Current State of Type 1 Diabetes Treatment in the U.S.: Updated Data From the T1D Exchange Clinic Registry

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To examine the overall state of metabolic control and current use of advanced diabetes technologies in the U.S., we report recent data collected on individuals with type 1 diabetes participating in the T1D Exchange clinic registry. Data from 16,061 participants updated between 1 September 2013 and 1 December 2014 were compared with registry enrollment data collected from 1 September 2010 to 1 August 2012. Mean hemoglobin A_{1c} (HbA_{1c}) was assessed by year of age from <4 to >75 years. The overall average HbA_{1c} was 8.2% (66 mmol/mol) at enrollment and 8.4% (68 mmol/mol) at the most recent update. During childhood, mean HbA_{1c} decreased from 8.3% (67 mmol/mol) in 2–4-year-olds to 8.1% (65 mmol/mol) at 7 years of age, followed by an increase to 9.2% (77 mmol/mol) in 19-year-olds. Subsequently, mean HbA_{1c} values decline gradually until ~30 years of age, plateauing at 7.5–7.8% (58–62 mmol/mol) beyond age 30 until a modest drop in HbA_{1c} below 7.5% (58 mmol/mol) in those 65 years of age. Severe hypoglycemia (SH) and diabetic ketoacidosis (DKA) remain all too common complications of treatment, especially in older (SH) and younger patients (DKA). Insulin pump use increased slightly from enrollment (58–62%), and use of continuous glucose monitoring (CGM) did not change (7%). Although the T1D Exchange registry findings are not population based and could be biased, it is clear that there remains considerable room for improving outcomes of treatment of type 1 diabetes across all age-groups. Barriers to more effective use of current treatments need to be addressed and new therapies are needed to achieve optimal metabolic control in people with type 1 diabetes.

Results of the Diabetes Control and Complications Trial (DCCT) and the Epidemiology of Diabetes Interventions and Complications (EDIC) follow-up study of the DCCT cohort have demonstrated that most people with type 1 diabetes should be treated intensively to achieve hemoglobin A_{1c} (HbA_{1c}) levels as close to normal as possible and as early in the course of the disease as possible to prevent and delay the late micro- and macrovascular complications of the disease (1). Most recently, the DCCT/EDIC study group reported that all-cause mortality also was reduced over 30 years of follow-up during DCCT/EDIC in the original DCCT intensive treatment group compared with the original conventional treatment group (2). Consequently, the American Diabetes Association (ADA) treatment guidelines indicate that adults with type 1 diabetes should aim at target HbA_{1c} levels <7.0% (53 mmol/mol) unless there is a reason, such as recurrent severe hypoglycemia (SH), to set a higher target, whereas the target is set slightly higher in children and adolescents at <7.5% (58 mmol/mol) by both the ADA and the International Society for Pediatric and Adolescent Diabetes (ISPAD) (3,4).

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Compared with treatment methods used in the DCCT 20–30 years ago, rapid- and long-acting insulin analogs, improved insulin pumps and blood glucose meters, continuous glucose monitoring (CGM) devices, and integrated sensor-augmented insulin pump systems with automatic threshold suspend capabilities have provided clinicians and patients with new tools to achieve target HbA_{1c} levels more readily and safely (5). Whether and to what extent these advances in diabetes technology have been translated into better glycemic control in patients with type 1 diabetes in the U.S. has not been established due, in part, to the lack of a broad-based, large-scale, multisite registry that covered patients at all ages across the life span. Supported by a grant by the Helmsley Charitable Trust, the T1D Exchange Clinic Network was established to fill this gap. Leading adult and pediatric diabetes treatment centers with a wide geographical distribution throughout the U.S. (Supplementary Fig. 1) are participating in the T1D Exchange Clinic Network, with the Jaeb Center for Health Research in Tampa, FL serving as the coordinating center. The first initiative of the T1D Exchange Clinic Network was the establishment of the T1D Exchange clinic registry.

Initially, 25,833 participants who ranged in age from 2 to 95 years were enrolled into the registry between September 2010 and August 2012. A comprehensive set of baseline clinical, laboratory, and demographic data were obtained for each participant at registry enrollment and the core data have been updated annually. The data collected at baseline have provided a number of particularly notable findings (Supplementary Table 1), including showing that most adults and children with type 1 diabetes were not achieving HbA_{1c} goals set by the ADA and ISPAD (6–8); that there was a relationship between increased frequency of blood glucose testing and lower HbA_{1c} levels (9); that ethnic/racial and socioeconomic factors played a role in differences in metabolic control and use of insulin pumps in youth with type 1 diabetes (10); that diabetic ketoacidosis (DKA) occurred less frequently in insulin pump users than injection users (11,12); and that CGM was being used by only a small proportion of adults and children with type 1 diabetes (13).

In this article we report the results of the most recent follow-up data for registry participants—data that have allowed us to prospectively assess trends in outcomes over time. We examine the current state of metabolic control and use of advanced diabetes technologies and whether cross-sectional changes have occurred over time, as well as assess the current frequencies of SH and DKA by participant self-report.

METHODS

The T1D Exchange Clinic Network currently includes 76 U.S.-based pediatric and adult endocrinology practices in 33 states. Seventeen of the centers primarily care for adult patients, 38 primarily care for pediatric patients, and 21 care for both; 58 are institution based, 17 are community based, and 1 is in a managed care setting. During the initial registry enrollment period, 25,833 individuals with type 1 diabetes (14,593 $<$18 years old and 11,240 $\geq$18 years old) were enrolled. Details on the eligibility criteria, informed consent process, and baseline data collection have been reported previously (14). Core enrollment data are updated annually from medical records of all participants who had at least one clinic visit in the prior year. New modules concerning issues not addressed at enrollment have been designed for subsets of participants during annual updates.

