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Clinical phenotyping of people living with type 1 diabetes according to their levels of diabetes-related distress: results from the SFDT1 cohort

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ABSTRACT

Introduction Type 1 diabetes is burdensome, requiring complex daily management and making people more prone to emotional distress. To better detect diabetes-related distress (DD) and identify at-risk patients, we aimed to provide an in-depth characterization of DD in people with type 1 diabetes.

Research design and methods We included adults with type 1 diabetes from the *Suivi en France des personnes avec un Diabète de Type 1* cohort who filled in the Problem Areas in Diabetes questionnaire (PAID ≥40 indicates high DD). Age and sex-adjusted multivariable logistic regression models analyzed individual characteristics, clinical indicators, diabetes-related complications and psychological factors. We further analyzed DD according to six data-driven subdimensions: emotional distress, fear of complications, social distress, eating distress, management distress, and diabetes burnout.

Results In total, 1220 participants (50.6% female, age 42 years (SD 13.9), diabetes duration 24.7 years (13.6)) had a total mean PAID score of 39.6 (21.7) and 592 (48.5%) reported high DD. Leading subdimensions of DD included fear of complications (50.1 (24.4)) and diabetes burnout (45.9 (24.5)). Females, younger age, social vulnerability, smoking, and the presence of retinopathy were positively associated with high DD ($p<0.05$). We observed similar DD levels across HbA1c levels and treatment modalities, including automated insulin delivery and continuous glucose monitoring use. Several psychological factors, such as anxiety/depression, poor sleep quality, and treatment burden, were strongly associated with DD ($p<0.001$).

Conclusions We provide a holistic clinical phenotyping approach that enables the identification of determinants and prevalence of DD, overall and according to key DD subdimensions, in a large and diverse population. Our results underscore the importance of developing DD-targeted prevention and intervention strategies focused specifically on high-risk groups and the most impactful distress subdimensions to reduce the impact of type 1 diabetes burden.

Trial registration number NCT04657783.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ High diabetes-related distress (DD) is present in one in four persons with type 1 diabetes and has been associated with poor glycemic outcomes and poor quality of life. To better detect and understand DD in type 1 diabetes, this study aimed to identify at-risk individuals and address gaps in existing research on DD prevalence and determinants.

WHAT THIS STUDY ADDS

⇒ We found high DD to be more common than previously described, affecting nearly half of respondents. We identified potential determinants of DD, including individual and diabetes-related characteristics, and showed its centrality to other psychological factors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our findings provide new evidence for developing targeted psychological prevention and intervention strategies for better detection and management of DD, particularly for high-risk groups and key DD subdimensions identified in our study.

INTRODUCTION

Diabetes-related distress (DD) is characterized by the negative emotional or affective experience resulting from the challenges and demands of living with diabetes. This distress is a response to having diabetes, distinguishable from, but often coexisting with, other psychological disorders such as depression and anxiety.[1] High DD is estimated to affect one in four individuals with type 1 diabetes,[2] impacting glycemic outcomes, self-management behavior, and quality of life.[1 3] Previous studies have shown that factors like female sex, younger age and unemployment

are associated with higher levels of DD.[4 5] Moreover, the recent progress of continuous glucose monitoring (CGM) and insulin therapy, in particular automated insulin delivery (AID), is associated with some reduction in DD at the individual level but fails to reduce its prevalence.[6]

With increasing focus on psychological health in diabetes, monitoring DD has become part of clinical guidelines.[7] Recent research[4] has begun to address the previously identified gap in large-scale studies on the prevalence and determinants of DD at the population level.[2] However, the need for further research persists.[8] Therefore, this study aims to provide an in-depth clinical phenotyping of adults with type 1 diabetes according to their levels of DD. Based on a large cohort study in France, this comprehensive analysis seeks to expand existing knowledge by exploring a broad range of individual characteristics, clinical indicators, diabetes-related complications, and psychological factors. By expanding the scope and depth of analysis, we hope to uncover novel insights and contribute to more targeted and effective interventions for detecting, managing, and preventing DD in adults with type 1 diabetes.

MATERIALS AND METHODS

Study design

This work is based on participants of *Suivi en France des personnes avec un Diabète de Type 1* (SFDT1), an ongoing cohort study of people with type 1 diabetes attending hospitals or private ambulatory diabetes centers located in the entire French territory. The SFDT1 study combines data based on patient-reported outcomes (PROs), face-to-face interviews, physical examinations, clinical assessments, blood samples and CGM measures.[9] The SFDT1 ClinicalTrials.gov registration number is NCT04657783. Sanoïa supported the study protocol design, ethical procedures, and implementation, and orchestrated the data collection and data flows on its secure platform.

The current analysis is cross-sectional and includes participants enrolled between December 2020 and October 2023. In addition to the inclusion criteria of this cohort study,[9] the present study analyzes variables measured at baseline and only includes patients who filled out the Problem Areas in Diabetes (PAID) questionnaire[10] (online supplemental figure S1). The PAID questionnaire was self-reported and answered 3 months after the inclusion.

Diabetes distress assessment

Our primary outcome was DD, assessed with PAID, a 20-item questionnaire measuring common diabetes-related issues,[11] completed remotely by the participants 3 months after inclusion. Each item is graded on a Likert scale from 0 (not a problem) to 4 (serious problem). Individual scores are added up and multiplied by 1.25, generating a total score between 0 and 100, with ≥40 indicating clinically significant high DD.[2]

Using the 'psych' R package, we performed exploratory factor analysis (EFA) to identify DD subdimensions. First, we calculated the Kaiser-Meyer-Olkin (KMO) index to evaluate the sampling adequacy for the factor analysis.[12] Then, we determined the optimal number of factors to retain using parallel analysis and scree plots.[13] Given the interrelated nature of psychological constructs,[14] factors were extracted using promax rotation to allow for potential correlation between PAID factors. Each factor was considered a DD subdimension, and items were assigned to the factor with the highest loading, indicating a stronger correlation. Cronbach's alpha coefficients were computed for each factor to assess internal consistency and reliability. Finally, we calculated the PAID subscores by summing the respective item scores of each factor and then normalizing them on a 0–100 scale for comparison.

Variables tested as determinants of diabetes distress

Individual characteristics

Age, sex, higher education (defined as 2 or more years after high school), work status (categorized as employed, student, retired or unemployed), social vulnerability (measured using the *Evaluation de la Précarité et des Inégalités de santé dans les Centres d'Examens de Santé* score with a cut-off of ≥30.17 indicating vulnerability)[15], physical activity (total metabolic equivalent of task minutes a week using the short version of the International Physical Activity Questionnaire)[16], alcohol consumption (categorized as never, yes or excess—defined as more than three drinks for females and four for males)[17], and smoking status (categorized as never, past smoker or current smoker).

