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Stress and Health-Related Quality of Life in Adults With Type 1 Diabetes: The Mediating Role of Perceived Support and Treatment Adherence

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ABSTRACT

Aims: To examine the associations among diabetes-related stress, treatment adherence, perceived social support, and health-related quality of life (HRQoL) in adults with type 1 diabetes mellitus (DM1), and to explore the mediating roles of support and adherence in this relationship.

Design: A cross-sectional observational study using self-report standardised measures and mediation analysis.

Methods: A total of 772 Spanish adults with DM1 completed validated instruments measuring diabetes-related distress, perceived social support, treatment adherence, and HRQoL. Hierarchical multiple regression and serial mediation analysis (PROCESS Model 6, 10,000 bootstraps) were conducted, controlling for age, sex, and time since diagnosis.

Data Sources: Not applicable (primary data collection, not a review).

Results: Diabetes-related stress was the strongest predictor of lower HRQoL. Perceived social support and treatment adherence also contributed significantly. Mediation analyses indicated that the impact of stress on HRQoL was partially mediated by perceived social support and, in sequence, by treatment adherence. The indirect path through social support alone and the sequential path involving both mediators were significant.

Conclusion: Stress and social support are critical in understanding and improving HRQoL in adults with DM1. Treatment adherence appears to be influenced by perceived support, highlighting an indirect mechanism linking stress to quality of life.

Implications for the Profession and/or Patient Care: Healthcare professionals should integrate psychosocial assessments and interventions into routine diabetes care. Targeting stress reduction and enhancing social support may improve adherence and overall well-being in adults with DM1.

Impact: What problem did the study address? The study addressed the need to understand how psychosocial factors—specifically stress, perceived social support, and treatment adherence—contribute to HRQoL in adults with DM1. While prior research often focused on paediatric or clinical populations and rarely explored mediation models, this study sought to fill those gaps with data from a large community sample of adults.

What were the main findings? The main findings indicate that diabetes-related stress is the most significant predictor of reduced HRQoL. This relationship is partially mediated by perceived social support and, sequentially, by treatment adherence. While stress directly affects HRQoL, its negative impact is also channelled through diminished social support and decreased adherence. The indirect effect through treatment adherence alone was not significant.

Where and on whom will the research have an impact? The research has implications for adults living with DM1, particularly those in community settings outside of clinical supervision. It informs healthcare providers, diabetes educators, and policymakers on the importance of addressing emotional distress and strengthening support networks to improve both treatment adherence and overall quality of life.

Reporting Method: This study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies. All methods and results are reported in alignment with EQUATOR Network recommendations for transparent and rigorous research reporting.

Patient or Public Contribution: The study was conducted in collaboration with the Spanish Diabetes Federation (FEDE), which supported participant recruitment and dissemination through its affiliated associations. Patient input was incorporated throughout the study. A person with lived experience of type 1 diabetes contributed to the conceptual development of the research questions and the interpretation of findings. Their perspective helped ensure that the study design, choice of measures, and implications were relevant and meaningful to people living with the condition. This involvement supported a patient-centred approach to both the research and the manuscript preparation. Patients' participation as voluntary contributors was essential to the data collection process.

1 | Introduction

Type 1 diabetes mellitus (DM1) constitutes one of the most prevalent autoimmune diseases (Norris et al. 2020). It has an estimated incidence of 15 per 100,000 population and a prevalence of 9.5 per 100,000 population (Mobasseri et al. 2020). It is a chronic pathology whose prognosis depends directly on the patient's following treatment. Complications due to poor glycaemic control can lead to the patient's death. Chronic complications include neuropathy, nephropathy, diabetic foot, retinopathy, and sexual dysfunctions, among others. This underlines the importance of paying attention to adherence to treatment.

When studying adherence to treatment, social and family support have been shown to be positively associated (Gu et al. 2017). Stress, in turn, has been found to be associated with lower treatment adherence and poorer glycaemic control (Ahola et al. 2020). The importance of stress related to this condition led to the concept of diabetes distress (DD). DD refers to the negative emotions that result from living with diabetes and the burden of managing the disease.

A chronic pathology as complex as DM1 necessarily has an impact on the health-related quality of life (HRQoL) (Raymakers et al. 2018). HRQoL emphasises the impact of health status on the performance of daily activities and the importance of being able to maintain an overall level of functionality (Oluchi et al. 2021).

