



Providing optimal service delivery for children and adolescents with type 1 diabetes: a systematic review

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Introduction

Type 1 diabetes in adolescence presents special challenges. The combination of severe insulin deficiency and the physical and psychological challenges that accompany normal growth and development make day to day management of type 1 diabetes difficult. Moreover, the results of the Diabetes Control and Complications Trial (DCCT)^{1,2} and the Epidemiology of Diabetes Interventions and Complications (EDIC) study^{3,4} have raised the bar considerably higher in respect to goals of treatment. These landmark studies have clearly shown that intensified insulin treatment significantly reduces the risk of the development and progression of both micro- and macrovascular complications of diabetes. In line with these findings, current recommendations mandate that adolescents with type 1 diabetes (T1DM) should aim to achieve glycaemic control (as measured by glycosylated haemoglobin [HbA_{1c}]) as close to normal as possible and as early as possible within their disease process, while still allowing for normal growth and development.^{5,6} Achieving these reduced HbA_{1c} concentrations in adolescence is vitally important as this can reduce the risk of complications in adulthood, irrespective of later levels of glycaemic control.⁴

Reassuringly, the Hvidore Study^{7,8} has shown that it is possible for a large proportion of young patients to meet these strict standards. However, this also appears to require intensi-

ABSTRACT

The purpose of this systematic review was (1) to perform a comprehensive examination of the literature to identify aspects of service delivery which are associated with improved glycaemic control in young people with type 1 diabetes, and (2) to identify gaps in the current literature and suggest areas for future research.

The online medical databases Medline, Embase, Psycinfo and Cinahl were searched using a series of keywords. We reviewed randomised controlled trials and cross-sectional, comparison and retrospective audit studies from 1980 to December 2007 which involved children, adolescents and young adults with type 1 diabetes. In total, 540 studies were screened for inclusion, with 68 papers retrieved for further analysis 23 of which were retained for inclusion in the review.

The service delivery indicators identified in the review which have an impact on glycaemic control in young people with type 1 diabetes include access to specialist care, number of clinic visits attended, access to care from a multidisciplinary diabetes team and regular telephone contact.

This review confirmed that various aspects of paediatric diabetes service delivery do impact on the glycaemic control of children and adolescents with type 1 diabetes. It has also identified the need for studies to examine further the complex interplay of multiple aspects of service delivery, including the impact of a family-centred model of care, on glycaemic control. Copyright © 2009 John Wiley & Sons.

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KEY WORDS

children; adolescents; type 1 diabetes; service delivery; glycaemic control

fied care which is resource hungry and requires a team of specialised health care professionals comprising paediatric physicians or endocrinologists, highly specialised nursing staff, dietitians, pharmacists and mental health specialists. Moreover, the Hvidore Study highlighted that these standards are not being achieved in all centres around the world,⁷ with substantial differences among the international multidisciplinary paediatric centres within the Hvidore Group both in average HbA_{1c} and in the frequency and severity of hypoglycaemia, independent of HbA_{1c}. While these differences may be due

to the heterogeneity of T1DM itself, other factors such as the adolescents' attitudes toward treatment⁹ and their perception of services^{9,10} may also play an important role. The findings may equally relate to features of diabetes care delivery such as staffing structure,¹¹ deployment of resources,^{11,12} strategies of care¹² and the service delivery model. The centres involved in the Hvidore Study were heterogeneous, in that they were all specialised paediatric diabetes units. These authors suggested that 'differing attitudes of the diabetes teams within these units and/or differing degrees of

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patient empowerment' may have contributed towards the differences in observed outcomes.

This view is supported by research conducted in other chronic illnesses which suggests that the way the team works together is an important predictor of treatment outcome.¹³ For example, there is an association between improved survival of young cancer patients and models of care that are specialist, family-centred and comprehensive in support systems compared to other chronic disease models which also use a multidisciplinary team.^{14,15} Whether similar models will produce more favourable outcomes for adolescents with diabetes is unknown as there is no clear evidence in the literature to suggest what elements of service delivery or usual care combine to determine an optimal model of health care for young people with T1DM.

The goals of this systematic review are therefore to examine the literature and identify aspects of service delivery which are associated with improved diabetes outcomes, and to identify gaps in the current literature and suggest areas for future research.

