Can J Diabetes xxx (2022) 1–8

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Original Research

An Integrated Care Model to Support Adolescents With Diabetes-related Quality-of-life Concerns: An Intervention Study

Judith Versloot PhD [a,b,*]; Hana Saab PhD [a]; Simona C. Minotti PhD [a,c]; Amna Ali MSc [a]; Julia Ma MSc [a,d]; Robert J. Reid MD, PhD [a,b]; Sheryl Parks MSW, RSW [e]; Ian Zenlea MD [a,f]

[a] *Institute for Better Health, Trillium Health Partners, Mississauga, Ontario, Canada*
[b] *Institute for Health Policy, Evaluation and Management, University of Toronto, Toronto, Ontario, Canada*
[c] *Department of Statistics and Quantitative Methods, University of Milano-Bicocca, Milano, Italy*
[d] *Precision Analytics, Montreal, Québec, Canada*
[e] *Women's and Children's Health Program, Trillium Health Partners, Mississauga, Ontario, Canada*
[f] *Department of Paediatrics, Temerty Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada*

Key Messages

- It is important for the care team and the adolescent to have a conversation around identified diabetes-related quality of life concerns.
- Screening for and addressing diabetes related quality of life concerns during adolescents' routine diabetes care improves their lives.

ARTICLE INFO

Article history:
Received 4 August 2021
Received in revised form
21 April 2022
Accepted 17 May 2022

Keywords:
adolescents
integrated care
mental health
type 1 diabetes

ABSTRACT

Background: Our aim in this study was to determine whether participating in an integrated stepped care model for adolescents with type 1 diabetes (T1D) would lead to improvements in overall quality of life (QoL), diabetes-related quality of life (DRQoL) and glycated hemoglobin (A1C) levels compared with usual care.

Methods: A nonrandomized, 2-group, pre/post, delayed-intervention design was used for this study. The Mind Youth Questionnaire (MY-Q) was used to assess QoL and DRQoL. Adolescents attending the diabetes clinic using the stepped care model formed the intervention group (n=77). These adolescents completed the MY-Q, and the identified concerns were discussed and addressed with them by their care team as part of the care model. Adolescents attending a pediatric diabetes clinic on another site completed the MY-Q as a comparison group (n=39), results were not shared with their care team, and they received the standard care.

Results: There were 116 adolescents between 13 to 17 years of age, who completed the MY-Q on 2 occasions. Baseline data were obtained on the first occasion, and, on the second occasion, an average of 12 months later, there was a follow-up assessment. At follow up, adolescents in the intervention group had a significantly higher overall QoL and reported significantly less concerns on DRQoL domains than those in the comparison group. Participation in the intervention group, however, did not lead to improvements in A1C.

Conclusion: This study shows that implementing an integrated stepped care model within an interprofessional pediatric diabetes clinic can lead to the improvement of adolescents' overall QoL and DRQoL.

* Address for correspondence: Judith Versloot PhD, Institute for Better Health, Trillium Health Partners, 100 Queensway W, Mississauga, Ontario L5B 1B8, Canada.
E-mail address: judith.versloot@thp.ca

https://doi.org/10.1016/j.jcjd.2022.05.004

Mots clés:
adolescents
soins intégrés
santé mentale
diabète de type 1

RÉSUMÉ

Introduction : L'objectif de notre étude était de déterminer si la participation des adolescents atteints du diabète de type 1 (DT1) à un modèle de soins intégrés par paliers plutôt qu'à un modèle de soins courants contribuait à améliorer la qualité de vie (QdV) globale, la qualité de vie liée au diabète (QdVLD) et les concentrations de l'hémoglobine glyquée (A1c).

Méthodes : Pour cette étude, nous avons utilisé un plan d'intervention tardive non randomisé, avant/après, en 2 groupes. Nous avons utilisé le Mind Youth Questionnaire (MY-Q) pour évaluer la QdV et la QdVLD. Les adolescents qui fréquentaient la clinique spécialisée en diabète utilisant un modèle de soins par paliers ont constitué le groupe d'intervention (n = 77). Après que ces adolescents ont rempli le MY-Q, les préoccupations relevées ont fait l'objet de discussions et ont été abordées avec eux par leur équipe de soins dans le cadre du modèle de soins. Les adolescents qui fréquentaient une clinique pédiatrique spécialisée en diabète d'un autre établissement ont constitué le groupe de comparaison (n = 39), ont rempli le MY-Q dont les résultats n'ont pas été partagés avec leur équipe de soins, et ont reçu les soins courants.

Résultats : Cent seize adolescents de 13 à 17 ans ont rempli le MY-Q 2 fois. La première fois, les données initiales ont été obtenues et, la seconde fois, en moyenne 12 mois plus tard, une évaluation de suivi a eu lieu. Au suivi, les adolescents du groupe d'intervention avaient une QdV globale nettement supérieure et signalaient des préoccupations beaucoup moins importantes dans les domaines de la QdVLD que ceux du groupe de comparaison. Toutefois, la participation au groupe d'intervention n'a pas entraîné l'amélioration de l'A1c.

Conclusion : Cette étude montre que la mise en œuvre d'un modèle de soins intégrés par paliers dans une clinique pédiatrique interprofessionnelle spécialisée en diabète peut mener à l'amélioration de la QdV globale et de la QdVLD des adolescents.

Introduction

Living with type 1 diabetes (T1D) requires disciplined and complex self-management skills, and can be both challenging and emotionally demanding (1–4). Adolescents with T1D are twice as likely as their peers to develop symptoms of depression and anxiety, increasing their risk of mental health problems and lower quality of life compared with their peers without T1D (5). The co-occurrence of mental health disorders and T1D diabetes can lead to poorer self-management and health outcomes, contributing to higher health-care utilization rates and costs than for either condition alone (6–8).