Several factors, such as hypoglycemia (Ahola et al. 2020), complications such as diabetic foot (Khunkaew et al. 2019) and musculoskeletal disorders (Gutefeldt et al. 2021), seem to explain lower HRQoL in DM1 patients. Conversely, adequate glycemic control and an appropriate lifestyle are associated with better HRQoL (Domínguez-Domínguez et al. 2021).

Despite the relevance and interconnectedness between the variables outlined above (treatment adherence, diabetes distress, supports, and HRQoL), existing studies generally employ a limited number of these variables, and few mediation studies that focus on HRQoL are available (Charalambous et al. 2019; Strandberg et al. 2017). The current study is consistent with previous research, which identified the mediating role of psychological factors in the relationship between illness perception and HRQoL (Knowles et al. 2020). However, since DM1 generally has its origin in childhood, most of those studies have been conducted with an infant-juvenile population (Hasan et al. 2021). In other cases, studies have been conducted with an outpatient population in hospital settings (Álvarez Casaño et al. 2021; Knowles et al. 2020), rather than in people with DM1 from non-healthcare settings. Further research is needed on the facilitating and hindering factors in the patients' own management of diabetes and their impact on HRQoL (Adu et al. 2019). Therefore, developing theory-driven and empirically supported stress management studies in relation to DM1 is a research challenge.

In the field of chronic diseases, the stress and coping model of Lazarus and Folkman (Lazarus and Folkman 1984) has been used (Iwanaga et al. 2023; Lee et al. 1991). According to the model, the person who is exposed to a potentially stressful situation performs a primary appraisal. This assessment involves evaluating whether the situation (e.g., diabetes) is a threat or a challenge. This primary assessment is followed by a secondary assessment. In this step, the person makes a more detailed assessment of the internal or external resources and skills available to cope with the situation. It is at this point that the perception of interpersonal resources, such as social supports, comes into play. Coping is defined as the conscious efforts that the person makes to regulate the stressors to be faced. When resources are evaluated as inadequate or insufficient, the person's distress increases. The appraisal process determines

Summary

- What does this paper contribute to the wider global clinical community?
  - Highlights the central role of diabetes-related stress in determining health-related quality of life (HRQoL) in adults with type 1 diabetes, beyond clinical indicators or demographic factors.
  - Demonstrates the mediating impact of perceived social support, showing it as a critical pathway through which stress influences treatment adherence and ultimately HRQoL.
  - Supports the development of psychosocial interventions—especially those focused on stress management and enhancing interpersonal support networks—to improve treatment adherence and patient well-being in chronic disease care.

an individual′s coping strategies. Coping techniques can be problem-focused or emotion-focused. Problem-focused coping is dealing with the problem or stressor directly. This includes devising solutions, weighing the pros and cons, and taking action (e.g., behaviours related to treatment adherence). Emotion-focused coping is aimed at minimising the distress (e.g., by venting to others or meditating) that often accompanies stress. The Lazarus and Folkman model provides the framework for the approach of the present study and the processes involved. Through the transactional model of stress and coping, the appraisal process demonstrates how thoughts shape feelings and, in turn, how feelings shape thoughts and behaviours. This theoretical perspective also supports the proposed serial mediation model, in which diabetes-related distress influences perceived social support, which subsequently affects treatment adherence and, ultimately, health-related quality of life.

The study of causal processes represents one of the main focuses of psychological enquiry. Researchers often seek to establish if a specific independent variable (e.g., diabetes distress) exerts an effect on a dependent variable (e.g., HRQoL). Researchers not only verify the existence of a relationship between two variables but also postulate one or more mechanisms by which such an effect results, that is, how the effect is mediated (Igartua and Hayes 2021). Specifically, it is necessary to analyse the factors that determine and contribute to improved adherence to treatment, contribute to the impact of DM1 on the HRQoL of adults with DM1, and identify the associations between these variables. Mediation analysis allows for the statistical examination of how diabetes-related stress is associated with lower HRQoL, and to what extent this relationship may be accounted for by variables such as treatment adherence, perceived social support, and glycemic control. Understanding the relative magnitude of these indirect associations can help inform more tailored patient guidance and support the development of targeted interventions focused on the factors most strongly linked to HRQoL.

