Psychometric Evaluation of the Adherence in Diabetes Questionnaire

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OBJECTIVE—To assess the psychometric properties of a short, new, self-administered questionnaire (17–19 items) for evaluating the adherence behavior of children and adolescents with type 1 diabetes and their caregivers. This instrument has separate versions depending on the means of insulin administration, i.e., continuous subcutaneous insulin infusion (Adherence in Diabetes Questionnaire [ADQ]-I), or conventional insulin injection (ADQ-C).

RESEARCH DESIGN AND METHODS—A total of 1,028 caregivers and 766 children and adolescents 2–17 years of age were recruited through the Danish Registry of Childhood Diabetes and completed the national web survey, including the ADQ and psychosocial measures of self-efficacy, parental support, family conflict, and aspects of diabetes-related quality of life. Blood samples were obtained for central HbA_{1c} analysis. The psychometric properties of the ADQ were evaluated, and the association with glycemic control was assessed.

RESULTS—There was good internal consistency for both the youth and caregiver reports and strong agreement between the caregiver and youth reports. Higher ADQ scores, indicating better adherence, were associated with better self-efficacy, more parental support, less diabetes-related conflict, and less experience with treatment barriers. Factor analysis supported maintaining the one-factor structure of the ADQ. Higher ADQ scores were associated with lower HbA_{1c} levels.

CONCLUSIONS—The ADQ showed good psychometric properties. Although the test-retest reliability and sensitivity to change of the instrument still need to be established, the ADQ appears to be a valuable tool for assessing adherence in families with children and adolescents with type 1 diabetes in both clinical and research settings.

It has long been acknowledged that adherence plays an important role in the glycemic control of young patients with type 1 diabetes mellitus (1). Ongoing efforts are needed to ensure that the measures used to assess adherence behavior in patients reflect the ever-evolving diabetes treatment and thus the current guidelines to which patients are expected to adhere. Even so, the increasing complexity of modern diabetes treatment poses a challenge for many of the existing measures used for evaluating adherence (2). For example, only a few self-reported instruments, such as the Self-Management of Type 1 Diabetes in Adolescents (SMOD-A) (3) and the Diabetes Behavior Rating Scale (DBRS) (4), have been able to fully adapt to the widespread use of continuous

subcutaneous insulin injection (CSII). On the other hand, these measures are quite extensive, making them less suitable for studies assessing multiple components related to diabetes care.

Shorter adherence measures have been used in some studies (5–7), but none adequately encompass all necessary elements of adherence in relation to diabetes care, including questions about CSII, while maintaining strong internal consistency and relevance to glycemic control.

The Diabetes Self-Management Profile (DSMP) is a widely used semistructured interview for the assessment of diabetes regimen adherence (4,8) that is both relatively short and sensitive to the use of insulin pumps. However, this instrument requires the use of trained

personnel to administer and to score the measure, which makes it less appropriate for larger surveys.

In order to conduct a national diabetes web survey in Danish children and adolescents with type 1 diabetes, we needed a short, self-reported adherence measure that was sensitive to different treatment regimens and applicable across a relatively wide pediatric age range. Accordingly, the Adherence in Diabetes Questionnaire (ADQ) was developed to assess components of adherence behavior in this population.

This report describes the development, evaluation, and validation of the self-administered ADQ and provides results about how this new instrument correlates with psychosocial variables and glycemic control.

RESEARCH DESIGN AND METHODS

—In the spring of 2009, a nationwide web survey was initiated to assess the influence of psychosocial variables on adherence, glycemic control, and quality of life in all Danish children and adolescents with type 1 diabetes.

The Danish Registry of Childhood Diabetes (the Registry) includes information about all children and adolescents treated at Danish diabetes centers (9). Based on information from the Registry, all families in Denmark with a child or adolescent between 2 and 17 years of age with a diagnosis of type 1 diabetes ($n = 1,716$) were invited to participate. We excluded families ($n = 258$) who were registered as being unwilling to participate in scientific research, who had an unlisted address, or who were no longer residing at the address registered in the Danish Civil Registration System.