Although current pediatric diabetes clinical practice guidelines recommend the regular assessment of psychosocial well-being and mental health disorders as part of routine diabetes care (9), a common approach to management of co-occurring mental and physical health conditions has been referral to non–diabetes-specific mental health-care providers, thereby fragmenting the care across multiple health-care providers (10). Assessing and managing patients' mental health concerns can be challenging within diabetes clinics that operate without reliable and timely access to social work or mental health support (11). Promising care models that aim to integrate the care for people with co-occurring mental and physical health conditions (e.g. diabetes and depression) include person-centred care models, collaborative care and interdisciplinary care approaches in combination with multicomponent interventions (12–14) and the inclusion of comprehensive case management when needed (15).

The use of person-reported outcome measures (PROMs) for screening and assessment of psychosocial and emotional factors (e.g. family functioning and diabetes-related quality of life [DRQoL]) has emerged as a promising modality for gaining insight into the experiences and concerns salient to adolescents with T1D (16) and for helping clinicians to provide patient-centred supports. The routine use of PROMs in clinical practices enables a model of care that integrates mental and physical health care (13,17,18) that is proactive rather than reactive (19), and has the potential to improve care outcomes when used in clinical management (20) to direct adolescents into appropriate psychosocial care pathways guided by the outcomes of PROMs and discussion with adolescents and their family (13).

To address a local practice gap, we developed and implemented an integrated stepped care model (referred to as "Care Model" hereafter) wherein the level of intensity of support was matched to the complexity of the issues raised in our interprofessional pediatric diabetes outpatient clinics (18,21). The Care Model, informed by the principles of collaborative care (22), included: systematic screening of emotional well-being and psychosocial issues for adolescents with T1D using a diabetes-specific PROM, the Mind Youth Questionnaire (MY-Q) (17), and secondary screening for depression when indicated. Identified concerns were then discussed and addressed with the adolescent, caregiver and care team. A previous mixed-methods evaluation of the Care Model showed it to be acceptable to adolescents and their caregivers that adolescents and their caregivers appreciated the integrated approach to providing physical and mental health care, and that salient issues were identified and addressed by members of the interprofessional care team (18). In this work we describe the results of a pragmatic delayed intervention study to determine whether participation in Care Model for adolescents with T1D led to improvements in overall quality of life (QoL) and DRQoL (primary outcomes) as compared with usual care. We also examined whether participating in the Care Model led to an improvement in glycated hemoglobin (A1C) (secondary outcome). Specifically, we hypothesized that an integrated stepped care model focussed on the identification and management of psychosocial concerns would lead to improvements in: 1) QoL, 2) DRQoL measured as number of concerns and 3) glycemic control (A1C) between baseline and follow-up assessments when compared with adolescents with T1D receiving usual care.

Methods

Care model and study setting

The evaluation study was conducted at Trillium Health Partners (THP), a large, community-based hospital system in Mississauga, Ontario, Canada, comprised of 3 different hospital sites. At the time of the study, there were 2 separate pediatric diabetes clinics, with separate staff, exception for 1 physician who worked in both clinics located at 2 different THP hospital sites. These 2 clinics were later colocated and integrated partway through the study. Before colocation and integration, both clinics had similar care models and were supported by interprofessional diabetes care teams that included pediatricians, pediatric endocrinologists, nurses, social workers and dietitians. Together, the clinics served a population of approximately 250 adolescents with T1D per year.

The Care Model was implemented in 2016 at 1 of the 2 diabetes clinics for adolescents with T1D 13 to 17 years of age. To support the Care Model, additional administrative support and augmented work hours for the social worker, nurses and physicians were funded. Design and implementation of the Care Model have been described in detail elsewhere (18). Briefly, the Care Model included 3 steps: In step 1, adolescents with T1D were screened for QoL, DRQoL and emotional well-being using the MY-Q (17) every 9 months, during their routine clinic visits, and the results of the screening were discussed by the social worker with the adolescent, family and full care team. Based on the discussion, the team developed an integrated care plan that addressed both physical as well as mental health. In step 2, adolescents with low emotional well-being score (WHO-5 score <13) were screened for depression using the Patient Heath Questionnaire for Adolescents (PHQ-A) (23). In step 3, adolescents with identified mental health concerns were presented at the monthly systematic case review (SCR) team meetings. A consulting child psychiatrist would join the SCR meetings through the TeleLink Mental Health Program (24). This program uses tele-video to provide virtual psychiatric consultations, and the use of this program was funded by the Medical Psychiatry Alliance. The need for a psychiatric assessment of the adolescent by the consultant psychiatrist was determined during the SCR, and, if indicated, was arranged to occur through the TeleLink Mental Health Program. Formulated mental treatment plans were delivered by the diabetes clinic social worker working closely with the other staff to ensure that an integrated approach was taken with joint medical and mental health goals.

Evaluation study design

A nonrandomized, 2-group, pre/post, delayed-intervention design was used for this study. This approach was chosen because intraclinic randomization would have resulted in a high risk of contamination (25). Adolescents attending diabetes clinic A, where the new Care Model was implemented, formed the *intervention group*, whereas adolescents attending diabetes clinic B, where the new Care Model had not yet been implemented, formed the *comparison group*. Eligible participants for the intervention group were automatically enrolled as part of a quality improvement project. Eligible participants for the comparison group were invited to participate in the evaluation study and consented. After 6 months, when baseline data collection was completed for the comparison group, the Care Model was implemented as a delayed intervention at diabetes clinic B. This evaluation study was approved by the THP research ethics board after group A had received the intervention as part of standard of care, so the study team received permission to collect data for the intervention group retrospectively by chart abstraction under a waiver of informed consent.

Participants

Adolescents were eligible to participate in the study if they were between 13 and 17 years of age and had been diagnosed with T1D for at least 6 months to allow time to adjust after their diagnosis (18). The MY-Q was only available in Dutch and English at the time of our study, and therefore only patients who could speak English were included. Adolescents with a history of a pervasive developmental or autism spectrum disorder were excluded. Data were collected between August 2016 and June 2019.