The aim of this study was twofold. First, it sought to examine whether diabetes-related distress (DD) and person–environment factors—specifically perceived social support and treatment adherence—are statistically associated with subjective well-being, operationalised as health-related quality of life (HRQoL), in adults with type 1 diabetes mellitus (DM1). We hypothesised (1) that all selected variables would show significant associations with HRQoL, and (2) that, collectively, they would explain a significant proportion of its variance.

Second, the study aimed to explore potential mediating mechanisms by testing whether the relationship between diabetes-related distress and HRQoL is sequentially mediated by perceived social support and treatment adherence (Hypothesis 3).

2 | Methods

2.1 | Participants

The sample selection was carried out using non-probability sampling of volunteers. The final sample consisted of 864 participants, which corresponds to approximately 20.5% of the total target population ($N = 4200$). This sample size exceeds the minimum required ($n = 353$) to ensure a 95% confidence level and a 5% margin of error. The following inclusion criteria were established for participation in the study: (1) being over 18 years of age; (2) offering informed consent; (3) residing in Spain; (4) having a diagnosis of DM1. Of the total number of responses, 11 participants were excluded for not meeting inclusion criterion 1, three participants for not meeting inclusion criterion 2, 75 participants for not meeting inclusion criterion 3, and three participants for not meeting inclusion criterion 4. Of the 772 participants, 144 (18.7%) were men, while 628 (81.3%) were women. The participants were between 18 and 75 years (M = 36.9; SD = 10.6). As for age of disease onset, the minimum age was 6 months and the maximum age was 68 years (M = 19.4; SD = 11.6). The age range of diagnosis was between 0 and 58 years (M = 17.5; SD = 11.9).

The most common treatment among the participants was multiple insulin doses (71.9%). The most common method of glucose measurement was a combination of the flash system (freestyle) together with capillary measurement by finger prick (39.4%). The glycated haemoglobin (HbA1c) levels were within the typical range for individuals with DM1, with 58.4% of the participants maintaining excellent metabolic control. Finally, 61.4% of the participants did not report any complications associated with diabetes. Of the remaining 38.6%, the most common complications were diabetic retinopathy and other ocular complications (13%), periodontitis and other dental diseases (12.2%), as well as sexual complications (11.5%).

2.2 | Procedure and Design

This cross-sectional study was conducted over a six-month period and forms part of a broader research project on chronic pain-related diseases, approved by the Research Ethics Committee of the University of Salamanca, Spain (ref. num. 1164). This study was reported in accordance with the STROBE Checklist for cross-sectional studies (see Appendix S1). To facilitate data collection, the Spanish Diabetes Federation (FEDE) was contacted and granted approval after verifying that the study met all ethical and legal requirements. FEDE comprises 19 regional federations

and represents approximately 150 associations across Spain, with nearly 70,000 members, including around 4200 adults diagnosed with type 1 diabetes mellitus (DM1). An evaluation dossier was distributed by FEDE through an external online platform, independent from the research team. The dossier provided detailed information about the study's objectives, ethical safeguards, and data protection protocols. Participation was contingent upon the explicit provision of informed consent. Participants who did not give their consent were redirected to the end of the questionnaire, and only their non-consent was recorded.

2.3 | Instruments

To measure the levels of health-related quality of life (HRQoL), the Diabetes Quality of Life Questionnaire (DQOL or Diabetes Quality of Life) created by the Diabetes Control and Complications Trial group (Jacobson et al. 2013; The DCCT Research Group 1988) was applied. Specifically, the revised version of the Spanish adaptation (EsDQOL) by Millán et al. (2002) was applied. It consists of 43 items, after eliminating three items from the original scale that showed low internal consistency. As in the original version, the measure assesses four dimensions: Life satisfaction, Diabetes impact, Social/Vocational related worries, and Diabetes-related worries. The response format consists of a 5-point Likert-type scale, where 1 denotes the highest satisfaction and 5 the lowest (Oluchi et al. 2021). This instrument enables a multidimensional assessment of health-related quality of life (HRQoL), capturing not only overall life satisfaction but also the extent to which a health condition—such as diabetes—affects daily functioning, social interactions, and vocational activities. Table 1 presents the reliability indices obtained for the overall scale and its individual dimensions in the present study. It is important to note that, in this instrument, higher scores indicate a lower perceived quality of life.