This report includes data from 16,061 participants for whom an annual update was completed between 1 September 2013 and 1 December 2014 who had an available HbA_{1c} value associated with the office visit used for the medical record update. Participants with a history of pancreas or islet cell transplantation and those pregnant at the time of the most recent annual update were excluded. This report also includes the responses to a detailed questionnaire directed at specific aspects of diabetes management completed by a subset of 2,561 participants who chose to complete an electronic questionnaire during 2013. For the 16,061 with an annual update, clinical characteristics and diabetes management at the time of the most recent annual update were tabulated according to age-group. Use of an insulin pump and CGM were obtained from clinic medical records, and the frequency of self-monitoring of blood glucose (SMBG) was from the meter download at the clinic visit (available for 10,555 [66%] participants). Due to the variability and incompleteness of medical record recording of SH and DKA, the occurrence of these events during the prior 3 months was based on self-report data obtained from the subset of participants/caregivers who completed the web-based questionnaire. SH was defined as a participant-reported event that resulted in loss of consciousness or seizure. DKA was defined as participant-reported DKA diagnosed by a doctor that required treatment in a health care facility. Cross-sectional comparisons of data collected at enrollment were compared with the most recent update data for the 13,848 of the 16,061 participants who already had diabetes for at least 1 year at the time of initial registry enrollment. Cross-sectional comparisons of the occurrences of DKA and SH at enrollment versus recent update were not performed due to differences in the way in which events were collected between the two time points. In order to assess HbA_{1c} over the life span, participants were grouped by year of age at the time of the most recent HbA_{1c} value available (87% measured with an in-clinic point of care device, 11% local laboratory, and 2% unknown), and a mean HbA_{1c} was computed for that age using data from each of the 16,061 participants with a recent update. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

At the time of the most recent update, the 16,061 participants ranged in age from 2.7 to 93.9 years old, duration of type 1 diabetes ranged from 1.5 to 83.1 years, and 50% were female and 83% non-Hispanic white. Socioeconomic factors and clinical and diabetes management characteristics of the cohort stratified by age-group are shown in Table 1. Among participants with diabetes duration of $\geq$1 year at the time of registry enrollment, those with a recent update had a slightly lower HbA_{1c} at enrollment compared with those who did not have an update, particularly in participants $>$13 years of age (Supplementary Table 2).

Metabolic Control

Compared with the overall average HbA_{1c} of 8.2 $\pm$1.4% (66 $\pm$ 15.3 mmol/mol) at enrollment, the average HbA_{1c} was 8.4 $\pm$1.6% (68 $\pm$ 17.5 mmol/mol) at the most recent update, with the worsening over time largely being limited to the 13–25-year-olds (Table 2).

Table 1—Participant characteristics

	Overall	2–5 years old	6–12 years old	13–17 years old	18–25 years old	26–49 years old	≥50 years old
	n = 16,061	*n* = 236	*n* = 3,313	*n* = 4,914	*n* = 2,867	*n* = 2,606	*n* = 2,125
Demographic and clinical characteristics							
Race/ethnicity, *n* (%)							
White non-Hispanic	13,310 (83)	179 (76)	2,610 (79)	3,823 (78)	2,357 (82)	2,327 (89)	2,014 (95)
Black non-Hispanic	740 (5)	16 (7)	164 (5)	292 (6)	124 (4)	89 (3)	55 (3)
Hispanic or Latino	1,294 (8)	25 (11)	336 (10)	540 (11)	263 (9)	106 (4)	24 (1)
Other	699 (4)	16 (7)	194 (6)	255 (5)	121 (4)	81 (3)	32 (2)
Annual household income, *n* (%)‡							
<$50,000	3,540 (30)	76 (38)	823 (32)	1,045 (29)	514 (28)	652 (30)	430 (27)
$50,000 to <$100,000	4,299 (36)	77 (39)	934 (36)	1,246 (34)	639 (35)	814 (38)	589 (37)
≥$100,000	4,116 (34)	45 (23)	845 (32)	1,324 (37)	653 (36)	693 (32)	556 (35)
Education level, *n* (%)‡							
Less than Bachelor's degree	6,459 (49)	98 (44)	1,415 (46)	2,153 (46)	1,229 (91)	937 (38)	927 (47)
Bachelor's degree	3,959 (29)	60 (27)	926 (30)	1,324 (29)	120 (9)	993 (40)	536 (27)
Master's, professional, or doctorate	3,072 (22)	64 (28)	786 (25)	1,146 (25)	5 (<1)	554 (23)	517 (26)
Insurance status, *n* (%)							
Private	11,226 (77)	153 (70)	2,263 (73)	3,378 (75)	1,816 (77)	2,068 (85)	1,548 (76)
Other	3,254 (22)	64 (29)	822 (27)	1,096 (24)	507 (22)	321 (13)	444 (22)
None	149 (1)	1 (<1)	13 (<1)	24 (<1)	26 (1)	53 (2)	32 (2)
Duration of diabetes, mean ± SD	13.3 ± 11.9	3.1 ± 0.8	5.5 ± 2.3	7.6 ± 3.6	11.1 ± 4.9	27.7 ± 10.1	32.6 ± 14.8
Duration group, *n* (%)							
1 to <5 years	3,766 (23)	232 (98)	1,630 (49)	1,433 (29)	314 (11)	120 (5)	37 (2)
5 to <10 years	5,027 (31)	4 (2)	1,517 (46)	2,154 (44)	962 (34)	269 (10)	121 (6)
10 to <20 years	4,095 (25)		166 (5)	1,327 (27)	1,481 (52)	794 (30)	327 (15)
20 to <30 years	1,382 (9)				110 (4)	847 (33)	425 (20)
30 to <40 years	949 (6)					477 (18)	472 (22)
≥40 years	842 (5)					99 (4)	743 (35)
BMI *z* score, mean ± SD	0.4 ± 1.1	0.8 ± 0.9	0.6 ± 1.1	0.8 ± 1.0	0.2 ± 1.3	0.1 ± 1.1	−0.1 ± 0.9
BMI group, *n* (%)*							
Underweight/normal weight	7,863 (54)	136 (59)	2,257 (69)	2,885 (59)	1,443 (55)	639 (32)	503 (32)
Overweight	4,120 (28)	53 (23)	651 (20)	1,237 (25)	837 (31)	729 (37)	613 (39)
Obese	2,633 (18)	42 (18)	388 (12)	745 (15)	389 (15)	610 (31)	459 (29)
Diabetes management							
Pump use, *n* (%)	9,530 (60)	146 (63)	2,131 (65)	2,810 (58)	1,555 (55)	1,625 (63)	1,263 (60)
CGM use, *n* (%)	1,703 (11)	31 (13)	263 (8)	249 (5)	193 (7)	590 (23)	377 (18)
SMBG, mean ± SD#	4.7 ± 2.7	7.4 ± 2.9	6.2 ± 2.6	4.2 ± 2.3	3.5 ± 2.4	4.3 ± 2.7	4.8 ± 2.7
0–3 times per day	3,630 (34)	3 (2)	253 (11)	1,316 (39)	994 (55)	689 (41)	375 (30)
4–6 times per day	4,781 (45)	63 (37)	1,174 (50)	1,575 (47)	625 (35)	712 (43)	632 (51)
6–9 times per day	1,566 (15)	75 (44)	627 (27)	360 (11)	124 (7)	193 (12)	187 (15)
≥10 times per day	578 (5)	28 (17)	286 (12)	87 (3)	48 (3)	73 (4)	56 (4)
Downloading of meter at home, *n* (%)§							
≥1 time per month	298 (12)	6 (13)	92 (17)	73 (16)	40 (9)	49 (7)	38 (9)
Never	1,671 (65)	33 (70)	277 (52)	252 (55)	310 (69)	506 (77)	293 (71)
Noninsulin medications for blood glucose control, *n* (%)							
Metformin	515 (3)	0	12 (<1)	121 (2)	100 (3)	168 (6)	114 (5)
GLP-1 agonist	116 (<1)	0	0	2 (<1)	18 (<1)	64 (2)	32 (2)
DPP-4*i*	12 (<1)	0	0	0	0	9 (<1)	3 (<1)
SGLT2*i*	14 (<1)	0	0	0	0	9 (<1)	5 (<1)
Pramlintide	128 (<1)	0	1 (<1)	2 (<1)	11 (<1)	61 (2)	53 (2)
Other‖	30 (<1)	0	0	0	1 (<1)	12 (<1)	17 (<1)