All eligible families received a letter with detailed information about the study along with individualized web passwords for each potential participant. The caregiver who was primarily involved in the daily diabetes treatment of the child was asked to complete the web survey. Only children 10 years of age and older ($n = 1,390$) were asked to complete the ADQ. All families were asked to send in a blood sample from the child or adolescent. Blood samples were analyzed centrally at Glostrup Hospital, which is

responsible for all HbA$_{1c}$ measures included in the Registry.

The results described below are based on data collected in the national web survey, but only data pertaining to the testing of the ADQ are reported.

Development of the ADQ

The pediatric diabetes literature was reviewed to identify existing instruments that measured adherence, self-management, or self-care behavior. In particular, the revised version of the DBRS (4) was found to be inspirational, because it included separate instruments depending on the treatment modality of the child (CSII vs. conventional treatment). Based on the literature review and interviews with clinical providers of diabetes care, sample items reflecting current diabetes treatment recommendations were generated in Danish to cover the range of adherence behaviors and tasks. All items were reviewed by experts in pediatric endocrinology, clinical and developmental psychology, and child health behavior (n = 8). These experts identified inappropriate items, ensured adequacy of coverage of all relevant content areas, and recommended rewording of certain items. The ADQ was approved by the board of the Danish Society for Child and Adolescent Diabetes, which manages the Registry. After approval, to further assess the face validity of the instrument, it was distributed to all Danish pediatric diabetes clinics (n = 19) along with an invitation to comment on the content, ambiguities, and misleading or inappropriate questions. Subsequently, pilot testing of the ADQ and interviews was conducted in 4 children and adolescents with type 1 diabetes and their caregivers.

This refinement and testing process resulted in a shorter instrument with two slightly different versions depending on the diabetes treatment regimen: the Adherence in Diabetes Questionnaire–Conventional treatment (ADQ-C) and the Adherence in Diabetes Questionnaire–Insulin pump (ADQ-I). The ADQ-C has 19 items pertaining to adherence related to conventional and intensive diabetes treatment. The ADQ-I has 17 items regarding adherence behavior in children and adolescents using CSII in which the insulin injection–specific items have been replaced with items appropriate for pump users.

Both the ADQ-C and the ADQ-I include items about daily diabetes care practices, adjustments due to physical exercise, illness, and high or low blood glucose levels, and collaboration with diabetes health care staff. The ADQ-C and ADQ-I both include a child self-report version for children 10 years of age and older (ADQ-C-C and ADQ-I-C, respectively) plus a questionnaire for the parent/caregiver (ADQ-C-P and ADQ-I-P) with identical item content (Table 1).

All items are rated on a 5-point Likert scale with responses to the question "How did you (possibly with the help of your parents) within the preceding month manage your diabetes care with regard to…(child self-report)?"/"How did your child (possibly with your help) within the preceding month manage his/her diabetes care with regard to…(caregiver report)?" The response options range from "1 = haven't done it at all" to "5 = have always done it."

The ADQ is scored by calculating the mean of all item responses, with higher mean scores reflecting greater adherence (possible score range: 1.00–5.00). The questionnaire takes less than 10 min to complete.

Additional measures. Several other self-report measures of psychosocial variables were included to evaluate their possible association with the ADQ.

The Self-Efficacy for Diabetes Self-Management (SEDM) was completed by adolescents (12–17 years of age) as a measure of self-efficacy related to core elements of diabetes self-management in adolescents with type 1 diabetes in potentially problematic situations (10). The mean score was calculated, with a higher value indicating a more positive perception of self-efficacy. The SEDM has been shown previously to be both valid and reliable (α = 0.90) (10). The SEDM was translated into Danish through multiple-forward translation by a panel of three clinical and health psychologists and a pediatric endocrinologist, all of whom had good English skills. The translations were compared, and the discrepancies were discussed and reconciled by the panel before a final translation was tested with patients and caregivers.