Diabetes distress (DD) was assessed using the Problem Areas in Diabetes (PAID) scale, originally developed by Polonsky et al. (1995) and adapted and validated for the Spanish population by Beléndez et al. (2014). This instrument, validated across multiple languages (Lygidakis et al. 2021), comprises 20 items grouped into four factors: Negative Emotions, Treatment Problems, Food-Related Problems, and Social Support Problems. It captures a broad range of emotional responses associated with living with diabetes and its management, including guilt, anger, depressed mood, worry, and fear. Responses are rated on a 5-point Likert-type scale, with higher scores indicating greater diabetes-related distress and more pronounced issues in each subscale. Table 1 shows the reliability coefficients obtained in the present study, with overall internal consistency comparable to or exceeding that reported in prior research (Lygidakis et al. 2021).

Perceived social support was measured using the Social Support Scale (EAS) developed by Palomar et al. (2013), which comprises 21 items distributed across three dimensions: (1) General Social Support (e.g., "I have at least one person I can count on in case of need"), (2) Family Support (e.g., "My family supports me and helps me when I need it"), and (3) Support from Friends (e.g., "I can talk about my problems with my friends"). The original validation study reported Cronbach's alpha coefficients ranging from 0.71 to 0.94. The scale uses a 4-point Likert response format, with higher scores

TABLE 1 | Internal consistency (Cronbach's α) of the measures and their dimensions used in the study.

	Cronbach's α
EsDQOL	0.935
Satisfaction	0.864
Impact	0.879
Social/vocational concern	0.793
Diabetes concern	0.749
PAID	0.953
Emotional problems	0.935
Treatment problems	0.791
Food-related problems	0.787
Social support problems	0.859
EAS	0.948
Social support	0.940
Family support	0.908
Support from friends	0.826
SCI-R	0.691
General factor	0.676
Regularity factor	0.638

Note: Higher α indicates stronger internal consistency.
Source: Personal elaboration.

reflecting a greater perceived level of support. Table 1 presents the reliability indices obtained in the current study, which surpass those reported in the original validation (Lygidakis et al. 2021).

To assess the level of self-care adherence among adults with diabetes, the Spanish adaptation (Jansà et al. 2013) of the Self-Care Inventory-Revised (SCI-R) questionnaire (Weinger et al. 2005) was employed. This instrument consists of 15 items rated on a 5-point Likert-type scale, ranging from 1 ("Never") to 5 ("Always"). The items are grouped into two factors (Jansà et al. 2013): (1) *General*, comprising nine items related to essential diabetes self-management behaviours—such as consuming the recommended amount of carbohydrates, adjusting insulin dosage based on glucose levels, food intake, physical activity, checking ketones during hyperglycemia, and reading food labels; and (2) *Regularity*, which includes six items addressing routine practices such as taking medication on time, maintaining records of blood glucose readings, and eating at regular intervals. Table 1 presents the reliability indices obtained in the current study.

2.4 | Analysis

Statistical analyses were conducted using IBM SPSS Statistics, version 25.0. In addition to descriptive and correlational analyses, hierarchical regression analysis was used to test the study's second hypothesis. Before performing the regression, key assumptions—including linearity, independence of errors, homoscedasticity, normality of residuals, and absence of

multicollinearity—were assessed and met. To test the third hypothesis, we used the PROCESS macro for SPSS (Model 6, 10,000 bootstrapping samples to generate 95% confidence intervals by the percentile method [Hayes 2022]). Model 6 (serial mediation) performs analysis of specific indirect effects of diabetes-related stress on HRQoL through social support (mediating mechanism 1) and treatment adherence (mediating mechanism 2). Using ordinary least squares (OLS) regression equations, the PROCESS macro estimates a total effect and a direct effect of stress on HRQoL. In addition, it estimates three specific indirect effects of stress on HRQoL: through social support, through adherence to treatment, and through the inclusion of the two mediating variables (i.e., social support and adherence to treatment) operating in sequence. Evidence of a mediation process is provided through the analysis of these indirect effects (Igartua and Hayes 2021).