Data collection

The MY-Q is self-administered and composed of 36 items that reflect 7 DRQoL domains: social impact, parents, perceptions of diabetes control, responsibility, worries, treatment satisfaction and body image and eating behaviour (17). Each item is scored on a 5-point Likert scale with lower scale numbers indicating a concern in these domains. Example questions include: “How often does diabetes get in the way of playing sports or doing physical activities?” and “How often do you argue with your parents about meals and snacks?” The answer options are: “All the time,” “Often,” “Sometimes,” “Very seldom” and “Never.” The answers “All the time” and “Often” would indicate a concern. The MY-Q also assesses overall QoL, with 1 general item that asks adolescents to rate their life on a 10-point scale (1=worst life possible to 10=best life possible) (17) and a short, 5-item, self-reported emotional well-being measure, the World Health Organization 5-item Well-Being Index (WHO-5) (26).

Based on recommendations from the local research ethics board, the MY-Q was modified for participants in the delayed-intervention comparison group. Items related to body image, eating behaviour and the WHO-5 were removed due to concerns around lack of equity and increased risk because the adolescents in the comparison group would not be receiving the same level of enhanced mental health support through the new Care Model. Therefore, the modified MY-Q for use as the baseline measure in the comparison group included the following domains: social impact, parents, diabetes control perceptions, responsibility, worries, treatment satisfaction and the question assessing overall QoL.

Demographics and clinical characteristics were abstracted from adolescents’ medical records at baseline assessment and included age, sex, time since T1D diagnosis, A1C and diabetes treatment modality (insulin pump or multiple daily injection therapy).

Intervention group

As part of the Care Model, adolescents were asked to complete the MY-Q during their routine clinic visit. Baseline data included the initial MY-Q assessment and follow up included data from the second MY-Q completed at a routine clinic visit between 6 and 18 months later. The study sample was retrospectively selected from all adolescents meeting the eligibility criteria, who received care at diabetes clinic A in which the Care Model was first implemented, who had come for their regular diabetes visit between September 2016 and July 2017 and who had a record of both a baseline and a follow-up MY-Q.

Comparison group

All adolescents meeting the eligibility criteria who received care at diabetes clinic B in which the Care Model was not implemented were invited to participate in the study. Recruitment was from a convenience sample of adolescents who attended their routine diabetes visit between August and December 2017. Eligible adolescents were approached during their routine diabetes clinic visit,

and those who were interested provided consent to participate. The study participants completed a demographics questionnaire and the modified MY-Q with a research coordinator, which comprised the *baseline data*. The baseline data from the modified MY-Q were obtained for research purposes only and the results were not shared with the diabetes care team. Data collection took place in the diabetes clinic.

After the new Care Model was implemented at diabetes clinic B, the adolescents in the comparison group completed the original MY-Q with a member of their diabetes care team as part of the quality improvement project. This MY-Q was used as the *follow-up data* for the comparison group. However, there were delays in collecting the follow-up data, because, shortly after implementation of the new Care Model at diabetes clinic B, the 2 clinics were colocated and integrated at the site of clinic A. This process resulted in disruptions to clinic flow and implementation of the new Care Model for the adolescents who previously received care at clinic B.

Data analysis

Baseline demographics and clinical characteristics in the intervention and comparison groups are reported as count and percentage (for categorical variables) and as mean and standard deviation (for numerical variables). Comparison between the 2 groups was performed using the chi-square test (for categorical variables) and the independent-samples t test (for numerical variables). The outcome variables in the intervention and comparison groups are reported as median and interquartile range (IQR) (for categorical variables) and as mean and standard deviation (for numerical variables). Within- and between-group comparisons of medians were performed using Wilcoxon's matched-pairs signed-rank test and the median test (for medians) and the paired-samples t test and independent-sample t tests (for means), respectively.

Linear regression was used to determine whether receiving the intervention significantly predicted each of the primary outcomes (overall QoL and DRQoL, as indicated by the total number of concerns on the MY-Q) and the secondary outcome (A1C) at follow up. In addition, stepwise linear regression was used to determine which of the independent variables (intervention, sex, age, diabetes duration and diabetes treatment modality [insulin pump or multiple daily injections]) were the strongest predictors of the primary and secondary outcomes at follow up. An interaction term between the intervention and the baseline QoL score was included in the model for the overall QoL at follow up. The p values were 2-sided, with $p<0.05$ considered statistically significant. The adjusted R^2 was used to measure the goodness of fit of the models. All analyses were performed using SPSS for Windows version 25 (27).

Results

Our total sample included 130 adolescents who completed a baseline and follow-up MY-Q, either modified or original, within our data collection period. Fourteen participants were excluded from the analyses because their data were incomplete: specifically, 9 participants from the intervention group and 5 from the comparison group had missing data for at least 1 of the main outcome measures. The final sample size consisted of 116 adolescents, including 77 (66%) from the intervention group and 39 from the comparison group. There were no significant differences for baseline characteristics between the participants with incomplete and complete data (data not shown).

Baseline characteristics

Participants' characteristics at baseline for both the intervention and comparison groups are presented in Table 1. Both groups were similar, with no statistically significant differences with regard to sex, age, diabetes duration and treatment modality. As expected, due to the colocation and integration of the clinics at the first clinic site, there was a significant difference ($p<0.001$) in the number of days between baseline and follow-up assessments, which was shorter for the intervention group (263.5±100.7) than for the comparison group (335.1±80.7).