The Diabetes Family Behavior Checklist (DFBC) was completed by children and adolescents to assess the perception of parental support and nonsupport pertaining to diabetes self-care regimens (11). The reliability and internal consistency of the subscales of the DFBC have been found previously to be adequate (11).

For the pilot study preceding this study (unpublished results), the DFBC was translated into Danish in accordance with the procedure described for SEDM.

Subscales of the Pediatric Quality of Life Inventory-Diabetes Module 3.0 (PedsQL DM) were completed by children and adolescents. The PedsQL DM encompasses five scales measuring: 1) diabetes symptoms, 2) treatment barriers, 3) treatment adherence, 4) worry, and 5) communication (12). Two of the PedsQL DM subscales ("treatment barriers" and "treatment adherence") were included in the current study as measures of convergent validity, because their correlation with adherence has previously been established (13). The reliability and validity of the PedsQL DM have previously been shown to be sufficient (12). The PedsQL DM was translated into Danish in accordance with the guidelines provided by the Mapi Research Institute and Dr. James W. Varni (14). The subscales are scored by calculating the mean score.

The Diabetes Family Conflict Scale (DFCS) was completed by participants to measure diabetes-related conflict in the family. The revised version of the DFCS, which was used in this study, has demonstrated strong psychometric properties regarding satisfactory internal consistency, ample concurrent validity, and predictive validity in relation to glycemic control (15). The DFCS is scored by calculating the sum score for all items.

The DFCS was translated into Danish following the procedure described for the SEDM.

Sociodemographic and clinical data, including household income, parental level of education and employment, family structure, and treatment regimen, were provided by participants. These data supplemented the data regarding the duration of diabetes and treatment that were provided by the Registry.

Ethics

The regulations of The Danish National Ethics Committee specify that questionnaire-based studies do not have to be approved. The project was registered at The Danish Data Protection Agency.

Statistical analysis

All analyses were performed using SPSS version 19.0 for Windows. Data are presented as means and SD unless otherwise indicated. Because this was a new measure, and correlations between items were expected, exploratory factor analysis with oblique rotation was performed to examine the factor structure of the ADQ. Eigenvalues >1, examination of scree plots, and Monte Carlo analysis were