Mediation analysis focuses on determining the extent to which a given indirect effect is different from zero. The statistical inference strategy for the indirect effect uses the bootstrapping technique; a resampling method is used to approximate the distribution of a statistic (of the indirect effect) and confidence intervals (CIs) to make the statistical decision about whether the observed effect is different from zero (Hayes 2022).

3 | Results

As a preliminary step before addressing the study's main objectives, descriptive statistics (mean [M] and standard deviation [SD]) were calculated for the primary variables. Concerning HRQoL as assessed with the EsDQOL, descriptive analyses suggested high levels of diabetes concern (M = 2.93, SD = 0.92), substantial life dissatisfaction (M = 2.70, SD = 0.92), considerable social/vocational impact (M = 2.44, SD = 0.93), and a strong overall impact of diabetes (M = 2.40, SD = 0.93). Regarding diabetes distress, as measured by the PAID, participants reported moderately elevated scores in emotional problems (M = 2.75, SD = 1.00) and treatment problems (M = 2.66, SD = 1.13), along with moderate-to-high scores in social support problems (M = 2.38, SD = 1.40) and food-related problems (M = 2.36, SD = 1.11). With respect to perceived social support, as measured by the EAS, the data indicated that participants reported high levels of overall social support (M = 3.48, SD = 0.61), as well as support from friends (M = 3.29, SD = 0.70) and family support (M = 3.05, SD = 0.70). Finally, regarding self-care adherence as assessed by the SCI-R, participants scored high on both the Regularity factor (M = 4.00, SD = 0.56) and the General factor (M = 3.57, SD = 0.55).

The initial analyses addressed the hypothesised relationships between selected variables and health-related quality of life (HRQoL) (Hypothesis 1). Table 2 summarises the correlation results. Significant correlations were observed between diabetes-related distress—as measured by the PAID and its subscales—and HRQoL, as assessed by the EsDQOL. Similarly, all subscales of the EAS, along with the total score reflecting perceived social support, were significantly correlated with HRQoL. Lastly, treatment adherence, measured by the SCI-R and its subscales, also showed significant correlations with HRQoL. All reported correlations reached statistical significance ($p < 0.01$).

TABLE 2 | Pearson's correlations between the measures and HRQoL as measured by the EsDQOL.

Scales and subscales	EsDQOL	p
PAID	0.558	< 0.001
Emotional problems	0.576	< 0.001
Treatment problems	0.343	< 0.001
Food-related problems	0.546	< 0.001
Social support problems	0.341	< 0.001
EAS	−0.353	< 0.001
Social support	−0.301	< 0.001
Family support	−0.247	< 0.001
Support from friends	−0.255	< 0.001
SCI-R	−0.219	< 0.001
General factor	−0.221	< 0.001
Regularity factor	−0.158	0.004

Note: Values represent Pearson's *r* coefficients between the main study variables (stress, social support, treatment adherence, and HRQoL). All correlations are two-tailed.
Source: Personal elaboration.

In terms of strength, diabetes-related distress (PAID) and its subscales demonstrated moderate to strong positive correlations with HRQoL, particularly emotional problems ($r = 0.576$) and food-related problems ($r = 0.546$), indicating that higher levels of distress are associated with poorer HRQoL. In contrast, perceived social support (EAS) and treatment adherence (SCI-R) exhibited small to moderate negative correlations with HRQoL (e.g., $r = -0.353$ for total EAS and $r = -0.219$ for SCI-R), suggesting that greater support and better adherence are linked to better HRQoL, albeit with weaker associations. These findings provide empirical support for our first hypothesis.

For the second hypothesis, focused on determining the predictive value of the different measures on HRQoL (as measured by the EsDQOL), a hierarchical multiple regression was conducted to examine the contribution of diabetes-related stress (PAIDT), perceived social support (EAST), and treatment adherence (SCIRT) to health-related quality of life (HRQoL), while controlling for sociodemographic variables (sex, age, and time since diagnosis, complications). In Block 1, the sociodemographic variables accounted for a small but statistically significant proportion of the variance in HRQoL, $R^2 = 0.148$, adjusted $R^2 = 0.143$, $F(4, 758) = 32.89$, $p < 0.001$.