Methods

Searching

A comprehensive search strategy was used to identify studies or reports relating to diabetes service delivery or models of care in adolescent populations. A series of keywords were used to obtain articles that met these criteria. Keywords included type 1 diabetes, child/children, adolescent/adolescence, glycosylated haemoglobin (HbA_{1c}), glycaemic control, blood glucose, health care, quality of care, quality of health care, model of health care, organisational models, delivery of health care, clinic visits, ambulatory care, diabetes care, specialist care, multidisciplinary, patient-centred care, telephone, clinic resources, rural health care, clinic attendance, complications screening, and family-centred care. The number of keywords used is indicative of both the large variety of service delivery models being used and the complexity of determining which model provides optimal care in what situation and environment. The terms were searched in the electronic

databases Medline, Embase, Psycinfo and Cinahl. The search was limited to include literature written in the English language, between 1980 and December 2007. Reference lists of included papers were also checked for potentially relevant studies.

Selection

The initial search of the literature identified 540 potential studies. Based on a visual inspection of the title and/or abstract, 472 papers were excluded from further analysis as they were concerned with treatment adherence, dietary studies, insulin modality, and pharmacokinetics and pharmacodynamics of insulin preparations, rather than service delivery. Sixty-eight full papers were thus retrieved for further assessment. Studies were included only if they related to service delivery and if the patient population included young people aged 25 years or younger with T1DM. Articles were excluded if they related to adult care, diabetes care in pregnancy or management of young people with type 2 diabetes. In addition, for the purpose of this review, diabetes outcomes were defined as HbA_{1c}, frequency and severity of hypoglycaemia, ketoacidotic events and microvascular complications. Only papers reporting these outcomes were included.

Results

The criteria for inclusion in the review were met by only 23 studies. The low number of studies retrieved is further evidence of the paucity of research looking at the complex interaction of factors involved in service delivery to young people with T1DM. It is, however, an area worthy of review. This led to the decision to include all 23 studies without applying further exclusion criteria, including those related to methodologies used. Therefore, included in this review are four cohort studies, six retrospective evaluations or clinical audits of usual care, five comparison studies, three cross-sectional studies and five randomised controlled trials (RCTs) with sample sizes ranging from 2579 in one of the cross-sectional studies to 46 in one of the RCTs. All except one study reported effects of service delivery on HbA_{1c}.

The number of severe hypoglycaemic events, episodes of diabetic ketoacidosis and development of complications were reported as additional outcomes in some studies (see Table 1). A formal meta-analysis was not conducted because of the heterogeneity of identified articles and outcome measures used. This review cannot, therefore, be definitive in its conclusions. It can, however, provide insights into what is currently understood about the factors influencing optimal service delivery. Results have therefore been synthesised narratively and are organised around the service delivery indicators used in the studies and set out in Table 1.

Data synthesis

Clinic attendance

The literature strongly suggests an association between clinic attendance and HbA_{1c}. Young people who regularly attend diabetes clinics are more likely to have a lower HbA_{1c} value than those with irregular follow up.^{16,17} The number of yearly clinic visits may also play an important role. Results from a number of studies show an association between increasing number of clinic visits and improved glycaemic control.^{18–22} A cohort study by Chalew *et al.* found that young people who had attended only one clinic visit per year had the highest HbA_{1c} of their clinic population; however, those who attended three or more clinic visits per year had the lowest HbA_{1c}.¹⁹ In a longitudinal study, Kaufman *et al.* found that children or adolescents who attended the clinic three to four times per year had a lower mean HbA_{1c} compared to children who had attended two or fewer clinic visits per year,²⁰ and a UK regional audit found that exactly four clinic visits per year was optimal.¹⁸ Paradoxically, a nationwide cross-sectional study of children with T1DM in Denmark found that increasing the number of visits to the outpatient clinic was significantly associated with higher HbA_{1c} ($p=0.0005$), with the lowest HbA_{1c} associated with less than four visits per year.²¹ A cross-sectional study by Urbach *et al.* also found a higher HbA_{1c} in subjects attending five or more clinic visits per year when compared to those attending three to four clinic visits per year.²²



Service delivery in children and adolescents with type 1 diabetes

Table 1. Summary of literature measuring impact of aspects of service delivery on glycaemic outcome in young people with type 1 diabetes