Table 1
Demographics and clinical characteristics of adolescents in intervention and comparison groups at baseline

Variable (N=116)	Intervention (n=77)	Comparison (n=39)	p Value
Sex, n (%)			
Female	45 (58.4%)	17 (43.6%)	0.130*
Male	32 (41.6%)	22 (56.4%)	
Age, mean ± SD	14.55±1.25	14.59±1.14	0.853†
Diabetes duration, mean ± SD	6.26±3.83	7.26±4.28	0.437†
Treatment modality, n (%)			
Injection	36 (46.8%)	20 (51.3%)	0.645*
Insulin pump	41 (53.2%)	19 (48.7%)	

SD, standard deviation.
* Difference between groups tested with chi-square test.
† Difference between groups tested with an independent-samples t test.

Univariate analysis

At baseline, none of the outcome variables differed significantly between the intervention and comparison groups (Table 2). From baseline to follow up, the adolescents in the intervention group had a significant increase in their overall QoL from 7.73 (standard deviation [SD]=1.71) to 8.05 (SD=1.25), a decrease in their median number of concerns from 3 [IQR, 1 to 5] to 1 [IQR, 0 to 4] and an increase in their A1C levels from 8.37 (SD=1.54) to 9.00 (SD=1.70). In contrast, none of the outcomes changed significantly for the comparison group from baseline to follow up.

Multivariate analysis

The outcomes of the linear regression analyses are shown in Table 3. The assumptions of normality and homoscedasticity of the residuals were satisfied, and the variance inflator factor showed that the independent variables were not highly collinear, with all scores <5.

The regression models for overall QoL showed a significant interaction effect between participating in the Care Model and the baseline QoL score ($p<0.001$). Participating in the Care Model had a differential impact on the overall QoL score at follow up, which was dependent on the baseline overall QoL score. To explore the interaction effect and determine who benefited most from the intervention we split the intervention and comparison groups into

Table 2
Outcome variables in intervention and comparison groups at baseline and follow up: A within-group comparison

Outcome	Group	N	Baseline	Follow-up	p Value
Overall quality of life, mean ± SD	Intervention	77	7.73±1.71	8.05±1.25	0.048
	Comparison	39	7.38±1.71	7.26±1.86	0.463
Number of concerns on MY-Q, mean ± SD	Intervention	77	3.53±3.15	2.49±3.05	0.001
	Comparison	39	4.15±3.77	4.31±4.40	0.749
Number of concerns on MY-Q, median [IQR]	Intervention	77	3 [1–5]	1 [0–4]	<0.001*
	Comparison	39	3 [1–7]	3 [1–8]	0.678*
A1C levels, mean ± SD	Intervention	77	8.37±1.54	9.00±1.70	0.001
	Comparison	39	8.88±1.95	8.75±2.02	0.599

A1C, glycated hemoglobin; *MY-Q*, Mind Youth Questionnaire; *SD*, standard deviation.
* Wilcoxon matched-pairs signed-rank test.

Table 3
Multiple linear regression models for overall QoL, MY-Q concerns and A1C scores at follow up

Outcome	Model*	Adjusted R^2	Variables	Parameter estimates	95% CI		p Value
Overall QoL	1	0.502	(Intercept)	0.774	−2.073	3.622	0.591
			Care model	0.457	0.042	0.872	0.031
			Sex (female)	−0.265	−0.672	0.143	0.201
			Age	0.010	−0.159	0.178	0.910
			Diabetes duration	−0.029	−0.084	0.026	0.298
			Treatment method (INJ)	−0.106	−0.529	0.317	0.621
			A1C level at baseline	−0.046	−0.176	0.083	0.478
			Overall QoL at baseline†	0.833	0.619	1.047	<0.001
			Overall QoL at baseline×intervention	−0.422	−0.677	−0.167	0.001
	2	0.507	(Intercept)	−0.230	−0.559	0.099	0.170
			Care model	0.452	0.048	0.855	0.029
			Overall QoL at baseline	0.901	0.705	1.098	<0.001
			Overall QoL at baseline×intervention	−0.489	−0.730	−0.248	<0.001
Number of concerns	1	0.503	(Intercept)	−4.070	−10.848	2.709	0.427
			Care model	−1.258	−2.284	−0.232	0.017
			Sex (female)	0.422	−0.564	1.407	0.398
			Age	0.147	−0.261	0.554	0.477
			Diabetes duration	0.120	−0.011	0.252	0.071
			Treatment method (INJ)	1.116	0.072	2.161	0.036
			A1C at baseline	0.021	−0.293	0.334	0.895
			Number of concerns at baseline	0.694	0.548	0.841	<0.001
	2	0.511	(Intercept)	−1.354	−3.426	0.717	0.198
			Care model	−1.201	−2.205	−0.197	0.019
			Treatment method (INJ)	1.228	0.263	2.194	0.013
			Diabetes duration	0.123	0.002	0.245	0.047
			Number of concerns at baseline	0.701	0.560	0.841	<0.001
A1C	1	0.459	(Intercept)	1.067	−3.124	5.258	0.615
			Care model	0.536	0.002	1.071	0.049
			Sex (female)	0.656	0.133	1.180	0.014
			Age	0.002	−0.212	0.216	0.984
			Diabetes duration	−0.001	−0.069	0.068	0.983
			Treatment method (INJ)	0.801	0.259	1.344	0.004
			Overall QoL at baseline	−0.027	−0.202	0.149	0.765
			Number of concerns at baseline	0.038	−0.048	0.124	0.383
			A1C at baseline	0.624	0.460	0.788	<0.001
	2	0.459	(Intercept)	1.177	−0.421	2.775	0.147
			Sex (female)	0.788	0.291	1.284	0.002
			Treatment method (INJ)	0.812	0.308	1.315	0.002
			A1C at baseline	0.624	0.474	0.773	<0.001

A1C, glycated hemoglobin; *CI*, confidence interval; *INJ*, injection; *MY-Q*, Mind Youth Questionnaire; *ND*, no difference; *QoL*, quality of life.
* Model 1 includes all the independent variables, whereas model 2 includes only the independent variables selected by stepwise regression.
† Overall QoL is centered around its mean to reduce the multicollinearity problems that may arise as a result of including an interaction term.

