Closing the Gap: Results of the Multicenter Canadian Randomized Controlled Trial of Structured Transition in Young Adults With Type 1 Diabetes

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OBJECTIVE

To determine if a structured transition program for young adults with type 1 diabetes improves clinic attendance, glycemic control, diabetes-related distress, quality of life, and satisfaction with care.

RESEARCH DESIGN AND METHODS

In this multicenter randomized controlled trial, young adults (17–20 years) with type 1 diabetes were randomly assigned to a transition program with a transition coordinator or to standard care. The intervention lasted 18 months (6 in pediatric and 12 in adult care). The primary outcome was the proportion of participants who failed to attend at least one adult diabetes clinic visit during the 12-month follow-up after completion of the intervention.

RESULTS

We randomized 205 participants, 104 to the transition program and 101 to standard care. Clinic attendance was improved in the transition program (mean [SD] number of visits 4.1 [1.1] vs. 3.6 [1.2], $P = 0.002$), and there was greater satisfaction with care (mean [SD] score 29.0 [2.7] vs. 27.9 [3.4], $P = 0.032$) and less diabetes-related distress (mean [SD] score 1.9 [0.8] vs. 2.1 [0.8], $P = 0.049$) reported than in standard care. There was a trend toward improvement in mean HbA_{1c} (8.33% [68 mmol/mol] vs. 8.80% [73 mmol/mol], $P = 0.057$). During the 12-month follow-up, there was no difference in those failing to attend at least one clinic visit ($P = 0.846$), and the mean change in HbA_{1c} did not differ between the groups ($P = 0.073$). At completion of follow-up, the groups did not differ with respect to satisfaction with care or diabetes-related distress and quality of life.

CONCLUSIONS

Transition support during this 18-month intervention was associated with increased clinic attendance, improved satisfaction with care, and decreased diabetes-related distress, but these benefits were not sustained 12 months after completion of the intervention.

Transitional care is the purposeful, planned movement of adolescents and young adults with chronic conditions from pediatric to adult care health care systems (1). Emergent adulthood is a challenging period of increasing maturity, independence, and personal identity (2). Many health care systems require that pediatric patients be

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transferred to adult care at ~18 years of age, which is also a time of major changes in school, work status, and residence (3). Differences in child-centered and adult health systems contribute to the abrupt change (1) and dissatisfaction with care (4,5).

For young adults with type 1 diabetes, the additional stress associated with managing their disease (3,6) together with other competing demands can lead to a decline in metabolic control (7,8). Other possible factors that negatively impact control include insulin resistance associated with pubertal hormonal changes, reduced blood glucose monitoring, intentional insulin omission for weight management, risk-taking behavior, or mental health issues (9–11). As many as 30% of young adults with type 1 diabetes disengage from care during transition and 46% report difficulties with the transition process (12–14). Clinic attendance declines (15,16), and among those lost to follow-up, the HbA_{1c} is 1.5% higher than among those who remain in medical care (17). There is also evidence that challenges and behaviors experienced during transition track into adulthood (4,14), particularly for those patients with identified predictors of risk (18–20). Suboptimal glycemic control in young adults with type 1 diabetes increases the risk for hospitalization and diabetes-related complications (13,21) and increases the burden on health care systems.

Studies that have evaluated transitional care in young adults with type 1 diabetes have identified a need for more support during the transition (4,7). However, evidence for the types of supports that are effective in improving this important care gap is unclear (22). Moreover, although several interventions have been assessed (4,17,23,24), there have been no multicenter randomized trials that have tested the effect of transition strategies on follow-up visit adherence and glycemic control after transfer of care. We report results of a multicenter randomized trial that compared posttransition clinic attendance, HbA_{1c} levels, satisfaction with care, diabetes-related distress, and impact of diabetes on quality of life between young adults with type 1 diabetes receiving usual transition care or a structured transition program in which involvement of a transition coordinator (TC) over 18 months was a key component.

RESEARCH DESIGN AND METHODS

Trial Design and Participants

The study was a multicenter, randomized, parallel-group, controlled trial conducted in three pediatric (two tertiary and one secondary) centers together with their usual adult care referral centers in Ontario, Canada. The study was approved by each site's local institutional review board, and informed consent was obtained from all study participants. The main inclusion criteria were patients with type 1 diabetes aged 17–20 years who had at least one clinic visit with their pediatric endocrinologist in the previous 12 months and who were scheduled to be transferred to adult diabetes care in the next 6 months. The full study protocol was published previously (25).

Interventions

The transition program was designed to provide additional support during transition of care and was introduced 6 months prior to referral to adult diabetes care. The intervention was 18 months long and spanned six clinic visits (three pediatric and three adult). There were also two clinic visits in the 12 months of follow-up, so the total number of study visits was eight. Central to the program were TCs at each site who provided a link between pediatric and adult diabetes care. The TCs were Certified Diabetes Educators who provided transitional education and clinical support where appropriate. The role of the TC was to assist participants during the visits in the first 18 months, maintain contact with participants between the visits (by phone, text messages, or e-mail), facilitate support for insulin adjustments and sick day/hypoglycemia management during regular hours, send reminders and help reschedule appointments, and assess needs and facilitate referrals to other services (e.g., psychology, social work, nurse educator, or dietitian). The TCs also provided specific transition-related education and education materials and at the last pediatric visit a bio sketch of the adult endocrinologist to whom the participant had been referred as well as written instructions and maps to navigate adult diabetes centers.

