



Research article

Using person reported outcomes: Psychometric properties of the German diabetes treatment satisfaction questionnaire (DTSQ) for teens and parents

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ABSTRACT

Aims: To examine psychometric properties including the factor structure of the German versions of the Diabetes Treatment Satisfaction Questionnaire for teens and parents (DTSQ-T/-P).

Methods: Linguistically validated questionnaires were completed by 363 adolescents with type 1 diabetes and 655 parent-caregivers in a multicenter study. Confirmatory factor analysis (CFA), reliability, and correlations were examined.

Results: CFA confirmed the 2-factor model of *treatment satisfaction (TS)* & *perceived diabetes control (PDC)* with an adjustment of removing the "medical support" item from the *TS* and examining it as a single item in this study. Cronbach's α of *TS* for DTSQ-T/-P was 0.82 & 0.83, respectively, and α of the two-item *PDC* factor was 0.70 & 0.60, respectively. The DTSQ scale scores positively correlated with time in range and inversely correlated with HbA1c. Scale scores of DTSQ-T/-P showed significantly positive relations to the KIDSCREEN-10 Index and negative associations with the Problem Areas in Diabetes (PAID). The *TS* of the parents was correlated with depressive symptoms measured in the Patient Health Questionnaire-9.

Conclusions: The DTSQ-T/-P produced psychometrically sound scores in measuring diabetes treatment satisfaction in German teens with type 1 diabetes and their parents. German DTSQ versions for teens and parents are recommended in research and clinical practice.

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1. Introduction

Type 1 diabetes is one of the most common chronic conditions among children with a rising incidence worldwide [1]. To prevent devastating short- and long-term complications, continuous daily monitoring and management of the condition is required [2,3]. However, diabetes management is particularly challenging in the adolescent years because the multifaceted developmental changes of teenage years often interfere with diabetes treatment goals [4–6]. As a result, the suboptimal glycemic outcome is frequently evidenced in adolescents and is often accompanied by diabetes distress, psychological comorbidities [5–9], and reduced quality of life for teens and their parents [6,10]. Recognizing this important relationship, a holistic approach to diabetes management has been suggested including monitoring the psychosocial impact of diabetes for the whole family instead of exclusively relying on clinical outcomes such as HbA1c as a marker of successful diabetes management [6,11,12]. To achieve this goal, the use of person-reported outcomes (PROs) has been recommended. PROs assess information about how the person functions or feels in relation to a health condition and its treatment and can supplement and/or enhance clinical outcome measures [11].

One of the important PROs emerging in diabetes care is treatment satisfaction. Evidence suggests a patient's view of his or her treatment experience is linked to adherence, perceived diabetes burden, and clinical outcomes [12,13]. The Diabetes Treatment Satisfaction Questionnaire (DTSQ) [14,15] is a frequently used measure of treatment satisfaction worldwide [12,16]. The eight-item DTSQ for adults has been used extensively and demonstrated two underlying constructs, treatment satisfaction, and glycemic control [17,18]. Considering the importance of assessing treatment satisfaction, the teen and parent versions of DTSQ have been developed along similar lines to the eight-item DTSQ for adults following interviews with teenagers with diabetes and parents of children of all ages with diabetes in the UK and translated into multiple languages [14,15,19]. The initial 12-item teen- and 13-item parent-version in English have been evaluated and reported two components: treatment satisfaction and perceived diabetes control. Nevertheless, compared to the adult DTSQ, the DTSQ-teen and -parent versions have different types and numbers of items. Moreover, since the development of these versions, an additional item was introduced to the parent version to deliver the most recent version, the 14-item DTSQ for parents [20]. Despite the importance of accurate assessment of treatment satisfaction among teens and their parents, the use of these two instruments has been limited compared to the DTSQ for adults. The DTSQ for teens and parents have been examined in English in the original development work, but the sample sizes were less than ideal (teen $n = 38$, parent $n = 90$) and the psychometric properties in languages other than English have not been examined thus far. Given that tremendous progress has been made in diabetes treatment in the last decade, the examination of treatment satisfaction and its relation to metabolic and psychological measures is essential.

The goal of this study was to examine the psychometric properties of the German versions of 12- and 14-item Diabetes Treatment Satisfaction Questionnaire-Teen (DTSQ-T) and -Parent (DTSQ-P) to provide a tool that can be used in both clinical and research settings. A threefold research aim emerged from this goal 1) to confirm factor structures, 2) to provide internal consistency, and 3) to examine relations between the German DTSQ-T/-P with socio-demographic and clinical measures, and other PROs (Problem Areas in Diabetes Scale (PAID), KIDSCREEN10-Index, and Patient Health Questionnaire (PHQ-9)).