Study	Sample	Design	Outcomes measured	Service delivery indicators
Baumer <i>et al.</i> ²⁶ (1997)	N=801 children and young people; study completed in South Western region of England	Retrospective audit	HbA _{1c}	Specialist care (including specialist caseload)
Bloomfield <i>et al.</i> ²⁸ (1990)	N=177 children; study conducted in UK	Prospective comparison study	HbA _{1c} Days in hospital	Specialist care
Cameron <i>et al.</i> ²³ (2002)	N=167 children; study conducted in Victoria, Australia	Prospective comparison study	HbA _{1c} ; Access to services; Quality of life; Diabetes knowledge	Geographic location Complications screening
Cardwell <i>et al.</i> ¹⁸ (2005)	N=914 children and adolescents; study conducted in UK	Audit of care	HbA _{1c}	Clinic visits
Chalew <i>et al.</i> ¹⁹ (2000)	N=151 (evaluation study) and n=40 (intervention study), Caucasian and African-American children; study completed in US	Evaluation/cohort study and intervention study	HbA _{1c}	Number of yearly clinic visits Multidisciplinary care
Dorcy <i>et al.</i> ¹⁶ (1997)	N=144 children and adolescents <18 years; study conducted in Belgium	Cross-sectional cohort study	HbA _{1c}	Clinic visits
Dyrlov <i>et al.</i> ¹¹ (2000)	Children and adolescents 0–18 years; study conducted in Denmark	Audit	HbA _{1c}	Telephone contact Multidisciplinary team
Edge <i>et al.</i> ⁴³ (2005)	N=187 consultant paediatricians; study conducted in UK	Audit	HbA _{1c}	Specialist care
Farmer <i>et al.</i> ³⁶ (2005)	N=94 young adults; study conducted in UK	Randomised controlled trial	HbA _{1c}	Telephone contact
Franklin <i>et al.</i> ³⁵ (2006)	N=92 children and adolescents aged 8–18 years; study conducted in UK	Randomised controlled trial	HbA _{1c} ; Self-efficacy Adherence	Telephone contact
Handelsman <i>et al.</i> ²⁴ (2001)	N=1190 children <15 years; study conducted in Australia	Audit	HbA _{1c}	Geographic location
Jacobson <i>et al.</i> ¹⁷ (1997)	N=61 children and adolescents; study conducted in US	Comparison study	HbA _{1c} Ketoacidosis Retinopathy	Clinic visits
Kaufman <i>et al.</i> ²⁰ (1999)	N=360 (1995), n=412 (1996) and n=442 (1997) children and adolescents; study conducted in US	Comparison study	HbA _{1c}	Clinic visits
Laffel <i>et al.</i> ³² (2003)	N=105 children and adolescents 8–17 years; study conducted in US	Randomised controlled trial	HbA _{1c} Family involvement	Multidisciplinary care Family-focused care
Laron <i>et al.</i> ³⁰ (1979)	N=262 children	Comparison study	HbA _{1c}	Multidisciplinary team
Lawson <i>et al.</i> ³³ (2005)	N=46 adolescents 13–17 years; study conducted in Canada	Randomised controlled trial	HbA _{1c}	Telephone contact
Nordly <i>et al.</i> ²¹ (2005)	N=1087 children and adolescents <16 years; study conducted in Denmark	Cross-sectional study	HbA _{1c}	Clinic visits Telephone contact
Nunn <i>et al.</i> ³⁴ (2006)	N=123 children and adolescents; study conducted in Australia	Randomised controlled trial	HbA _{1c}	Telephone contact
Rosilio <i>et al.</i> ²⁷ (1998)	N=2579 children and adolescents 1–19 years; study conducted in France	Cross-sectional	HbA _{1c}	Specialist care (size and type of clinic)
Summersett <i>et al.</i> ²⁵ (2003)	N=57 children; study conducted in US	Retrospective cohort study	Access to services	Geographic location (and access to services)
Urbach <i>et al.</i> ²² (2005)	N=155 children and adolescents; study conducted in Canada	Retrospective cross-sectional	HbA _{1c}	Clinic visits
Von Sengbusch <i>et al.</i> ²⁹ (2006)	N=107 children and adolescents; study conducted in Germany	Cohort study	HbA _{1c} Hospitalisation Severe hypoglycaemia	Telephone contact
Wills <i>et al.</i> ³¹ (2003)	N=397 young people 16–25 years; study conducted in UK	Retrospective review/audit	HbA _{1c} ; Prevalence of complications	Multidisciplinary team



Geographic location

It has been suggested by researchers that the geographic location of the diabetes clinic is not a significant predictor of glycaemic control. Two Australian studies reported there was no significant difference in median HbA_{1c} level between young people living in a rural area when compared to an urban area. An American study also reported there was no significant difference in mean HbA_{1c} between the two geographic locations.^{23–25} However, there were differences with regard to access to services, including access to team-based diabetes care,²³ and number of HbA_{1c} tests and yearly clinic visits²⁵ between urban and rural locations.