Table 1—*The Adherence in Diabetes Questionnaire: Items and item mean scores*

	Youths on conventional treatment/youths on insulin pump	Caregivers to youths on conventional treatment/insulin pump
N	458/309	600/427
How did you (possibly with the help of your parents/caregivers) within the preceding month manage your diabetes care in relation to:		
1. Planning meals in accordance with the system that you've been taught?	3.09 ± 1.29/3.42 ± 1.25	3.47 ± 1.15/3.76 ± 1.08
2. Weighing or measuring your food, or counting carbohydrates?	2.50 ± 1.44/3.50 ± 1.38	2.68 ± 1.47/3.88 ± 1.16
3. Limiting the amount of food you eat that contains a lot of sugar or fat?	3.14 ± 1.20/3.03 ± 1.22	3.33 ± 1.15/3.32 ± 1.08
4. Taking the amount of insulin that your doctors prescribed (including adjustments based on blood glucose level)?	4.38 ± 0.92/4.49 ± 0.78	4.32 ± 0.93/4.43 ± 0.76
5. Taking your insulin at the right times?/*taking your insulin every time you eat?**	4.16 ± 0.80/4.39 ± 0.71	4.14 ± 0.87/4.47 ± 0.65
6. Alternating injection sites to avoid lipohypertrophy (buildup of lumps under the skin)?/*changing the pump site at least every three days?**	4.16 ± 1.05/4.36 ± 1.04	4.13 ± 1.06/4.45 ± 0.95
7. How often you should check your blood glucose?/*checking the injection site for infection?**	4.09 ± 0.95/4.14 ± 1.26	4.13 ± 0.96/4.47 ± 0.94
8. Measuring blood glucose before every meal?	4.06 ± 1.01/4.05 ± 0.82	4.14 ± 1.00/4.28 ± 0.77
9. Remembering to carry "fast sugar" (e.g., juice, dextrose, or the like)?	4.04 ± 1.16/4.17 ± 1.03	4.16 ± 1.06/4.24 ± 0.97
10. Exercising or participating in some form of physical activity?	4.07 ± 1.10/4.31 ± 0.94	3.86 ± 1.16/4.15 ± 1.01
11. Adjusting the amount of insulin or food based on how much and how strenuously you have exercised?	4.06 ± 1.11/4.05 ± 1.11	3.91 ± 1.14/3.94 ± 1.08
12. Adjusting the amount of insulin based on your blood glucose levels?	4.47 ± 0.87/4.51 ± 0.80	4.28 ± 0.98/4.52 ± 0.74
How do you generally handle your diabetes treatment in relation to:		
13. Adjusting the amount of insulin when you are ill?	3.91 ± 1.35/4.06 ± 1.22	3.76 ± 1.51/4.04 ± 1.26
14. Detecting and responding to the early signs of low blood glucose?	4.50 ± 0.74/4.43 ± 0.79	4.36 ± 0.85/4.33 ± 0.79
15. Detecting and responding to the early signs of high blood glucose?	3.76 ± 1.11/3.87 ± 0.95	3.41 ± 1.24/3.62 ± 1.07
16. Attending check-ups at the diabetes clinic every 3 months?	4.81 ± 0.61/4.88 ± 0.45	4.85 ± 0.61/4.91 ± 0.39
17. Keeping the agreements that you made with health care personnel regarding your treatment?	4.31 ± 0.89/4.43 ± 0.76	4.29 ± 0.90/4.46 ± 0.71
18. Keeping a "diary" of the amount of insulin you take when your health care personnel ask you to?**	3.36 ± 1.58/*not included in the ADQ-I*	3.69 ± 1.51/*not included in the ADQ-I*
19. Recording your blood glucose levels in your chart/diabetes diary when your health care personnel asks you to?**	3.64 ± 1.49/*not included in the ADQ-I*	3.85 ± 1.48/*not included in the ADQ-I*
Total scale	3.93 ± 0.59/4.12 ± 0.51	3.94 ± 0.68/4.19 ± 0.52

Data are *n* or means ± SD. Scores ranged from 1 ("haven't done it at all") to 5 ("have always done it"). The Danish version of the ADQ has been through a translation process in which a trained interpreter supervised the initial translation conducted by the first author of this article. An independent forward translation was conducted by a native English speaker with a thorough knowledge of Danish. Discrepancies between these two translations were discussed, and the agreed-upon version was subjected to a back translation to ensure concordance with the original Danish version. No validation of this English version of the ADQ has been conducted. *Item content varies based on whether the patient is on conventional treatment or insulin pump (*italics*). **Not included in the questionnaires for patients using an insulin pump.

used to assess the factor structure of the ADQ (16,17). The psychometric properties of the ADQ were examined by Pearson bivariate correlation and Cronbach α.

T tests were used to examine mean differences in HbA_{1c} between participants and nonparticipants, children and caregivers, and to assess possible differences in ADQ

responses based on the sex of the child, sex of the responding caregiver, and treatment regimen. P values ≤ 0.05 were considered significant. The magnitude of the

differences between groups was calculated using effect size correlations (r). Hierarchical multiple regression was used to assess the contribution of adherence at the level of glycemic control while controlling for the possible contributing factors of age, duration of diabetes, means of insulin administration, family structure, and parental level of education.

RESULTS—Data regarding the adherence level of children/adolescents with diabetes that were obtained with the ADQ were provided by 1,028 (59.9%) of the caregivers of children between the ages of 2 and 17 years; 766 (55.1%) children and adolescents 10–17 years of age completed the ADQ along with the psychosocial measures described above. Table 2 provides descriptive statistics for participant- and treatment-related variables for the participating families.

