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Characteristics of children with type 1 diabetes and persistent suboptimal glycemic control.

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Quarterly Visits With Glycated Hemoglobin Monitoring: The Sweet Spot for Glycemic Control in Youth With Type 1 Diabetes

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OBJECTIVE

To evaluate the association between the frequency of visits and glycated hemoglobin (GHb) measurements on glycemic control in youth with type 1 diabetes.

RESEARCH DESIGN AND METHODS

A retrospective longitudinal cohort study of 1,449 youth with type 1 diabetes (mean age 11.4 years, 50% female, 74% Caucasian, 24% with Medicaid) followed at five pediatric endocrinology clinics from the years 2008–2011 was conducted. By hierarchical cluster analysis, three homogeneous groups of patients were generated: those with a relative increase in GHb (worsened [*n* = 237]), no change in GHb (stable [*n* = 842]), and a decrease in GHb (improved [*n* = 370]) over the study period. The number of visits and GHb measurements per year were compared among the three groups by multinomial logistic regression analysis using one visit or GHb test per year as a reference and controlling for patient demographic and baseline characteristics.

RESULTS

Patients with quarterly visits were least likely to have worsened glycemic control (odds ratio 0.33, $P < 0.05$) and were most likely to have improved glycemic control (3.48, $P < 0.01$). Patients with four GHb tests a year (0.53, $P < 0.05$) were least likely to have worsened glycemic control.

CONCLUSIONS

Quarterly visits and GHb testing are associated with glycemic control in youth with type 1 diabetes.

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Optimal glycemic control is associated with a reduction in the risk for complications associated with diabetes (1–3). However, glycemic control remains suboptimal in many youth with type 1 diabetes (4–7). The American Diabetes Association proposed guidelines recommending visits with a health care provider and glycated hemoglobin (GHb) testing at least two times a year for patients with good glycemic control and quarterly for patients with poor glycemic control (8,9), presuming that close monitoring improves management and reduces complications.

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Despite the perceived value of routinely monitoring GHb, the importance of GHb testing at regular intervals has not been well described in youth and has been documented in only one adult study (10). Studies in adults have demonstrated the important role of frequent visits in achieving glycemic control (11,12), a finding supported by one study in youth with type 1 diabetes that found improved glycemic control in those who had three or four visits per year compared with those who had only one or two (13). The frequency of visits and GHb testing is determined by provider preference but can also be influenced by patient treatment adherence, with higher rates of nonadherence described in patients of lower socioeconomic status, single-parent households, and minority race (13–15).

Determination of the optimal number of visits and GHb testing in youth with type 1 diabetes to optimize glycemic control may inform the practice of cost-effective medicine. Furthermore, adoption of different management schedules may be more effective for patient subgroups according to baseline characteristics. In the present study, we examined the relationship between frequency of visits and GHb testing on glycemic control in youth with type 1 diabetes.

RESEARCH DESIGN AND METHODS

The dataset from a retrospective cohort study was extracted from the electronic medical record (EMR). This longitudinal study used deidentified records extending from July 2008 to June 2011 and was approved by the Nemours Institutional Review Board.

Patients were included in the study if they were seen at any of five Nemours pediatric endocrinology clinics (Jacksonville, Orlando, and Pensacola, FL; Philadelphia, PA; and Wilmington, DE) during the first two fiscal quarters of 2008 and had a previous diagnosis of type 1 diabetes identified on their problem list. Scheduled visits with an endocrinology provider (visit) were recorded in and extracted from the EMR. No routine scheduling protocols were used at any of the practices. Patients were excluded from the study if they had only one visit, had a single GHb test, or were followed for $<$1 year. Demographics, including age, sex, race, practice location, and insurance status, were obtained from the EMR.

GHb Measurement

GHb measurements were obtained at the discretion of the provider. Each site was internally consistent, using the same device to provide a point of care (POC) GHb assay. The same type of POC GHb device (Siemens DCA Vantage Analyzer) was used at all sites. The detection range with this device for the GHb assay is 2.5–14% (4–130 mmol/mol), with a reference range of 4.4–6.4% (25–46 mmol/mol). GHb values $>$14% were unable to be quantified and, thus, were coded as 14% in the dataset. The standard operating procedure at each site was to collect blood samples for POC testing at the time of the office visit, but GHb from external laboratory specimens were also included if available. The DCA Vantage Analyzer has acceptable precision (16).

