ORIGINAL ARTICLE

Diabetes care provision and glycaemic control in Northern Ireland: a UK regional audit

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Aims: To assess the care received, compared to national guidelines, and to investigate factors associated with glycaemic control in children and adolescents with type 1 diabetes attending clinics in Northern Ireland.

Methods: An audit of the care provided to all patients attending 11 paediatric diabetes clinics commenced in 2002. A research nurse interviewed 914 patients completing a questionnaire recording characteristics, social circumstances, and aspects of diabetes management, including the monitoring of complications and access to members of the diabetes team. Glycaemic control was measured by glycosylated haemoglobin (HbA_{1c}), determined at a DCCT aligned central laboratory.

Results: The average HbA_{1c} concentration was 8.8% (SD 1.5%), with 20% of patients achieving recommended HbA_{1c} levels of less than 7.5%. In the year prior to the audit, 76% of patients were reviewed by a diabetes specialist nurse and 42% were tested for microalbuminuria. After adjustment for confounding factors, better glycaemic control was identified, particularly in patients who had attended exactly four diabetes clinics in the previous year, were members of the patient association Diabetes UK, and lived with both natural parents.

Conclusions: In Northern Ireland only a minority of patients achieved recommended HbA_{1c} levels. Furthermore, children and adolescents with diabetes were reviewed by fewer specialists and were less intensively monitored for microvascular complications than recommended. There was evidence of better control in children who were members of Diabetes UK, suggesting that parental attitude and involvement could lead to benefits.

Good glycaemic control in children and adolescents with type 1 diabetes has been associated with better quality of life[1] and reduced or delayed development of long term complications.[2 3] The structure of an appropriate multi-professional team was recommended in the UK by *The principles of good practice for the care of young people with diabetes*.[4] The provision of these services has been surveyed on three occasions between 1988 and 1999,[5–7] and although few clinics achieve all standards, results have improved over time. However, information was obtained from questionnaires completed by paediatricians without reference to individual patients or their medical records.

The provision of a motivated multi-disciplinary team of diabetes specialists[8 9] is thought to be vital in attaining optimal glycaemic control. However, international[10] and national cross-sectional studies[11–14] continue to report glycosylated haemoglobin (HbA_{1c}) results for the majority of patients above the levels desirable to minimise the risk of complications in adulthood. Various factors have been identified which are associated with glycaemic control,[10 12 13 15–20] but further work is required.[21]

The goals of this audit were to identify all patients attending paediatric diabetes clinics in Northern Ireland and obtain information about the care received over the previous 12 months directly from patients and/or their parents and from medical records. The audit also determined HbA_{1c} levels for these patients and investigated factors associated with glycaemic control.

RESEARCH DESIGN AND METHODS

Between April 2002 and June 2003 all children and adolescents attending 11 paediatric diabetes clinics in Northern Ireland were invited to participate. An estimated ascertainment rate was calculated as the percentage of patients on the Northern Ireland childhood type 1 diabetes register[22] on 1 January 2002, under 15 years of age, still resident in Northern Ireland, and not attending adult clinics, who were included in the audit. A single research nurse collected information during routine outpatient visits. Families missing their appointments were interviewed at a subsequent appointment. For each patient a structured questionnaire was completed recording characteristics (including age, weight, height, duration of diabetes, postcode of usual address, clinical history, and family history of autoimmune disease), aspects of diabetes management (including insulin dosage, blood glucose monitoring, attendance at clinics, occurrence of severe hypoglycaemia, and other complications), and social factors (including social class and family circumstances). This questionnaire also recorded contacts with healthcare specialists and the monitoring of complications over the previous 12 months; simultaneously, this information was independently retrieved from hospital case notes. Hypoglycaemic episodes were considered severe if intramuscular glucagon or intravenous glucose was administered. Finally, a 50 µl blood sample was taken and HbA_{1c} measured at the Special Investigations Haematology Laboratory, Royal Group Hospitals Trust, Belfast by a DCCT aligned HPLC method.