2. Methods

2.1. Participants and procedure

Adolescents between the ages of 13 and 18 years with type 1 diabetes diagnosis duration of at least one year and their parents were recruited from five pediatric diabetes centers in Germany (Bad Kösen, Hamburg, Hannover, Lübeck, and Tübingen). An additional group of parents of younger children (7–12 years) also completed the questionnaire as the DTSQ-P is developed for parents of all children ≤ 18 years. These parents were eligible if they had a child meeting the diabetes duration criteria. All participants were German-speaking.

Data were collected between January 2021 and December 2022. Participants were recruited by in-clinic solicitation in a waiting area. Participating teens and parents were informed of the purposes and anonymous data collection process of the study and provided verbal consent. No medical records were viewed for this study. Participants self-administered the questionnaire and put them in a mailbox located in the waiting area upon departure. For the teen and parent dyad group, the lack of completion of the questionnaire by one party was not an exclusion criterion for the other. This study was approved and monitored by the Ethical Committee on Human Studies at Hannover Medical School (no. 9359_BO_K_2020) in accordance with the Declaration of Helsinki.

2.2. Measures

2.2.1. Socio-demographic and clinical measures

Demographic information included gender, age, living arrangement, parental education, and migrant status. Youth clinical measures were disease duration, current use of insulin pump and continuous glucose monitoring (CGM), and the average number of glucose checks per day. The current HbA1c, and time in range (TiR) (70–180 mg/dL based on the last 14 days) were provided by the healthcare provider during the check-up and recorded in the questionnaire by the participant.

2.2.2. DTSQ-T and DTSQ-P

The 12-item DTSQ-T and 14-item DTSQ-P assess diabetes treatment satisfaction over the past few weeks from the teens' and parents' perspectives (e.g., "How satisfied are you with your current treatment?" and "How satisfied are you with your child's current

treatment?”). Each question is answered on a 7-point Likert scale (e.g., 6 = “very satisfied” to 0 = “very dissatisfied”) with higher scores representing greater satisfaction. The *treatment satisfaction* (TS) scale score is created by summing eight items for teens and 10 items for parents [19]. The *perceived diabetes control* (PDC) scale score is calculated by adding two items, “control” and “perceived frequency (p. freq.) of hyperglycemia” for both teens and parents [19]. The “p. freq. of hypoglycemia” item is analyzed separately as a single item in both versions of DTSQ. The “low discomfort” for teens was also recommended for use as a single item. In the present study, we also examined the recently added item “own life” of the DTSQ-P in TS. Cronbach’s α s for TS of teens and parents of the English-speaking sample were 0.86 and 0.80, respectively, and α s for PDC were 0.77 and 0.57 [19]. The translated versions and permission to use DTSQ-T/-P were obtained from the author of DTSQ (Prof. Clare Bradley).

2.2.3. PAID-teen and -parent

The 14-item PAID-T measures diabetes-specific distress in adolescents with diabetes. The 15-item PAID for parents of teens and 16-item PAID for parents of younger children evaluate parents’ own diabetes-specific distress. As we include parents of both teens and younger children, these two versions are referred to as the PAID-Parent (PAID-P) hereafter. Respondents rate how much each item bothered them over the past month using a 6-point Likert scale (1 = “Not a Problem” to 6 = “Serious Problem”) with higher scores indicating greater distress. Both PAID-T/-P have demonstrated excellent reliability in the US (Cronbach’s α s = 0.93 & 0.94, respectively) and German samples (α s = 0.91 & 0.93) [21,22].

2.2.4. KIDSCREEN-10 index for self and proxy

The KIDSCREEN-10 Index provides a singular index of global health-related quality of life (HRQoL) addressing physical, psychological, and social dimensions in healthy and chronically ill children and adolescents [23–25]. Ten items are rated on a 5-point Likert scale ranging from “never” (1) to “always” (5) with the time frame referring to the last week. Higher values indicate a better HRQoL. Cronbach’s α for self-version and proxy-version was 0.82 and 0.78, respectively, and test-retest reliability was 0.70 and 0.67, respectively [23].

2.2.5. Patient Health Questionnaire (PHQ-9)

Participating parents were asked about symptoms of depression using a 4-point Likert scale ranging from “not at all” (0) to “nearly every day” (3) with the time frame referring to the last two weeks. The summed total score can range from 0 to 27 with a higher score indicating a higher probability of depression. The PHQ-9 demonstrated great reliability (Cronbach’s α = 0.89) and test-retest reliability of 0.84 [26].

2.3. Statistical analyses

Data were analyzed by using IBM SPSS Statistics for Windows, version 28.0 (IBM Corporation, Armonk, N.Y., USA) and R’s lavaan package v0.6-12 (ROSSEL, 2012). The statistical significance was set at $p < .01$ (two-tailed) to account for the large sample size and multiple analyses. When appropriate, sensitivity analyses were conducted to confirm the results of the main analyses.