Statistical Analysis

The number of visits and GHb tests per year were calculated and served as the primary independent variables. The number of fiscal quarters in a year with visits and GHb tests obtained were calculated and served as secondary independent variables. We used a mixed-effects model (17) to characterize the individual- and population-level changes in GHb over time and with visit frequency. Change from baseline GHb was used as the response variable, and patient demographic variables, baseline GHb, and time from study entry were used as fixed-effects variables in the model. The intercept and visit frequencies were used as random effects in the model to capture the pattern of individual-level changes in GHb over visit frequencies. A hierarchical cluster analysis of random effects (17,18) was performed to group patients by homogeneous patterns of glycemic control. The cluster analysis identified the following three distinct and significantly different group patterns of change in GHb per year ($P <$ 0.001): a relative increase (worsened glycemic control), no change (stable glycemic control), or a decrease (improved glycemic control) in GHb over the study period. Study variables, including demographics, baseline characteristics, and the independent variables of visit and GHb testing frequency, were compared among the three groups.

Quantitative variables are presented as mean (SD). Categorical variables are presented as frequencies and percentages. Multivariable multinomial logistic regression analyses were performed to explore the association of study variables with glycemic control groups. The adjusted odds ratios (ORs) with *P* values are presented in the text, with CIs also presented in the tables. Model assumptions were verified before analyses. All tests were two tailed at the 0.05 level of significance. SAS (SAS Institute, Cary, NC) and SPSS (IBM Corporation, Chicago, IL) statistical software programs were used for the analyses.

RESULTS

Categorization of Patients on the Basis of Change in GHb

Mean GHb in the cohort remained relatively stable over the study period, increasing slightly from 8.3% (SD 1.5%) (67 mmol/mol) during the initial year of study to 8.5% (1.4%) (69 mmol/mol) during the last year of study. Table 1 shows the GHb trends over the study period for the three groups of glycemic control generated by the hierarchical cluster analysis: worsened (n = 237), stable (n = 842), and improved (n = 370).

Patient Characteristics

There were 1,449 patients included in the study (Table 2). The mean age was 11.4 (SD 3.3) years. There were an equal proportion of males and females. The majority of patients were Caucasian (74%) and had commercial insurance (67%). Patients who were African American (OR 1.78, $P < 0.01$), had Medicaid insurance (1.51, $P < 0.01$), or were older (F = 1.11, $P < 0.001$) were more likely to have worsened glycemic control (Table 2). Patients with higher baseline GHb were more likely to have improved glycemic control (F = 1.43, $P < 0.001$).

Table 1—Mean patient GHb over time by glycemic control group

	GHb			
		Glycemic control		
Year	All patients	Worsened	Stable	Improved
2008				
%	8.3 (0.03)	8.8 (0.07)	8.1 (0.03)	8.3 (0.06)
mmol/mol	66.8 (0.27)	72.8 (0.77)	64.8 (0.31)	67.6 (0.63)
n	1,449	237	842	370
2009				
%	8.4 (0.02)	9.8 (0.06)	8.3 (0.02)	7.9 (0.04)
mmol/mol	68.5 (0.24)	83.6 (0.67)	66.8 (0.25)	62.3 (0.44)
n	1,419	230	832	357
2010				
%	8.4 (0.02)	10.1 (0.06)	8.3 (0.02)	7.8 (0.04)
mmol/mol	68.8 (0.25)	86.9 (0.70)	67.2 (0.26)	61.2 (0.41)
n	1,359	213	798	348
2011				
%	8.5 (0.03)	10.2 (0.10)	8.4 (0.04)	7.9 (0.06)
mmol/mol	69.9 (0.38)	88.1 (1.07)	68.2 (0.39)	63.1 (0.65)
n	1,094	160	649	285

Data are mean (SD) unless otherwise indicated.

Relationship Between Glycemic Control and Office Visit Frequency

On average, patients had 3.2 (SD 1.1, range 1–11) visits per year and 2.9 (0.7) fiscal quarters with visits per year. Table 3 compares groups on the basis of visit frequency, with the reference group being patients with one visit or one fiscal quarter with visits per year and adjusting for demographic and baseline characteristics. Patients with four visits per year (OR 0.36, $P < 0.05$) or quarterly visits (0.33, $P < 0.05$) were least likely to have worsened glycemic control. Patients with quarterly visits were also most likely to have improved glycemic control (3.48, $P < 0.01$). In multivariable regression analysis, race ($P < 0.005$), insurance status ($P < 0.01$), and initial age ($P < 0.05$) had significant effects on visit frequency.