‡Income data missing for 4,106 participants, education data missing for 2,271 participants, and insurance data missing for 1,432 participants. Education level is the parents' highest education level for participants <18 years of age and is the participants' education level for participants >18 years of age. *Underweight/normal weight defined as <85th BMI percentile adjusted for age and sex for participants <20 years of age and BMI <25 for adults ≥20 years of age. Overweight defined as 85th to <95th BMI percentile for participants <20 years of age and BMI 25 to <30 for adults ≥20 years of age. Obese defined as ≥95th BMI percentile for participants <20 years of age and BMI ≥30 for adults ≥20 years of age. #SMBG from meter download was available for 10,555 participants. §Only available for a subset of participants who completed an electronic questionnaire asking about insulin and device use; *n* = 2,561 (*n* = 47 for 2–5 years, 534 for 6–12 years, 455 for 13–17 years, 451 for 18–25 years, 661 for 26–49 years, and 413 for ≥50 years). ‖Includes thiazolidinediones and sulfonylureas.

As shown in Fig. 1, the mean of the most recent HbA_{1c} levels varied considerably with age. During childhood, mean HbA_{1c} levels decreased from 8.3% (67 mmol/mol) in 2–4-year-olds to 8.1% (65 mmol/mol) at 7 years of age, followed by an increase to 9.2% (77 mmol/mol) in 19-year-olds. Subsequently, mean HbA_{1c} values showed a gradual decline until ~30 years of age, plateauing at a level of 7.5–7.8% (58–62 mmol/mol) beyond age 30 until a modest drop in HbA_{1c} below 7.5% (58 mmol/mol) after 65 years of age. The ADA HbA_{1c} goal of <7.5% (58 mmol/mol) was achieved by only a small percentage of children and adolescents <18 years of age (17–23%), and even fewer 18–25-year-olds (14%) met the ADA goal for adults of <7.0% (53 mmol/mol); this percentage increased to ~30% in older adults (Fig. 2).

As previously reported, across all age-groups, HbA_{1c} was highest among non-Hispanic black participants, participants with lower annual household income, and those who performed SMBG less than four times per day (Table 3). On average, participants using an insulin pump or continuous glucose monitor tended to have lower HbA_{1c} values (Table 3).

Utilization of Diabetes Technologies, Insulin, and Other Glucose-Lowering Agents

An insulin pump was being used by 60% of participants, ranging from a low of 55% in 18–25-year-olds to 65% in 6–12-year-olds. In a cross-sectional comparison of enrollment with most recent update, the greatest relative increase in pump use was in pediatric participants likely due to an increase in mean diabetes duration, whereas pump use did not change in 18–25-year-olds and increased only slightly in older participants (Tables 1 and 2).

Across all age-groups, the use of CGM was more frequent at most recent update compared with enrollment and the frequency of SMBG by meter download did not change from enrollment; on both occasions, the frequency of SMBG was highest but CGM use was lowest in pediatric patients. Nearly two-thirds of patients/families reported never downloading SMBG data.

Insulin aspart was being used in pumps slightly more frequently than insulin lispro (Supplementary Table 3). Among injection users, lispro was the most common rapid-acting insulin being used and glargine the most common long-acting insulin (Supplementary Table 3). Use of glucose-lowering agents as adjuncts to insulin treatment of type 1 diabetes was uncommon across all age-groups. Metformin was the most common noninsulin glucose-lowering drug being used but only by 6% of those ≥26 years of age. No other noninsulin drug was being used by >2% of those ≥26 years of age or by >1% of younger participants.