4 subgroups based on overall QoL score at baseline. We found that overall QoL score for participants in the intervention group with a baseline score <7 (low QoL) increased from an average of 4.92 (SD=1.5) to 6.46 (SD=1.5). The subgroups with an overall QoL score at baseline of 7 (medium QoL) and those with a score of 8 (medium–high QoL) also increased significantly from 7.0 (SD=0) to 7.74 (SD=1) and from 8.0 (SD=0) to 8.5 (SD=0.7), respectively. The subgroup with an overall QoL score at baseline of 9 or 10 (high QoL) had a significant decrease from baseline 9.41 (SD 0.5) to follow up 8.74 (SD=0.76). In contrast, there was no difference for any of the 4 subgroups from the comparison group from baseline to follow up (Table 4 and Figure 1).

The regression model for the number of DRQoL concerns from the MY-Q at follow up showed that participation in the Care Model resulted in fewer concerns on the MY-Q at follow up. Furthermore, participating in the Care Model, treatment with an insulin pump, shorter diabetes duration and reporting fewer concerns on the MY-Q at baseline were significantly associated with fewer concerns at follow up. The findings were confirmed by Poisson regression and are available upon request.

The regression model for A1C levels at follow up showed that participation in the Care Model was significantly associated with higher A1C levels at follow up. In addition, being male, receiving treatment with an insulin pump and having lower A1C levels at baseline were significantly associated with lower A1C levels at follow up. Participating in the Care Model was not a significant predictor of A1C in the stepwise linear regression model.

Discussion

Our findings show that participation in the Care Model resulted in improvements in overall QoL, particularly for the adolescents with a lower level of overall QoL at baseline, who had the largest increase. The positive impact of the Care Model on overall QoL of adolescents with a lower score at baseline suggests that these

Table 4
Subgroup analyses according to baseline overall QoL score

Outcome	Group	n	Baseline*	Follow up*	p Value
Overall QoL: 0–6	Intervention	13	4.92±1.5	6.46±1.5	0.03
	Comparison	8	4.63±1.06	4.63±1.3	ND
Overall QoL: 7	Intervention	19	7.00±0	7.74±1	0.005
	Comparison	10	7.00±0	7.10±1.2	0.798
Overall QoL: 8	Intervention	18	8.00±0	8.50±0.7	0.008
	Comparison	10	8.00±0	7.60±1.08	0.269
Overall QoL: 9–10	Intervention	27	9.41±0.5	8.74±0.76	0.000
	Comparison	11	9.18±0.41	9.00±0.78	0.506

A1C, glycated hemoglobin; *MY-Q*, Mind Youth Questionnaire; *ND*, no difference; *QoL*, quality of life.
* Data expressed as mean ± standard deviation.

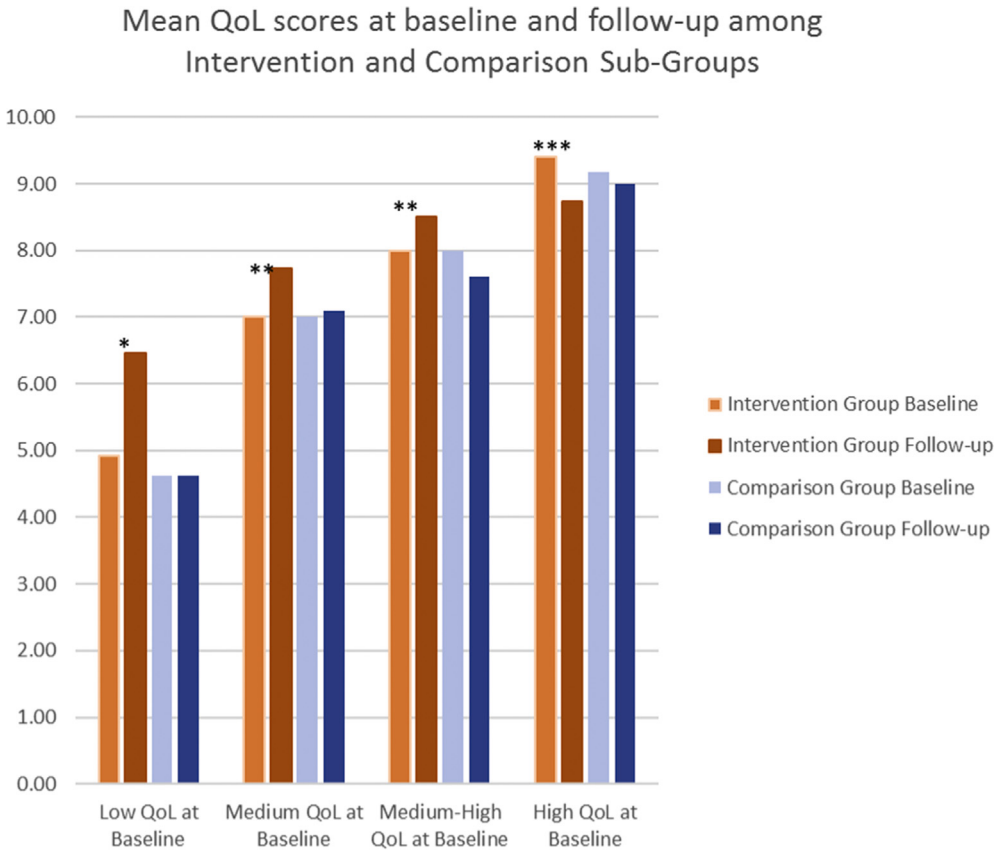

Figure 1. Mean QoL scores at baseline and follow up among intervention and comparison subgroups. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$. *QoL*, quality of life.

adolescents benefited most from the intervention. Adolescents with very high QoL scores at baseline saw a decrease at follow up, likely due to a ceiling effect. Adolescents receiving the Care Model had an average reduction of 1 concern on the MY-Q specific to DRQoL from baseline to follow up. A core component of the Care Model was the discussion between the adolescent and the care team of all the identified DRQoL concerns and the development of an integrated care plan to address these concerns. The reduction in concerns highlights the impact and importance of routinely assessing and addressing psychosocial concerns, and is in line with other longitudinal studies showing that monitoring and discussing health-related QoL improved adolescents' psychosocial health (28,29). Although the time to complete a follow-up MY-Q (about 1 year) was longer than intended (9 months), we were still able to demonstrate a positive impact on both primary outcomes (QoL and DRQoL).