Relationship Between Glycemic Control and Frequency of GHb Testing

On average, patients had 3.0 (SD 1.0, range 1–10) GHb tests per year and 2.8 (0.7) fiscal quarters in a year with a GHb test. Table 3 compares groups on the basis of GHb testing frequency, with the reference group being patients with one GHb test per year or one fiscal quarter per year with a GHb obtained and adjusting for demographic and baseline characteristics. Patients with four GHb tests per year were least likely to have worsened glycemic control (OR 0.53, $P < 0.05$), and patients with more than five GHb tests per year were least likely to have improved glycemic control (0.28, $P < 0.01$). In multivariable regression analysis, race ($P < 0.01$), insurance status ($P < 0.05$), and initial age ($P < 0.05$) had significant effects on frequency of GHb testing.

Characterization of Patients With More Than Five Office Visits per Year

A small percentage (7.9%) of patients had five or more visits per year (mean 5.7 [SD 1.3], range 5–11). These patients were more likely to have a higher baseline GHb ($F = 1.15$, $P < 0.05$), have Medicaid (OR 2.13, $P < 0.001$), or be non-Hispanic (2.94, $P < 0.05$) and were less likely to have improved glycemic control (0.31, $P < 0.001$).

Table 2—Comparison of glycemic control groups on the basis of patient characteristics

		Glycemic control			*F* or adjusted OR (CI) for glycemic control	
	All patients (*n* = 1,449)	Improved (*n* = 370)	Stable (*n* = 842)	Worsened (*n* = 237)	Worsened†‡	Improved‡§
Baseline GHb, mean (SD)					0.93	1.43***
%	8.3 (1.5)	8.8 (1.8)	8.0 (1.3)	8.3 (1.4)		
mmol/mol	66.8 (16.6)	73.1 (19.9)	64.1 (14.4)	66.7 (15.4)		
Age (years), mean (SD)	11.4 (3.3)	11.0 (3.6)	11.4 (3.3)	12.2 (2.7)	1.11***	0.93***
Sex						
Male	726 (50.1)	174 (24.1)	424 (58.6)	125 (17.3)	Reference	Reference
Female	723 (49.9)	196 (27.0)	418 (57.6)	112 (15.4)	0.88 (0.66–1.17)	1.05 (0.82–1.35)
Race/ethnicity						
Caucasian	1,076 (74.3)	265 (24.6)	653 (60.7)	158 (14.7)	Reference	Reference
African American	161 (11.1)	41 (25.5)	81 (50.3)	39 (24.2)	1.78** (1.17–2.72)	0.71 (0.47–1.01)
Hispanic	148 (10.2)	43 (29.1)	76 (51.4)	29 (19.6)	1.41 (0.89–2.23)	0.97 (0.65–1.45)
Other	64 (4.4)	21 (32.8)	32 (50)	11 (17.2)	1.34 (0.67–2.67)	1.18 (0.66–2.09)
Insurance						
Commercial	972 (67.1)	238 (24.5)	594 (61.1)	140 (14.4)	Reference	Reference
Medicaid	346 (23.9)	104 (30.1)	169 (48.8)	73 (21.1)	1.51* (1.08–2.11)	0.91 (0.58–1.44)
Other	131 (9.0)	28 (21.4)	79 (60.3)	24 (18.3)	1.15 (0.70–1.87)	1.08 (0.80–1.46)

Data are mean (SD) or *n* (%) unless otherwise indicated. *$P < 0.05$. **$P < 0.01$. ***$P < 0.001$. †Compared with groups with stable or improved glycemic control. ‡Controlling for remainder of patient characteristics. §Compared with group with stable or worsened glycemic control.

Table 3—Comparison of glycemic control groups on the basis of visit and laboratory frequency