Audit criteria were adapted from the third national UK survey[7] and from the International Society for Pediatric and Adolescent Diabetes recommendations.[23] Analysis of audit criteria were conducted in patients whose diabetes had been diagnosed for at least 12 months prior to interview, as many criteria refer to care in that period.

Table 1 Characteristics of all patients included in the study attending paediatric diabetes clinics in Northern Ireland (n = 914)

Characteristic	Mean (SD)	n (%)
Gender		
Males		473 (51.8)
Females		441 (48.3)
Age at visit (years)	11.8 (4.0)	–
0–5		93 (10.2)
6–10		259 (28.3)
11–15		434 (47.5)
16+		128 (14.0)
Age at diagnosis (years)	7.23 (3.8)	
0–5		382 (41.8)
6–10		341 (37.3)
11–15		190 (20.8)
16+		1 (0.1)
Height (SDS)	0.04 (1.2)	
Less than −2 SD		38 (4.2)
−2 SD to −1 SD		96 (10.6)
−1 SD to +1 SD		600 (65.9)
1 SD to 2 SD		147 (16.2)
Over 2 SD		29 (3.2)
Weight (SDS)	0.68 (1.0)	
Less than −2 SD		8 (0.9)
−2 SD to −1 SD		37 (4.1)
−1 SD to +1 SD		520 (57.1)
1 SD to 2 SD		266 (29.2)
Over 2 SD		79 (8.7)
BMI (SDS)	0.86 (1.0)	
Less than −2 SD		5 (0.6)
−2 SD to −1 SD		20 (2.2)
−1 SD to +1 SD		463 (50.9)
1 SD to 2 SD		320 (35.2)
Over 2 SD		102 (11.2)
Duration of diabetes	4.6 (3.8)	–
0–12 months		136 (14.8)
12–18 months		112 (12.3)
19 months –5 years		391 (42.8)
Over 5 years		275 (30.1)

Analysis of glycaemic control, severe hypoglycaemic episodes, and readmissions for diabetic ketoacidosis (DKA) were restricted to patients interviewed prior to their 16th birthday as coverage of older patients was considered less complete. Patients whose diabetes had been diagnosed for less than 12 months who may be in a phase of partial remission were also excluded. A deprivation score was calculated for each postcode based on the Carstairs index, derived from four 1991 census indicators: unemployment, car ownership, social class, and household crowding.[24]

Statistical analysis

Height, weight, and BMI were converted into standard deviation scores (SDS) to take account of children's gender and age using the 1990 British Growth Standard[25] and then divided by quintiles into fifths. The mean and standard deviation of HbA_{1c} was obtained for each category of potential explanatory variables and compared using *t* tests and one way analysis of variance. Multiple regression analysis was conducted controlling first for sex, age, and duration (in categories), as these were factors over which clinics had no control, and then for other factors on a variable-by-variable basis. Rates of DKA and severe hypoglycaemic episodes were calculated and a χ^2 test used to compare severe hypoglycaemia by HbA_{1c} level (categorised as $>7.5\%$ or $\leqslant 7.5\%$).

Statistical analyses were performed using STATA release 8.0 (Stata Corporation, College Station, Texas).

RESULTS

There were 914 patients included in the audit, all Caucasian, and none with type 2 diabetes. Other patient characteristics are shown in table 1. The estimated ascertainment rate was 97.4%.

There were 778 patients whose diabetes had been diagnosed for at least one year. Review and monitoring of complications by healthcare specialists are shown in table 2.

Mean HbA_{1c} was 8.8%, standard deviation 1.53%, in the 95% (621/651) of patients, interviewed prior to their 16th birthday whose diabetes had been diagnosed for at least one year, for whom this was available. Comparison of HbA_{1c} levels in subgroups of these 621 patients are shown in table 3 (sociodemographic factors) and table 4 (clinic related factors). These tables show comparisons with a reference category for each patient characteristic after controlling for sex, age, and duration.