Participants were expected to be seen in three pediatric diabetes clinic visits over 6 months followed by three adult diabetes clinic visits over 12 months. The TC was to attend all visits. Participants randomized to the standard diabetes care group followed the same clinic visit schedule with the only difference being the exclusion of additional support by the TC. Participants in both groups received diabetes care as per Diabetes Canada clinical practice guidelines (26).

Data Collection

At each of the eight visits (six visits during intervention and two during follow-up), data collected for both groups included clinic attendance; diabetes-related data including participant weight, height, BMI, blood pressure, insulin dosage, and method of delivery; and any interim diabetes-related emergency room, hospital visits, and adverse events. Also recorded was the frequency of complication screening (retinal, monofilament, lipid profile testing, and microalbumin-to-creatinine ratio). A local HbA_{1c} was done at visits one, two, three, four, and five (capillary and/or venous sample by the center's usual method of testing). Central laboratory (DynaCare, Brantford, Ontario, Canada) HbA_{1c} measurements were done at visits one, six, seven, and eight using Diabetes Control and Complications Trial (DCCT)–validated assay. The complete details of visit assessments are in the study protocol, which was published previously (25).

Randomization and Blinding

Participants were randomly assigned in a 1:1 ratio to the transition program or standard care. The randomization schedule was computer generated in variable blocks stratified by HbA_{1c} ($<$8.5% [69 mmol/mol] or $\geq$8.5% [69 mmol/mol]) and site and held centrally at the data coordinating center. Because of the nature of the intervention, we could not blind participants and members of the diabetes treatment team to group allocation. The outcome assessors and data analysis personnel were blinded to the group assignment. There was no contact between the TC and the control group to minimize cross contamination.

Outcomes

We assessed outcomes during the 18 months of the intervention period and 12 months after completion of the intervention (follow-up period). The primary outcome was the proportion of participants who failed to attend at least one adult diabetes clinic visit during the 12-month follow-up period. Prespecified

secondary outcomes were the frequency of HbA_{1c} testing, mean HbA_{1c} level, frequency of complication screening (nephropathy, retinopathy, and peripheral neuropathy), diabetes-related emergency room visits and hospitalizations for diabetic ketoacidosis (DKA) and hypoglycemia, patient satisfaction with the transition process, and diabetes distress and impact of diabetes on quality of life. The mean HbA_{1c} was calculated separately for the central and local measurements collected during the designated periods. Patient satisfaction with diabetes care was assessed using the Client Satisfaction Questionnaire (CSQ), diabetes distress using the Diabetes Distress Scale (DDS), and the impact of diabetes on quality of life with the Diabetes Quality of Life (DQL). These were done at baseline, completion of the intervention, and completion of follow-up. A transition intervention evaluation questionnaire was administered to those in the transition program at completion of follow-up. This 25-item survey evaluated the overall transition experience as well as perceived personal support from the TC, educational elements, and structural/navigation support.

Sample Size and Statistical Analysis

The study sample size determination was based on the projected proportion of participants in each group who would fail to attend at least one diabetes clinic visit during the 12 months after the intervention period. We reviewed the records of 156 young adults who were transferred from the Children's Hospital, London Health Sciences Centre, to adult care at St. Joseph's Health Care London between January 2005 and December 2008 and found a rate of nonattendance at the adult diabetes clinic between 2 and 5 years after transfer of 28%. To detect an absolute difference of 16% (28% nonattendance rate in the control group compared with 12% in the intervention group), 188 participants (94 per group) were required to provide 80% power at the 0.05 level of significance. Because loss to clinical follow-up was the study's primary outcome, we did not increase the sample size to allow for loss to follow-up.

The primary outcome was the proportion of participants who failed to attend at least one outpatient adult diabetes clinic visit during the 12 months after the intervention period. Between-group comparisons, adjusting for center and baseline HbA_{1c} ($<$8.5% [69 mmol/mol] or $\geq$8.5% [69 mmol/mol]), used the Cochran-Mantel-Haenszel score test. The primary analysis was based on the comparison of participants in the two treatment groups who attended zero, one, and two clinical visits in the 12 months after the 18-month intervention period.

To control for covariates of interest, the proportional odds model was adopted. Exploratory analysis was performed to assess possible interactions between the intervention and control groups and baseline variables (such as center effect, age of transfer, sex, HbA_{1c} level, distance to diabetes center, postsecondary education institution attendance and location, and clinic attendance rate/year prior to transfer) to examine if the effect of the intervention (transition program) on the rate of nonattendance was influenced by one of the prognostic factors (e.g., HbA_{1c} level), taking into account the baseline covariates. Questionnaires were analyzed using ANCOVA adjusting for site baseline HbA_{1c} group ($<$8.5% [69 mmol/mol] or $\geq$8.5% [69 mmol/mol]) and the baseline value of the end point. Difference in change from baseline scores was calculated between the groups based on ANCOVA adjusted for the same variables as above.