Participating in the Care Model did not lead to improvements in A1C and the intervention group saw a worsening of their A1C levels. A systematic review of 20 randomized controlled trials of children and adolescents with T1D showed that psychological interventions were overall not more effective in improving glycemic control than a control group; however, there was variation across studies with some showing positive, neutral and negative impacts of the interventions on glycemic control (30). The authors suggested the low intensity of the interventions as a potential reason for the lack of impact (30). Perhaps by shifting the focus of clinical visits to issues related to DRQoL rather than glycemic control or self-management, opportunities were missed to optimize therapy, resulting in an increase in subsequent A1C levels.

Our findings indicate that being female and receiving treatment with insulin injections were associated with higher A1C levels at follow up. The higher A1C seen at follow up for females corresponds with patterns in longitudinal studies (31), and can potentially be explained by differences in hormonal factors between sexes during puberty (32), concerns with body image, a higher prevalence of depressive symptoms, irregular and inconsistent eating habits and self-monitoring of blood glucose resulting in reduced adherence and insulin omission among some adolescent females (2,8,33–35). Although not statistically significant, our intervention group had slightly more females, which may have contributed to the overall increased A1C in this group. Regardless, these findings suggest that there are major sex and gender differences that should be explored in future studies or considered when designing interventions for adolescents with T1D.

Insulin pump therapy was associated with lower A1C as well as a reduced number of concerns on the MY-Q at follow up. The lower A1C values for insulin pump users may have been due in part to the eligibility criteria for insulin pump funding in Ontario, Canada, where the study was conducted. To qualify for provincial funding to support insulin pump therapy, adolescents must have a diagnosis of diabetes for at least 1 year and 3 A1C measurements of $<10\%$ per year (36). Although insulin pump therapy introduces new and challenging diabetes self-management tasks, studies have shown that it has positive effects on QoL (37,38).

Finally, we found no association between A1C levels and overall QoL and DRQoL, which is consistent with results from cross-sectional and longitudinal studies that generally demonstrated no or only weak associations (39). Further research is needed to gain

better insights into the causal and temporal relationships between A1C levels and psychosocial constructs, such as DRQoL. The minimal relationship between A1C and DRQL indicates that the 2 therapy goals, namely achievement and maintenance of glycemic targets and high DRQL, should be considered and evaluated independently in the clinical routine (39).

Limitations

There are several limitations to consider when interpreting the results of this study. Several major variables, such as race/ethnicity, socioeconomic status or marginalization, which could have independent impacts on QoL, DRQoL and glycemic control, were not available for our analyses, which may account for some of the unexplained variation. Research has shown that adolescents with higher socioeconomic status have greater adherence to treatment (40–42), whereas ethnic minority children have poorer diabetes control (43). Although we did not collect data on race or ethnicity, our clinic is located in a region with high diversity (44). Given the natural tendency for A1C to vary considerably during adolescence (45), a longer follow up with additional A1C measurements would have enabled us to investigate more fully the impact of the Care Model on A1C. Because the MY-Q was modified for this study, we were unable to ascertain the impact of the Care Model on concerns related to body image, eating behaviours or emotional well-being. The time between baseline and follow-up assessments was also longer than planned, and, for the intervention group, on average 72 days shorter compared with the comparison group, which could have influenced the results. This discrepancy was due to the colocation and integration of the clinics partway through the study. In addition, some adolescents in the comparison group had their follow-up assessment done after the 2 clinic locations merged, which could have also delayed the results because there was turnover in the social work role and time was lost with recruitment and training of the new person. Recruitment of adolescents for the comparison group was also challenging, which may have introduced selection bias. However, both the intervention and comparison groups had comparable baseline characteristics and the baseline and follow-up scores on the main outcome variables for the adolescents in the comparison group were very similar, suggesting these factors had little impact on the outcomes. Last, this Care Model received external funding and was implemented in a pediatric diabetes clinic supported by an interprofessional diabetes care team that included pediatricians, pediatric endocrinologists, nurses, social workers and dietitians. Implementing the full Care Model may be challenging in diabetes clinics without embedded mental health support and with limited opportunities to form alliances between the diabetes care team and outside mental health providers that can support adolescents with diabetes (11).

Implications for future research and practice

Recent diabetes guidelines recommend consistent and frequent psychosocial screening that includes both parent and child reports of functioning (46). Therefore, expanding screening in younger age groups and including measures specific to caregivers would be important in future iterations of the Care Model. To our knowledge, this is the first longitudinal study of its kind in Canada using the MY-Q to screen for overall QoL and DRQoL among adolescents with T1D as part of an integrated stepped care model. We recommend eplication of our study in other contexts with stronger research designs, such as randomized controlled trials, as well as the use of the full MY-Q in a comparison group, which would allow for conclusions to be drawn regarding the impact of the Care Model on emotional well-being, body image and eating behaviours. Further studies should be performed using larger sample sizes to assess the impact of the Care Model on specific outcomes, including A1C, emotional well-being and QoL, for adolescents progressing through steps 2 and 3. In addition, further study of the interplay between glycemic control and QoL within a longitudinal study of greater duration would also be informative.