SH and DKA

Among the subset of 2,561 participants who completed the participant questionnaire, 6% reported having had a seizure or loss of consciousness due to hypoglycemia in the prior 3 months, with the highest occurrence being among those who were 50 years old or older. An increase in frequency of SH with increasing age and duration of diabetes was also observed on enrollment (12). Insulin pump use was associated with a lower frequency of SH. Participants across all age-groups who

Table 2—Comparison of enrollment and most current registry data*

	Overall	Age at most current registry data					
		2–5 years old	6–12 years old	13–17 years old	18–25 years old	26–49 years old	≥50 years old
	Enrollment/ Current	Enrollment/ Current	Enrollment/ Current	Enrollment/ Current	Enrollment/ Current	Enrollment/ Current	Enrollment/ Current
n	13,848	522/54	4,061/2,347	3,213/4,065	1,686/2,717	2,553/2,557	1,810/2,108
Age, mean	23.6/26.4	4.1/4.9	9.6/10.0	14.7/15.1	20.4/20.6	37.4/37.3	60.0/61.1
Duration, mean	11.7/15.0	1.9/4.2	4.2/6.5	6.4/8.5	10.1/11.6	20.3/22.0	30.1/32.9
Pump use, %	58/62	50/69	58/68	57/61	56/56	61/64	58/61
CGM use, %	7/11	4/15	4/8	3/5	5/7	15/23	15/18
CGM device type, %							
Medtronic	53/39	—	60/21	62/41	47/38	52/41	51/43
Dexcom	45/61	—	34/79	34/59	52/62	47/59	48/57
Abbott	2/0	—	5/0	3/0	0/0	<1/0	<1/0
HbA_{1c}, mean, % (mmol/mol)	8.2/8.4 (66/68)	8.2/8.2 (66/66)	8.3/8.5 (67/69)	8.7/9.0 (72/75)	8.3/8.7 (67/72)	7.7/7.7 (61/61)	7.6/7.6 (60/60)
HbA_{1c} <7.5% (58 mmol/mol)	32/29	24/22	24/20	21/16	31/25	50/48	49/50
HbA_{1c} <7.0% (53 mmol/mol)	17/15	10/7	9/7	9/6	17/13	30/29	29/29
SMBG per day, mean#	5.1/4.7	7.1/7.1	6.0/6.2	4.3/4.3	4.0/3.5	4.7/4.5	5.0/5.0
Downloading of meter at home ≥1 times per month, %§	12/11	20/20	20/15	10/14	5/9	8/8	13/9

Severe hypoglycemia and DKA frequencies were not compared due to changes in how the data were collected. Dash (—) indicates *n* <20.
*Enrollment data were collected from 1 September 2010 to 1 August 2012. Current data were collected from 1 September 2013 to 1 December 2014. There are less participants in the younger age-groups for the current update data due to aging over time and they are included in the older age-groups. #Available for 5,787 participants with a meter download in the medical record at enrollment and most recent clinic visit. §Available for 2,124 participants who completed the participant questionnaire and did not respond "Don't know."