Four mixed logistic regression models were used to analyze the effect of the intervention adjusted for the study period and baseline HbA_{1c} level. The minimal Akaike information criterion was used as the indicator of the best fitted model. The statistical analysis was performed using SAS (version 9.4) and R (version 3.4.4). P values $\leq$0.05 were considered statistically significant.

RESULTS

Between 17 April 2012 and 24 July 2014, 466 participants in the three pediatric centers were assessed for eligibility and 205 participants were randomized to the structured transition program (n = 104) or to standard care (n = 101) groups. Baseline characteristics were similar between groups (Table 1). The mean number of pediatric diabetes clinic visits in the 12 months preceding the enrollment was 3.2 (SD 0.9) in each group. The number of clinic visits attended in the year prior to study entry did not have an effect on clinic attendance during the 12 months after the intervention completion (odds ratio 1.29 [95% CI 0.86, 1.94], P = 0.214) (Supplementary Table 3).

The following results are presented first for the intervention period (18 months) and then for the follow-up period (12 months) during which the primary outcomes were assessed. During the intervention period, there were more visits in the transition program than in standard care. The mean number of visits over 18 months was 4.1 (SD 1.1) in the transition program versus 3.6 (SD 1.2) in standard care (P = 0.002) (Table 2). There were 51 (49%) participants in the transition program and 26 (26%) participants in standard care who attended all six visits. There was no difference in the mean change in HbA_{1c} from baseline to 18 months between the two groups (adjusted difference −0.04% [0.40 mmol/mol] [95% CI −0.49, 0.40], P = 0.848) (Table 3).

There were more participants in the transition program than standard care who had at least one emergency room visit for a diabetes-related problem other than DKA and/or hypoglycemia during the intervention period (9 [9%] vs. 2 [2%], P = 0.002). There was no difference in hospitalizations or emergency room visits for DKA and/or hypoglycemia between the groups (data not shown). More participants had monofilament foot testing in the transition program than standard care during the initial 18 months (71.2% vs. 57.4%, P = 0.036). During the 18 months of intervention, there were on average 17.6 (SD 7.3) indirect contacts with the TC. In addition, the TC attended almost all six visits in person (mean number of in-person visits 5.0 [SD 1.4]). The majority of contacts occurred by text messages (7.4 [SD 8.1]), whereas e-mail and phone contacts were less frequent (3.2 [SD 3.9] vs. 1.7 [SD 2.8]).

CSQ and DDS questionnaires were completed by 71 (68.3%) participants in the transition program and by 57 (56.4%) participants in standard care. Participants who had access to the TC showed improved satisfaction with care (CSQ mean score 29.0 [SD 2.7] vs. 27.9 [SD 3.4], P = 0.032), less diabetes-related distress (mean score 1.95 [SD 0.8] vs. 2.18 [SD 0.8], P = 0.049), and less emotional burden of diabetes (mean score 2.3 [SD 1.1] vs. 2.7 [SD 1.2], P = 0.027) compared with their baseline scores. The change in DQL scores was similar between the groups (Table 4).

Table 1—Baseline characteristics

	Intervention group (n = 104)	Control group (n = 101)
Sex		
Male	57 (55%)	47 (47%)
Female	47 (45%)	54 (53%)
Age (years)	17.9 (0.7)	17.9 (0.6)
Ethnic origin		
Caucasian	90 (87%)	85 (84%)
African American	7 (7%)	4 (4%)
Asian or Pacific Islander	2 (2%)	4 (4%)
Aboriginal	0 (0%)	0 (0%)
Other	5 (5%)	8 (8%)
Weight (kg)	72.5 (12.6)	72.2 (13.9)
BMI (kg/m^2)	24.9 (4.5)	24.9 (5.0)
Time since diabetes diagnosis (years)	8.5 (4.1)	7.7 (4.3)
Age at diabetes diagnosis (years)	9.4 (4.2)	10.1 (4.2)
Total insulin dose (units/kg/day)	0.92 (0.27)	0.93 (0.28)
Insulin injections (≥3 injections/day)	40 (38%)	44 (44%)
Insulin pump	60 (58%)	52 (52%)
Continuous glucose monitoring	4 (4%)	3 (3%)
Education		
High school (currently enrolled or graduated)	82 (79%)	83 (82%)
High school (dropped out)	3 (3%)	2 (2%)
College	8 (8%)	10 (10%)
University	9 (9%)	6 (6%)
Other (home schooled)	2 (2%)	0 (0%)
Distance from diabetes clinic (km)		
≤50	75 (72%)	86 (85%)
51–100	18 (17%)	12 (12%)
>100	11 (11%)	3 (3%)
Family structure		
Single-parent household	22 (21%)	26 (26%)
Two-parent household	75 (72%)	73 (72%)
Other	7 (7%)	2 (2%)
Current smoker	6 (6%)	9 (9%)
Alcohol use (≥3 units/week)	12 (12%)	8 (8%)
Cannabis use	12 (11%)	13 (13%)

Data are mean (SD) or n (%).