Clinical indicators

Diabetes duration, insulin treatment (use of multiple daily injections (MDI), an insulin pump, an insulin pump combined with another device (open loop), or AID systems), CGM use (categorized by device type: FreeStyle Libre I, FreeStyle Libre II–III, Dexcom, Medtronic, or none), body mass index (body mass index, kg/m^2), last glycated hemoglobin test (HbA1c (mmol/mol, %)), systolic blood pressure (mm Hg), heart rate (ppm), total cholesterol (mmol/L), high-density lipoprotein (mmol/L), low-density lipoprotein (mmol/L) and triglycerides (mmol/L). We also included CGM-derived data: time below range (TBR, below 70 mg/dL or 3.9 mmol/L), time in range (TIR, between 70 and 180 mg/dL or between 3.9 and 10.0 mmol/L), time above range (TAR, above 180 mg/dL or 10.0 mmol/L), glycemic risk index (GRI, evaluates the risk of acute hypoglycemic and hyperglycemic events from four CGM variables)[17] and coefficient of variation (CV, %). The CGM data should capture the 14 days before inclusion and capture at least 70% of the data, as mentioned in the Advanced Technologies & Treatments for Diabetes consensus recommendations.[18] The sum of rounded values of TBR, TAR and TIR should be between 98% and 102%.

Diabetes-related complications

Severe hypoglycemia and diabetic ketoacidosis (DKA) as acute complications (at least one event in the previous year) and cardiovascular disease (CVD), retinopathy, proliferative retinopathy, nephropathy, neuropathy, and history of diabetic foot ulcer as long-term complications. CVD was defined as any of the following: history of stable angina, acute coronary syndrome, coronary artery bypass graft, stroke, transient ischemic attack or hospitalization for heart failure. Retinopathy diagnosis was based on patient interview, retinography, fundus examination and/or ophthalmologist consultation report. Proliferative retinopathy was defined as retinopathy with residual new vessels. Nephropathy was defined as albumin/creatinine ratio >3 mg/mmoL or estimated glomerular filtration rate <60 mL/min/1.73 m^2.[18 19] Neuropathy was defined according to the Michigan criteria (Michigan Neuropathy Screening Instrument).[20]

Psychological factors

Diabetes-dependent quality of life (measured using the Audit of Diabetes-Dependent Quality of Life, with an average weighted impact score ranging from −9 (worse) to +3)[21], anxiety/depression (moderate to severe symptoms assessed using question 5 of the EuroQol 5-Dimension 5-Level tool)[22], sleep quality (assessed using the Pittsburgh Sleep Quality Index, with a global score of 0–21 and a cut-off of >5 indicating poor sleep quality)[23 24], eating disorders (screened using the SCOFF questionnaire, with a global score of 1–5, where a cut-off ≥2 suggests a likely eating disorder)[25], insulin misuse (assessed with two diabetes-specific questions added to SCOFF: forget/underestimate insulin doses and take less insulin than recommended), hypoglycemia awareness (assessed using the Gold Score, where a score of 1–2 indicates awareness, 3 is undetermined, and 4–7 indicates impaired awareness)[26], fear of hypoglycemia (measured with the short form of the Hypoglycemia Fear Survey II), providing separate behavioral and affective scores from 0 to 16)[27], treatment burden (assessed using the Treatment Burden Questionnaire, with a total score of 0–150)[28] and treatment satisfaction and glycemic burden (measured with the Diabetes Treatment Satisfaction Questionnaire, providing two separate factors scoring 0–36 and 0–12, respectively)[29].

Sociodemographic data, clinical data, and complications were collected at baseline during the inclusion visit. All used questionnaires, used to assess psychological factors and some individual characteristics, are validated and adapted to French. Details about the setting and timeline are provided in online supplemental figure S2.

Missing data and multiple imputation

Some data were missing (online supplemental table S1). For all variables except glucose variables from CGM devices (TBR, TAR, TIR, GRI and CV), assuming a missing at-random mechanism, we applied multiple imputations using the chained equation approach with the 'mice' R package.[30] We generated 40 imputed datasets based on the maximum percentage of missing cases, following White *et al*'s rule of thumb.[31] The number of iterations was 15, in agreement with van Buuren, who proposed that 5–20 iterations are enough to reach convergence.[32] The author also stated that it is suitable to select between 15 and 25 variables as predictors of missing data. Accordingly, the 'quickpred()' R function was used to select the best 25 predictors, and the 'vif()' R function was used to exclude highly correlated variables. Convergence was assessed by checking means, variances, and visual representations using the 'ggmice' R package.[33]

Analyses

All statistical analyses were performed using R software (V.4.2.2). We calculated total and subdimensional PAID scores and identified the top five items by mean score. Participants were categorized into distress levels based on PAID score ranges: low (≤16), moderate (17–39), and high (≥40). These align with the threshold of 40 for high distress and the recently suggested 17–39 cut-off for moderate distress.[34]

We present the characteristics of the study population overall and stratified by DD levels. Continuous variables were summarized using means, SDs, and categorical variables as counts and percentages.

We used multivariable logistic regression models to investigate associations between potential factors and DD levels (reference level: low), adjusting for age and sex due to their strong influence on DD.[4] Additionally, we evaluated the correlation of different insulin treatment modalities with PAID scores.

We pooled the estimates along with their SEs from the multiple imputations, applying Rubin's rules,[32] and converted them into ORs and 95% CIs using exponentiation. Continuous predictor variables were scaled to standardize their units, allowing for meaningful comparisons between variables. Categorical variables remained unscaled, with their ORs comparing the odds of the outcome for each category relative to a reference category. Statistical significance was determined at an alpha level of 0.05. The p values were corrected for multiple tests using the Benjamini-Hochberg method.[35]

We performed a sensitivity analysis to evaluate potential selection bias. This involves comparing the characteristics of included participants to those excluded, particularly non-completers of the PAID questionnaire.