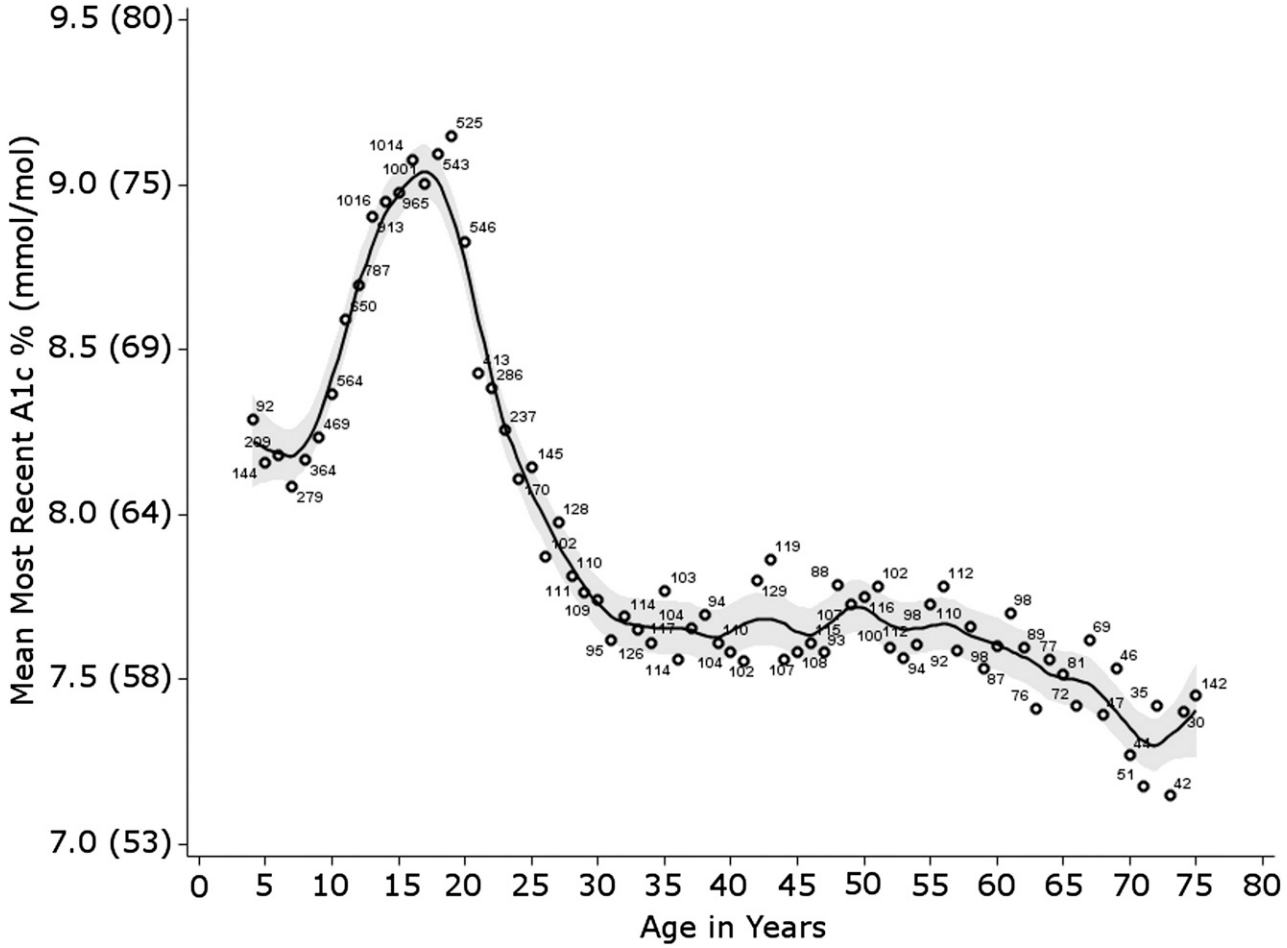

Figure 1—Mean HbA_{1c} by age. Average HbA_{1c} for each year of age was plotted using the most recent HbA_{1c} value available for each of the 16,057 participants with a recent update. The line was estimated using local regression scatter plot smoothing (LOESS), which is a nonparametric method for estimating the regression equation that fits a smoothing parameter. Circles represent the mean HbA_{1c} for each year of age. Participants <4 years were lumped as age 4 and participants ≥75 years were lumped at age 75. Gray shaded area represents the 95% CI around the smoothed LOESS line. Numbers next to circles are the *n* for each year of age.

achieved lower HbA_{1c} levels did so without increased frequency of SH (Table 4).

At least one DKA event in the prior 3 months was reported by 3% of the 2,561 participants, with the highest occurrence being young adults (5%). With the exception of the 2–5-year-old age-group where the sample size was small, the frequency of DKA tended to be higher among participants with higher HbA_{1c} levels and slightly lower among participants using an insulin pump.

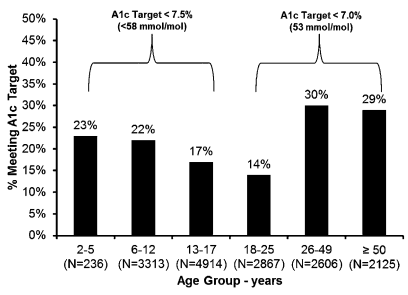

Figure 2—Percent of patients achieving HbA_{1c} ADA targets by age-group. HbA_{1c} target for those aged <18 years is <7.5% (<58 mmol/mol). HbA_{1c} target for those aged ≥18 years is <7.0% (<53 mmol/mol).

CONCLUSIONS

The HbA_{1c} data collected by the T1D Exchange clinic registry at a large, geographically diverse number of pediatric and adult diabetes treatment centers provide an up-to-date picture of metabolic control of type 1 diabetes across the life span. A positive aspect of these data is that the mean HbA_{1c} levels in patients ≥30 years of age are lower than the ~8.0% (~64 mmol/mol) that has been observed in DCCT/EDIC patients during the past 20 years (1). The most troubling aspect of the data is that the mean HbA_{1c} level of 9.0% (75 mmol/mol) in 13–17-year-olds in the registry is only slightly lower than the 9.5% (80 mmol/mol) seen in 13–17-year-olds at the start of the DCCT in the 1980s (15). Clearly, advances in diabetes management over the past two decades have been less successful in overcoming the special challenges in managing teenagers than adults with type 1 diabetes. Our data also indicate that the majority of "emerging adults" in their 20s do not fully emerge with regard to glycemic control until they reach 30 years of age. Given DCCT/EDIC data on the persistent benefit of intensive versus conventional glucose control (7.3 vs. 9.1% [56 vs. 76 mmol/mol] during the DCCT) on vascular outcomes 20 years later (16), the contemporary elevated HbA_{1c} seen in the adolescents and young adults in the T1D Exchange suggests a similarly elevated risk for future complications until they reach 30 years of age.

In a cross-sectional comparison, the average HbA_{1c} at the most recent update was higher than at enrollment (8.4 vs.