In the 12-month follow-up after the intervention period, 21 (20%) participants in the transition program and 20 (20%) in standard care were lost to follow-up. The mean number of visits, 1.3 (SD 0.8) in the transition program and 1.3 (SD 0.8) in standard care, was the same during the follow-up period (P = 0.846). Fifty-one (49%) participants in the transition program and 47 (47%) in standard care attended both follow-up visits (Table 2). There was no difference in the frequency of diabetes-related testing (retinal exam, albumin-to-creatinine ratio, lipid profile, and monofilament testing) in the follow-up period (Supplementary Table 1) or diabetes-related hospitalizations and/or emergency room visits. Questionnaires were completed by 70 (67%) participants in the transition program and by 68 (67%) in standard care. At completion of the study, there was no between-group difference in CSQ, DDS, DQL, or emotional burden of diabetes scores compared with baseline (CSQ score change difference −1.21 [95% CI −2.49, 0.07], P = 0.064; DDS scores change difference 0.06 [95% CI −0.20, 0.32], P = 0.642; emotional burden of diabetes scores change difference 0.05 [95% CI −0.28, 0.39], P = 0.756).

Post hoc analysis using a linear regression model showed that the odds of attending a clinical visit in the follow-up period was 1.3 times higher (95% CI 1.00, 1.79) in the intervention group (Supplementary Table 2). HbA_{1c} measurements were available for 73 (70%) participants in the transition program and 71 (70%) participants in standard care. Mean change in HbA_{1c} did not differ between the groups (adjusted difference 0.37% [95% CI −0.04, 0.78], P = 0.073) (Table 3).

The exploratory analysis showed that the mean HbA_{1c} at each visit in the control group was significantly higher than the mean HbA_{1c} at the same time point in the intervention group for the 30 months of study duration (mean difference 0.31% [95% CI 0.08, 0.54], P = 0.013) (Supplementary Fig. 2).

In the logistic regression model, we did not identify any baseline characteristics associated with a risk of disengagement with specialist care. To analyze the effect of the intervention on the clinic visits, the logistic mixed model with random intercept was applied (Supplementary Table 2). According to the prespecified criteria, model 3 was chosen as the "best." It demonstrated that the odds

Table 2—Primary outcome of clinic attendance

	Intervention period (0–18 months)			Follow-up period (18–30 months)		
	Intervention group (n = 104)	Control group (n = 101)	P value	Intervention group (n = 104)	Control group (n = 101)	P value
Number of scheduled visits			0.002*			0.846
0	–	–		21 (20.2%)	20 (19.8%)	
1	1 (1.0%)	1 (1.0%)		32 (30.8%)	34 (33.7%)	
2	4 (3.9%)	6 (5.9%)		51 (49.0%)	47 (46.5%)	
3	2 (1.9%)	13 (12.9%)		–	–	
4	18 (17.3%)	17 (16.8%)		–	–	
5	28 (26.9%)	38 (37.6%)		–	–	
6	51 (49.0%)	26 (25.7%)		–	–	
Mean (SD)	4.1 (1.1)	3.6 (1.2)		1.3 (0.8)	1.3 (0.8)	
Median	4.0	4.0		1.0	1.0	
Number of scheduled or unscheduled visits			0.001*			0.905
0	1 (1.0%)	1 (1.0%)		21 (20.2%)	20 (19.8%)	
1	4 (3.9%)	6 (5.9%)		32 (30.8%)	32 (31.7%)	
2	2 (1.9%)	11 (10.9%)		45 (43.3%)	41 (40.6%)	
3	16 (15.4%)	18 (17.8%)		4 (3.9%)	8 (7.9%)	
4	26 (25.0%)	37 (36.6%)		1 (1.0%)	0 (0.0%)	
5	51 (49.0%)	28 (27.7%)		0 (0.0%)	0 (0.0%)	
6	4 (3.9%)	0 (0.0%)		1 (1.0%)	0 (0.0%)	
Mean (SD)	4.2 (1.2)	3.7 (1.2)		1.4 (1.0)	1.4 (0.9)	
Median	5.0	4.0		1.0	1.0	
Attended visit 7	–	–	–	66 (63.5%)	66 (65.4%)	0.773
Attended visit 8	–	–	–	68 (65.4%)	62 (61.4%)	0.545

Data are mean (SD) or n (%) unless otherwise indicated. Analyses were performed using the Mantel-Haenszel test, adjusting for site and local baseline HbA_{1c} ($<$8.5% [69 mmol/mol] or $\geq$8.5% [69 mmol/mol]). For any visit or scheduled visit, where the visits are ordinal, the test used for comparing means score differences was equivalent to a Kruskal-Wallis test, adjusting for strata. *$P < 0.05$.

of clinic attendance in the transition program was 1.34 (95% CI 1.005, 1.788, P value = 0.0457) higher than in standard care. The effect of the follow-up period had no effect on clinic attendance, with an odds ratio of 0.808 (95% CI 0.647, 1.009, P value = 0.06). The baseline HbA_{1c} level had no significant effect on clinic attendance.

