Patients: A Qualitative Study in Deprived Areas of Iran. Chronic Illn. 2022;18(4):937-49. https://doi.org/10.1177/17423953211049438 PMid:34747200

62. Robinson S, Newson RS, Liao B, Kennedy-Martin T, Battelino T. Missed and Mistimed Insulin Doses in People with Diabetes: A Systematic Literature Review. Diabetes Technol Ther. 2021;23(12):844-56. https://doi.org/10.1089/dia.2021.0164 PMid:34270324

63. Datye KA, Moore DJ, Russell WE, Jaser SS. A review of adolescent adherence in type 1 diabetes and the untapped potential of diabetes providers to improve outcomes. Curr Diab Rep. 2015;15(8):51. https://doi.org/10.1007/s11892-015-0621-6 PMid:26084580 PMCid:PMC4692366

64. Alzawahreh S, Ozturk C. Improving Self-Efficacy, Quality of Life, and Glycemic Control in Adolescents With Type 1 Diabetes: Randomized Controlled Trial for the Evaluation of the Family-Centered Empowerment Model. JMIR Form Res. 2024;8:e64463. https://doi.org/10.2196/64463 PMid:39658013 PMCid:PMC11668983

65. Feldman MA, Anderson LM, Shapiro JB, Jedraszko AM, Evans M, Weil LEG, et al. Family-Based Interventions Targeting Improvements in Health and Family Outcomes of Children and Adolescents with

Type 1 Diabetes: a Systematic Review. Curr Diab Rep. 2018;18(3):15. https://doi.org/10.1007/s11892-018-0981-9 PMid:29457190

66. AlBurno H, Schneider F, de Vries H, Al Mohannadi D, Mercken L. Determinants of adherence to insulin and blood glucose monitoring among adolescents and young adults with type 1 diabetes in Qatar: a qualitative study. F1000Res. 2022;11:907. https://doi.org/10.12688/f1000research.123468.2 PMid:38515508

67. Sabbah MM, Hjazeen AA, Arabiat D. Adherence to diabetes management among school-aged children and adolescents living with type 1 diabetes in Jordan. J Pediatr Nurs. 2024;74:110-5. https://doi.org/10.1016/j.pedn.2023.11.021 PMid:38039929