2.3.1. Confirmatory factor analysis (CFA)

Separate CFA for teens and parents was conducted with robust maximum likelihood estimation. Our final sample size of adolescents ($n = 363$) and parents ($n = 655$) was determined to be sufficient for CFA [27]. To evaluate the overall model fit, the χ^2 -statistic was used in combination with Tucker-Lewis-Index (TLI) ≥ 0.90 [28], Comparative-Fit-Index (CFI) ≥ 0.90 [29], Root-Mean-Square-Error of Approximation (RMSEA) ≤ 0.08 [30], and Standardized Root Mean Square Residual (SRMR) ≤ 0.08 [31] indicating a reasonable model fit. To assess convergent and discriminant validity of the constructs, the average variance extracted (AVE) was calculated and used to test the Fornell-Larcker-criterion (FLC) [32]. Each construct’s AVE should exceed 0.5, meaning that at least 50% of the indicators’ variance is explained by the construct. Fulfilling FLC indicates discriminant validity.

For teens and parents, previously proposed original 2-factor models [19] and a competing 1-factor model were examined. In case acceptable model fit was not achieved, alternative models were explored by examining modification indices [27]. Correlations between measurement errors were set free one by one between items starting with the largest estimated parameter change for covariance within factor and stopping when all model fit indices reached the threshold of acceptable model fit specified. Factor loading was also examined to assess the option of removing items while only considering theoretically logical adjustments.

2.3.2. Internal consistency and construct reliability

Cronbach’s $\alpha \geq 0.70$ was considered acceptable. To examine model-based construct reliability, McDonald’s ω was calculated based on CFA results or Bollen’s ω^* for factors with correlated measurement errors among the items. The ω and ω^* values ≥ 0.70 were considered acceptable [27,33,34].

2.3.3. Correlation with other outcomes

Correlation between DTSQ-T/-P scale scores with socio-demographic characteristics, clinical measures, and other PROs including PAID, KIDSCREEN-10 Index, and PHQ-9 was evaluated using Pearson’s and point-biserial correlation coefficients (r & r_{pb}) as appropriate. The correlation coefficient of 0.1–0.29 was considered small, 0.3–0.49 moderate, and ≥ 0.5 as large.

3. Results

Of the 921 families who met the inclusion criteria and were approached, 802 families (87.1% response rate) agreed to participate in the study. The detailed recruitment and data collection process is depicted as a flowchart in the supplementary document.

3.1. Data screening and data management

3.1.1. DTSQ

A total of 382 adolescents' data was available and 95% had no missing items. Of the 715 parents, 91.6% had no missing items. Participants with incomplete DTSQs were excluded from the analysis. Demographic information of these participants is provided in the supplementary document.

3.1.2. Other measures

For the PAID and PHQ-9 data, one missing value was replaced with the respondent-specific mean by using the remaining answered items to generate mean and summed total scores, respectively. For the KIDSCREEN-10 Index, a T-score was generated. Participants with incomplete demographic and clinical information were included and missing variables were handled by using the pairwise deletion method for analyses to maximize all data available.

3.2. Participant characteristics and DTSQ descriptives

The socio-demographic and clinical characteristics of the final sample of 363 teens and 655 parents are presented in [Table 1](#). The mean age of the teens was 15.1 (SD 1.5) years and 43% were female. The majority of parents (75%) were mothers, and 15% were born

Table 1
Demographic and clinical characteristics of 363 teens and 655 parents.

	Mean (SD) or n (%) ^b	
Teens^a		
Current age, yrs	15.1 (1.5)	
Female gender	152 (43.4%)	
Living with both parents	276 (76.9%)	
Diabetes duration, yrs	6.9 (4.1)	
HbA1c, %/mmol/mol	7.7 (1.1)/61 (12)	
Time in Range (70–180 mg/dL; 3.9–10.0 mmol/L) last 14 days, %	54.4 (18.0)	
Insulin pump use	209 (57.6%)	
CGM use	296 (81.5%)	
Number of glucose monitoring per day		
0	1 (0.3%)	
1-2	18 (5.0%)	
3-4	65 (18.0%)	
5-6	97 (26.9%)	
7-8	84 (23.3%)	
>9	96 (26.6%)	
Parents	Teens, n = 328	Children, n = 327
Age, yrs	47.3 (6.2)	42.3 (6.1)
Relationship to child, mother	243 (75.5%)	241 (74.6%)
Education, ≥12 years	177 (55.0%)	168 (51.4%)
Birthplace, Germany	267 (83.2%)	280 (87.2%)
Co-parenting (with a partner)	264 (83.0%)	283 (88.4%)
Child Characteristics		
Current age, yrs	15.0 (1.5)	10.1 (1.5)
Female gender	135 (43.7%)	146 (47.4%)
Diabetes duration, yrs	6.9 (4.2)	4 (2.7)
HbA1c, %/mmol/mol	7.8 (1.1)/61.3 (12.5)	7.3 (0.9)/56.6 (10.4)
Time in Range (70–180 mg/dL; 3.9–10.0 mmol/L) last 14 days, %	54.7 (17.9)	64.0 (16.8)
Insulin pump use	195 (59.5%)	198 (60.7%)
CGM use	268 (81.7%)	283 (86.5%)
Number of glucose monitoring per day		
0	2 (0.6%)	3 (0.9%)
1-2	14 (4.3%)	14 (4.3%)
3-4	55 (16.9%)	36 (11.0%)
5-6	86 (26.4%)	72 (22.0%)
7-8	78 (23.9%)	64 (19.6%)
>9	91 (27.9%)	138 (42.2%)

Note.