In conclusion, our study has shown that implementing an integrated stepped care model within pediatric diabetes clinics with interprofessional teams that already include mental health providers can lead to improvements in adolescents' overall QoL and DRQoL. Given the association between mental health disorders and poor health outcomes for adolescents with T1D, our findings are useful to clinicians at other diabetes clinics who are considering incorporation of psychosocial screening into routine care.

Author Disclosures

I.Z. reports funding from the Medical Psychiatry Alliance and personal fees from Abbott Diabetes Care and Novo Nordisk Canada, all unrelated to this work. R.J.R. served in a senior leadership role at Trillium Health Partners, one of the funders of Medical Psychiatry Alliance. No other authors have any conflicts of interest to disclose.

Author Contributions

J.V., S.M., I.Z. and R.R. contributed to the conception of the current data analyses and idea for this manuscript; J.V., H.S., S.M., A.A. and I.Z. drafted the manuscript; S.M., J.V. and J.M. conducted the data analyses; J.V., A.A., I.Z., S.M., S.P. and R.R. contributed to research execution along with acquisition and interpretation of data; S.P., I.Z. and R.R. contributed to the execution of the project and critically reviewed the manuscript; J.V., H.S., S.M., A.A., J.M., R.R., S.P. and I.Z. critically reviewed the manuscript and gave final approval to submit this work for publication.

Acknowledgments

The authors thank the study participants, health-care providers and clinic staff for generously sharing their time, experience and knowledge. We also acknowledge all past and present members of the THP-MPA research and evaluation team for their support with different components of the evaluation that informed this work. This study was supported by the Medical Psychiatry Alliance, a collaborative health partnership of the Centre for Addiction and Mental Health; The Hospital for Sick Children; Trillium Health Partners; the University of Toronto; the Ontario Ministry of Health and Long-Term Care; and an anonymous donor.

References

1. Datye K, Bonnet K, Schlundt D, Jaser S. Experiences of adolescents and emerging adults living with type 1 diabetes. Diabetes Educ 2019;45:194–202.
2. Glick BA, Hong KMC, Obrynba K, Kamboj MK, Hoffman RP. Identifying depressive symptoms among diabetes type and the impact on hemoglobin A1c. J Pediatr Endocrinol Metab 2018;31:39–44.
3. Rechenberg K, Whittemore R, Grey M. Anxiety in youth with type 1 diabetes. J Pediatr Nurs 2017;32:64–71.
4. Massengale J. Depression and the adolescent with type 1 diabetes: The covert comorbidity. Issues Mental Health Nurs 2005;26:137–48.
5. Northam EA, Lin A, Finch S, Werther GA, Cameron FJ. Psychosocial well-being and functional outcomes in youth with type 1 diabetes 12 years after disease onset. Diabetes Care 2010;33:1430–7.
6. Foster NC, Beck RW, Miller KM, et al. State of type 1 diabetes management and outcomes from the T1D exchange in 2016–2018. Diabetes Technol Ther 2019;21:66–72.
7. King PSPD, Berg CAPD, Butner JPD, et al. Longitudinal trajectories of metabolic control across adolescence: Associations with parental involvement, adolescents' psychosocial maturity, and health care utilization. J Adolesc Health 2012;50:491–6.
8. Hilliard MEPD, Wu YPPD, Rausch JPD, Dolan LMMD, Hood KKPD. Predictors of deteriorations in diabetes management and control in adolescents with type 1 diabetes. J Adolesc Health 2013;52:28–34.