Based on information from the Registry, HbA$_{1c}$ levels for participants and nonparticipants were compared and analyzed. The mean ± SD HbA$_{1c}$ was significantly lower in participants (8.11 ± 1.19) than in nonparticipants (8.71 ± 1.44, $P < 0.0001$), with a moderate effect size ($r = 0.26$). The mean HbA$_{1c}$ for all children and adolescents (<18 years) in the Registry at the time of data collection was 8.25 ± 1.3. There was no significant difference in the mean ADQ scores according to whether the responding caregiver was male (3.99 ± 0.77) or female (4.06 ± 0.59, $P = 0.25$, $r = 0.08$).

Readability
The readability of the ADQ was assessed with the readability-assessment function in the Danish version of Microsoft Office Word. The readability index (LIX) for the ADQ was 20.4. Texts with a LIX score below 24 are considered "easy for all readers."

Psychometric properties of the ADQ Factor structure. The purpose of the ADQ was to measure a unitary concept of adherence across different types of adherence behavior. Exploratory factor analysis was conducted to examine whether a single general factor could be identified. For the ADQ-C-C and the ADQ-I-C, the scree plots of the initial unrotated factor solution showed five components, all with eigenvalues above one, whereas analysis based on the same criteria showed a four-component solution for both the ADQ-C-P and the ADQ-I-P. However, nearly all items loaded quite strongly (above 0.4) on the first factor component suggested for each of the different versions of the ADQ. Monte Carlo parallel analysis did not support retention of the suggested number of factors, just as no meaningful, uniform factors could be distinguished across all scales. Therefore all 19 items of the ADQ-C and all 17 items of the ADQ-I were retained, and the one factor solution was maintained.

Reliability. There was good internal consistency for the ADQ-C-C ($\alpha = 0.85$), the ADQ-I-C ($\alpha = 0.82$), the ADQ-C-P ($\alpha = 0.89$), and the ADQ-I-P ($\alpha = 0.86$). No single-item deletion led to a significant increase in Cronbach α, indicating that the ADQ-C and ADQ-I are homogeneous scales. The item-total correlations were all positive and ranged from 0.27–0.75.

ADQ scores. Item analysis showed nearly all items to be skewed to the left, with 90% of the mean scores for the items in the child/adolescent and caregiver responses in the 3.3–4.5 range, indicating high levels of adherence. The exceptions to this were the scores for questions 1, 2, and 3 for those on a conventional treatment plan, and question number 3 for those on CSII. This indicates that these tasks, which were related to dietary recommendations, might be the most challenging in terms of adherence. There was no ceiling effect, because only 0.6% of children/adolescents and 1.4% of caregivers reported the highest maximum score. The items and mean item scores are displayed in Table 1.

The ADQ scores were significantly correlated to the age of the child ($r = -0.31$, $P < 0.001$), the duration of diabetes ($r = -0.17$, $P < 0.001$), and household income ($r = 0.18$, $P < 0.001$), but not to the level of education of the caregiver ($r = 0.05$, $P < 0.18$). The mean ± SD ADQ scores were significantly higher for children/adolescents living in two-parent homes (4.05 ± 0.53) compared with those living with a single parent (3.92 ± 0.59, $P = 0.03$). However, the difference in the means was very small ($r = 0.08$).

The mean ADQ scores for girls were significantly higher (4.04 ± 0.56) compared with those for boys (3.96 ± 0.57, $P = 0.05$). However, the size of this effect was small ($r = 0.07$), indicating that girls seemed only slightly more adherent than boys. Patients on CSII appeared to be somewhat more adherent (4.1 ± 0.50) than patients on conventional treatment (3.92 ± 0.59, $P < 0.001$). However, the size of the effect of this difference was again relatively small ($r = 0.18$).

Child/adolescent and parent agreement. There was a strong correlation between caregiver and child/adolescent ADQ reports ($r = 0.62$, $P < 0.001$). There was no significant difference in mean adherence scores based on the ADQ reports of children/adolescents (4.0173 ± 0.56) or caregivers (4.0196 ± 0.59, $P = 0.90$, $r = 0.0002$), indicating that parents and children/adolescents are in fairly good agreement concerning their perceptions of the adherence behavior.