^a A subset of 305 teens and parents are dyad recruits.

^b The % is calculated excluding missing values.

Table 2
DTSQ teen and parent item descriptives and inter-rater agreement.

Item Description	Teens n = 363				Item	Parents n = 655				P ^a	Teen-Parent agreement n = 305		
	Mean	SD	Skew	Kurtosis		Mean	SD	Skew	Kurtosis		ICC ^b	95% CI	
1.Satisfied	4.54	1.28	-1.17	1.57	1.	4.65	1.22	-1.08	1.15	0.193	0.465	0.330	0.572
2.Control	3.83	1.27	-0.65	0.27	2.	3.88	1.21	-0.53	0.43	0.521	0.629	0.535	0.703
3.p. freq. of hyperglycemia ^c	2.64	1.20	0.07	-0.39	3.	2.50	1.26	0.17	-0.15	0.070	0.510	0.387	0.608
4.p. freq. of hypoglycemia ^c	4.15	1.22	-0.54	-0.30	4.	3.80	1.10	-0.44	-0.17	<0.0001	0.430	0.287	0.545
5.Ease	4.12	1.30	-0.58	0.00	5.	3.48	1.37	-0.37	-0.25	<0.0001	0.482	0.333	0.595
6.Adaptability/Flexibility	4.59	1.20	-1.01	1.11	6.	4.01	1.25	-0.33	-0.20	<0.0001	0.394	0.237	0.518
7.School day	4.17	1.44	-0.86	0.26	7.	3.80	1.44	-0.61	-0.10	<0.001	0.559	0.448	0.648
8.Liked activities	3.98	1.47	-0.54	-0.38	8.	3.99	1.26	-0.50	-0.25	0.948	0.403	0.252	0.524
					9.Family life	3.79	1.44	-0.56	-0.24	-	-	-	-
					10.Own life	3.50	1.47	-0.43	-0.54	-	-	-	-
9.Understanding	5.17	1.04	-1.78	4.09	11.	4.75	1.10	-1.20	1.95	<0.0001	0.044	-0.185	0.230
10.Low discomfort	4.73	1.53	-1.30	0.99	12.	3.99	1.61	-0.61	-0.54	<0.0001	0.379	0.223	0.503
11.Medical support	5.08	1.12	-1.37	1.58	13.	4.83	1.27	-1.15	0.92	0.002	0.381	0.227	0.505
12.Continue treatment	4.83	1.22	-1.27	1.65	14.	4.66	1.37	-1.26	1.28	0.058	0.482	0.351	0.587

Note.

^a *p*-value based on independent t-tests (two-tailed) between teen and parent groups.

^b Intraclass correlation coefficient (ICC) estimates were calculated with a two-way mixed effects model and absolute agreement of the teen-parent dyads.

^c Reverse scored: higher scores indicate more satisfaction with this item.

outside of Germany. The descriptives of DTSQ are provided in Table 2. None of the items had extreme skewness or kurtosis (Table 2) [35].

3.3. Comparison of parent-youth dyads

Teens generally reported higher scores with several items reaching statistical significance (Table 2). According to the intraclass correlation coefficient (ICC) for dyad samples, the “control” item was in good agreement among dyads but, the rest of the items agreed moderately (seven items) to poorly (four items).

3.4. CFA and internal consistency

3.4.1. DTSQ-teen

The fit of the 1-factor and original 2-factor model was not acceptable (Table 3). Given the poor model fit, an improved model was sought by examining modification indices of the original 2-factor model. A modified 2-factor model after including two error correlations between “medical support” and “continue treatment” items, and between “medical support” and “satisfied” items achieved acceptable model fit. Both factors reached sufficient model-based reliability (TS: $\omega^* = 0.79$; PDC: $\omega = 0.74$) but AVE for TS was too low (0.38) and the factor did not meet FLC.

Because the “medical support” item showed severely low indicator reliability in the original 2-factor model (TS explaining only 22.9% of this item’s variance), we have also examined an alternate 2-factor model without this item. This model achieved an acceptable model fit (Table 3). The PDC showed sufficient AVE (=0.59) and met FLC, indicating both convergent and discriminant validity. However, AVE for TS was too low (0.40) and the factor did not meet FLC. See Table 4 for factor loading, AVE, and reliability measures of the original and alternate 2-factor models.