RESULTS

We analyzed data from 1220 adults with type 1 diabetes in France, covering 39 diabetic centers (online supplemental figure S3). The mean age was 42.0 (SD 13.9) years, with average diabetes duration at 24.7 (13.6) years, and 617 (50.6%) were females. Among SFDT1 respondents, 775 (63.5%) used insulin pumps, of which 150 (19.4%) used AID, 1145 (93.9%) employed CGM systems, and the mean HbA1c level was 7.6 (1.2)%. Participants who

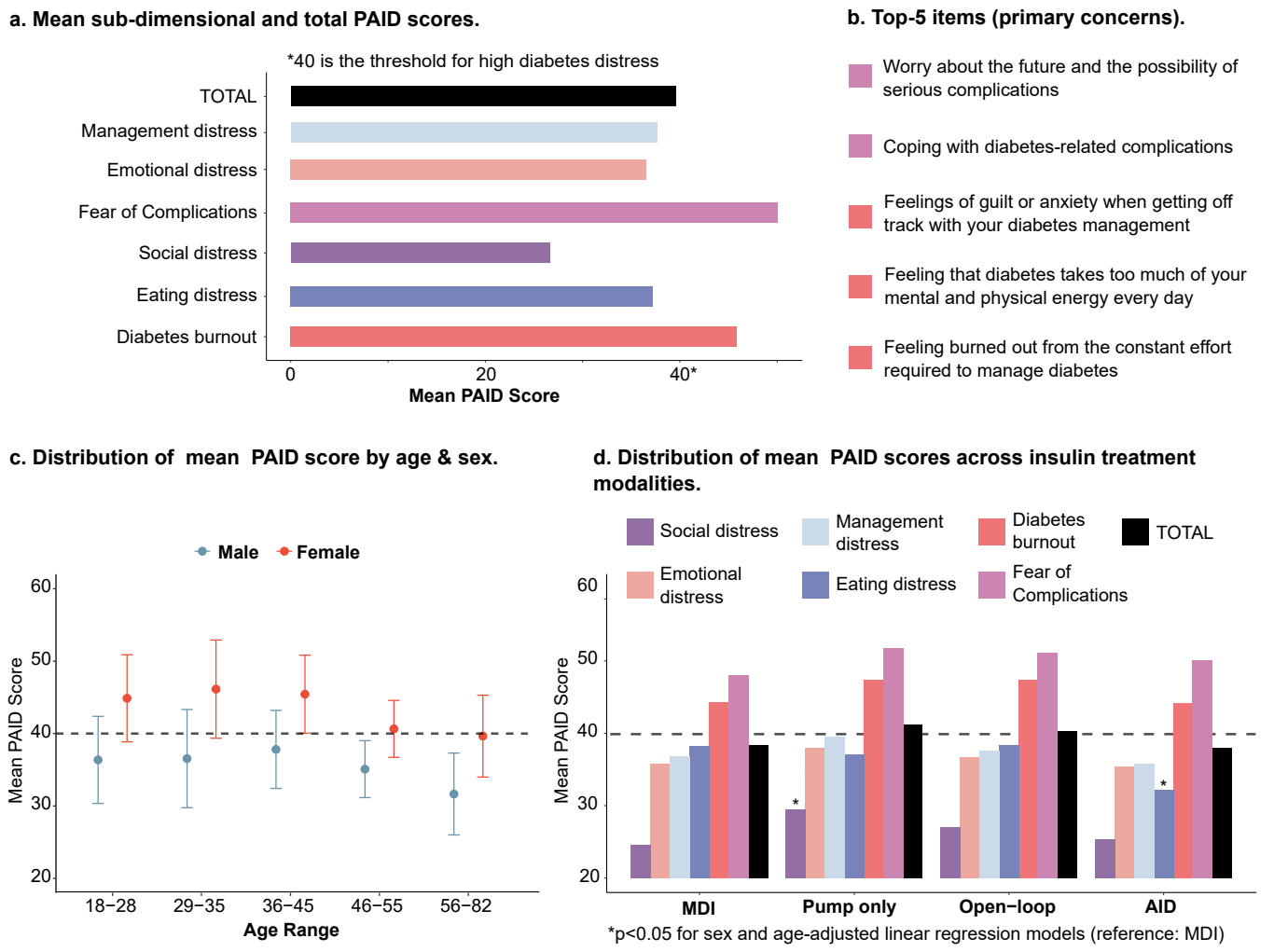

Figure 1 Problem Areas in Diabetes (PAID) characteristics in *Suivi en France des personnes avec un Diabète de Type 1* (SFDT1). (a) Comparison of PAID scores by diabetes distress subdimensions. (b) Top five (ie, higher mean) PAID items. (c) Comparison of total PAID scores by age and sex. (d) Comparison of PAID scores across insulin treatment modalities. (c and d) Dashed lines at y=40 indicate threshold for high diabetes distress. AID, automated insulin delivery; MDI, multiple daily injections.

did not complete the PAID questionnaire (n=966) were predominantly male, younger, and had poorer glycemic control, and the majority were using MDI as their insulin treatment (online supplemental table S2).

The overall KMO index was 0.96, indicating very good suitability for EFA,[36] which was used to identify DD subdimensions. Principal axis factoring with promax rotation extracted a six-factor solution, which explained 51% of the total variance (online supplemental table S3). The factors, representing DD subdimensions, were labeled following Dennick *et al*'s conceptualization study of DD[11]: emotional distress (α=0.90), fear of complications (α=0.73), social distress (α=0.78), eating distress (α=0.78), management distress (α=0.74), and diabetes burnout (α=0.86).

The mean PAID score was 39.6 (21.7), with the distribution of DD as follows: 213 participants (17.5%) in the low level, 415 (34%) in the moderate level, and 592 (48.5%) in the high level. The primary source of distress was fear of complications, as evidenced by a mean score of 50.1 (24.4) in this subdimension (table 1, figure 1a). Worrying about the future and serious complications (item 12) had the highest individual mean score (2.4 (1.1)), with 48.8% of participants considering it a somewhat serious (score 3) or serious problem (score 4). This item, together with feelings of guilt or anxiety about diabetes management (item 13) and coping with complications (item 19), constituted the top three items (figure 1b; top five are highlighted).

Tables 1 and 2 show the distribution of all explanatory variables across DD levels. Significant differences between moderate or high DD levels and the reference category, low DD, are highlighted in bold, with significance levels indicated by asterisks. The ORs and CIs from these associations are detailed in online supplemental tables S3 and S4.