Specialist vs generalist care

Three studies explored the comparative effects of type of care provided on metabolic outcome in young people with T1DM, one a cross-sectional, nationwide French study, one a prospective comparison study and the other a retrospective audit of care in a region of England.^{26–28} All three studies suggest that young people who receive care from paediatric diabetologists have significantly better metabolic control (as measured by HbA_{1c}), than those who receive care from general paediatricians. Moreover, these studies have suggested that children under the care of paediatric diabetologists with a higher caseload (>40 patients) have better clinical outcomes than those attending paediatric diabetologists with lower caseloads.²⁷ A study that compared metabolic control in children with T1DM living in rural areas of Germany before and after the establishment of a mobile specialised diabetes service further highlighted the importance of access to specialised care, with the proportion of children achieving acceptable HbA_{1c} values significantly improving following the specialist intervention.²⁹ Children under the care of diabetes specialists have also been reported to have lower hospital admission rates with all diabetes related problems including hypoglycaemia.²⁶ There is also evidence to suggest that children and adolescents seen by experienced diabetologists within a tertiary institution may do better. Rosilio *et al.* reported that the best glycaemic

control was observed in university-affiliated hospitals, as compared to general, regional and private hospitals and private practice.²⁷ A higher proportion of patients attending the university-affiliated hospital had an HbA_{1c} value <8%, the cut-off value suggested by the DCCT at which the chance of developing complications is significantly decreased.¹

Multidisciplinary team

While the majority of papers in the review reported that subjects attending a diabetologist did so within a multidisciplinary team, only three studies specifically discussed the impact of the team on glycaemic control. All three studies concluded that there was improved glycaemic control in the children who had been treated by a team compared to those who were not.^{11,19,30} One study reported that total HbA_{1c} levels in young Caucasian patients with T1DM decreased by ~2.0%, from 12.5% to 10.6%, over the six years of observation, following the implementation of a multidisciplinary intervention programme.¹⁹ It should be noted, however, that there was a differential effect in that there was no improvement in glycaemic control for African-American patients within the study cohort. Dyrlov *et al.* also reported a decrease in HbA_{1c} following the implementation of several changes to a paediatric diabetes clinic, including changes to the professions represented within the multidisciplinary team; however, it is unclear how much of this improvement can be attributed to the multidisciplinary team approach. Despite this, the authors suggested that psychological assistance within the diabetes team and extra nursing support were important factors in this improvement.¹¹

In addition to improved glycaemic control, access to multidisciplinary care has also been associated with a lower prevalence of acute complications. Laron *et al.* reported reduced frequency of severe hypoglycaemia and diabetic ketoacidosis, in children under the care of a multidisciplinary team.³⁰ On the other hand, lack of access has been shown to be associated with a higher prevalence of acute complications. The authors of a retrospective audit of care

received by young people (16–25 years) in the UK cited that inadequate access to multidisciplinary care, in particular to dietetic and psychological services,³¹ contributed towards poor metabolic control with a subsequent increase in risk of microvascular complications.

There is also research to suggest that the way in which a multidisciplinary team interrelates is important. In an RCT, Laffel *et al.* examined the impact on glycaemic control of standard multidisciplinary care *vs* ambulatory, family-focused care. Results suggested that the family-focused care prevented the expected deterioration in glycaemic control normally associated with adolescence. As hypothesised, the HbA_{1c} of adolescents randomised to receive standard multidisciplinary care deteriorated after one year of intervention (HbA_{1c} 8.7±1.5%). By contrast, the HbA_{1c} of subjects receiving the family-centred care remained stable (8.2±1.1%), despite similar levels of glycaemic control at baseline (HbA_{1c} 8.4±1.3% family-focused care group *vs* HbA_{1c} 8.3±1.0% standard care group). This resulted in significant differences in HbA_{1c} between these two groups at the end of the one-year period ($t = -2.01$, $df = 98$, $p < 0.05$).³² The study did not report what constituted 'standard' multidisciplinary care, but did suggest that incorporating family teamwork in diabetes management tasks within a multidisciplinary paediatric diabetes practice may be beneficial.