Table 3—HbA_{1c} according to demographic and clinical characteristics

	2–5 years old		6–12 years old		13–17 years old		18–25 years old		26–49 years old		≥50 years old	
	n	Mean ± SD (mmol/mol)	*n*	Mean ± SD (mmol/mol)	*n*	Mean ± SD (mmol/mol)	*n*	Mean ± SD (mmol/mol)	*n*	Mean ± SD (mmol/mol)	*n*	Mean ± SD (mmol/mol)
Overall	236	8.2 ± 1.0 (66 ± 10.9)	3,313	8.4 ± 1.3 (68 ± 14.2)	4,914	9.0 ± 1.8 (75 ± 19.7)	2,867	8.7 ± 1.9 (72 ± 20.8)	2,606	7.7 ± 1.3 (61 ± 14.2)	2,125	7.6 ± 1.1 (60 ± 12.0)
Race/ethnicity												
White non-Hispanic	179	8.2 ± 0.9 (66 ± 9.8)	2,610	8.3 ± 1.2 (67 ± 13.1)	3,823	8.8 ± 1.6 (73 ± 17.5)	2,357	8.6 ± 1.8 (71 ± 19.7)	2,327	7.7 ± 1.3 (61 ± 14.2)	2,014	7.5 ± 1.1 (58 ± 12.0)
Black non-Hispanic	16	—	164	9.6 ± 1.7 (81 ± 18.6)	292	10.2 ± 2.1 (88 ± 23.0)	124	10.2 ± 2.4 (88 ± 26.2)	89	8.5 ± 1.5 (69 ± 16.4)		8.4 ± 1.3 (68 ± 14.2)
Hispanic or Latino	25	8.3 ± 0.9 (67 ± 9.8)	336	8.6 ± 1.3 (71 ± 14.2)	540	9.2 ± 1.9 (77 ± 20.8)	263	9.1 ± 2.0 (76 ± 21.9)	106	7.9 ± 1.3 (63 ± 14.2)	24	7.6 ± 1.1 (60 ± 12.0)
Other	16	—	194	8.7 ± 1.6 (72 ± 17.5)	255	9.3 ± 2.0 (78 ± 21.9)	121	9.3 ± 2.0 (78 ± 21.9)	81	7.6 ± 1.7 (60 ± 18.6)	32	7.8 ± 1.7 (62 ± 18.6)
Annual household income*												
<$50,000	76	8.4 ± 1.1 (68 ± 12.0)	823	8.9 ± 1.5 (74 ± 16.4)	1,045	9.5 ± 2.0 (80 ± 21.9)	514	9.1 ± 2.0 (76 ± 21.9)	652	8.0 ± 1.5 (64 ± 16.4)	430	7.7 ± 1.2 (61 ± 13.1)
$50,000 to <$100,000	77	8.0 ± 0.8 (64 ± 8.7)	934	8.3 ± 1.1 (67 ± 12.0)	1,246	9.0 ± 1.7 (75 ± 18.6)	639	8.7 ± 1.9 (72 ± 20.8)	814	7.7 ± 1.2 (61 ± 13.1)	589	7.6 ± 1.1 (60 ± 12.0)
≥$100,000	45	8.0 ± 1.0 (64 ± 10.9)	845	8.0 ± 1.1 (64 ± 12.0)	1,324	8.5 ± 1.4 (69 ± 15.3)	653	8.2 ± 1.6 (66 ± 17.5)	693	7.3 ± 1.0 (56 ± 10.9)	556	7.4 ± 1.0 (57 ± 10.9)
Insulin delivery method												
Pump	146	8.0 ± 0.9 (64 ± 9.8)	2,131	8.2 ± 1.2 (66 ± 13.1)	2,810	8.7 ± 1.5 (72 ± 16.4)	1,555	8.4 ± 1.6 (68 ± 17.5)	1,625	7.6 ± 1.2 (60 ± 13.1)	1,263	7.5 ± 1.0 (58 ± 10.9)
Injections	87	8.5 ± 1.1 (69 ± 12.0)	1,136	8.8 ± 1.4 (73 ± 15.3)	2,008	9.4 ± 2.0 (79 ± 21.9)	1,277	9.1 ± 2.1 (76 ± 23.0)	940	7.8 ± 1.5 (62 ± 16.4)	833	7.7 ± 1.2 (61 ± 13.1)
CGM												
Yes	20	7.4 ± 0.6 (57 ± 6.6)	164	7.9 ± 0.9 (63 ± 9.8)	153	8.2 ± 1.4 (66 ± 15.3)	130	8.1 ± 1.3 (65 ± 14.2)	399	7.3 ± 1.1 (56 ± 12.0)	238	7.4 ± 1.0 (57 ± 10.9)
No	216	8.3 ± 1.0 (67 ± 10.9)	3,149	8.4 ± 1.3 (68 ± 14.2)	4,761	9.0 ± 1.8 (75 ± 19.7)	2,737	8.7 ± 1.9 (72 ± 20.8)	2,207	7.8 ± 1.4 (62 ± 15.3)	1,887	7.6 ± 1.1 (60 ± 12.0)
SMBG#												
0–3 times per day	3	—	253	9.5 ± 1.9 (80 ± 20.8)	1,316	9.7 ± 1.9 (83 ± 20.8)	994	9.2 ± 1.9 (77 ± 20.8)	689	8.0 ± 1.3 (64 ± 14.2)	375	7.9 ± 1.2 (63 ± 13.1)
4–6 times per day	63	8.4 ± 1.0 (68 ± 10.9)	1,174	8.5 ± 1.2 (69 ± 13.1)	1,575	8.6 ± 1.4 (71 ± 15.3)	625	8.0 ± 1.3 (64 ± 14.2)	712	7.4 ± 1.0 (57 ± 10.9)	632	7.5 ± 1.0 (58 ± 10.9)
6–9 times per day	75	8.1 ± 0.9 (65 ± 9.8)	627	8.1 ± 1.0 (65 ± 10.9)	360	8.0 ± 1.1 (64 ± 12.0)	124	7.5 ± 1.0 (58 ± 10.9)	193	7.1 ± 0.9 (54 ± 9.8)	187	7.1 ± 0.8 (54 ± 8.7)
≥10 times per day	28	7.5 ± 0.7 (58 ± 7.7)	286	7.7 ± 0.9 (61 ± 9.8)	87	7.9 ± 1.1 (63 ± 12.0)	48	7.2 ± 1.1 (55 ± 12.0)	73	7.0 ± 1.1 (53 ± 12.0)	56	7.0 ± 0.8 (53 ± 8.7)

Dash (—) indicates $n < 20$. *Income is from participant report at enrollment. #SMBG from meter download was available for 10,555 participants.

Table 4—Number (%) of patients reporting one or more severe hypoglycemic and one or more DKA events

	2–5 years old		6–12 years old		13–17 years old		18–25 years old		26–49 years old		≥50 years old	
	n	≥1 event (%)	*n*	≥1 event (%)	*n*	≥1 event (%)	*n*	≥1 event (%)	*n*	≥1 event (%)	*n*	≥1 event (%)
Frequency of ≥1 SH event in prior 3 months												
Overall	47	3 (6)	534	12 (2)	455	24 (5)	451	26 (6)	661	50 (8)	413	35 (8)
Insulin delivery method												
Pump	31	1 (3)	388	9 (2)	304	14 (5)	272	14 (5)	433	28 (6)	255	19 (7)
Injections	16	2 (13)	128	3 (2)	124	8 (6)	158	12 (8)	204	18 (9)	129	13 (10)
Most recent HbA_{1c}*												
<7.0% (<53 mmol/mol)	5	—	50	3 (6)	29	1 (3)	72	2 (3)	215	13 (6)	120	7 (6)
7.0 to <7.5% (53 to <58 mmol/mol)	6	—	66	2 (3)	44	4 (9)	45	2 (4)	104	6 (6)	80	7 (9)
7.5 to <8.0% (58 to <64 mmol/mol)	9	—	105	1 (1)	76	2 (3)	75	2 (3)	100	12 (12)	80	5 (6)
8.0 to <9.0% (64 to <75 mmol/mol)	15	—	181	4 (2)	145	8 (6)	90	8 (9)	102	9 (9)	64	5 (8)
≥9.0% (≥75 mmol/mol)	9	—	102	2 (2)	133	6 (5)	97	8 (8)	52	7 (13)	20	2 (10)
Frequency of ≥1 DKA event in prior 3 months												
Overall	47	2 (4)	534	17 (3)	455	20 (4)	451	22 (5)	661	12 (2)	413	5 (1)
Insulin delivery method												
Pump	31	2 (6)	388	13 (3)	304	8 (3)	272	9 (3)	433	4 (1)	255	2 (1)
Injections	16	—	128	4 (3)	124	11 (9)	158	10 (6)	204	7 (3)	129	1 (1)
Most recent HbA_{1c}*												
<7.0% (<53 mmol/mol)	5	—	50	2 (4)	29	1 (3)	72	1 (1)	215	0	120	1 (1)
7.0 to <7.5% (53 to <58 mmol/mol)	6	—	66	0	44	0	45	3 (7)	104	1 (1)	80	1 (1)
7.5 to <8.0% (58 to <64 mmol/mol)	9	—	105	3 (3)	76	0	75	0	100	2 (2)	80	1 (1)
8.0 to <9.0% (64 to <75 mmol/mol)	15	—	181	5 (3)	145	3 (2)	90	2 (2)	102	5 (5)	64	2 (3)
≥9.0% (≥75 mmol/mol)	9	—	102	5 (5)	133	13 (10)	97	12 (12)	52	2 (4)	20	0