Our analysis revealed that female sex and younger age were strongly linked to increased DD levels. This relationship is visually depicted in figure 1c; specifically, females

Table 1 Clinical phenotyping of SFDT1 cohort: diabetes distress scores and individual and clinical characteristics of adults with type 1 diabetes and their associations with PAID levels

Diabetes distress levels (cut-off scores)	Overall population	Low (0–16)	Moderate (17–39)	High (40–100)
n (%)	1220	213 (17.5)	415 (34)	592 (48.5)
Variable				
PAID				
Total score (0–100)	39.6 (21.7)	9.2 (4.9)	28.5 (6.4)	58.3 (12.8)
Dimensions (0–100)				
Emotional distress	36.5 (27.2)	4.5 (5.9)	22.2 (12.6)	58.1 (20.5)
Fear of complications	50.1 (24.4)	18.7 (13.3)	42.6 (16.1)	66.6 (17.8)
Social distress	26.6 (25.9)	2.2 (4.8)	14.2 (14.2)	44.1 (24.6)
Eating distress	37.2 (26.6)	10.2 (11.9)	28.6 (19.2)	52.9 (24.3)
Management distress	37.6 (26.7)	9.2 (14.9)	27.5 (20)	55 (21.2)
Diabetes burnout	45.9 (24.5)	11.8 (8.8)	35.2 (12)	65.6 (14.8)
Individual				
Age, years	42.0 (13.9)	44.5 (15.4)	42.8 (14.1)	**40.5 (12.9)***
Female	617 (50.6%)	69 (32.4%)	**206 (49.6%)*****	**342 (57.8%)*****
Higher education	794 (65.1%)	137 (64.3%)	286 (68.9%)	371 (62.7%)
Work status				
Employed (reference)	886 (72.6%)	139 (65.3%)	307 (74%)	440 (74.3%)
Student	82 (6.7%)	17 (8%)	29 (7%)	36 (6.1%)
Retired	110 (9%)	33 (15.5%)	38 (9.2%)	39 (6.6%)
Unemployed	142 (11.6%)	24 (11.3%)	41 (9.9%)	77 (13%)
Social vulnerability	245 (20.1%)	28 (13.1%)	65 (15.7%)	**152 (25.7%)****
Physical activity, MET	2422.0 (1828.7)	2283.8 (1635.3)	2361.9 (1815.6)	2513.8 (1900.4)
Alcohol consumption				
Never (reference)	364 (29.8%)	57 (26.8%)	107 (25.8%)	200 (33.8%)
Yes, but no excess	812 (66.6%)	145 (68.1%)	299 (72%)	368 (62.2%)
Yes, in excess	44 (3.6%)	11 (5.2%)	9 (2.2%)	24 (4.1%)
Smoking status				
Never (reference)	688 (56.4%)	119 (55.9%)	255 (61.4%)	314 (53%)
Past smoker	300 (24.6%)	64 (30%)	92 (22.2%)	144 (24.3%)
Current smoker	232 (19%)	30 (14.1%)	68 (16.4%)	**134 (22.6%)***
Clinical				
Diabetes duration, years	24.7 (13.6)	27.2 (14.6)	25.5 (13.7)	23.2 (13.1)
Insulin treatment				
MDI (reference)	443 (36.3%)	88 (41.3%)	148 (35.7%)	207 (35.0%)
Insulin pump	338 (27.7%)	50 (23.5%)	116 (28%)	172 (29.1%)
Open loop	289 (23.7%)	41 (19.2%)	107 (25.8%)	141 (23.8%)
AID	150 (12.3%)	34 (16%)	44 (10.6%)	72 (12.2%)
AID duration, years	0.9 (0.8)	0.9 (0.8)	0.8 (0.8)	1 (0.9)
CGM use				
FreeStyle Libre I (reference)	399 (32.7%)	64 (30%)	140 (33.7%)	195 (32.9%)
Dexcom	113 (9.3%)	27 (12.7%)	29 (7%)	57 (9.6%)
FreeStyle Libre II or III	469 (38.4%)	72 (33.8%)	165 (39.8%)	232 (39.2%)
Medtronic	164 (13.4%)	34 (16%)	54 (13%)	76 (12.8%)

Continued

Table 1 Continued

Diabetes distress levels (cut-off scores)	Overall population	Low (0–16)	Moderate (17–39)	High (40–100)
None, traditional reader	75 (6.1%)	16 (7.5%)	27 (6.5%)	32 (5.4%)
BMI, kg/m²	26.3 (5.1)	26.3 (4.6)	26.2 (4.8)	26.4 (5.5)
HbA1c, %	7.6 (1.2)	7.4 (0.9)	7.5 (1.1)	7.7 (1.4)
HbA1c, mmol/mol	59.5 (13.4)	57.8 (10.3)	58.4 (12.5)	60.9 (14.8)
TBR (<70 mg/dL), % of time	4.7 (5.7)	4.1 (4.6)	5.2 (5.6)	4.6 (6.1)
TIR, % of time	59.5 (16.3)	61.4 (16.2)	61.8 (14.7)	57.1 (17.1)
TAR (>180 mg/dL), % of time	35.8 (17.4)	34.6 (16.3)	33 (15.9)	38.2 (18.5)
GRI, %	59.2 (30)	54.3 (28.4)	57 (28.7)	62.6 (31.1)
Coefficient of variation, %	37.9 (7.6)	37.9 (7.7)	38 (7.4)	37.8 (7.7)
Systolic blood pressure, mm Hg	124.4 (15.8)	126.4 (15.4)	124.5 (16.4)	123.6 (15.4)
Heart rate, bpm	76.1 (13.4)	75.2 (13.2)	75.4 (14.2)	76.8 (12.8)
Total cholesterol, mmol/L	4.6 (1)	4.6 (0.7)	4.5 (0.9)	4.7 (1.1)
HDL, mmol/L	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)	1.6 (0.5)
LDL, mmol/L	2.5 (0.8)	2.5 (0.7)	2.5 (0.8)	2.6 (0.8)
Triglycerides, mmol/L	1 (0.5)	0.9 (0.4)	0.9 (0.5)	1 (0.5)

PAID scores per DD level: 0–16 (low); 17–39 (moderate); 40–100 (high).
*0.01≤p<0.05, **0.001≤p<0.01, ***p<0.001.
(Min–max) indicates the minimum and maximum values for that variable.
AID, automated insulin delivery; BMI, body mass index; bpm, beats per minute; CGM, continuous glucose monitoring; DD, diabetes-related distress; GRI, glycemic risk index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MDI, multiple daily injections; MET, metabolic equivalent of task; PAID, Problem Areas in Diabetes; SFDT1, *Suivi en France des personnes avec un Diabète de Type 1*; TAR, time above range; TBR, time below range; TIR, time in range.

were shown to have an average increase of 8.4 points in PAID scores compared with males.

Results from the age and sex-adjusted logistic regression models indicated that social vulnerability and current smoking were positively associated with high DD. Although clinical indicators did not reach statistical significance, there was a notable increase in HbA1c and GRI values from the low to high DD categories.