3.4.2. DTSQ-parent

The fit indices of the 1-factor and original 2-factor were not acceptable for parents (Table 3). Modification indices of the original 2-factor model indicated the correlated measurement errors among items “medical support”, “continue treatment”, and “satisfied”. The modified 2-factor model showed good model fit (Table 3). The TS factor showed good construct reliability ($\omega^* = 0.80$) but insufficient convergent and discriminant validity with AVE = 0.36. The PDC factor showed low construct reliability ($\omega = 0.66$) but sufficient convergent and discriminant validity (AVE = 0.52 and met FLC).

As a parallel model to the teens’ alternate 2-factor model, the original 2-factor model excluding “medical support” was examined and showed acceptable model fit (Table 3). Construct reliability for TS was good ($\omega = 0.84$), but AVE was below the cut-off (0.38). The PDC factor showed low construct reliability ($\omega = 0.67$), but sufficient AVE (0.52) meeting the FLC indicating discriminant validity (Table 4). The newly developed item “own life” had a factor loading of 0.808 on TS in the alternate 2-factor model, but adding this item led to a substantial decrease in overall model fit (Table 3).

Table 3
Confirmatory factor analyses with one- and two-factor models for teens and parents.

	TS items	PDC items	χ^2	df	p	TLI	CFI	RMSEA	(90%CI)	SRMR
Teens, n = 363										
1-Factor Model	1,2,3,5,6,7,8,9,11,12		168.651	35	<0.001	0.781	0.830	0.103	0.090; 0.116	0.073
2-Factor Model										
Original	1,5,6,7,8,9,11,12	2,3	122.705	34	<0.001	0.850	0.887	0.085	0.071; 0.099	0.061
Modified (11&12, 1&11)	1,5,6,7,8,9,11,12	2,3	79.842	32	<0.001	0.914	0.939	0.064	0.049; 0.079	0.048
Alternate (item 11 removed)	1,5,6,7,8,9,12	2,3	71.977	26	<0.001	0.906	0.932	0.070	0.054; 0.086	0.049
Parents, n = 655										
1-Factor Model	1,2,3,5,6,7,8,9,11,12,13,14		373.025	54	<0.001	0.797	0.834	0.095	0.087; 0.103	0.065
2-Factor Model										
Original	1,5,6,7,8,9,11,12,13,14	2,3	321.946	53	<0.001	0.825	0.860	0.088	0.080; 0.096	0.060
Modified (13&14, 1&13, 1&14)	1,5,6,7,8,9,11,12,13,14	2,3	184.723	50	<0.001	0.907	0.930	0.064	0.055; 0.073	0.046
Alternate (item 13 removed)	1,5,6,7,8,9,11,12,14	2,3	186.925	43	<0.001	0.889	0.913	0.071	0.062; 0.081	0.049
Alternate (item 13 removed) & 10 added	1,5,6,7,8,9,10,11,12,14	2,3	320.119	53	<0.001	0.846	0.876	0.088	0.080; 0.096	0.057

Note. TS = Treatment Satisfaction; PDC = Perceived Diabetes Control. Acceptable model fit cutoffs: TLI & CFI ≥ 0.9 ; RMSEA & SRMR ≤ 0.08 .

Table 4

Factor loading, AVE, and reliability measures for the original 2-factor and alternate 2-factor models for 363 teens and 655 parents.

Item Description	Teens				Item Description	Parents			
	Original 2-Factor		Alternate 2-Factor (11 removed)			Original 2-Factor		Alternate 2-Factor (13 removed)	
	TS	PDC	TS	PDC		TS	PDC	TS	PDC
1.Satisfied	0.628		0.596		1.Satisfied	0.580		0.549	
2.Control		0.908		0.907	2.Control		0.923		0.909
3.p. freq. of hyperglycemia		0.598		0.599	3.p. freq. of hyperglycemia		0.461		0.468
5.Ease	0.615		0.610		5.Ease	0.634		0.646	
6.Adaptability/Flexibility	0.693		0.720		6.Adaptability/Flexibility	0.595		0.602	
7.School day	0.738		0.760		7.School day	0.666		0.680	
8.Liked activities	0.623		0.626		8.Liked activities	0.685		0.707	
9.Understanding	0.519		0.522		9.Family life	0.733		0.750	
11.Medical support	0.479		–	–	11.Understanding	0.469		0.451	
12.Continue treatment	0.625		0.586		12.Low discomfort	0.434		0.431	
AVE	0.384	0.591	0.404	0.591	13.Medical support	0.561		–	–
McDonald's ω^a			0.824	0.735	14.Continue treatment	0.658		0.614	
Cronbach's α	0.831	0.703	0.822	0.703		0.370	0.532	0.375	0.523
						0.848	0.597	0.840	0.665
								0.834	0.597

Note. TS = Treatment Satisfaction; PDC = Perceived Diabetes Control.

^a McDonald's omega is provided for the model with acceptable fit.