In table 3 the unadjusted analysis shows that age, pubertal status, duration of diabetes, SDS height, and SDS weight were all significantly associated with HbA_{1c} level. The association with age was independent of sex and duration ($p < 0.0001$) and the association with duration was independent of age and sex ($p = 0.01$). Patients who were not living with both their natural parents had a significantly higher HbA_{1c} by an estimated 0.55% (95% CI 0.22% to 0.88%) after adjusting for sex, age, and duration. Although parental occupation was significantly associated both before ($p = 0.0004$) and after adjustment ($p = 0.005$), the effect was attributable to high HbA_{1c} levels in those patients where the head of the household's occupation could not be classified (for example, never worked, long term unemployed, or armed forces).

In table 4 the crude analysis shows that the number of blood glucose tests per day, number of HbA_{1c} tests, number of doses of insulin, and total insulin dose were all associated with HbA_{1c} level. However, some of these associations could be attributed to other factors. After adjustment for sex, age, and duration the associations between the number of doses of insulin per day and the total insulin dose were no longer significant. After additionally adjusting for the attended diabetes clinic the associations between both number of blood glucose tests per day ($p = 0.21$) and number of HbA_{1c} tests ($p = 0.10$) were no longer significant.

The number of diabetes clinic attendances was associated with HbA_{1c} level both before and after adjustment. Specifically, after adjusting for sex, age, and duration, those patients attending less than four clinics in the last year had a significantly higher HbA_{1c} level by an estimated 0.42% (95% CI 0.14% to 0.70%) compared to those attending exactly four clinics, while those attending more than four clinics had a higher HbA_{1c} level by an estimated 0.32% (95% CI 0.03% to 0.61%) compared to those attending exactly four clinics. Members of Diabetes UK had a significantly lower HbA_{1c} by an estimated 0.49% (95% CI 0.26% to 0.73%), after adjustment for sex, age, and duration. Other factors investigated for which no association between HbA_{1c} was detected included season of visit and time from home to clinic. The model containing sex, age, duration, clinic attendance, natural parents, and Diabetes UK membership explained 13% ($R^2 = 0.13$) of patient-to-patient variation in HbA_{1c} levels; adding clinic to this model raised the figure to 21%, indicating that clinic-to-clinic differences in HbA_{1c} values remained that could not be explained by the available patient characteristics.

There were 92 patients (14%), interviewed prior to their 16th birthday whose diabetes had been diagnosed for at least one year, who reported 191 severe hypoglycaemic episodes in the previous year, which corresponded to 29.5 episodes per 100 person-years. In contrast, the hospital chart recorded a

Table 2 Compliance with audit criteria, taken from hospital charts, of patients attending paediatric diabetes clinics in Northern Ireland whose diabetes had been diagnosed for at least one year (n = 778) and for children over 11 years of age (n = 452)

Audit criteria	All children n (%)	Patients ⩾12 years n (%)
Reviewed at any clinic appointment in the 12 month period prior to interview by:		
Diabetes specialist nurse*†	589 (75.7)	
Dietician*†	575 (73.9)	
Psychologist	23 (3.0)	
Podiatrist*	195 (25.1)	
Contact‡ in the 12 month period prior to interview by:		
Diabetes specialist nurse	61 (7.9)	
Doctor	16 (2.1)	
Complications monitored in 12 months prior to interview by conducting:		
Retinal examination*†	432 (55.5)	277 (61.3)
Test for microalbuminuria*†	327 (42.0)	197 (43.6)
Blood pressure measurement†	603 (77.5)	360 (79.7)
Injection site check*	745 (96.1)	
Foot check*§	533 (68.5)	
Growth plotted*¶	488 (75.0)**	
HbA_{1c}		
HbA_{1c} measurement at each visit †	735 (95.2)	
HbA_{1c} measurement ⩽ 7.5%*††	124 (20.0)**	

*Adapted from ISPAD recommendations.
†Adapted from BDA (now Diabetes UK) recommendations.
‡Excluding clinic appointment, e.g. house visit or telephone call.
§Foot check conducted by either podiatrist, doctor, or nurse.
¶Height and weight plotted on a growth chart.
**Only calculated for children less than 16 years old.
††Determined at audit visit.

total of 13 severe hypoglycaemic episodes, a rate of 2.0 per 100 person-years, occurring in 1% (8/648) of patients. There was no significant difference (p = 0.27) in the prevalence of severe hypoglycaemia by HbA_{1c}; patients with HbA_{1c} ⩽7.5% experienced a rate of 25.0 episodes per 100 person-years compared with 31.1 in patients with HbA_{1c} >7.5%. There was little difference between the chart and interview record of readmissions for DKA; overall the chart recorded 7.1 DKA episodes per 100 person-years, which occurred in 6% (36/649) of the children.