Dash (—) indicates *n* <20. *Most recent HbA_{1c} 6 months prior to when participant questionnaire was completed (270 participants were missing HbA_{1c} within 6 months of questionnaire).

8.2% [68 vs. 66 mmol/mol]), suggesting a worsening in glycemic control over time. The greatest increase in HbA_{1c} was observed in the 13–17 (9.0 vs. 8.7% [75 vs. 72 mmol/mol]) and 18–26-year-old (8.7 vs. 8.3% [72 vs. 67 mmol/mol]) groups. Although this could reflect differences in age and type 1 diabetes duration, the results nevertheless indicate that there certainly is no indication of improving glycemic control in these age-groups. Additional studies are needed to understand and overcome the special challenges in treating teenagers with type 1 diabetes, as well as the racial/ethnic factors that contribute to elevated HbA_{1c} levels in African American children and adolescents (17). Since only 30% of adults aged >30 years had achieved target HbA_{1c} levels, there remains considerable room for improving metabolic control and long-term clinical outcomes in patients with type 1 diabetes across all age-groups.

The observation that many patients in the registry were able to achieve target HbA_{1c} levels without the exponential increase in the frequency of SH seen in the DCCT is a very positive finding (6,7). Similar decreases in HbA_{1c} levels without concomitant increases in SH have been observed in clinical trials of new insulin analogs (18), with use of new insulin pumps (19), and in CGM trials (20). Our data also indicate that DKA remains a problem in a substantial percentage of patients (11,12). Since the risk of DKA was increased in participants with HbA_{1c} levels >9.0% (75 mmol/mol), poor compliance with their diabetes treatment regimens undoubtedly contributes to the increased risk of DKA. Conversely, greater compliance with the daily tasks of managing diabetes may help explain the lower frequency of DKA that we observed in pump versus injection patients. The data provide no indication of a higher DKA rate in pump users, a theoretical concern due to the potential for infusion set failure.

Despite elevations in HbA_{1c} levels in every age-group of participants with type 1 diabetes, only ~5% were being treated with an adjunctive glucose-lowering agent, mostly metformin. Treatment with metformin has been associated with only a modest lowering of HbA_{1c} in adults with type 1 diabetes (21), whereas no change in metabolic control was seen in a recent large-scale clinical trial in overweight adolescents (22). These observations underscore the continuing need for the testing of new classes of glucose-lowering agents that have been approved for treatment of type 2 diabetes in patients with type 1 diabetes. Since adolescents with type 1 diabetes are at greatest need for new treatment options, pivotal trials for approval of these drugs in type 1 diabetes in adolescents should not be delayed until completion of adult studies.

A limitation in interpreting these results is that all subjects in the T1D Exchange clinic registry are treated at centers that focus on the care of type 1 diabetes. Thus, uninsured individuals likely are underrepresented in the cohort and pump use may

be higher than it is in the overall population of type 1 diabetes in the U.S. Even higher HbA_{1c} values might be expected in a national, population-based sample of type 1 diabetes, especially in adults who are more likely to be treated in primary care settings rather than in diabetes specialty practices than are children with type 1 diabetes. The T1D Exchange pediatric participant characteristics generally are similar to those of participants in the SEARCH for Diabetes in Youth Study (SEARCH), a study of individuals <20 years of age with diabetes in six areas of the U.S. that began in 2001 (23). We do not know of a population-based cohort in adults with type 1 diabetes for comparison with our T1D Exchange adult cohort.

Even if certain biases are present, it is highly unlikely that the T1D Exchange data demonstrating that only a minority of children and adults with type 1 diabetes achieve HbA_{1c} targets is an underestimate. The high proportions of individuals not achieving glycemic targets with current therapies highlighted in our analyses make development and dissemination of an artificial pancreas or safe and effective islet replacement imperative.

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Duality of Interest. R.W.B.'s nonprofit employer has received consultant payments on his behalf from Sanofi and Animas and a research grant from Novo Nordisk with no personal compensation to R.W.B. R.M.B. has served on a scientific advisory board, consulted, or performed clinical research with Abbott Diabetes Care, Amylin, Bayer, Becton Dickinson, Boehringer Ingelheim, Intuity, Calibra, Dexcom, Eli Lilly and Company, Halozyme Therapeutics, Helmsley Trust, Hygieia, Johnson & Johnson, Medtronic, Merck, NIH, Novo Nordisk, ResMed, Roche, Sanofi, and Takeda. His employer, Park Nicollet, has contracts with the listed companies for his services, and no personal income goes to R.M.B. He has inherited Merck stock and has been a volunteer officer of the ADA. L.A.D. has received consultancy payments from Sanofi, and her nonprofit employer has received research support from Sanofi, Novo Nordisk, and Medtronic on her behalf. D.M.M. is on the scientific advisory board for Insulet, and his nonprofit employer has received research grants from Medtronic and Dexcom. W.V.T. has received consultancy payments from Janssen, Medtronic, Novo Nordisk, Sanofi, and Unomedical. No other potential conflicts of interest relevant to this article were reported.