Validity. Concurrent validity was evaluated by comparing child/adolescent and caregiver responses on the ADQ to the child/adolescent responses on the SEDM, the DFBC, the subscales of the PedsQL DM, and the DFCS. It was hypothesized that higher levels of adherence behavior would be positively correlated with children's/adolescents' perception of self-efficacy in relation to diabetes care (10,18,19) and parental support (20). Lower adherence scores were predicted to be associated

Table 2—Sample characteristics

Number of participating caregivers/children and adolescents	1,028/766
Age of child/adolescent (years)	12.3 ± 3.69
Sex of child (female/male)	546/526
HbA$_{1c}$	8.1 ± 1.14
Diabetes duration (years)	5.2 ± 3.31
Insulin pump use	41.3% (443/1,072)
Danish as the primary language	98.2%
Two-parent home	84.3%
Sex of responding caregiver (female/male)	852/176
Relationship of the responding caregiver to child/adolescent with diabetes	81.3% biological mothers
	16.6% biological fathers
	1.6% otherwise related to child (foster parent, partner of parent, etc.)
	0.1% declined to contribute this information

Data are reported as means ± SD unless otherwise indicated.

with diabetes-specific parental nonsupport (20,21) and with more diabetes-specific family conflicts (22,23). The treatment-related subscales of the PedsQL DM, particularly the "treatment adherence" subscale, should essentially reflect a construct similar to that of the ADQ; thus, a correlation >0.50 would indicate good construct validity.

These hypotheses were all confirmed. Specifically, adherence reported by children/adolescents correlated positively with diabetes-related self-efficacy ($r = 0.61$, $P < 0.001$), parental support ($r = 0.38$, $P < 0.001$), fewer "barriers to treatment" ($r = 0.43$, $P < 0.001$), and fewer problems related to "treatment adherence" ($r = 0.51$, $P < 0.001$). As expected, adherence was negatively correlated with children's/adolescents' perception of parental nonsupport ($r = -0.29$, $P < 0.001$) and diabetes-related conflict in the family ($r = -0.36$, $P < 0.001$). A similar pattern of correlations was found for caregiver ADQ reports and child/adolescent reports of self-efficacy (0.51), parental support (0.18), fewer barriers to treatment (0.38), treatment adherence (0.45), nonsupport (−0.34), and conflict (−0.38, all $P < 0.001$).

Relationship between ADQ and glycemic control. ADQ scores were negatively correlated with HbA$_{1c}$ values for both children/adolescents ($r = -0.36$) and caregivers ($r = -0.32$, $P < 0.001$), indicating that higher ADQ scores were moderately associated with lower HbA$_{1c}$. The 95% confidence interval for these correlations was quite narrow (the lower and upper bounds were −0.42 and −0.297 for the children/adolescents, and −0.373 and −0.265 for the caregivers).

To evaluate the ability of the ADQ to distinguish between patients with optimal versus suboptimal glycemic control, patients were divided into groups based on HbA$_{1c}$ and the mean scores of the two groups were compared. The group with optimal glycemic control ($n = 230$, HbA$_{1c}$ <7.5) had a significantly higher mean ADQ score (4.19 ± 0.49) than the group with suboptimal control ($n = 156$, HbA$_{1c}$ ≥9.0, 3.70 ± 0.65, $P < 0.001$, $r = 0.45$), indicating that the ADQ is sensitive to differences in glycemic control.

Hierarchical multiple regression was used to assess the ability of the ADQ to predict HbA$_{1c}$ after controlling for the influence of age, diabetes duration, insulin administration method (pump vs. conventional treatment), family structure (two-parent vs. single-parent homes),

and parental level of education. The variables that we wished to control for were entered in step 1 and explained 12% of the variance in HbA$_{1c}$. After the child ADQ self-report was entered in step 2, 19% of the total variance was explained by the model F (6, 719) = 28.18, $P <$ 0.001. The ADQ thus explained an additional 7% of the variance in HbA$_{1c}$ after controlling for the variables listed above. All of the variables in the model, except for parental level of education, made a significant contribution to glycemic control.