CONCLUSIONS

In this multicenter randomized controlled trial (RCT), clinic attendance was improved in young adults with type 1 diabetes who received an 18-month structured transition program with a TC. They also reported greater satisfaction with care and experienced less diabetes-related distress than those in standard

Table 3—Glycemic control

	Intervention group	n	Control group	n	P value	Difference	P value
Baseline							
% HbA_{1c}	8.46 (1.30)	103 (99%)	8.61 (1.57)	99 (98%)			
mmol/mol	69 (14.2)		71 (17.2)				
Intervention period (0–18 months)							
% HbA_{1c}	8.59 (1.47)	63 (61%)	8.63 (1.49)	50 (50%)	0.758		
mmol/mol	70 (16.1)		71 (16.3)				
Follow-up period (18–24 months)							
% HbA_{1c}	8.33 (1.21)	73 (70%)	8.80 (1.55)	71 (70%)	0.057		
mmol/mol	68 (13.2)		73 (16.9)				
			Change from baseline				
Intervention period (0–18 months)							
% HbA_{1c}	−0.20 (1.24)		−0.19 (1.29)			−0.04 (−0.49, 0.40)	0.848
mmol/mol	−2.20 (13.6)		−2.10 (14.1)			−0.40 (−5.40, 4.40)	
			Change from baseline				
Follow-up period (18–24 months)							
% HbA_{1c}	0.03 (1.09)*		−0.28 (1.64)			0.37 (−0.04, 0.78)*	0.073
mmol/mol	0.30 (11.9)*		−3.10 (17.9)			4.00 (−4.40, 8.50)*	

Data are mean (SD), n (%), or difference (95% CI). The difference is based on ANCOVA adjusted for baseline HbA_{1c} and site. HbA_{1c} represents central laboratory value. *Positive difference depicts decrease (improvement) from the baseline HbA_{1c} value.

Table 4—Questionnaires' scores over study duration

	Intervention group (n = 104)	Control group (n = 101)	Between-group difference in change from enrollment	P value
CSQ (total score)				
Enrollment	[101] 29.1 (2.8)	[99] 29.3 (2.9)		
Intervention	[71] 29.0 (2.7)	[57] 27.9 (3.4)	−1.17 (−2.24, −0.10)	0.032*
Follow-up	[71] 28.6 (3.0)	[67] 27.4 (4.6)	−1.21 (−2.49, 0.07)	0.064
DDS				
Total score				
Enrollment	[99] 2.00 (0.79)	[95] 2.01 (0.86)		
Intervention	[68] 1.95 (0.76)	[55] 2.18 (0.83)	0.26 (0.00, 0.51)	0.049*
Follow-up	[66] 2.16 (0.90)	[65] 2.22 (0.94)	0.06 (−0.20, 0.32)	0.642
Emotional burden of diabetes				
Enrollment	[101] 2.43 (1.11)	[101] 2.44 (1.27)		
Intervention	[70] 2.32 (1.06)	[59] 2.68 (1.17)	0.36 (0.04, 0.69)	0.027*
Follow-up	[70] 2.57 (1.21)	[67] 2.64 (1.26)	0.05 (−0.28, 0.39)	0.756
Physician-related distress				
Enrollment	[102] 1.18 (0.40)	[98] 1.14 (0.54)		
Intervention	[70] 1.27 (0.58)	[57] 1.32 (0.68)	0.05 (−0.14, 0.25)	0.578
Follow-up	[70] 2.6 (1.2)	[67] 2.6 (1.3)	0.02 (−0.21, 0.24)	0.889
Regimen-related distress				
Enrollment	[103] 2.35 (1.17)	[97] 2.45 (1.28)		
Intervention	[70] 2.35 (1.02)	[57] 2.68 (1.24)	0.27 (−0.09, 0.62)	0.140
Follow-up	[68] 2.62 (1.32)	[67] 2.69 (1.29)	0.20 (−0.17, 0.57)	0.293
Interpersonal distress				
Enrollment	[101] 1.76 (0.90)	[101] 1.82 (0.97)		
Intervention	[71] 1.64 (0.92)	[58] 1.95 (1.13)	0.27 (−0.07, 0.61)	0.117
Follow-up	[70] 2.6 (1.2)	[67] 2.6 (1.3)	0.13 (−0.17, 0.44)	0.391
DQL				
Satisfaction				
Enrollment	[103] 68.2 (9.9)	[101] 67.8 (10.5)		
Intervention	[71] 68.2 (9.5)	[59] 66.3 (9.4)	−1.5 (−4.0, 1.0)	0.227
Follow-up	[70] 65.5 (10.8)	[68] 65.8 (9.4)	0.1 (−2.9, 3.0)	0.964
Impact				
Enrollment	[103] 97.2 (11.4)	[101] 99.2 (11.5)		
Intervention	[71] 98.8 (9.5)	[59] 100.3 (10.6)	−0.4 (−3.1, 2.4)	0.798
Follow-up	[70] 99.5 (11.3)	[68] 99.6 (11.3)	−1.7 (−4.8, 1.4)	0.284
Social worry and diabetes worry				
Enrollment	[103] 55.9 (9.7)	[101] 56.8 (9.7)		
Intervention	[70] 56.7 (10.5)	[59] 56.3 (9.4)	−1.1 (−3.5, 1.3)	0.376
Follow-up	[70] 55.6 (10.9)	[68] 56.0 (9.3)	−0.9 (−3.7, 1.8)	0.493
General health				
Enrollment	[98] 2.96 (0.73)	[97] 2.89 (0.78)		
Intervention	[68] 2.79 (0.72)	[56] 2.75 (0.84)	−0.06 (−0.30, 0.17)	0.594
Follow-up	[68] 2.71 (0.81)	[65] 2.86 (0.77)	0.19 (−0.05, 0.43)	0.114

