Original Article

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Comparison of compliance and outcomes in adolescents with type 1 diabetes mellitus attending a co-located pediatric and transition diabetes service

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Abstract

Objectives: Adolescence is a challenging period for diabetes management, particularly when transitioning to adult care. There are reports highlighting concerns that transition to adult care may lead to poor glycemic control and clinic engagement. Our aim was to determine if a co-located pediatric and transition diabetes service would lead to better transition outcomes.

Methods: A retrospective medical records review was conducted on patients with type 1 diabetes attending a transition clinic in a metropolitan teaching hospital in Sydney, Australia. Patients referred from the hospital's

co-located pediatric diabetes clinic to the transition clinic were compared to those referred from external sources regarding important clinical outcomes such as glycosylated haemoglobin (HbA_{1c}), clinic attendances, and complication rates between referral sources. Confounders such as age, gender, duration of diabetes and socioeconomic status were considered.

Results: Data was collected from 356 patients of which 121 patients were referred from the co-located pediatric diabetes clinic (IRG) and 235 patients from external sources (ERG). Improvements in HbA_{1c} were only seen in the ERG at 6 and 12 months ($p < 0.001$). Altogether 93% attended one or more medical appointments in the IRG compared to 83% in the ERG ($p = 0.03$). There were more admissions for acute diabetes complications (17 vs. 8%, $p = 0.01$) and more microvascular complications (20 vs. 9%, $p < 0.01$) in the IRG vs. ERG group.

Conclusions: Although co-location of a pediatric and transition clinic improved medical engagement, this did not equate to better glycemic control or complication rates. Further research is warranted to determine what other strategies are required to optimise the transition process in diabetes care.

Keywords: clinic visit; diabetes; glycosylated hemoglobin HbA_{1c}; transition.

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Introduction

Transition is a particularly important life event for adolescents with chronic medical conditions as it involves transfer from pediatric to adult health care. The transition coincides with the stage of life known as emerging adulthood (18–24 years). This age is often marked by geographic, economic and emotional separation from the parental home. Feelings of invulnerability and a tendency to reject adult control are often present. In particular,

this may further limit receptiveness to recommendations for diabetes management thus resulting in suboptimal diabetes care. There are studies that have expressed the transfer to adult care may be accompanied by poor glycaemic control and decreased clinic attendances [1, 2].

Patients transitioning to an adult provider have a 2.5-fold risk of poor glycaemic control by the time of their first adult visit, with elevations in glycosylated haemoglobin (HbA_{1c}) from 7.5% in their final pediatric visit to 9.2% by their first adult visit [3]. Data from the T1D Exchange indicate that glycaemic control during the young adult period is poor, with higher haemoglobin HbA_{1c} levels than in any other age group [1].

The term ‘transition’ implies a gradual, co-ordinated shift from a pediatric, *family*-centred model to an adult, *patient*-centred model. Its timing and tempo depend on patients’ physical and psychological states, as well as practical considerations.

The transition is a vulnerable period marked by changes in physical, emotional, and social domains [4]. Changes in health self-management place emerging adults at risk for poor health later [5]. Challenges can include reluctance to end a trusting relationship with the pediatric team, worries about ‘starting over’ with a new care provider, and discomfort with the unfamiliar adult medical setting which can have shorter visits and less emphasis on multi-disciplinary care [6, 7].

A successful transition cannot always be predicted based on clinical factors, although low hospital attendances and poor glycaemic control at the time of transition might negatively affect transition. However, there is no clear consensus on the definition of a successful transition, and there is a lack of high-quality evidence on which a transition plan can be based. However, there have been a few interventions that have attempted to address transition issues which include the transition to an adult service with dedicated young adult clinics [8, 9]. In a pilot study of a support transition coordinator, Van Wallegghem et al. [10] showed that medical engagement improved. However, there was no evidence of improved short-term medical outcomes. Holmes-Walker et al. [11] also tested a program with a transition coordinator and demonstrated improved clinic attendance and reduction in admissions for diabetic ketoacidosis. In an analysis of the Ontario Diabetes Database, Nakhla et al. [12] showed that patients who remained with the same physician after transition were at lower risk for hospitalization.

Therefore, the aims of this study were to determine if there was a difference in glycaemic control, hospital admissions, microvascular complications, and clinic attendances in type 1 diabetic patients attending a

transition diabetes clinic, depending on where they received prior diabetes care. Prior diabetes care were from either the co-located pediatric diabetes service or from external referral sources.