DISCUSSION

This is the first audit of the care provided to children and adolescents with type 1 diabetes in Northern Ireland. Glycaemic control, mean HbA_{1c} 8.8%, was roughly comparable to other similar national audits from Scotland,[13] France,[12] and two audits from Denmark[11 14] (mean HbA_{1c} 8.9%, 9.0%, 9.1%, and 8.7%, respectively). However, the small percentage, 20%, of patients achieving recommended HbA_{1c} levels,[23] ⩽7.5%, is a cause for concern.

The lack of patients receiving an annual review by all members of the paediatric diabetes specialist team may reflect the failure to meet healthcare staffing recommendations. In particular, throughout Northern Ireland there were only 2.5 whole time equivalent (WTE) diabetes specialist nurses in post compared with the 9 diabetes specialist nurses recommended[26] for a clinic population of 914. Similarly, the low proportion of patients reviewed by a clinical psychologist may also reflect staff shortages rather than a lack of need for psychological input among children with persistently poor glycaemic control.[27]

Monitoring of children and adolescents for microvascular complications, particularly microalbuminuria and retinal examinations, fell below recommendations.[23] This study shows how the deficiencies in diabetes services, based on a recent UK survey of consultant paediatricians,[7] translate to deficiencies in the care received by patients. Importantly, this is the first study that is likely to accurately reflect the levels of care provided in the UK as information was directly recorded from parents/carers and was confirmed by chart review. In contrast, the previously mentioned survey relied on the perceptions of consultant paediatricians who were responsible for providing diabetes services. Two other UK audits,[13 28 29] to our knowledge the only UK audits of similar size and ascertainment rate, did not present information on care received directly recorded from the patient/carer.

The observation that less than 10% of children stating they had experienced severe hypoglycaemic episodes in the past year had this recorded in their hospital chart suggests that these episodes may not be receiving adequate attention at clinic visits. Furthermore, this result indicates that comparisons of severe hypoglycaemia between centres must be interpreted with caution.

The observed associations between HbA_{1c} level and age and diabetes duration and the lack of association with gender, were mostly consistent with previous large cross-sectional studies.[10 12 13] Earlier studies have also observed HbA_{1c} associations with total insulin dosage[12 13 16 18 20] and the number of insulin doses per day,[12 13] but in this study these associations could be explained by the duration of diabetes and the age of the patients. However, poorer control was noted in children prescribed four doses of insulin per day, which may reflect that this insulin regime is used for children with poor control or that it may be associated with poor compliance. The evidence supporting the concept that increased blood glucose testing improved control, a consistent finding in previous studies,[12 16 18] was less conclusive. An increase in the number of blood glucose tests was associated with a decrease in HbA_{1c}, but after adjusting for the attended diabetes clinic this effect was no longer apparent, suggesting that it may be explained by other clinic practices.

Glycaemic control was independently associated with Diabetes UK membership, diabetic clinic attendance, and living with both natural parents. The reduction in HbA_{1c} with

Table 3 Comparison of HbA_{1c} results by patient characteristics in patients interviewed prior to their 16th birthday whose diabetes had been diagnosed for at least one year (n = 621)