Data represent [n] mean (SD) and difference (95% CI) for between-group difference. P values reflect difference in change from the enrollment scores between the two groups. *$P < 0.05$.

care. The mean change in HbA_{1c} during the intervention showed a trend toward improvement but did not reach statistical significance. The young adults who had been in the structured transition program and had improved their clinic attendance during this period did not attend more clinic visits during the year after the intervention. Secondary outcomes that had improved during the intervention period (satisfaction with care and diabetes-related distress) were no longer different in the follow-up period. Diabetes complication screening, DKA, and severe hypoglycemia episodes occurred at the same frequency in both groups during the 12-month follow-up period.

Although the number of clinic visits increased during the intervention, this was not associated with an improvement in glycemic control. Interestingly, HbA_{1c} did not increase in the intervention group, which was a trend seen in the control group. In the exploratory analysis, the mean of the difference in HbA_{1c} between the groups during the follow-up period was statistically significant, with the intervention group HbA_{1c} continuing to improve.

There were significantly more diabetes-related emergency room visits in the intervention group during the study intervention. We think that frequent contact with the TC may have resulted in higher awareness of the risk of acute diabetes-related complications and more frequent emergency room visits. It is reassuring that the intervention did not result in a change in the rate of serious adverse events (DKA/hypoglycemia).

We have shown that there are benefits of additional support during the transition period in young adults with type 1 diabetes. These benefits included improved clinic attendance, satisfaction with care,

and less diabetes-related distress but did not translate to better glycemic control. We speculate that longer follow-up and/or a larger sample size would support the hypothesis that routine clinic visits result in better glycemic control and improved long-term diabetes-related outcomes.

To our knowledge, this is the first report of a multicenter RCT evaluating a transition intervention lasting for 18 months and extending to a 12-month follow-up. Strengths of our study included its robust design, pragmatic intervention, use of innovative, age-appropriate means of communication, and long follow-up duration spanning pediatric and adult care. To achieve an optimal study design, we built on various components of previously published transition interventions shown to improve health outcomes in observational studies (27,28) and aimed to maintain "real-world" conditions, with the only difference between the usual care and intervention groups being the addition of the structured transition program and TC. We successfully recruited and engaged this highly mobile and often challenging population throughout the transition period. The inclusion of two tertiary and a secondary clinical practice following young adults with type 1 diabetes allows for greater generalizability of our findings. The inclusion of electronic means of communication with the TC made our intervention more relevant and acceptable to young adults (29). Finally our intervention spanned pediatric and adult care and was longer than most reported transition interventions, which have been of 1 year duration or less.

Limitations of our study include lack of blinding and sample size, which possibly was not large enough to detect some differences. Blinding of participants and investigators was not possible; however, the group allocation was blinded, the treating physicians were not directly involved in the delivery of the transition-based interventions, and the TC had no contact with the control group participants.

Disengagement from care in the 12 months of follow-up was lower than anticipated and may have affected the ability to detect a difference between the groups at completion of the trial. We have shown that compared with the historic cohort in our center, rates of losses to clinical follow-up decreased in both groups. This can be explained by participation in a clinical trial and selection of a more motivated population that may perform better in a clinical trial setting.

A Cochrane Review in 2016 of registered controlled trials on transition care included adolescents with any chronic condition and any type of intervention and concluded that the limited number of evaluative studies with few randomized trials limits the strength of evidence (23,30). To our knowledge, there has been only one other RCT published since then, the Australian Transition to Adult Care in type 1 Diabetes (TrACeD) study (31), in which young adults with type 1 diabetes were assigned to an appointment manager group or to a control group. This study was smaller than ours, included a single center, and was not associated with increased clinic attendance in the first 12 months of the intervention but had a positive effect in the 2nd year (months 12–24). This is unlike our study, in which the improvement occurred in the first 18 months while the intervention was delivered but did not persist during the follow-up period when the extra support to young adults ended. Unlike the frequent TC/participant contact (an average of 17 contacts per participant over 18 months) in our study, in the TrACeD study, >50% of participants had infrequent contacts (defined as no contact over 12 months) with the appointment manager. Participant withdrawal rate was also much higher, with up to 38% of data missing for 2nd year outcome analysis. The TrACeD study was not powered to detect the difference in the follow-up period (12–24 months), and hence it is difficult to compare those results with our study. The number of participants in our trial exceeded all previous RCTs, including the TrACeD study. We are currently among very few reported RCTs to have studied the transition from both pediatric and adult perspectives. The only other RCT was an Australian pilot study in which young adults with type 1 diabetes were followed after discharge from pediatric care. The intervention included four contacts via phone from a TC over a 12-month period, together with educational and support materials (32). The sample size required for statistical power was determined at 30 individuals per group; however, results could only be reported on 14 in the control group and 12 in the intervention group due to challenges with recruitment and data collection. Hence, this study was also underpowered and in addition had a significant difference in HbA_{1c} between groups at baseline with minimal duration and frequency of phone contacts (32).