Our study found no association between PAID levels and diabetes duration, use of CGM or use of AID (table 1). Variations in DD between insulin treatment modalities were minor, with only a significant increase in social distress among insulin pump users and a reduction in eating distress among AID users, compared with the reference modality, MDI (figure 1d).

Among diabetes-related complications, only retinopathy was significantly associated with DD. Regarding psychological determinants, anxiety/depression, eating disorders, insulin misuse, impaired awareness of hypoglycemia, fear of hypoglycemia, treatment and glycemic burden were positively associated with high DD. Diabetes-dependent quality of life and sleep quality were negatively associated with DD.

A deeper examination of these associations indicated that psychological factors had the strongest association with DD (as shown by the highest ORs in figure 2 and detailed in online supplemental tables S4 and S5). Among individual characteristics, female sex showed the strongest association, followed by social vulnerability.

DISCUSSION

Main findings

This study explored the associations between various factors and DD among adults with type 1 diabetes who completed the PAID questionnaire (n=1220). We found a substantial prevalence of DD, with nearly half of the participants experiencing high distress (PAID≥40).

Prevalence of DD

The study conducted by Hernar *et al* in 2023 in Norway[4] stands out due to its large sample size of 10 186 participants with type 1 diabetes, making it one of the most comprehensive investigations into the determinants of DD to date. The authors found a DD prevalence in 21.7% of their respondents, with a mean PAID score of 25.4 (18.4), notably lower than the 48.5% prevalence and a mean score of 39.6 (21.7) observed in our study. This disparity might be attributed to differences in demographic compositions, such as the higher percentage of females (50.6% vs 46.0%) and younger individuals (mean age 42.0 years vs 46.7 years) in our population, which are factors associated with increased DD. Moreover, geographical differences might play a role in the prevalence of DD, particularly the more favorable

Table 2 Clinical phenotyping of the SFDT1 cohort: diabetes-related complications and psychological factors of adults with type 1 diabetes and their associations with PAID levels

Diabetes distress levels (cut-off scores)	Overall population	Low (0–16)	Moderate (17–39)	High (40–100)
n (%)	1220	213 (17.5)	415 (34)	592 (48.5)
Variable				
Complications				
Acute complications (at least one event in the previous year)				
Severe hypoglycemia	128 (10.5%)	20 (9.4%)	32 (7.7%)	76 (12.8%)
Diabetic ketoacidosis	59 (4.8%)	6 (2.8%)	21 (5.1%)	32 (5.4%)
Long-term complications				
CVD	59 (4.8%)	13 (6.1%)	18 (4.3%)	28 (4.7%)
Retinopathy†	450 (36.9%)	70 (32.9%)	151 (36.4%)	**229 (38.7%)***
Proliferative retinopathy	77 (6.3%)	11 (5.2%)	25 (6%)	41 (6.9%)
Nephropathy	141 (11.6%)	24 (11.3%)	55 (13.3%)	62 (10.5%)
Neuropathy	501 (41.1%)	94 (44.1%)	177 (42.7%)	230 (38.9%)
History of DFU	31 (2.5%)	6 (2.8%)	8 (1.9%)	17 (2.9%)
Psychological				
Impact on diabetes-dependent QoL (–9, 3)	–2.6 (1.7)	–1.3 (1.1)	**–2.1 (1.5)*****	**–3.3 (1.7)*****
Anxiety/depression	294 (24.1%)	16 (7.5%)	**69 (16.6%)***	**209 (35.3%)*****
Poor sleep quality	673 (55.2%)	72 (33.8%)	193 (46.5%)	**408 (68.9%)*****
Eating disorders	146 (12%)	11 (5.2%)	27 (6.5%)	**108 (18.2%)****
Forget/underestimate insulin doses	298 (24.4%)	28 (13.1%)	83 (20%)	**187 (31.6%)*****
Take less insulin than recommended	212 (17.4%)	16 (7.5%)	63 (15.2%)	**133 (22.5%)*****
Hypoglycemia awareness status				
Aware (reference)	707 (58%)	144 (67.6%)	248 (59.8%)	315 (53.2%)
Undetermined	246 (20.2%)	32 (15%)	78 (18.8%)	**136 (23%)***
Impaired awareness	267 (21.9%)	37 (17.4%)	89 (21.4%)	**141 (23.8%)****
Behavioral avoidance of hypoglycemia (0–16)	6.5 (2.7)	6.2 (2.9)	6.2 (2.6)	6.8 (2.6)
Affective fear of hypoglycemia (0–16)	4.5 (3.2)	2.9 (2.4)	**4 (3.1)****	**5.5 (3.2)*****
Treatment burden (0–150)	58.3 (29.4)	32.6 (23.5)	**51.2 (25.6)*****	**72.6 (25.4)*****
Treatment satisfaction (0–36)	27.1 (4.9)	29.7 (3.5)	**27.9 (4.3)*****	**25.6 (5.2)*****
Glycemic burden (0–12)	4.9 (1.8)	4.2 (2)	4.7 (1.7)	**5.3 (1.8)*****

PAID scores per DD level: 0–16 (low); 17–39 (moderate); 40–100 (high).
*0.01≤p<0.05, **0.001≤p<0.01, ***p<0.001.
(Min–max) indicates the minimum and maximum values for that variable.
†35% of retinopathy diagnosis was extracted from patient interviews only.
CVD, cardiovascular disease; DD, diabetes-related distress; DFU, diabetic foot ulcer; PAID, Problem Areas in Diabetes; QoL, quality of life; SFDT1, *Suivi en France des personnes avec un Diabète de Type 1*.

socioeconomic conditions encountered by individuals in Norway, as opposed to those in France.[37]

Our analysis also aligns with some studies and diverges from others across different geographical regions. Grulovic *et al*'s 2022 study in Croatia[38] reported a DD prevalence of 36% among 100 participants, with a mean PAID total score of 31.9 (21.1). Mach *et al*'s[39] research in Canada found that 45% of participants (n=200) scored high on DD using the PAID-5 scale,[40] which is closer to our study's prevalence rate. Similarly, Embaye *et al*'s 2023 study across the Netherlands and Italy[41] revealed that 54.6% of participants reported elevated DD. The high percentage of female participants (78.7%) in Embaye *et al*'s study emphasizes the substantial effect of sex. Lastly, Huisman *et al*'s 2023 study in the Netherlands[42] reported a 28% DD prevalence, with a mean total PAID score of 29.0 (21.1). Notably, this was the only study where PAID was administered during a clinical visit rather than remotely, which could have implications for participant responses due to the possible social desirability bias—'make your