To our knowledge, our study represents the largest retrospective sample size to date of a co-located pediatric and transition diabetes service. We hypothesised that adolescents who transition within the same facility, might result in having better outcomes.

Methods

Study setting – transition clinic

This study was performed in the transition diabetes clinic in a metropolitan teaching hospital in Western Sydney. The transition clinic is staffed by a multi-disciplinary team comprised of an adult endocrinologist, transition diabetic nurse educator, dietician, and psychologist. This hospital’s diabetes transition clinic is a unique model in which both the pediatric clinic and transition diabetes clinics are co-located within the same department and clinical area. Referral to the transition clinic come from either the hospital’s co-located pediatric diabetes service or from external referrers of adolescents managed in other pediatric diabetes services. Apart from age >16 years and living in the local health area, there were no other criteria to refuse acceptance to the transition clinic. Our hospital model enables the integration of the pediatric *family*-centred, holistic approach and the adult *individual*-centred approach. The hospital’s transition clinic commenced in June 2008 and averaged 54 new patients per annum. Fourteen patients on average, are transitioned onto these adolescent (>16 years of age) and young adult services every year. Those adolescents that did not continue with the service and sought care elsewhere for other reasons were not captured in this study. Irrespective of where adolescents receive prior diabetes care, management in the transition clinic is the same for all.

Data collection

This was a retrospective data analysis of medical records from type 1 diabetes mellitus (T1DM) patients who attended the transition clinic. The retrospective review included a total of 356 patients who attended the transition clinic between 2008 and 2016. Data were manually extracted from individual patient case notes.

Data extracted included gender, body mass index (BMI), age of diagnosis, and age and duration of diabetes at transition. HbA_{1c} prior to transition was extracted as well as at 6 and 12 months post-transition. In addition, data on clinic attendances (medical and allied health), complications, and socio-economic factors were also collected.

In Australia, where there is universal free healthcare, higher socio-economic status is associated with lower risks of infectious diseases, associated hospitalization, and death. Socio-Economic Indexes for Areas (SEIFA) is an Australian Bureau of Statistics product that ranks areas in Australia according to relative socio-economic advantage and disadvantage and was used to assess socio-economic

status in our study and was based on the postcode of residence. The SEIFA score is reported in deciles with the highest decile representing a higher socioeconomic status.

SPSS IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. was used for data analysis. Means and standard deviations were used to describe normally distributed data. R version 4.1.0 was used for the repeated measure ANCOVA analysis.

For comparisons, Fisher exact tests were used for categorical data, and independent t-tests were used for continuous data. Paired t-tests were used to compare pre and post transition HbA_{1c}'s. To explore the impact of confounders on glycemic control, repeated measures analysis of covariance (ANCOVA) was used. Logistic regression analysis was also used to further explore categorical outcomes. All respective assumptions were met and a p-value of <0.05 was considered statistically significant.

Results

Of the 356 patients attending the transition clinic, 121 patients were internally referred from the hospital's pediatric clinic (IRG), and 235 patients were externally referred from other sources pediatric (ERG). Out of the ERG, 56 patients were referred from the local tertiary Children's Hospital, 39 patients were self-referred, 37 patients were referred by their local general practitioner, 35 patients were referred from the inpatient ward and 26 patients from the emergency department of the same hospital, 25 patients were referred by private endocrinologists, and 17 patients were referred from other metropolitan hospitals.

Table 1 describes the demographic details and insulin treatment modalities of the patients according to their referral sources. The mean age of diagnosis in the IRG was significantly lower compared to the ERG ($p<0.001$). The mean age of transition in the internal group was slightly

Table 1: Patient demographics and insulin type.

	IRG n=121	ERG n=235	p-Value
Male/female, n, % male	67/54 (55)	118/117 (50)	0.37
BMI, kg/m ²	25.2 ± 5.3	28.4 ± 8.1	<0.001
Age at transition, years	17.1 ± 1.7	18.8 ± 2.6	<0.001
Age at diagnosis, years	9.9 ± 4.1	14.1 ± 5.8	<0.001
Duration of diabetes, years	7.3 ± 4.2	4.7 ± 5.3	<0.001
Insulin type at transition, n, %			
– MDI	71 (59)	136 (58)	0.02
– Pump	50 (41)	78 (33)	
– Others incl. oral hypo-glycaemic agents	0	21 (9)	
SEIFA scores	7.2 ± 2.5	6.6 ± 2.8	0.05
HbA _{1c} pre-transition	9.1 ± 2.0	9.7 ± 2.6	0.04

BMI, body mass index; MDI, multiple daily injections.