					Adjusted*		
	n (%)	Mean	SD	p	Effect (95% CI)		p
Gender							
Boy	313 (50.4)	8.77	1.52	0.99	0 [reference category]		0.92
Girl	308 (49.6)	8.77	1.54		−0.01	(−0.24 to 0.22)	
Age							
0–5 years	48 (7.7)	8.32	1.43	<0.0001	0 [reference category]		<0.0001
6–10 years	202 (32.5)	8.29	1.01		−0.15	(−0.62 to 0.32)	
11–15 years	371 (59.7)	9.09	1.69		+0.58	(0.12 to 1.04)	
Pubertal status‡							
Pre	366 (58.9)	8.57	1.35	0.0006	0 [reference category]		0.55
Peri	111 (17.8)	9.12	1.78		−0.05	(−0.44 to 0.33)	
Post	137 (22.1)	9.04	1.69		−0.14	(−0.52 to 0.24)	
Unknown	7 (1.1)	8.31	1.36		−0.76	(−1.88 to 0.36)	
Duration of diabetes							
12–18 months	101 (16.3)	8.29	1.46	0.001	0 [reference category]		0.01
19 months–5 years	332 (53.5)	8.72	1.44		+0.39	(0.06 to 0.72)	
Over 5 years	188 (30.3)	9.11	1.65		+0.58	(0.21 to 0.95)	
SDS height (fifths)							
1st shortest	120 (19.4)	9.16	1.77	0.03	0 [reference category]		0.09
2nd	127 (20.5)	8.70	1.30	(0.007)†	−0.40	(−0.76 to −0.03)	(0.02)†
3rd	122 (19.7)	8.71	1.51		−0.32	(−0.70 to 0.05)	
4th	138 (22.3)	8.73	1.55		−0.37	(−0.73 to 0.00)	
5th tallest	113 (18.2)	8.54	1.43		−0.52	(−0.90 to −0.14)	
SDS weight (fifths)							
1st lightest	121 (19.5)	9.10	1.65	0.05	0 [reference category]		0.07
2nd	129 (20.8)	8.82	1.58	(0.007)†	−0.25	(−0.62 to 0.11)	(0.008)†
3rd	129 (20.8)	8.73	1.36		−0.30	(−0.67 to 0.07)	
4th	118 (19.0)	8.53	1.61		−0.52	(−0.90 to −0.15)	
5th heaviest	124 (20.0)	8.65	1.40		−0.43	(−0.80 to −0.06)	
SDS BMI (fifths)							
1st lowest	116 (18.7)	8.93	1.57	0.55	0 [reference category]		0.68
2nd	118 (19.0)	8.82	1.52	(0.10)†	−0.08	(−0.47 to0.30)	(0.13)†
3rd	134 (21.6)	8.81	1.59		−0.10	(−0.47 to 0.27)	
4th	128 (20.6)	8.64	1.53		−0.19	(−0.57 to 0.18)	
5th greatest	125 (20.1)	8.66	1.43		−0.26	(−0.64 to 0.11)	
Family history of type 1 diabetes mellitus							
None	534 (86.0)	8.73	1.54	0.21	0 [reference category]		0.35
Parent	53 (8.5)	8.91	1.48		+0.14	(−0.28 to 0.56)	
Sibling only	34 (5.5)	9.17	1.37		+0.35	(−0.16 to 0.86)	
Both natural parents live at home							
Yes	514 (82.8)	8.66	1.45	0.0008	0 [reference category]		0.004
No	90 (14.5)	9.30	1.83		+0.55	(0.22 to 0.88)	
Unknown	17 (2.7)	9.11	1.45		+0.36	(−0.35 to 1.07)	
Deprivation of home address (fifths)							
1st affluent	115 (18.5)	8.75	1.42	0.88	0 [reference category]		0.90
2nd	121 (19.5)	8.67	1.35	(0.79)†	+0.03	(−0.35 to 0.41)	(0.69)†
3rd	133 (21.4)	8.88	1.77		+0.17	(−0.20 to 0.54)	
4th	125 (20.1)	8.76	1.59		+0.12	(−0.26 to 0.50)	
5th deprived	127 (20.5)	8.77	1.46		+0.04	(−0.33 to 0.42)	
Primary occupation							
Non-manual	319 (51.4)	8.68	1.51	0.0004	0 [reference category]		0.005
Manual	218 (35.1)	8.66	1.41		+0.03	(−0.22 to 0.28)	
Unclassifiable	84 (13.5)	9.38	1.74		+0.58	(0.22 to 0.93)	

*Model contains sex, age, and duration.
†p value of test for trend across categories.
‡Assessed from height velocity.