3.5. Correlates of DTSQ

The female gender of the teen was associated with lower satisfaction with comfort in DTSQ-T (see Table 5) and the independent *t*-test also confirmed the difference ($t(348) = 2.73, p = 0.007, \text{Cohen's } d = 0.294$). The *p*-values for all correlation coefficients are provided in the supplementary document. No significant correlations were found between the scale scores of DTSQ-T/-P and further demographic measures except for the *TS* scores of DTSQ-P showing a small magnitude of correlation with the increase in age of teens and parents. The increase in DTSQ scale scores was associated with lower HbA1c values and higher TiR for both teens and parents: *PDC* scores had the strongest magnitude of relations with these clinical measures. The average number of glucose checks was positively correlated only with DTSQ-T. Overall, clinical measures were correlated with the *TS* of DTSQ-T with greater magnitude than with the parents' *TS*. The use of an insulin pump was significantly associated with low satisfaction concerning treatment discomfort/pain in DTSQ-T and this finding was confirmed by the sensitivity analysis using a *t*-test (user = 4.55 (1.61), non-user = 4.97 (1.36), $t(361) = 2.61, p = 0.009, \text{Cohen's } d = 0.278$). However, the teens' satisfaction with "p. freq. of hypoglycemia" was higher for the pump users (Table 5) (user = 4.29 (1.25), non-user = 3.96 (1.17), $t(361) = -2.58, p = 0.010, \text{Cohen's } d = -0.275$). The CGM use did not make a difference in treatment satisfaction.

Large to moderate correlations were seen between DTSQ-T scale scores with PAID-T and KIDSCREEN-10 Index-T in the expected direction. Similarly, parents' reports on DTSQ scale scores had negative relations with PAID-P and PHQ-9; and positive relations with KIDSCREEN-10 Index-proxy (Table 5). The correlation of *TS* scores between teens and parents was $r = 0.436$ and *PDC* was $r = 0.514$, both significant at $p < 0.001$.

4. Discussion

The current study investigated the factor structure and psychometric properties of the translated version of the DTSQ-T/-P in a large representative German sample of teenagers with type 1 diabetes ($n = 363$) and parent-caregivers ($n = 655$). Of the more than 20 linguistically translated available versions of DTSQ-T/-P to date (healthpsychologyresearch.com), to the best of our knowledge, this was the first study to examine the psychometric properties of DTSQ-T/-P in languages other than English. Our results demonstrate that the DTSQ-T/-P produced psychometrically sound scores in measuring diabetes *TS* and *PDC* and support the previously suggested 2-factor model with an adjustment in German teens with diabetes and parents.

CFA of the original 2-factor model did not provide good fit for our data but this model revealed notably correlated error variances among "medical support", "continue treatment" and "satisfied" items in both teen and parent reports. This could mean either the information these items deliver is redundant or the existence of an unspecified factor underlying these items. Conceptually, satisfaction with support received from medical staff differs from satisfaction with the treatment itself even though it is part of the overarching construct of treatment satisfaction. Statistically, the "medical support" item had the lowest loading for teens in the original 2-factor model, with *TS* accounting for only 23% of this item's variance. Taken together, an alternative approach to the original 2-factor model, with "medical support" removed from the *TS* scale deemed appropriate. This alternate 2-factor model provided acceptable model fit for DTSQ-T and its parallel 2-factor model for DTSQ-P.

Interestingly, "medical support" was the highest-scoring item for parents and the second highest for teens. This might be a result of the German healthcare system requirement mandating treatment training for patients and caregivers at diagnosis and afterward, and the in-person quarterly check-up, often in the same clinic until transitioning to an adult diabetes center. All training and visits take

Table 5

Inter-correlations of DTSQ scale scores and single items with clinical and psychological measures, and normative data.