Figure 1: Graphical representation of mean HbA_{1c} between referral sources.

lower than the ERG (17.1 ± 1.7 vs. 18.8 ± 2.6 years respectively, $p<0.001$).

HbA_{1c} levels were measured during the transition appointments. Mean HbA_{1c} levels at the time of transition was lower in the IRG compared to the ERG ($9.1 \pm 1.9\%$ vs. $9.7 \pm 2.6\%$ respectively, $p=0.04$). To analyse the impact of time, univariate paired t-testing was performed comparing 6 and 12 month HbA_{1c} to the pretransition level. Significant improvements were only seen in the ERG ($p<0.001$), but in the IRG, the pretransition HbA_{1c} did not significantly change over the course of the study ($p=0.15$ at six months, $p=0.78$ at 12 months) (Figure 1). In addition, Table 2 describes the repeated measures ANCOVA analysis comparing these serial HbA_{1c}'s between the two referral sources whilst controlling for gender, age, duration of diabetes, and socioeconomic status. There was a difference between referral groups before and after transition controlling for these confounders ($F=7.49$, $p<0.001$).

Table 2: Repeated measures ANCOVA.

Variable	df	F	p-Value
Age	1	1.50	0.22
Gender	1	0.13	0.72
SEIFA	1	2.04	0.15
Duration of diabetes	1	2.50	0.11
Referral source	1	0.00	0.99
Time	2	8.05	<0.001
Referral source × time	2	7.49	<0.001

Table 3: Diabetes care visit attendance.

	IRG n=121	ERG n=235	p-Value
Attended 1st transition appointment, n, %	114 (94)	233 (99)	<0.01
Remained with service at 24 months, n, %	103 (85)	191 (82)	0.41
Medical appointments attended, n, %			0.03
– 0	9 (7)	40 (17)	
– 1–2	37 (31)	82 (35)	
– 3–4	44 (36)	60 (26)	
– 5+	31 (26)	52 (22)	
Allied health appointments attended, n, %			0.76
– 0	20 (17)	40 (17)	
– 1–2	76 (63)	136 (58)	
– 3–4	25 (21)	58 (25)	

Table 3 describes the clinic attendances for medical and allied health reviews. More patients in the ERG (99%) attended the 1st transition appointment (either medical or allied health) than the IRG (94%) ($p<0.01$). There was no difference between the IRG and ERG groups in retention of patients with the transition service at 24 months (85 vs. 82%, $p=0.41$)

Table 4: Diabetes complications, mental health and socioeconomic factors.

	IRG n=121	ERG n=235	p-Value
Hospital admissions for acute diabetes complications, n, %	20 (17)	17 (8)	0.01
– Diabetic ketoacidosis	18 (15)	18 (7)	
– Hypoglycaemia	2 (2)	1 (1)	
Microvascular complications, n, %	24 (20)	21 (9)	<0.01
Mental health issues, n, %	28 (23)	63 (27)	0.52
Education/career, n, %			<0.01
– Relationship – partner	26 (22)	63 (27)	
– Alcohol/smoking	17 (14)	40 (18)	
– Full time employment	24 (20)	67 (30)	
– Part time employment	33 (28)	45 (20)	
– Unemployed	43 (36)	72 (32)	
– Apprenticeship	14 (12)	20 (7)	
– University	0	17 (8)	
– Other	0	2 (1)	
Living arrangements, n, %			0.71
With family and friends	107 (89)	197 (85)	
With partner	8 (7)	25 (11)	
Alone	1 (1)	2 (1)	
Other	4 (3)	5 (2)	

There were more hospital admissions due to acute diabetes-related complications, including DKA and hypoglycaemia in the IRG compared to the ERG (17 vs. 8% respectively, $p=0.01$), which was similarly seen in the rates of chronic diabetic complications including diabetic retinopathy, peripheral neuropathy, and micro-albuminuria (20 vs. 9% respectively, $p<0.01$). There were higher rates of mental health issues reported in the ERG that, however, did not reach significance ($p=0.52$) (Table 4).

The outcomes of hospital admissions (DKA and hypoglycaemia combined) and microvascular complications between the two groups were further analysed by logistic regression to account for the confounders, of age, duration of diabetes, gender, and socioeconomic status (Table 5). Despite controlling for these confounders there was still a difference in hospital admissions between the IRG and ERG groups (OR 0.39, 95% CI 0.19–0.8, $p=0.01$). In regard to microvascular complications, there was still a difference between the groups with more complications occurring in the IRG compared to the ERG (OR 0.51, 95% CI 0.26–0.99, $p=0.046$). In addition, the duration of diabetes was found to significantly contribute to this finding (OR 1.10, 95% CI 1.03–1.17, $p=0.004$).