CONCLUSIONS—The purpose of this study was to describe and evaluate the psychometric properties of the ADQ questionnaire. In contrast to many of the instruments used previously, the ADQ is not only relatively short but is also appropriate for patients using either conventional treatment or CSII (2). Our data indicated that both versions, i.e., the ADQ-C and the ADQ-I, possess strong psychometric properties.

Factor analysis supported the presence of a general adherence factor in accordance with a consistent finding of good Cronbach α coefficients for all versions of the ADQ (0.82–0.89), indicating high internal reliability.

The ADQ was significantly correlated with age, diabetes duration, and household income, which confirms previous studies indicating that adherence decreases as children get older and with the duration of time since diagnosis (21,24). There was a strong association between child/adolescent and caregiver reports, which indicates that this instrument estimates the actual level of adherence to diabetes care in the family and surpasses the child-caregiver correlations found in other studies (6,25).

The validity of the ADQ was established, as both child/adolescent and caregiver scores on the ADQ were associated with psychosocial variables previously found to impact adherence. In particular, the moderately high correlations with the subscales of the PedsQL DM are an indication of concurrent validity, as these scales essentially measure constructs related to or reflecting adherence (12).

With regards to glycemic control, higher levels of adherence behavior were significantly associated with better HbA$_{1c}$, confirming the results of other studies that linked adherence and glycemic control (1), and showing an improvement concerning the confidence interval of this correlation comparing with these studies. This also

illustrates that the ADQ has an advantage compared with other instruments that are not able to show a significant correlation between adherence and glycemic control (7,25). The ADQ discriminated between patients with good versus poor glycemic control, and multivariate analysis showed the independent and additive predictive value of the ADQ in relation to HbA$_{1c}$.

This study has some limitations. The ADQ test-retest reliability and its sensitivity to changes need to be established. Another limitation is the lack of validation against an empirically validated measure of adherence in this patient group. However, the ADQ was validated with subscales of the PedsQL DM, which were developed to assess problems related to adherence.

Most items in the ADQ evaluate adherence behaviors relative to an ideal treatment regimen. However, adhering to all of these standards of diabetes care might not be the prescribed course of action for all Danish children/adolescents with diabetes. This could lead us to falsely classify some participants as nonadherent. So for the purpose of clinical assessment of the adherence level of individual children/adolescents, it is recommended that the responses to ADQ items be compared with the prescribed treatment plan of the individual patient, just as the use of mean scores for evaluating adherence makes it possible to leave out questions, thereby customizing the ADQ to fit the patient's specific treatment recommendations.

The fact that nonparticipants had slightly poorer glycemic control than participants is another possible limitation. The effect size of the mean difference in HbA$_{1c}$ between these groups was modest, so we speculate that the inclusion of nonparticipants might have strengthened the associations found in our study.

Notably, this study and the ADQ also have several strengths. First, an interdisciplinary panel of experts helped develop and evaluate the items on the ADQ. Second, the relative brevity of the ADQ make it a time-efficient and easy-to-use tool for evaluating adherence in clinical settings and for research purposes; no previous training is needed before health care staff can administer it. Third, the ADQ includes scale items that reflect most tasks related to diabetes management, can be used for evaluation of patients with a wide age range, and is relevant to different types of diabetes treatment regimens. No previous studies have examined adherence in a similar homogenous, national

sample with such a wide age range (almost the entire pediatric range, from early childhood to adolescence); thus, this study and the testing of the ADQ represent a valuable contribution to the study of adherence behavior and of the associated psychosocial and treatment-related factors.

Further studies are needed to examine the clinical application of the instrument as a screening tool, the test-retest stability, and the convergent validity of the ADQ against previously validated measures of adherence in relation to diabetes self-care activities.

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