	Teens, n = 363					Parents, n = 655				
	TS, 7 ^a	PDC, 2	p. freq. of hypo.	Low Discomfort	Medical Support	TS, 9	PDC, 2	p. freq. of hypo.	Own life	Medical Support
Child Gender, female	-0.037	-0.106	-0.029	-0.145*	-0.116	0.035	0.005	-0.007	0.023	0.025
Child Age	0.043	-0.072	0.112	-0.031	-0.053	0.142**	-0.014	0.064	0.155**	0.076
Parent Gender, female	-0.003	-0.022	0.023	0.011	0.011	0.039	0.063	0.032	0.072	0.000
Parent Age	0.023	0.056	0.052	0.066	-0.002	0.138**	0.142**	0.018	0.081	0.033
Parent Education >12 yrs	0.023	0.043	0.022	-0.014	-0.044	-0.046	0.013	0.063	-0.071	-0.046
Parent German-born	0.046	-0.007	0.027	0.066	0.027	0.031	0.016	0.069	0.013	0.086
Living Arrangement ^b	-0.007	0.053	0.021	0.032	0.040	-0.001	-0.074	-0.034	-0.065	0.021
HbA1c	-0.359**	-0.468**	0.102	-0.121	-0.135	-0.178**	-0.443**	0.106*	-0.043	-0.088
Time in Range	0.237**	0.514**	-0.124	0.122	0.069	0.151*	0.465**	-0.083	0.062	0.005
Insulin pump use	0.086	-0.109	0.135	-0.136*	-0.014	0.040	0.008	0.051	0.027	-0.018
CGM use	0.078	0.073	-0.044	-0.001	-0.025	0.069	0.037	0.008	0.051	0.075
Glucose check	0.170*	0.222**	-0.012	0.003	-0.095	0.005	0.097	-0.077	-0.026	-0.063
Diabetes duration	0.043	-0.035	0.072	-0.025	-0.001	0.121*	-0.052	0.052	0.110*	0.047
PAID-T	-0.584**	-0.493**	-0.038	-0.250**	-0.171*	-0.374**	-0.372**	0.104	-0.306**	-0.185*
KIDSCREEN-10-T	0.446**	0.378**	0.078	0.284**	0.249**	0.160*	0.134*	-0.083	0.215**	0.079
PAID-P	-0.277**	-0.329**	0.024	-0.036	-0.064	-0.580**	-0.505**	0.001	-0.543**	-0.236**
KIDSCREEN-10-P	0.313**	0.379**	0.018	0.155*	0.115	0.439**	0.364**	0.029	0.365**	0.218**
PHQ-9	-0.113	-0.163*	-0.031	-0.080	-0.020	-0.382**	-0.207**	-0.120*	-0.398**	-0.155**
Mean (SD)	31.39 (6.27)	6.47 (2.17)				37.12 (7.96)	6.38 (2.09)			

Note. TS = Treatment Satisfaction; PDC = Perceived Diabetes Control; PAID: Problem Areas in Diabetes scale; PHQ-9: Patient Health Questionnaire, 9-item.

^a The number of items summed in the scale score.

^b Living with both parents for teens and single parent status for parents. * $p < .01$; ** $p < .001$ based on Pearson's or point-biserial correlation.

place with highly qualified pediatric diabetologists and interdisciplinary diabetes teams. This frequent interaction with a well-trained team of care providers may have led to reporting high satisfaction with “medical support”, and this, in turn, may be linked to satisfaction with the current treatment. How much medical support plays a role in patient satisfaction in ambulatory settings is interesting to pursue and lends support for retaining and examining “medical support” as a single item.

It should be mentioned that despite good model fit, the alternate 2-factor had less than ideal construct and discriminant validity. The AVE of the TS factor was low for both teens (0.404) and parents (0.375). As AVE means the amount of variance of the items' overall variance explained by the construct (40.4% and 37.5%, respectively), these low values indicate other influences on teens' and parents' answers to the items besides the TS factor. Further psychometric studies are warranted to confirm our alternate 2-factor model found in our sample study and importantly to report factor loading and AVE in addition to fit indices to further inspect construct and discriminant validity of DTSQ-T/-P.

Despite creating a parallel model representative of both versions of DTSQ in our study, the original 2-factor model for parents included two additional items in the TS scale, namely “low discomfort” and “own life”. Therefore, the resulting alternate 2-factor models of parents were not identical to that of teens. Considering the DTSQ-P is a proxy report, it is rather understandable that some items may carry different meanings and significance for parents. For instance, parents may consider pain and discomfort caused by the treatment to be more relevant and significant compared to teens. Literature indicates that parents worry about their children incessantly especially when their child is suffering from a chronic disease such as diabetes [36]. As evidenced in our data, parents reported lower satisfaction with “low discomfort” than the teens did. Pain or discomfort from the treatment is an important aspect of TS not only because comparisons of comfort based on treatment are important but also because this could be an indication of poor coping abilities associated with treatment-related pain in a subgroup of adolescents [37]. The inclusion of this item in the DTSQ-T, although not as part of the TS scale, is important in the identification of these teens and to help reduce the perception of treatment discomfort in this sub-group.

Another item relevant for parents and yet completely absent from the DTSQ-T is “family life”. In the alternate 2-factor model for DTSQ-P, this item had the highest factor loading: TS accounting for more than 56% of the item's variance. The TS aspect that applies to the entire family was important for parents in the original study and lends theoretical support for further introducing a new item assessing treatment satisfaction on parent's “own life”. Despite this, adding “own life” to the existing TS scale created unacceptable model fit for the alternate 2-factor model. Perhaps “own life” and “family life” create another dimension of treatment satisfaction specific to parent-caregivers, which is beyond the treatment satisfaction relevant for the child with diabetes. Other studies of child and parent versions of diabetes questionnaires have also demonstrated the existence of additional dimensions of disease burden for parent-caregivers [21,38] Similar to the findings in these studies, TS for parents carries an additional implication for the family and their own life. This construct further merits thorough evaluation, perhaps with additional items, and how this facet of treatment satisfaction is linked to a child's glucose control. Until further utility is demonstrated, “own life” should remain in the questionnaire as a single item

for the lack of good fit for this model.