Discussion

We described the outcomes of 356 adolescents (>16 years of age) and young adults with type 1 diabetes mellitus attending the diabetes transition clinic in a Western Sydney metropolitan hospital between 2008 and 2016. We wanted to explore whether there were better outcomes of having a co-located pediatric and transition clinic. We found that although patient engagement was better, this was not associated with better glycemic control, less

Table 5: Logistic regression analysis exploring hospital admissions and microvascular complications.

	Admissions for acute complications			Microvascular complications		
	OR	95% CI	p-Value	OR	95% CI	p-Value
Referral source	0.39	0.19–0.80	0.01	0.51	0.26–0.99	0.046
Age	1.08	0.98–1.18	0.12	1.00	0.92–1.08	0.95
Duration of diabetes	1.00	0.94–1.09	0.79	1.10	1.03–1.17	0.004
Gender	1.09	0.54–2.20	0.80	0.84	0.44–1.61	0.59
SEIFA	1.07	0.93–1.23	0.36	1.18	1.03–1.36	0.02

OR, odds ratio; CI, confidence interval.

hospital admissions, and microvascular complications following the transition.

Internally referred vs. externally referred

In our study, there was an improvement in glycemic control in the ERG post transition period. The mean age of diagnosis in the IRG was lower compared to the ERG by around 50 months and the mean age of transition was also lower in the IRG compared to the ERG. This means that at the time of transition, the IRG was around 18 months younger with the majority still at school. In addition, the duration of diabetes in the IRG was longer (7.3 vs. 4.7 years). Although patients in the ERG were older and the diabetes duration shorter, these factors did not contribute to differences in HbA_{1c} levels or admissions for acute complications. It is plausible however, to partially consider the impact of these factors on glycemic outcomes in this group as this is supported in the literature [13–15]. In addition, taking into consideration the difference in the duration of diabetes, the ERG was also found to have a comparatively better outcome in hospitalizations due to acute diabetic complications and chronic complications of diabetes.

Van Walleggham et al. [10] and Holmes-Walker et al. [11] both highlight that more committed and focussed contact with families result in better engagement with follow-up. Van Walleggham reported a drop out rate of 40% reducing to 11% in those patients who had a ‘navigator’ who supported a young adult with diabetes through the transition process. Holmes-Walker concluded if young adults are appropriately supported in adult services, clinic attendance is maintained, diabetes control is improved and hospital admission rates with DKA are reduced. We surmise that as our paediatric diabetes service fed directly into the transition service the better attendance rate in the IRG at 24 months was probably due to the familiarity of patients with the diabetes centre and hospital.

Lee summarises in his paper the many key goals that need to be considered in the transition between pediatric and adult diabetes care which include the transition process occurring in the shortest timeframe and to improve post transition outcomes [16]. He encourages that the transition to an adult health care provider should occur within the same center, rather than referring the patient to another center.

For emerging young adults with diabetes, it is particularly important to create effective and translatable processes for the transition in care from pediatric to adult providers to optimize well-being and health [16]. It is additionally important for these young adults to achieve

target glycemic control to prevent long-term complications and to maximize lifelong functioning [17]. There are no proven strategies to achieve these goals. However, programs that particularly target young adults with diabetes through education, skills training, specialty transition clinics, or addition of transition coordinators appear to be beneficial. Successful family involvement may assist in the preservation of health and the prevention of long-term diabetes complications for youth with diabetes [18].

Despite the increasing awareness of the importance of transition care, there exist significant and persistent gaps in transition care. When emerging adults are supported through the transition period, adverse outcomes, clinic attendances, and loss to follow-ups improve. Our study tried to investigate this aspect to see if having a co-located paediatric clinic would assist in the transition process. However, this is not supported by the results of our study.

Limitations

A major limitation of this study is the retrospective nature of the design. The data, however, was complete with very little missing information. As this is a single centre experience, it would be unwise to make generalizations from our results. Another limitation is the selection bias of the IRG as we did not explore those patients that did not continue on in the transition clinic. There may have been a small cohort that decided to move to the private health care setting or move to another area health service. We believe that this would not have altered the results significantly however should be considered in future studies.