Diabetes UK membership suggests that parental attitude and involvement in the disease could lead to benefits in control. This study confirms an association between infrequent diabetes clinic attendance and worse control that has been noted previously.[16 17 19] However, caution should be exercised when interpreting the results in the most frequent category of attendance, as increased attendances could be a consequence rather than a cause of worse control. The worse control of children whose parents have separated has been observed in various studies;[13 18 19] the consistency of this finding indicates that single parents may merit assistance to meet the challenges involved in attaining good control.

In addition to previously mentioned advantages, this study also benefited from a relatively large sample size, a high ascertainment rate, and a detailed questionnaire on established and potential risk factors of poor control. This allowed not only the testing of previous hypotheses but also the adjustment for other risk factors of poor control. This study does have limitations; the cross-sectional design allows the association of factors with good control but not the ability to determine causation which would require a prospective study. Furthermore, the 21% of HbA_{1c} variation that was explained by available variables was similar to a Scottish study,[13] which accounted for 16% of HbA_{1c} variation, but indicated that knowledge of factors which establish good control remains incomplete.

In conclusion, the percentage of children and adolescents achieving recommended levels of glycaemic control was disappointing. Furthermore, annual reviews by healthcare specialists and monitoring of microvascular complications fell below recommended levels. Some of these failures may reflect staff shortages, in particular a lack of diabetes

Table 4 Comparison of HbA1c results by aspects of diabetes management in patients interviewed by the research nurse prior to their 16th birthday with duration of diabetes over 1 year (n = 621)

					Adjusted*	
	n (%)	Mean	SD	p	Effect (95% CI)	p
No. of blood glucose tests per day						
None	52 (8.4)	9.49	1.97	<0.0001	0 [reference category]	0.005
1	103 (16.6)	9.10	1.51		−0.36 (−0.85 to 0.13)	
2	174 (28.0)	8.71	1.45		−0.68 (−1.13 to −0.22)	
3	166 (26.7)	8.71	1.49		−0.55 (−1.02 to −0.09)	
>4	126 (20.3)	8.35	1.35		−0.85 (−1.33 to −0.37)	
No. of HbA_{1c} tests in last year						
<4	200 (32.5)	9.03	1.64	0.004	+0.37 (0.10 to 0.65)	0.03
4	244 (39.7)	8.55	1.38		0 [reference category]	
>4	171 (27.8)	8.72	1.51		+0.21 (−0.09 to 0.65)	
Doses of insulin per day						
1	35 (5.7)	8.69	1.33	0.02	+0.30 (−0.23 to 0.82)	0.07
2	465 (75.1)	8.71	1.47		0 [reference category]	
3	102 (16.5)	8.88	1.64		−0.14 (−0.46 to 0.19)	
4	17 (2.8)	9.84	2.30		+0.80 (0.08 to 1.51)	
Total insulin dose (U per kg per day)						
<0.5	41 (6.6)	8.20	1.33	0.0003	0 [reference category]	0.43
0.5–0.75	125 (20.2)	8.46	1.58		+0.11 (−0.43 to 0.65)	
0.75–1.0	206 (33.2)	8.70	1.48		+0.28 (−0.25 to 0.80)	
1–1.25	158 (25.5)	9.07	1.58		+0.43 (−0.13 to 0.98)	
>1.25	90 (14.5)	9.07	1.40		+0.33 (−0.27 to 0.93)	
No. of clinic attendances in last year						
<4	199 (32.2)	9.03	1.66	0.002	+0.42 (0.14 to 0.70)	0.007
4	242 (39.1)	8.51	1.34		0 [reference category]	
>4	178 (28.8)	8.80	1.57		+0.32 (0.03 to 0.61)	
Member of Diabetes UK						
No	243 (39.1)	9.08	1.67	<0.0001	0 [reference category]	<0.0001
Yes	378 (60.9)	8.56	1.40		−0.49 (−0.73 to −0.26)	

*Model contains sex, age, and duration.

specialist nurses and clinical psychologists. There was evidence of better control in children who were members of Diabetes UK, who lived with both natural parents, and who attended diabetes clinics regularly.

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