Previous studies demonstrated that the reduced parental burden was seen with the increasing age of the child with diabetes [36, 39]. This probably reflects the greater autonomy of older children resulting in less treatment responsibility for parents. In our study, parents reported higher *TS* as the child got older corroborating existing evidence. The *TS* and *PDC* scores were directly related to better glycemic control and higher *TiR*, and support the findings seen in a Swedish sample of adolescents with diabetes [13]. Furthermore, our study revealed a noteworthy association between insulin pump usage in teenagers and increased discomfort/pain yet heightened satisfaction with “p. freq. of hypoglycemia” reported in *DTSQ-T*. The insulin pump use did not make a significant difference in overall *TS*, *PDC*, and “medical support”. Interestingly, *CGM* use was not linked to treatment satisfaction. This may be partially because a large proportion of our sample (81.5%) was using *CGM*. During our study period, no participant reported using an automated insulin delivery (*AID*). As the prevalence of the *AID* usage has surged in recent years, its influence on treatment satisfaction reported by young *AID* users and their parents becomes an imperative avenue for future investigation.

The relations with other *PROs* showed both scale scores of *DTSQ-T/-P* were significantly associated with *PAID-T/-P* and *KIDSCREEN-10 Index-T/-Proxy* in the expected direction. The scale scores were directly linked to lower diabetes burdens and higher *HRQoL*, and the *TS* scale of the teens and parents had the highest correlation with their respective *PAID* and *KIDSCREEN-10 Index*, demonstrating the good utility of the treatment satisfaction construct. Moreover, scale scores of *DTSQ-P* were inversely correlated with *PHQ-9*, and the single “own life” item alone was also significantly correlated with *PHQ-9*. Understandably, treatment satisfaction in the parents’ own life is linked to depressive symptoms as well as general diabetes treatment satisfaction. Although causality could not be established in this correlation, “own life” can provide valuable information for use in clinical settings.

The current study has several limitations. Inherent to the anonymous study design, the missing items could not be controlled, and demographic and clinical information could not be confirmed for accuracy. The external validity of the study findings should be considered within the limitation of the sampling method given that families unable to provide verbal consent or complete the questionnaire in German were excluded from participation. Moreover, despite extending invitations to all families visiting one of these five clinics during the study period, the voluntary nature of questionnaire completion introduced the potential for self-selection bias. Similarly, the population demographics and patients’ experiences might differ based on the centers, particularly considering an unequal distribution of collected data from each center. Although our pooled sample is representative of the German youth with *T1D* in terms of *HbA1c*, and technology use [40,41], caution is advised in extrapolating our findings due to these biases. Finally, we used the *KIDSCREEN-10 Index* to examine a global *HRQoL*, but the *KIDSCREEN-10 Index* may not have been sensitive enough to detect issues specific to patients living with diabetes. As seen in our study, larger correlation coefficients between *DTSQ* with *PAID* in contrast to with *KIDSCREEN-10 index* perhaps indicate the use of *HRQoL* questionnaire specifically designed for patients with diabetes. Future studies ought to consider using diabetes-specific questionnaires [42].

Our study demonstrates that the German *DTSQ-T/-P* were in agreement with the previously suggested 2-factor structure with an adjustment of examining the “medical support” question as a single item. The *DTSQ* including a variety of single items and subscales addressing multifaceted components of treatment satisfaction in teens and parents seems to perform satisfactorily. Correlations between *DTSQ* with diabetes distress, *HRQoL*, and importantly with *HbA1c* and *TiR* establish utility in assessing treatment satisfaction in our German samples. The use of *DTSQ-T/-P* is recommended in assessing treatment satisfaction to compare and design diabetes treatment, and to aid in our understanding of psycho-behavioral components that tie the treatment and the end point of glycemic control to minimize acute and long-term complications. This tool may hold significance in the context of assessing treatment satisfaction, a crucial component of holistic diabetes treatment.

Data transparency statement

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Data availability statement

The datasets generated during the current study are available from the corresponding author upon reasonable request. For access to the *DTSQ*, visit www.healthpsychologyresearch.com.

CRediT authorship contribution statement

Su-Jong Kim-Dorner: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Heike Saßmann:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Bettina Heidtmann:** Writing – review & editing, Supervision, Project administration, Investigation. **Thomas M. Kapellen:** Writing – review & editing, Supervision, Project administration, Investigation. **Olga Kordonouri:** Writing – review & editing, Supervision, Project administration, Investigation. **Karolin M.E. Nettelrodt:** Writing – review & editing, Writing – original draft, Formal analysis. **Roland Schweizer:** Writing – review & editing, Supervision, Project administration, Investigation. **Simone von Sengbusch:** Writing – review & editing, Supervision, Project administration, Investigation. **Karin Lange:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Heike Saßmann reports financial support was provided by German diabetes association (Deutsche Diabetes Gesellschaft, DDG). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e27614>.

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