The important finding in our study was the significant improvement in clinic attendance in the intervention group during the initial 18 months when the transition program was delivered. Our study did not demonstrate a statistically significant improvement in the primary outcome, i.e., no difference in loss to clinic follow-up in the 12 months after the transition intervention. However, we have shown that the intervention can be effective. Our key finding speaks to the importance of ongoing transition support throughout the period of young adulthood. We also did not demonstrate an improvement in glycemic control in our study population. However, the mean HbA_{1c} in the intervention group did not increase over the study period (30 months) and may have shown some decreasing trend. Of note, our study population started with a mean baseline HbA_{1c} of 8.6% (70 mmol/mol) in the control group, compared with 8.9% (74 mmol/mol) in the same age cohort from the Type 1 Diabetes Exchange program (33). In our trial, disengagement rates were lower in both groups during the 12-month follow-up, which speaks to possible limitations of the clinical trial (recruitment of a highly motivated patient population). One of the most important results that should be emphasized is the improved satisfaction with care, decreased diabetes-related distress, and decreased emotional burden of illness. Any transition program that aims to change behavior should consider the emotional burdens of the disease in this population and aim to reduce barriers to access to care. We acknowledge that administering the transition program is time consuming, and inclusion of the TC (a Certified Diabetes Educator) is costly and may be a limiting factor to widespread implementation of this intervention. On the other hand, our intervention is easily translatable, and we ensured that insulin adjustments and medical care remained unchanged from usual care in our centers. Hence, the role of a TC could be modified and does not necessarily need to involve a diabetes educator or a highly specialized health care professional.

Conclusion

In summary, our study is the first to address the issue of transition support in a robust, pragmatic RCT. Young adults have a range of different needs related to their diabetes care and require flexibility when interacting with the health care system. We plan to build on our findings and develop technology-based solutions such as a "Virtual TC," which could be incorporated into more prolonged transitional care. Although the need for transition intervention has been evident for many years, there has been a paucity of high-quality evidence on which to base transition recommendations and practice. We anticipate that the results of this appropriately powered RCT will help to inform a more complete and prolonged solution for transition. Our study provides support that a structured transition program can alleviate some of the emotional burden of diabetes and help young adults maintain regular contact with their diabetes clinics and health care providers. In our study, the benefits of the intervention were demonstrated for the duration of the intervention. Our hope is that with a longer duration, positive effects of the intervention may persist and facilitate individual development of the necessary skills to bridge the care gap. Our study provides support that a structured transition program beginning in pediatric care can contribute to bridging the care gap. Sustaining these improvements requires sensitization of adult health care providers to invest in prolonged support for young adults beyond the first 2 years posttransition, which will continue to provide benefits throughout their life span.