		Glycemic control			Adjusted OR (CI) for glycemic control	
	All patients	Improved	Stable	Worsened	Worsened†‡	Improved‡§
Visits per year						
1 (*n* = 34)	34 (2.3)	11 (32.4)	13 (38.2)	10 (29.4)	Reference	Reference
2 (*n* = 214)	214 (14.8)	81 (37.9)	98 (45.8)	35 (16.4)	0.46 (0.20–1.07)	1.45 (0.65–3.26)
3 (*n* = 572)	527 (39.5)	150 (26.2)	323 (56.5)	99 (17.3)	0.51 (0.23–1.12)	0.87 (0.40–1.90)
4 (*n* = 515)	515 (35.5)	113 (21.9)	336 (65.2)	66 (12.8)	0.36 (0.16–0.81)*	0.75 (0.34–1.65)
≥5 (*n* = 114)	114 (7.9)	15 (13.2)	72 (63.2)	27 (23.7)	0.71 (0.29–1.70)	0.33 (0.13–0.85)
Quarters per year with visits||						
1 (*n* = 58)	58 (4.0)	16 (27.6)	27 (46.6)	15 (25.9)	Reference	Reference
2 (*n* = 300)	300 (20.7)	90 (30.0)	150 (50.0)	60 (20.0)	0.95 (0.37–1.91)	1.54 (0.70–3.39)
3 (*n* = 745)	745 (51.4)	188 (25.2)	440 (59)	117 (15.7)	0.56 (0.23–1.35)	2.32 (1.00–5.41)
4 (*n* = 346)	346 (23.9)	76 (22.0)	225 (65.0)	45 (13.0)	0.33 (0.12–0.90)*	3.48 (1.38–8.76)**
GHb per year						
1 (*n* = 65)	65 (4.5)	20 (30.8)	29 (44.6)	16 (24.6)	Reference	Reference
2 (*n* = 309)	309 (21.3)	111 (35.9)	153 (49.5)	45 (14.6)	0.58 (0.30–1.12)	1.26 (0.68–2.31)
3 (*n* = 686)	686 (47.3)	157 (22.9)	412 (60.1)	117 (17.1)	0.74 (0.40–1.36)	0.69 (0.38–1.24)
4 (*n* = 301)	301 (20.8)	71 (23.6)	191 (63.5)	39 (13)	0.53 (0.27–1.03)*	0.79 (0.42–1.47)
≥5 (*n* = 88)	88 (6.1)	10 (11.4)	55 (62.5)	23 (26.1)	0.96 (0.44–2.01)	0.28 (0.12–0.65)**
Quarters per year with GHb obtained¶						
1 (*n* = 75)	75 (5.2)	21 (28)	37 (49.3)	17 (22.7)	Reference	Reference
2 (*n* = 366)	366 (25.3)	120 (32.3)	181 (49.5)	65 (17.8)	5.84 (0.61–55.81)	2.26 (0.25–20.73)
3 (*n* = 730)	750 (50.4)	166 (22.7)	441 (60.4)	123 (16.8)	2.21 (0.24–20.08)	4.74 (0.47–47.52)
4 (*n* = 278)	278 (19.2)	63 (22.7)	183 (65.8)	32 (11.5)	0.97 (0.11–8.75)	7.18 (0.68–76.47)

Data are *n* (%) unless otherwise indicated. *$P < 0.05$. **$P < 0.01$. †Compared with group with stable or improved glycemic control. ‡Controlling for age, sex, race, insurance status, and baseline GHb. §Compared with group with stable or worsened glycemic control. ||OR also controlling for absolute number of visits per year. ¶OR also controlling for absolute number of GHb tests per year.

CONCLUSIONS

Consistent with prior studies (14,15), this longitudinal cohort study of 1,449 youth with type 1 diabetes supports the importance of routine visits and GHb testing in this population. The findings suggest that quarterly visits and GHb monitoring may prevent worsening glycemic control in youth with type 1 diabetes. These findings were present even when adjusting for factors known to affect glycemic control and treatment adherence, including race, insurance status, age, and baseline GHb. It is likely that patients with less frequent visits or GHb testing may miss opportunities to receive education, support, and changes to treatment regimens to promote glycemic control (11,19).

Patients with worsened glycemic control over the study period had lower baseline GHb than patients with stable and improved glycemic control. Although this may represent a regression of GHb values to the mean, the associations between visit and laboratory frequency with glycemic control were significant even after adjusting for baseline GHb. We also found that patients of African American race, with Medicaid, or of older age were more likely to have worsened glycemic control, findings consistent with other studies (13–15,19–22). These subgroups had fewer visits and GHb tests, which may explain their increased likelihood for worsened glycemic control.

A subgroup of patients required more than four visits a year and demonstrated worsened glycemic control. It is likely that these patients represent a need for more frequent follow-up and monitoring because of their poor glycemic control, as demonstrated by their higher baseline GHb. Of note, these patients were more likely to have Medicaid, which may be a proxy for low socioeconomic status and has been associated with poor glycemic control in prior studies (13–15,20,21).

Because this was a retrospective study using primarily administrative data and laboratory results previously recorded in our EMR, several limitations should be noted. We were unable to account for certain factors that may have influenced glycemic control, including interventions other than visits with endocrinology physicians and nurse practitioners, duration of diabetes diagnosis, type of insulin regimen used, maturation (Tanner stage), and GHb device used (whether with a POC device or at an external laboratory). We also were unable to account for certain factors that may have influenced visit frequency, such as provider preference, which may have been influenced by glycemic control, patient motivation and adherence, and other socioeconomic variables beyond insurance status. Future studies should examine the role of these factors on visit and GHb testing frequency in addition to glycemic control.

In summary, quarterly visits and GHb testing are associated with glycemic control in youth with type 1 diabetes. Certain patient subgroups have less frequent visits and GHb testing and may require increased support to ensure adherence to visit and GHb testing recommendations.

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