9. Young-Hyman D, de Groot M, Hill-Briggs F, Gonzalez JS, Hood K, Peyrot M. Psychosocial care for people with diabetes: A position statement of the American Diabetes Association. Diabetes Care 2016;39:2126–40.
10. Geist R, Versloot J, Mansfield E, DiEmanuele M, Reid RJ. The Collaborative Care Model for patients with both mental health and medical conditions implemented in hospital outpatient care settings. J Ambul Care Manage 2020;43:230–6.
11. Gallagher M. Mental health care in pediatric diabetes: Overcoming challenges and barriers. Am J Managed Care Evid Based Diabetes Manage 2017;23:SP220.
12. Corathers SD, Schoettker PJ, Clements MA, et al. Health-system-based interventions to improve care in pediatric and adolescent type 1 diabetes. Curr Diab Rep 2015;15:91.
13. Hilliard ME, De Wit M, Wasserman RM, et al. Screening and support for emotional burdens of youth with type 1 diabetes: Strategies for diabetes care providers. Pediatr Diabetes 2018;19:534–43.
14. DeSalvo KB, Gracia JN. Health is more than health care. Ann Intern Med 2020;172(Suppl):S66–7.
15. DeSalvo DJ, Maahs DM, Messer L, et al. Effect of lipohypertrophy on accuracy of continuous glucose monitoring in patients with type 1 diabetes. Diabetes Care 2015;38:e166.
16. de Wit M, Versloot J, Zenlea I, Goethals ER. Using person-reported outcomes (PROs) to motivate young people with diabetes. Curr Diab Rep 2020;20:23.
17. de Wit M, Winterdijk P, Aanstoot HJ, et al. Assessing diabetes-related quality of life of youth with type 1 diabetes in routine clinical care: The MIND Youth Questionnaire (MY-Q). Pediatr Diabetes 2012;13:638–46.
18. Versloot J, Ali A, Minotti SC, et al. All together: Integrated care for youth with type 1 diabetes. Pediatr Diabetes 2021;22:889–99.
19. Spaic T, Mahon JL, Hramiak I, et al. Multicentre randomized controlled trial of structured transition on diabetes care management compared to standard diabetes care in adolescents and young adults with type 1 diabetes (Transition Trial). BMC Pediatrics 2013;13:163.
20. Boyce MB, Browne JP. Does providing feedback on patient-reported outcomes to healthcare professionals result in better outcomes for patients? A systematic review. Qual Life Res 2013;22:2265–78.
21. Kates N. Mental health and primary care: Contributing to mental health system transformation in Canada 2017;36:33–67.
22. Katon WJ, Lin EH, Von Korff M, et al. Collaborative care for patients with depression and chronic illnesses. New Engl J Med 2010;363:2611–20.
23. Johnson JG, Harris ES, Spitzer RL, Williams JB. The Patient Health Questionnaire for Adolescents: Validation of an instrument for the assessment of mental disorders among adolescent primary care patients. J Adolesc Health 2002;30:196–204.
24. The Hospital for Sick Children (SickKids). TeleLink Mental Health Program. http://www.sickkids.ca/tele-link/what-we-do/clinical-services/clinical-services.html. 2019–2020. Accessed November 16, 2020.
25. Torgerson DJ. Contamination in trials: Is cluster randomisation the answer? 2001;322:355–7.
26. de Wit M, Pouwer F, Gemke RJ, Delemarre-van de Waal HA, Snoek FJ. Validation of the WHO-5 Well-Being Index in adolescents with type 1 diabetes. Diabetes Care 2007;30. 2003–6.
27. IBM SPSS Statistics for Windows version 25.0. Armonk, NY: IBM Corp, 2017.
28. de Wit M, Delemarre-van de Waal HA, Bokma JA, et al. Monitoring and discussing health-related quality of life in adolescents with type 1 diabetes improve psychosocial well-being: A randomized controlled trial. Diabetes Care 2008;31:1521–6.
29. Murillo M, Bel J, Pérez J, et al. Impact of monitoring health-related quality of life in clinical practice in children with type 1 diabetes mellitus. Qual Life Res 2017;26:3267–77.
30. Winkley K, Upsher R, Stahl D, et al. Systematic review and meta-analysis of randomized controlled trials of psychological interventions to improve glycaemic control in children and adults with type 1 diabetes. Diabet Med 2020;37:735–46.
31. Samuelsson U, Anderzén J, Gudbjörnsdottir S, Steineck I, Åkesson K, Hanberger L. Teenage girls with type 1 diabetes have poorer metabolic control than boys and face more complications in early adulthood. J Diabetes Complications 2016;30:917–22.
32. Hoffman RP, Vicini P, Sivitz WI, Cobelli C. Pubertal adolescent male-female differences in insulin sensitivity and glucose effectiveness determined by the one compartment minimal model. Pediatr Res 2000;48:384–8.
33. Lawes T, Franklin V, Farmer G. HbA1c tracking and bio-psychosocial determinants of glycaemic control in children and adolescents with type 1 diabetes: Retrospective cohort study and multilevel analysis. Pediatr Diabetes 2014;15:372–83.
34. Brink S. So what's the difference between teenage beys and girls, anyway? Diabetes Care 1997;20:1638.
35. Moore JM, Snell-Bergeon JK. Trajectories of hemoglobin A1c and body mass index z-score over four decades among 2 to 18 year olds with type 1 diabetes. Pediatr Diabetes 2019;20:594–603.
36. Ministry of Health & Long-Term Care, Assistive Devices Program. Insulin Pump and Supplies Policy and Administration Manual. https://www.health.gov.on.ca/en/pro/programs/adp/policies_procedures_manuals/docs/insulin_pump_manual.pdf May 2016; Accessed July 12, 2021.
37. Haynes E, Ley M, Talbot P, Dunbar M, Cummings E. Insulin pump therapy improves quality of life of young patients with type 1 diabetes enrolled in a government-funded insulin pump program: A qualitative study. Can J Diabetes 2021;45:395–402.
38. McMahon SK, Airey FL, Marangou DA, et al. Insulin pump therapy in children and adolescents: Improvements in key parameters of diabetes management including quality of life. Diabetic Med 2005;22:92–6.
39. Fischer KI, Fischer FH, Barthel D, et al. Trajectories of health-related quality of life and HbA1c values of children and adolescents with diabetes mellitus type 1 over 6 months: A longitudinal observational study. Front Pediatr 2019;7:566.
40. Clements MA, Lind M, Raman S, et al. Age at diagnosis predicts deterioration in glycaemic control among children and adolescents with type 1 diabetes. BMJ Open Diabetes Res Care 2014;2:e000039.
41. Clements MA, Foster NC, Maahs DM, et al. Hemoglobin A1c (HbA1c) changes over time among adolescent and young adult participants in the T1D exchange clinic registry. Pediatr Diabetes 2016;17:327–36.
42. Helgeson VS, Snyder PR, Seltman H, Escobar O, Becker D, Siminerio L. Brief report: Trajectories of glycemic control over early to middle adolescence. J Pediatr Psychol 2010;35:1161–7.
43. Khanolkar AR, Amin R, Taylor-Robinson D, et al. Ethnic differences in early glycemic control in childhood-onset type 1 diabetes. BMJ Open Diabetes Res Care 2017;5:e000423.
44. Statistics Canada. Census profile, 2016 Census Peel, Regional municipality [Census division], Ontario and Ontario [Province] 2016. https://www12.statcan.gc.ca/censusrecensement/2016/dppd/prof/details/page.cfm?b1=all&code1=3521&code2=35&data=count&geo1=cd&geo2=pr&lang=e&searchpr=01&searchtext=peel&searchtype=begins&tabid=1. Accessed January 25, 2021.
45. Schwandt A, Hermann JM, Rosenbauer J, et al. longitudinal trajectories of metabolic control from childhood to young adulthood in type 1 diabetes from a large German/Austrian Registry: A group-based modeling approach. Diabetes Care 2017;40:309–16.
46. Barry-Menkhaus SA, Stoner AM, MacGregor KL, Soyka LA. Special considerations in the systematic psychosocial screening of youth with type 1 diabetes. J Pediatr Psychol 2020;45:299–310.