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References

1. Blum RW, Garell D, Hodgman CH, et al. Transition from child-centered to adult healthcare systems for adolescents with chronic conditions. A position paper of the Society for Adolescent Medicine. J Adolesc Health 1993; 14:570–576
2. Arnett JJ. Emerging adulthood. A theory of development from the late teens through the twenties. Am Psychol 2000;55:469–480
3. Pacaud D, Yale JF. Exploring a black hole: transition from paediatric to adult care services for youth with diabetes. Paediatr Child Health 2005;10:31–34
4. Hynes L, Byrne M, Dinneen SF, McGuire BE, O'Donnell M, Mc Sharry J. Barriers and facilitators associated with attendance at hospital diabetes clinics among young adults (15-30 years) with type 1 diabetes mellitus: a systematic review. Pediatr Diabetes 2016;17:509–518
5. Visentin K, Koch T, Kralik D. Adolescents with type 1 diabetes: transition between diabetes services. J Clin Nurs 2006;15:761–769
6. Garvey KC, Wolpert HA. Identifying the unique needs of transition care for young adults with type 1 diabetes. Diabetes Spectr 2011;24: 22–25
7. Lotstein DS, Seid M, Klingensmith G, et al.; SEARCH for Diabetes in Youth Study Group. Transition from pediatric to adult care for youth diagnosed with type 1 diabetes in adolescence. Pediatrics 2013;131:e1062–e1070
8. de Beaufort C, Jarosz-Chobot P, Frank M, de Bart J, Deja G. Transition from pediatric to adult diabetes care: smooth or slippery? Pediatr Diabetes 2010;11:24–27
9. Bryden KS, Neil A, Mayou RA, Peveler RC, Fairburn CG, Dunger DB. Eating habits, body weight, and insulin misuse. A longitudinal study of teenagers and young adults with type 1 diabetes. Diabetes Care 1999;22:1956–1960
10. Patton GC, Viner R. Pubertal transitions in health. Lancet 2007;369:1130–1139
11. Hanna KM, Weaver MT, Slaven JE, Fortenberry JD, DiMeglio LA. Diabetes-related quality of life and the demands and burdens of diabetes care among emerging adults with type 1 diabetes in the year after high school graduation. Res Nurs Health 2014;37:399–408
12. Kipps S, Bahu T, Ong K, et al. Current methods of transfer of young people with type 1 diabetes to adult services. Diabet Med 2002;19:649–654
13. Sparud-Lundin C, Öhrn I, Danielson E, Forsander G. Glycaemic control and diabetes care utilization in young adults with type 1 diabetes. Diabet Med 2008;25:968–973
14. Insabella G, Grey M, Knafl G, Tamborlane W. The transition to young adulthood in youth with type 1 diabetes on intensive treatment. Pediatr Diabetes 2007;8:228–234
15. Busse FP, Hiermann P, Galler A, et al. Evaluation of patients' opinion and metabolic control after transfer of young adults with type 1 diabetes from a pediatric diabetes clinic to adult care. Horm Res 2007;67:132–138
16. Johnson B, Elliott J, Scott A, Heller S, Eiser C. Medical and psychological outcomes for young adults with type 1 diabetes: no improvement despite recent advances in diabetes care. Diabet Med 2014;31:227–231
17. Cadario F, Prodam F, Bellone S, et al. Transition process of patients with type 1 diabetes (T1DM) from paediatric to the adult health care service: a hospital-based approach. Clin Endocrinol (Oxf) 2009;71:346–350
18. Alassaf A, Gharaibeh L, Grant C, Punthakee Z. Predictors of type 1 diabetes mellitus outcomes in young adults after transition from pediatric care. J Diabetes 2017;9:1058–1064
19. Castensøe-Seidenfaden P, Jensen AK, Smedegaard H, et al. Clinical, behavioural and social indicators for poor glycaemic control

around the time of transfer to adult care: a longitudinal study of 126 young people with diabetes. Diabet Med 2017;34:667–675
20. Joensen LE, Almdal TP, Willaing I. Associations between patient characteristics, social relations, diabetes management, quality of life, glycaemic control and emotional burden in type 1 diabetes. Prim Care Diabetes 2016;10:41–50
21. Bryden KS, Dunger DB, Mayou RA, Peveler RC, Neil HA. Poor prognosis of young adults with type 1 diabetes: a longitudinal study. Diabetes Care 2003;26:1052–1057
22. Nakhla M, Bell LE, Wafa S, Dasgupta K. Improving the transition from pediatric to adult diabetes care: the pediatric care provider's perspective in Quebec, Canada. BMJ Open Diabetes Res Care 2017;5:e000390
23. Campbell F, Biggs K, Aldiss SK, et al. Transition of care for adolescents from paediatric services to adult health services. Cochrane Database Syst Rev 2016;4:CD009794
24. Betz CL, O'Kane LS, Nehring WM, Lobo ML. Systematic review: health care transition practice service models. Nurs Outlook 2016;64:229–243
25. Spaic T, Mahon JL, Hramiak I, et al.; JDRF Canadian Clinical Trial CCTN1102 Study Group. 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 Pediatr 2013;13:163
26. Cheng AY; Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2013 clinical practice guidelines for the prevention and management of diabetes in Canada. Introduction. Can J Diabetes 2013;37(Suppl. 1):S1–S3
27. Schultz AT, Smaldone A. Components of interventions that improve transitions to adult care for adolescents with type 1 diabetes. J Adolesc Health 2017;60:133–146
28. Gabriel P, McManus M, Rogers K, White P. Outcome evidence for structured pediatric to adult health care transition interventions: a systematic review. J Pediatr 2017;188:263–269.e15
29. Lenhart A. Teens, social media & technology overview 2015 [Internet], 2015. Available from https://www.pewresearch.org/wp-content/uploads/sites/9/2015/04/PI_TeensandTech_Update2015_0409151.pdf. Accessed 20 October 2017
30. Le Roux E, Mellerio H, Guilmin-Crépon S, et al. Methodology used in comparative studies assessing programmes of transition from paediatrics to adult care programmes: a systematic review. BMJ Open 2017;7:e012338
31. White M, O'Connell MA, Cameron FJ. Clinic attendance and disengagement of young adults with type 1 diabetes after transition of care from paediatric to adult services (TrACeD): a randomised, open-label, controlled trial. Lancet Child Adolesc Health 2017;1:274–283
32. Steinbeck KS, Shrewsbury VA, Harvey V, et al. A pilot randomized controlled trial of a post-discharge program to support emerging adults with type 1 diabetes mellitus transition from pediatric to adult care. Pediatr Diabetes 2015;16:634–639
33. Clements MA, Foster NC, Maahs DM, et al.; T1D Exchange Clinic Network. Hemoglobin A1c (HbA1c) changes over time among adolescent and young adult participants in the T1D exchange clinic registry. Pediatr Diabetes 2016;17:327–336