Telephone contact

Two RCTs showed that regular telephone contact between a paediatric diabetes nurse educator and children or adolescents with diabetes did not lead to immediate improvements in glycaemic control.^{33,34} A further RCT by Franklin *et al.* – that used text messaging designed to enhance self-efficacy through automated delivery of a series of appropriately tailored messages (including a weekly reminder of the goals set in clinic, and a daily message providing tips, information or reminders to reinforce this goal) – reported improvements in self-efficacy and adherence. This intervention, however, did not result in improved glycaemic control.³⁵ A



cross-sectional study also reported improved self-management of diabetes in terms of frequency of blood glucose monitoring for children with access to a telephone hotline service. In line with Franklin *et al.*, the increase in monitoring did not have a direct association with change in HbA_{1c}.²¹

In contrast with the above studies, a mobile phone-based telemedicine system, linking patients with clinicians, used to support young adults with T1DM through transmission and feedback of diabetes data (such as blood glucose results and insulin dose) resulted in increased numbers of patients achieving HbA_{1c} targets of <8% among the intervention group.³⁶ A second study by a group of Danish researchers also suggested that the introduction of a dedicated 24-hour telephone service contributed towards the significant improvement in glycaemic control seen in the study clinic over a four-year period.¹¹ However, this study introduced several changes to service delivery over this time, including the implementation of a team approach, and no direct association between the telephone service and improved control was presented in the study results.

Discussion

This review has provided evidence to confirm that various aspects of paediatric diabetes service delivery may impact on the glycaemic outcome of children and adolescents with T1DM. Although there have been no comprehensive studies looking at the combined effects of multiple aspects of service delivery on glycaemic control, there have been several individual indicators suggested in RCTs, cross-sectional studies, cohort studies and retrospective clinical audits.

The literature suggests that increased attendance at diabetes clinics is associated with improved control, with four visits per year appearing optimal. These results support the current international treatment guidelines for young people with T1DM, which recommend that a young person should attend a diabetes clinic four times per year, at three-monthly intervals. As seen in

the studies reported in this review, it has been found that glycaemic control was significantly worse if the number of clinic visits exceeded four visits per year. It is plausible that this represents an increased need for diabetes care to help manage blood glucose levels to an acceptable level. Based on current research it cannot be assumed that increased visits result in poorer control. Moreover, adolescents within the intensive therapy cohort of the DCCT, who received monthly outpatient follow up, with frequent telephone contact between visits, achieved significantly lower HbA_{1c} levels than those receiving conventional therapy. There is a need for an RCT to evaluate the impact of the many confounders influencing glycaemic outcomes associated with number of clinic visits, so that optimal care can be provided by diabetes treatment teams.

The finding that glycaemic control was significantly worse if the number of yearly clinic visits was less than three may be related to patient motivation, where those patients who are not motivated to attend regular clinic visits are also less motivated to manage their diabetes, resulting in poor blood glucose control. Inadequate access to diabetes clinics must also be considered as a potential reason behind fewer clinic visits. Lack of access to diabetes care has been shown to be an important factor in glycaemic outcomes of adult diabetes care.³⁷ Although an Australian comparative study has suggested that children with T1DM who live in rural areas have less access to team-based diabetes care,²³ there was no apparent impact of this on glycaemic control. The paucity of research on this issue greatly limits the confidence with which any conclusions can be drawn. Future research needs to consider more carefully the impact of access to care on glycaemic control in children and adolescents, and also the type of health professionals seen within diabetes clinics to assess whether patients have access to 'appropriate' diabetes care, and what services are being utilised by those most in need.

Many treatment guidelines recommend that young people should be under the care of an experienced

paediatric diabetes specialist, such as an endocrinologist, a diabetologist or a paediatrician with a special interest in diabetes, and this is supported by results from this review. However, care must be taken when interpreting reported associations between improved glycaemic control and specialist care. It is important to recognise that much of specialist care does not simply involve an individual practitioner and, whilst they are an important member of the multidisciplinary team, it is vital to consider the contribution to care of the other team members and how this may affect glycaemic outcomes. The literature suggests that paediatric diabetes clinics with a large caseload of patients (>40 young people) are associated with improved metabolic control. This may reflect the trend towards centralising paediatric diabetes expertise into larger centres, where there is access to endocrinologists or diabetologists who have experience in working with children and adolescents with T1DM and a team.