In Block 2, the inclusion of diabetes-related stress (PAIDT) significantly improved the model, $\Delta R^2 = 0.218$, $p < 0.001$, resulting in an adjusted $R^2 = 0.361$. Block 3, which added perceived social support (EAST), further improved the model, $\Delta R^2 = 0.066$, $p < 0.001$, yielding an adjusted $R^2 = 0.427$. Finally, Block 4 included treatment adherence (SCIRT), which produced a modest but statistically significant increase in explained variance, $\Delta R^2 = 0.007$, $p < 0.002$, with a final adjusted $R^2 = 0.433$. The results indicate (see Table 3) that diabetes-related stress is the strongest predictor of HRQoL, followed by perceived social support and, to a lesser extent, treatment adherence. Sociodemographic

variables, although significant, contributed less to the overall variance. Sex (coded as 1 = Male, 2 = Female) was positively related, indicating that men reported slightly higher HRQoL scores compared to women. Age showed a negative association, suggesting that older participants tended to report lower HRQoL. In addition, complications (coded as 1 = None, 2 = At least one) emerged as significant predictors, meaning that those who have complications tended to report lower HRQoL. In contrast, time since diagnosis was not significantly related to quality of life. These findings provide strong support for the second hypothesis.

To test the third hypothesis, a serial mediation analysis was performed using PROCESS macro (Model 6, 10,000 bootstrap samples, 95% bias-corrected confidence intervals) to examine whether the association between diabetes-related stress (PAID) and HRQoL (ESQOL) was sequentially mediated by perceived social support (EAS) and treatment adherence (SCI-R), controlling for sex, age, time since diagnosis, and complications. Higher scores on ESQOL indicate poorer quality of life. A total of 762 participants were included in the analysis, after listwise deletion of cases with missing data on the variables of interest (from an initial sample of 772). Standardised results indicated (see Figure 1) that diabetes-related stress was negatively associated with perceived social support ($\beta = -0.26$, $p < 0.001$), which

TABLE 3 | Regression coefficients for Model 4 (dependent variable: HRQoL).

Predictor	B	SE	β	t	p
Sex	4.34	1.93	0.062	2.24	0.025
Age	−0.19	0.08	−0.074	−2.29	0.022
Time since diagnosis	−0.10	0.07	−0.043	−1.30	0.194
Complications	12.67	1.66	0.229	7.63	<0.001
PAIDT	0.62	0.04	0.445	14.97	<0.001
EAST	−0.52	0.06	−0.240	−8.36	<0.001
SCIRT	−0.35	0.11	−0.090	−3.12	0.002

Note: Sex coded as 1 = Male, 2 = Female. Complications coded as 1 = None, 2 = At least one.
Abbreviations: β, Standardised coefficient; SE, Standard error.
Source: Personal elaboration.

in turn positively predicted treatment adherence ($\beta = 0.17$, $p < 0.001$). Both Social support and treatment adherence were negatively associated with HRQoL ($\beta = -0.52$ and $\beta = -0.11$, respectively; both $p \leq 0.001$), indicating that higher support and better adherence were linked to better quality of life (since higher ESQOL scores reflect poorer HRQoL). The direct association between stress and adherence was not significant ($\beta = -0.03$, $p = 0.303$), suggesting that the effect of stress on adherence operates primarily through perceived social support. Stress remained a strong predictor of poorer HRQoL even after accounting for the mediators ($\beta = 0.54$, $p < 0.001$), supporting a model of partial serial mediation in which stress affects HRQoL both directly and indirectly via reduced social support and lower adherence.

Three specific indirect pathways were examined. First, an indirect effect through perceived social support was significant: higher stress predicted lower perceived social support ($B = -0.14$, SE = 0.02, $p < 0.001$), which in turn predicted better HRQoL ($B = -0.52$, SE = 0.06, $p < 0.001$), resulting in a significant indirect effect ($B = 0.0671$, SE = 0.0149, 95% CI [0.0393, 0.0995]). Second, the path from stress to adherence was not significant, as stress did not significantly predict adherence ($B = -0.01$, SE = 0.01, $p = 0.303$), although adherence itself predicted better HRQoL ($B = -0.16$, SE = 0.05, $p = 0.001$). Consequently, this indirect path was not significant (95% CI [−0.0114, 0.0056]). Third, the serial indirect effect—stress → lower perceived social support → lower adherence → poorer HRQoL—was statistically significant ($B = 0.0068$, SE = 0.0026, 95% CI [0.0021, 0.0133]). The persistence of a significant direct effect of stress on HRQoL even after accounting for both mediators ($B = 0.68$, SE = 0.04, $p < 0.001$) indicates partial, complementary mediation. In other words, while both perceived social support and treatment adherence serve as mediators, diabetes-related distress continues to exert a direct influence on HRQoL. These findings provide robust support for the third hypothesis.