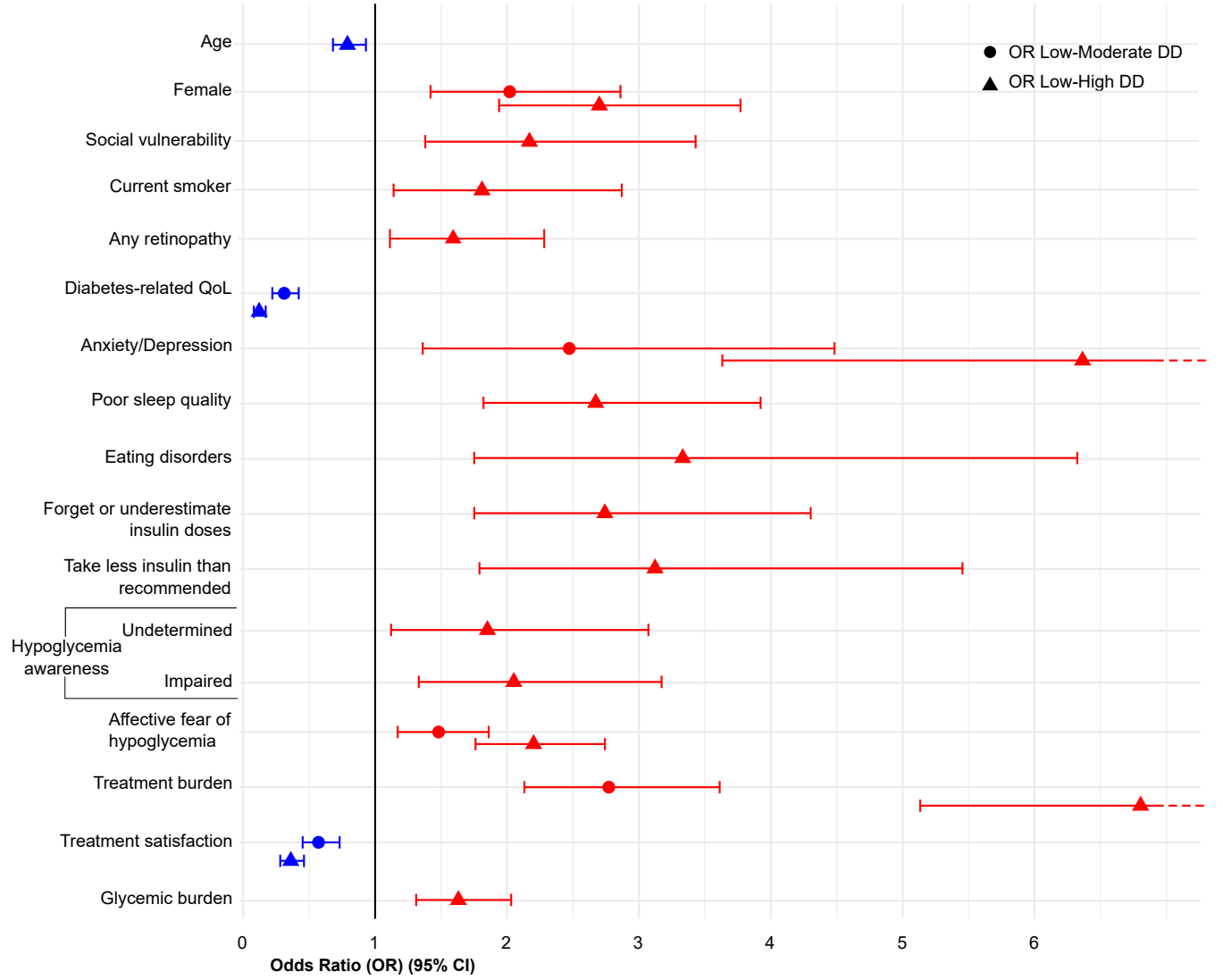

Figure 2 Clinical phenotyping of *Suivi en France des personnes avec un Diabète de Type 1* (SFDT1) cohort participants: significant associations (p<0.05) between study variables and moderate (circle) and high (triangle) diabetes distress levels (reference: low). Red: positive association (OR>1). Blue: negative association (OR<1). The lines represent ORs and 95% CIs from age and sex-adjusted multivariable logistic regression models. Age and sex variables are adjusted for each other. DD, diabetes-related distress; QoL, quality of life.

doctor happy' effect. Previous research supports that this effect is in the direction of interviewer-administered questionnaires underestimating mental health state, as participants are motivated to respond in a way they believe is expected by the clinician.[43]

These comparisons suggest the multifaceted nature of DD prevalence, influenced by factors such as geographical location, sociodemographic characteristics and PAID administration modes, that can shape the emotional experiences of individuals with type 1 diabetes.

DD subdimensions

The top five items identified in our study replicate previous findings,[1 4 38] except for item 9 ('worrying about low blood sugar reactions'). However, it is essential to acknowledge its relevance given the elevated mean score (50.1 (24.4)) shown in the fear of complications subdimension, where this item is included. Indeed, the leading subdimensions within our cohort are fear of complications and diabetes burnout, the last capturing the sense of being heavily loaded or overwhelmed by the demands of managing diabetes. Interestingly, DD related to social relationships appears to be a minor concern among our participants, suggesting that this subdimension may not be as pressing as worrying about complications and the challenges and burden of self-management.

Despite the lack of a strong and significant correlation between current clinically diagnosed complications (other than retinopathy) and DD levels, the subdimension fear of complications emerges as the primary source of distress. These results indicate an increased fear of severe complications and coping with other complications that also include the daily challenges and minor

complications associated with diabetes management, such as insulin management issues or fear of hypoglycemia. Moreover, there is a trend linking severe hypoglycemia and DKA events with DD levels (table 2); however, these correlations may not have reached significance due to a lack of statistical power.

Determinants of DD

Our analysis revealed that using advanced diabetes management technologies such as CGM and AID does not directly correlate with lower DD. The only subdimension of DD that was reduced in the participants using AID systems was eating-related distress (figure 1d). This finding emphasizes that while AID systems can address specific regimen challenges, they do not fully alleviate the emotional and psychological challenges associated with living with diabetes, such as the feeling of being burned out by diabetes management, as supported by the IMPLIQUE study, a multicentre longitudinal real-life study conducetd in French university hospitals.[6]

Our study confirms that female sex and younger age are associated with higher levels of DD. Notably, the difference between females and males is very marked, with the first reporting substantially higher PAID scores. Smoking is associated with high DD, as noted in other studies.[4] Additionally, we observed that social vulnerability has a strong association with DD, emphasizing the need for socioeconomic-appropriate support services and interventions. Moreover, the significant correlation of smoking status with DD and the observed trend in increased physical activity (table 1) suggests that lifestyle factors play a role in the emotional well-being of individuals with type 1 diabetes.