The literature commonly reported that young people attending a diabetes clinic also received multidisciplinary diabetes care. However, the exact composition and interaction of the diabetes team were often not described. Further research into the functioning of multidisciplinary teams should explore the different models of existing health care in more depth – i.e. what combination of health professionals are currently being seen by young people with T1DM, and how successful are these different models in achieving glycaemic control? Research conducted in other chronic diseases in children and adolescents has highlighted the importance of these multidisciplinary models of care, in particular the functioning of the treatment team in relation to the young person and their family. In defining quality of care for children and adolescents with T1DM, Daneman and Frank concluded that, as well as having a multidisciplinary team, care must be family-centred and multi-dimensional. This concept of family-centred care has been defined as 'a philosophy of care that recognises and respects the pivotal role of the



family in the lives of children with special health needs'.³⁸ Daneman and Frank suggest that, in the diabetes context, this 'puts the child or adolescent and his or her family at the core of the multidisciplinary team involved in their care'.

The idea of family-centred care is not a new one, and it has been suggested that part of the success of the DCCT was the philosophy of care, which involved patients and parents in becoming empowered to identify and solve their own problems and issues.³⁹ It has also been suggested that a clinician's effectiveness is mediated by the family, and that parents' perceptions of diabetes care are influential determinants in successful diabetes management.⁹

As seen in this review, there is limited evidence in the literature of the implementation and outcome of this family-centred model of service delivery in young people with T1DM. The effectiveness of various models of family-centred care and, ultimately, a clear definition of the aspects of service delivery which constitute an optimal model of family-centred care are certainly important considerations for future research.

One way of expanding current models of diabetes care is the use of regular telephone contact with young people with T1DM. However, the literature presents mixed results regarding the impact of regular phone contact on glycaemic control. Nunn *et al.*, who found no effect of telephone contact on glycaemic control, suggested that for phone calls to be effective in improving HbA_{1c} the subjects need to be motivated, have clear goals set with a specific objective and have frequent calls.³⁴ This suggests that not all patients are likely to benefit from this service and that it should be reserved for patients with a specific problem or be used to reduce the need for clinic visits in those patients managing well. It should also be considered that improvements in knowledge and skills gained during regular telephone contact may in fact have a delayed beneficial effect on glycaemic control, with a need for follow-up studies to assess the impact of this.³³

There were limitations encountered in conducting this systematic review. The vast majority of literature

Key points

- Type 1 diabetes in adolescence is a challenging time both physiologically and psychologically
- Achieving reduced HbA_{1c} concentrations in adolescence is vitally important as this can reduce the risk of complications in adulthood, irrespective of later levels of glycaemic control
- Achieving reduced HbA_{1c} concentrations appears to require intensified care which is resource hungry and requires a team of specialised health care professionals comprising paediatric physicians or endocrinologists, highly specialised nursing staff, dietitians, pharmacists and mental health specialists
- Although there have been no comprehensive studies looking at the combined effects of multiple aspects of service delivery on glycaemic control, there have been several individual indicators suggested in RCTs, cross-sectional studies, cohort studies and retrospective clinical audits
- The service delivery indicators identified in the review which have an impact on glycaemic control in young people with type 1 diabetes include access to specialist care, number of clinic visits attended, access to care from a multidisciplinary diabetes team and regular telephone contact
- Future research should look at the complex interplay of multiple aspects of service delivery, within the construct of self-management, and the role this plays in glycaemic control

found was reported mainly by individual diabetes clinics and hospitals and, as such, the ability to generalise the results presented to the general T1DM paediatric population is limited. The type and quality of study reported also varied, and included RCTs, cross-sectional studies, cohort studies and retrospective evaluations and audits of care. This makes comparison between studies difficult and did not allow meta-analysis of data. Despite extensive searching, there may also have been some relevant studies in the literature which were not identified.

This review has identified current gaps in our knowledge on the impact of service delivery on young people with T1DM. Despite research across many aspects of diabetes care and education, there is still a large proportion of young people who have poor glycaemic control,^{7,40–42} and there are persistent differences in control between diabetes centres and between countries.^{7,42} Indeed, the impact of culture is yet another factor deserving of attention and one which may further reduce the ability to generalise study findings.

With increasing numbers of young people being diagnosed with T1DM, the issue of poor metabolic control throughout adolescence cannot be ignored. Further research is required to identify ways in which young

people can be helped to achieve and maintain good metabolic control throughout adolescence, thereby improving their quality of life into adulthood and reducing the strain on the health care system in the future. The relationships between service delivery and glycaemic control are complex, but there is currently limited evidence in the literature to suggest what these significant associations may be. Future research should look at the complex interplay of multiple aspects of service delivery, within the construct of self-management, and the role this plays in glycaemic control.

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Conflict of interest statement

There are no conflicts of interest. Novo Nordisk Pharmaceuticals, one of this project's Industry Partners, did not have any input into this paper.

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Service delivery in children and adolescents with type 1 diabetes

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