4 | Discussion

The present study examined the correlations among treatment adherence, diabetes-related distress, perceived social support, and health-related quality of life (HRQoL) in adults with type 1 diabetes (DM1). We found that greater adherence to treatment was associated with higher HRQoL, consistent
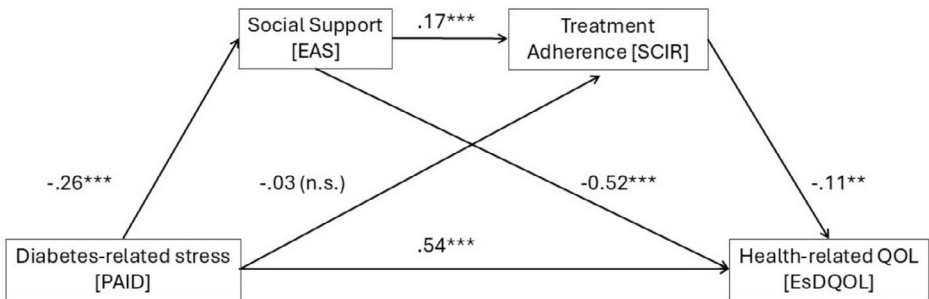

FIGURE 1 | Results of serial multiple mediator model: Indirect effect of diabetes-related stress on quality of life through perceived social support and treatment adherence (PROCESS, Model 6). *Source:* Personal elaboration. Figure shows standardised regression coefficients (β). **$p < 0.01$, ***$p < 0.001$.

with findings from paediatric populations with DM1 (Álvarez Casaño et al. 2021), thereby extending the evidence to adults.

Diabetes-related distress—encompassing emotional, dietary, treatment-related, and social difficulties—was associated with lower HRQoL, accounting for a significant proportion of its variance. This aligns with research showing that emotional maladjustment is linked to reduced HRQoL in individuals with diabetes (Charalambous et al. 2019). Lower perceived social support was also related to poorer HRQoL. These results underscore the importance of addressing diabetes-related distress, particularly in individuals who perceive limited or unsupportive social environments. The relevance of social support is further highlighted by its association with treatment adherence, consistent with earlier findings (Gu et al. 2017). Our mediation analysis extends prior research by suggesting that the link between diabetes-related distress and lower treatment adherence may be explained, in part, by variations in perceived support (Polonsky et al. 1995).

The study provides further support for the hypothesised serial multiple mediator model. Hierarchical regression analyses revealed that diabetes-related distress was the strongest predictor of poorer HRQoL, even after controlling for sociodemographic factors, perceived social support, and treatment adherence. Mediation analysis further showed that the effect of distress on HRQoL was partially accounted for by low perceived social support, which in turn was related to lower adherence. The indirect pathway through social support alone was significant, as was the sequential pathway through both mediators. However, the indirect effect via adherence alone was not statistically significant. These results complement prior findings linking distress to adherence difficulties (Ahola et al. 2020) and provide more nuanced evidence regarding the mechanisms through which distress relates to lower HRQoL. These findings are consistent with Lazarus and Folkman's stress and coping model (1984), suggesting that individuals experiencing diabetes distress may appraise their social and family resources as insufficient, leading to diminished coping efforts. Such reduced coping responses may contribute to poorer disease management and lower HRQoL. The partial mediation observed here suggests that, while social support plays a protective role, it may not be sufficient to fully buffer the negative impact of distress. This is consistent with research indicating that emotional burdens often persist even in the presence of strong social networks, particularly when the support provided does not align with the individual's specific needs (Baek et al. 2014). Moreover, diabetes-related distress may involve internal psychological processes—such as guilt, fear of complications, or burnout—that are not easily alleviated by external support alone. Therefore, interventions targeting HRQoL in people with diabetes should consider not only enhancing social support but also addressing the psychological and emotional dimensions of distress directly.