We observed increased HbA1c and GRI values from low to moderate to high DD (table 1). While not statistically significant, this trend aligns with previous studies[4 34] that suggest tighter glycemic control is associated with lower DD. However, it is interesting that no direct correlation was found to CGM use (table 2). This suggests that while CGM is beneficial for achieving management targets, the relationship between these and DD is not bound to CGM use alone.

Our study reveals the central role of DD in diabetes burden, demonstrated by the significantly strong correlation between almost all mental health determinants, assessed with several PROs, and PAID levels (table 2; figure 2). Our results align with previous studies,[1 3 41 44] which found that individuals experiencing higher DD also report increased depression scores, disordered eating behaviors, lower self-management actions, diminished self-esteem and lower quality of life. Furthermore, our study enhances the understanding of DD by analyzing its correlations with sleep quality, insulin misuse, hypoglycemia awareness, treatment and glycemic burden, and treatment satisfaction.

Strengths and limitations

In our analysis, there is a risk of selection bias. To assess this, we conducted a sensitivity analysis (online supplemental table S2), which showed that the characteristics of individuals who did not respond to the PAID questionnaire included factors typically associated with both higher (eg, lower age) and lower (eg, fewer females) levels of DD. While these opposing effects may suggest a minimal impact on the overall prevalence of DD in our study, further research is needed to fully understand any potential influence. Additionally, the study encompasses a diverse array of centers representing various regions of France and different healthcare settings, thereby mitigating the risk of selection bias.

The inherent limitations of the cross-sectional study design constrain the capacity to establish temporal relationships between the study variables and the observed levels of DD. Furthermore, it is essential to note that the PAID questionnaire was administered 3 months after the baseline visit. It may introduce additional limitations, as changes in participants' conditions or treatment regimens during this period could influence the reported scores.

Despite these limitations, a key strength of our study is the large and diverse sample size, which allows for a comprehensive analysis of DD among adults with type 1 diabetes. To our knowledge, our analysis in the SFDT1 study is the second largest (after Hernar *et al*)[4] and the most comprehensive clinical and digital phenotyping of people with type 1 diabetes according to their levels of DD, as it integrates individual, clinical, complications-related, and psychological characteristics and a joint analysis of DD overall and according to key DD subdimensions. The adherence to robust methodological standards and a high-quality dataset enhances the validity of our results.

Future directions

Prevention-focused, tailored interventions that specifically target DD reduction are essential, especially for high-risk groups (eg, females, younger age, socially vulnerable) and key distress subdimensions, such as fear of complications and diabetes burnout. For example, cognitive–behavioral therapy tailored to DD often involves identifying and managing negative thoughts related to mood, beliefs about diabetes, and self-management challenges.[45] This could help patients reduce high levels of fear of complications and diabetes burnout by enhancing stress management skills. Moreover, psychoeducational initiatives focused on the link between physical and mental health may also prevent escalating and/or reducing DD.

Future studies should investigate the centrality of DD within the spectrum of diabetes burden. Moreover, there is a need to better assess how technological advancements, like AID systems, can be optimized to address psychological dimensions of diabetes care. These types of studies, ideally in varied geographical and cultural contexts, could expand on our work to enhance the generalizability of our findings.

Finally, longitudinal research is crucial to unraveling the temporal dynamics of DD,[1] offering insights into its onset, progression, or the long-term effects of various intervention strategies. Such studies could inform on the pathways through which reduced DD can also improve glycemic outcomes. Additionally, while CGM use provides clear benefits for diabetes management, these advantages may not directly correlate with reductions in DD. It is important to address this complex relationship to better understand the dynamics between glycemic control, DD, and the use of CGM in diabetes management.

CONCLUSION

We found high DD to be more common than previously described, affecting nearly half of the large SFDT1 study participants, regardless of their therapeutic modality. We identified potential determinants of DD and its subdimensions, including sociodemographic factors, such as social vulnerability and sex, which were shown to be strongly correlated with high DD. We also showed the central role of DD to other dimensions of diabetes burden.

Our findings highlight the need for more holistic and tailored prevention and intervention strategies that address the psychological and emotional dimensions of diabetes, alongside the clinical aspects.

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Contributors GF conceptualized the study. DC wrote the first draft. J-PR and EC are the coprincipal investigators. DC, GA, GF, J-PR, FA and EC had full access to the data in the study, verified the data and had full responsibility for the decision to submit and publish. DC performed the statistical analyses. DC, GA, GF, J-PR, FA and EC wrote the statistical analysis plan (SAP). All authors read the SAP, critically revised it for important intellectual content and approved the final version. All authors read the manuscript, critically revised it for academic content and approved the final version. GF is the guarantor of this work and, as such, has full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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REFERENCES