Conclusions

To our knowledge, this is the largest retrospective study to date of a co-located pediatric and transition diabetes service, which compares the transition outcomes between two groups of patients who were referred from different referral sources. Our results highlight that despite serial HbA_{1c}'s being comparatively better in the patients referred from the ERG compared to the IRG, their clinic attendance was the opposite. We also found that hospital admissions and microvascular complications were less in the ERG as well. The shorter duration of diabetes in the ERG could explain the lower rate of microvascular complications, however this did not contribute to the difference seen with hospital admission rates between the groups. Apart from better engagement in follow-up clinics, our study did not identify further strengths of a co-located pediatric and transition

diabetes clinic. As we did not obtain prospective patient satisfaction data about the transition process between the two referral groups, we can only speculate on this important facet of transition. Further research is needed to determine if other strategies could be implemented to optimise the transition process in diabetes care.

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References

1. Miller KM, Foster NC, Beck RW, Bergenstal RM, DuBose SN, DiMeglio LA. Current state of type 1 diabetes treatment in the U.S: updated data from the T1D exchange clinic registry. *Diabetes Care* 2015;38:971–8.
2. Peters A, Laffel L. Diabetes care for emerging adults: recommendations for transition from pediatric to adult diabetes care systems. *Diabetes Care* 2011;34:2477–85.
3. Lotstein DS, Seid M, Klingensmith G, Case D, Lawrence JM, Pihoker C. Transition from pediatric to adult care for youth diagnosed with type 1 diabetes in adolescence. *Pediatrics* 2013; 131:1062–70.
4. Arnett JJ. Emerging adulthood. A theory of development from the late teens through the twenties. *Am Psychol* 2000;55:469–80.
5. Park MJ, Mulye YP, Adams SH, Brindis CD, Irwin CE Jr. The health status of young adults in the United States. *J Adolesc Health* 2006;39:305–17.
6. Weissberg-Benchell J, Wolpert H, Anderson BJ. Transitioning from pediatric to adult care: a new approach to the post-adolescent young person with type 1 diabetes. *Diabetes Care* 2007;30:2441–6.
7. Allen D, Gregory J. The transition from children to adult diabetes services: understanding the ‘problem’. *Diabet Med* 2009;26: 162–6.
8. Mary F, Eunseok C, Eugene W, Faulkner MS. A systematic review of transitional care for emerging adults with diabetes. *J Paediatr Nurs* 2015;30:e47–62.
9. Suwannaphant K, Laohasiriwong W, Puttanapong N, Saengsuwan J, Phajan T. Association between socioeconomic status and diabetes mellitus. *J Clin Diagn Res* 2017;11:LC 18–22.
10. Van Walleghem N, Macdonald CA, Dean HJ. Evaluation of a systems navigator model for transition from pediatric to adult care for young adults with type 1 diabetes. *Diabetes Care* 2008;31: 1529–30.
11. Holmes-Walker DJ, Llewellyn AC, Farrell K. A transition care programme with improves diabetes control and reduces hospital admission rates in young adults with type 1 diabetes aged 15–25 years. *Diabet Med* 2007;2:764–9.
12. Nakhla M, Daneman D, To T, Paradis G, Guttman A. Transition to adult care for youths with diabetes mellitus: findings from a universal health care system. *Pediatrics* 2009;124:1134–41.
13. Pinhas-Hamiel O, Hamiel U, Boyko V, Graph-Barel C, Reichman B, Lerner-Geva L. Trajectories of HbA_{1c} levels in children and youth with type 1 diabetes. *PLoS One* 2014;9:e109109.
14. Clements MA, Foster NC, Maahs DM, Schatz DA, Olson BA, Tsalkian E, et al. Hemoglobin A_{1c} (HbA_{1c}) changes over time among adolescent and young adult participants in the T1D exchange clinic registry. *Pediatr Diabetes* 2016;17:327–36.
15. Clements MA, Lind M, Raman S, Patton SR, Lipska KJ, Fridlington AG, 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.
16. Lee YA. Diabetes care for emerging adults: transition from paediatrics to adult diabetes care systems. *Ann Paediatr Endocrinol Metab* 2013;18:106–10.
17. Rausch JR, Hood KK, Delamater A, Pendley JS, Rohan JM, Reeves G, et al. Changes in treatment adherence and glycemic control during the transition to adolescence in type 1 diabetes. *Diabetes Care* 2012;35:1219–24.
18. Laffel LM, Vangsness L, Connell A, Goebel-Fabbri A, Butler D, Anderson BJ. Impact of ambulatory, family-focused teamwork intervention on glycemic control in youth with type 1 diabetes. *J Paediatr* 2003;142:409–16.