These findings have implications for the design of interventions aimed at improving HRQoL in adults with DM1. Interventions that reduce diabetes-related distress may be beneficial both directly and indirectly by strengthening social support and promoting adherence. Such interventions could include fostering adaptive coping strategies and increasing awareness of support resources.

Before concluding, several limitations should be acknowledged. First, the sample was composed of voluntary participants recruited through patient associations rather than clinical settings. This recruitment strategy, along with the observation that all participants maintained glycemic control within recommended ranges, may limit the generalisability of the findings to broader or more clinically diverse populations. Second, the use of online data collection excluded individuals without internet access, which may have introduced a selection bias. Third, although hierarchical regression analyses identified diabetes-related stress as the variable most strongly associated with HRQoL, followed by perceived social support and, to a lesser extent, treatment adherence, these findings should be interpreted with caution. Due to the cross-sectional nature of the study, temporal or causal relationships between variables cannot be established. The mediation analysis provides a statistical model to explore potential mechanisms of association, but prospective designs are necessary to confirm the directionality of these pathways.

Furthermore, the relatively low internal consistency observed for the SCI-R scale (particularly in its subdimensions) may limit the reliability of the results concerning treatment adherence. Future studies should consider using complementary instruments or alternative adherence measures to strengthen this dimension. Additional limitations include the use of self-report measures, which may be influenced by social desirability or recall bias, and the sampling strategy based on volunteers from patient associations. This may result in an overrepresentation of individuals who are more engaged in disease management and have better glycaemic control, thus limiting generalisability to the broader DM1 population. Lastly, the sample was predominantly female (81.3%), which suggests the need for replication in more gender-balanced samples. Differences in illness perception, coping strategies, or adherence patterns by gender and age should be further explored.

Despite the aforementioned limitations, this study provides meaningful contributions to the understanding of psychosocial correlates of HRQoL in adults with type 1 diabetes. It is one of the few studies to test a theoretically grounded model of sequential mediation in this population, using validated instruments and a large sample size. By incorporating variables such as diabetes-related distress, social support, and treatment adherence, the study offers a more integrative perspective on how personal and contextual factors may interplay in shaping well-being. The results support the relevance of targeting emotional and relational dimensions in diabetes care, beyond glycaemic indicators alone.

Sociodemographic variables (sex, age, and time since diagnosis) were included as covariates, and although they explained a small proportion of variance in HRQoL, their inclusion improved model precision. These variables should continue to be explored, particularly given evidence of their moderating role in metabolic control and psychological adjustment (Bernstein 2004; Coskun et al. 2021).

Our findings suggest several directions for improving HRQoL in adults with DM1. Interventions grounded in the stress–appraisal–coping framework (Lazarus and Folkman 1984; Iwanaga et al. 2023) can focus on how individuals appraise symptoms and manage disease-related stress. Programs can also

aim to enhance coping skills, strengthen support networks, and increase adherence through self-compassion and self-efficacy training (Akbari et al. 2022). Ultimately, multicomponent strategies targeting stress, support, and adherence may offer the most comprehensive improvements in HRQoL. These findings are especially relevant because they highlight that modifiable factors such as social support and adherence can influence HRQoL. This opens the door for evidence-based interventions, including coaching (Ammmentorp et al. 2020) and digital tools (Kim et al. 2019), to promote sustained improvements in well-being for people with DM1.

Author Contributions

R.S.-M.: conceptualisation, methodology, data curation, writing – original draft, writing – review and editing. F.J.D.S.-H.: conceptualisation, writing – original draft, data curation, writing – review and editing. M.M.G.-M.: writing – original draft, data curation, writing – review and editing. M.F.S.: Project administration, conceptualisation, writing – original draft, data curation, writing – review and editing, supervision. C.J.: conceptualisation, methodology, data curation, writing – original draft, writing – review and editing, supervision. J.-J.I.: conceptualisation, methodology, data curation, writing – original draft, writing – review and editing.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in Zenodo at https://doi.org/10.5281/zenodo.15807827.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Appendix S1:** jocn70114-sup-0001-AppendixS1.docx.