1 Skinner TC, Joensen L, Parkin T. Twenty-five years of diabetes distress research. *Diabet Med* 2020;37:393–400.
2 Dennick K, Sturt J, Hessler D, *et al*. High rates of elevated diabetes distress in research populations: A systematic review and meta-analysis. *International Diabetes Nursing* 2015;12:93–107.
3 Schmitt A, Bendig E, Baumeister H, *et al*. Associations of depression and diabetes distress with self-management behavior and glycemic control. *Health Psychol* 2021;40:113–24.
4 Hernar I, G. Cooper J, M. Nilsen R, *et al*. Diabetes distress and associations with demographic and clinical variables. A nationwide population-based registry study of 10,186 adults with type 1 diabetes in Norway. *Diabetes Care* 2023.
5 Todd PJ, Edwards F, Spratling L, *et al*. Evaluating the relationships of hypoglycaemia and HbA1c with screening-detected diabetes distress in type 1 diabetes. *Endocrino Diabet & Metabol* 2018;1.
6 Reznik Y, Bonnemaison E, Fagherazzi G, *et al*. The use of an automated insulin delivery system is associated with a reduction in diabetes distress and improvement in quality of life in people with type 1 diabetes. *Diabetes Obes Metab* 2024;26:1962–6.
7 ElSayed NA, Aleppo G, Aroda VR, *et al*. 5. Facilitating Positive Health Behaviors and Well-being to Improve Health Outcomes: Standards of Care in Diabetes-2023. *Diabetes Care* 2023;46:S68–96.
8 Rodríguez-Muñoz A, Picón-César MJ, Tinahones FJ, *et al*. Type 1 diabetes-related distress: Current implications in care. *Eur J Intern Med* 2024;125:19–27.
9 Riveline JP, Vergés B, Detournay B, *et al*. Design of a prospective, longitudinal cohort of people living with type 1 diabetes exploring factors associated with the residual cardiovascular risk and other diabetes-related complications: The SFDT1 study. *Diabetes Metab* 2022;48:101306.
10 Polonsky WH, Anderson BJ, Lohrer PA, *et al*. Assessment of diabetes-related distress. *Diabetes Care* 1995;18:754–60.
11 Dennick K, Sturt J, Speight J. What is diabetes distress and how can we measure it? A narrative review and conceptual model. *J Diabetes Complications* 2017;31:898–911.
12 Kaiser HF. An Index of Factorial Simplicity. *Psychometrika* 1974;39:31–6.
13 Zwick WR, Velicer WF. Comparison of five rules for determining the number of components to retain. *Psychol Bull* 1986;99:432–42.
14 Shao K, Elahi Shirvan M, Alamer A. How Accurate Is Your Correlation? Different Methods Derive Different Results and Different Interpretations. *Front Psychol* 2022;13:901412.
15 Guilloteau A, Binquet C, Bourredjem A, *et al*. Social deprivation among socio-economic contrasted french areas: Using item response theory analysis to assess differential item functioning of the EPICES questionnaire in stroke patients. *PLoS One* 2020;15:e0230661.
16 Craig CL, Marshall AL, Sjöström M, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;35:1381–95.
17 Drinking Patterns and Their Definitions. *Alcohol Res* 2018;39:17.
18 Kidney Disease: Improving Global Outcomes (KDIGO) Diabetes Work Group. KDIGO 2020 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease. *Kidney Int* 2020;98:S1–115.
19 Inker LA, Eneanya ND, Coresh J, *et al*. New Creatinine- and Cystatin C-Based Equations to Estimate GFR without Race. *N Engl J Med* 2021;385:1737–49.
20 Feldman EL, Stevens MJ, Thomas PK, *et al*. A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care* 1994;17:1281–9.
21 Krzemińska S, Bąk E, Šáteková L, *et al*. Comparison of Diabetes-Dependent Quality of Life (ADDQoL) in Patients with T2DM in Poland, The Czech Republic, and Slovakia. *Diabetes Metab Syndr Obes* 2020;13:3773–86.
22 Devlin N, Pickard S, Busschbach J. The Development of the EQ-5D-5L and Its Value Sets. Cham (CH): Springer, 2022.
23 Buysse DJ, Reynolds CF III, Monk TH, *et al*. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213.
24 Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: A systematic review and meta-analysis. *Sleep Med Rev* 2017;31:91–101.
25 Luck AJ, Morgan JF, Reid F, *et al*. The SCOFF questionnaire and clinical interview for eating disorders in general practice: comparative study. *BMJ* 2002;325:755–6.
26 Gold AE, MacLeod KM, Frier BM. Frequency of severe hypoglycemia in patients with type I diabetes with impaired awareness of hypoglycemia. *Diabetes Care* 1994;17:697–703.
27 Gonder-Frederick LA, Schmidt KM, Vajda KA, *et al*. Psychometric properties of the hypoglycemia fear survey-ii for adults with type 1 diabetes. *Diabetes Care* 2011;34:801–6.
28 Tran V-T, Montori VM, Eton DT, *et al*. Development and description of measurement properties of an instrument to assess treatment burden among patients with multiple chronic conditions. *BMC Med* 2012;10:68.
29 Saisho Y. Use of Diabetes Treatment Satisfaction Questionnaire in Diabetes Care: Importance of Patient-Reported Outcomes. *Int J Environ Res Public Health* 2018;15:947.
30 Buuren S, mice G-O. Multivariate Imputation by Chained Equations inR. *J Stat Softw* 2011.
31 White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. *Stat Med* 2011;30:377–99.
32 van Buuren S. *Flexible Imputation of Missing Data*. 2nd edn. Chapman and Hall/CRC, 2018.
33 Oberman HI. Ggmice (version v0.0.1) [computer software]. 2022. Available: https://github.com/amices/ggmice
34 de Wit M, Pouwer F, Snoek FJ. How to identify clinically significant diabetes distress using the Problem Areas in Diabetes (PAID) scale in adults with diabetes treated in primary or secondary care? Evidence for new cut points based on latent class analyses. *BMJ Open* 2022;12:e056304.
35 Armstrong RA. When to use the Bonferroni correction. *Ophthalmic Physiol Opt* 2014;34:502–8.
36 3.1 Kaiser-Meyer-Olkin (KMO), Available: https://bookdown.org/luguben/EFA_in_R/kaiser-meyer-olkin-kmo.html
37 Living conditions in Europe - poverty and social exclusion, Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_poverty_and_social_exclusion [Accessed 29 Apr 2024].
38 Grulovic N, Rojnic Kuzman M, Baretic M. Prevalence and predictors of diabetes-related distress in adults with type 1 diabetes. *Sci Rep* 2022;12:15758.
39 Mach C, Bulanadi J, Gucciardi E, *et al*. Exploring the Needs of Adults Living With Type 1 or Type 2 Diabetes Distress Using the Problem Areas in Diabetes 5 Tool. *Can J Diabetes* 2023;47:51–7.
40 McGuire BE, Morrison TG, Hermanns N, *et al*. Short-form measures of diabetes-related emotional distress: the Problem Areas in Diabetes Scale (PAID)-5 and PAID-1. *Diabetologia* 2010;53:66–9.
41 Embaye J, Bassi G, Dingemans AE, *et al*. Associations between disordered eating behaviour, diabetes distress and emotion regulation strategies in adults with type 1 diabetes: Results from a Dutch-Italian cross-sectional study. *Diabet Med* 2023;40:e15122.
42 Huisman SD, Hendrieckx C, Bot M, *et al*. Prevalence, associations and health outcomes of binge eating in adults with type 1 or type 2 diabetes: Results from Diabetes MILES - The Netherlands. *Diabet Med* 2023;40:e14953.
43 Rickwood DJ, Coleman-Rose CL. The effect of survey administration mode on youth mental health measures: Social desirability bias and sensitive questions. *Heliyon* 2023;9:e20131.
44 Powers MA, Richter SA, Ackard DM, *et al*. Diabetes Distress Among Persons With Type 1 Diabetes. *Diabetes Educ* 2017;43:105–13.
45 Jenkinson E, Knoop I, Hudson JL, *et al*. The effectiveness of cognitive behavioural therapy and third-wave cognitive behavioural interventions on diabetes-related distress: A systematic review and meta-analysis. *Diabet Med* 2022;39:e14948.