References

1. Nathan DM; DCCT/EDIC Research Group. The diabetes control and complications trial/epidemiology of diabetes interventions and complications study at 30 years: overview. Diabetes Care 2014;37:9–16
2. Orchard TJ, Nathan DM, Zinman B, et al.; Writing Group for the DCCT/EDIC Research Group. Association between 7 years of intensive treatment of type 1 diabetes and long-term mortality. JAMA 2015;313:45–53
3. American Diabetes Association. (11) Children and adolescents. Diabetes Care 2015;38 (Suppl.):S70–S76
4. Rewers MJ, Pillay K, de Beaufort C, et al. Assessment and monitoring of glycemic control in children and adolescents with diabetes. Pediatr Diabetes 2014;15(Suppl. 20):102–114
5. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Effectiveness of continuous glucose monitoring in a clinical care environment: evidence from the Juvenile Diabetes Research Foundation continuous glucose monitoring (JDRF-CGM) trial. Diabetes Care 2010;33:17–22
6. Campbell MS, Schatz DA, Chen V, et al.; T1D Exchange Clinic Network. A contrast between children and adolescents with excellent and poor control: the T1D Exchange clinic registry experience. Pediatr Diabetes 2014;15:110–117
7. Simmons JH, Chen V, Miller KM, et al.; T1D Exchange Clinic Network. Differences in the management of type 1 diabetes among adults under excellent control compared with those under poor control in the T1D Exchange clinic registry. Diabetes Care 2013;36:3573–3577
8. Wood JR, Miller KM, Maahs DM, et al. Most youth with type 1 diabetes in the T1D Exchange clinic registry do not meet American Diabetes Association or International Society for Pediatric and Adolescent Diabetes clinical guidelines. Diabetes Care 2013;36:2035–2037
9. Miller KM, Beck RW, Bergenstal RM, Goland RS, Haller MJ, McGill JB, et al. Evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A1c levels in T1D Exchange clinic registry participants. Diabetes Care 2013;36:2009–2014
10. Blackman SM, Raghinaru D, Adi S, et al. Insulin pump use in young children in the T1D Exchange clinic registry is associated with lower hemoglobin A1c levels than injection therapy. Pediatr Diabetes 2014;15:564–572
11. Cengiz E, Xing D, Wong JC, et al.; T1D Exchange Clinic Network. Severe hypoglycemia and diabetic ketoacidosis among youth with type 1 diabetes in the T1D Exchange clinic registry. Pediatr Diabetes 2013;14:447–454
12. Weinstock RS, Xing D, Maahs DM, et al.; T1D Exchange Clinic Network. Severe hypoglycemia and diabetic ketoacidosis in adults with type 1 diabetes: results from the T1D Exchange clinic registry. J Clin Endocrinol Metab 2013;98:3411–3419
13. Wong JC, Foster NC, Maahs DM, et al.; T1D Exchange Clinic Network. Real-time continuous glucose monitoring among participants in the T1D Exchange clinic registry. Diabetes Care 2014;37:2702–2709
14. Beck RW, Tamborlane WV, Bergenstal RM, Miller KM, DuBose SN, Hall CA; T1D Exchange Clinic Network. The T1D Exchange clinic registry. J Clin Endocrinol Metab 2012;97:4383–4389
15. Diabetes Control and Complications Trial Research Group. Effect of intensive diabetes treatment on the development and progression of long-term complications in adolescents with insulin-dependent diabetes mellitus: Diabetes Control and Complications Trial. J Pediatr 1994;125:177–188
16. Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus. JAMA 2002;287:2563–2569
17. Willi SM, Miller KM, DiMeglio LA, et al.; for the T1D Exchange Clinic Network. Racial-ethnic disparities in management and outcomes among children with type 1 diabetes. Pediatrics 2015;135:424–434
18. Pedersen-Bjergaard U, Kristensen PL, Beck-Nielsen H, et al. Effect of insulin analogues on risk of severe hypoglycaemia in patients with type 1 diabetes prone to recurrent severe hypoglycaemia (HypoAna trial): a prospective, randomised, open-label, blinded-endpoint crossover trial. Lancet Diabetes Endocrinol 2014;2:553–561
19. Bergenstal RM, Tamborlane WV, Ahmann A, et al.; STAR 3 Study Group. Effectiveness of sensor-augmented insulin-pump therapy in type 1 diabetes. N Engl J Med 2010;363:311–320
20. Tamborlane WV, Beck RW, Bode BW, et al.; Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Continuous glucose monitoring and intensive treatment of type 1 diabetes. N Engl J Med 2008;359: 1464–1476
21. Vella S, Buetow L, Royle P, Livingstone S, Colhoun HM, Petrie JR. The use of metformin in type 1 diabetes: a systematic review of efficacy. Diabetologia 2010;53:809–820
22. Libman IM, Miller KM, Dimeglio LA, et al. Metformin as an adjunct therapy does not improve glycemic control among overweight adolescents with type 1 diabetes (T1D). Presented at the 97th Annual Meeting of the Endocrine Society, 5–8 March 2015, San Diego, CA
23. Liese AD, D'Agostino RB Jr, Hamman RF, et al.; SEARCH for Diabetes in Youth Study Group. The burden of diabetes mellitus among US youth: prevalence estimates from the SEARCH for Diabetes in Youth Study. Pediatrics 2006;118:1510–1518

SUPPLEMENTARY DATA

Supplementary Figure 1. T1D Exchange Clinic Network Centers

Map includes 76 centers in 33 states
Red dotes represent location of clinical center, some locations include more than one clinical center.

SUPPLEMENTARY DATA

Supplementary Table 1. Summary of T1D Exchange Peer Reviewed Publications

Citation/PubMed Link and Summary
Beck RW, Tamborlane WV, Bergenstal RM, Miller KM, DuBose SN, Hall CA. The T1D Exchange Clinic Registry. J Clin Endocrinol Metab. 2012;97:4383-9. http://www.ncbi.nlm.nih.gov/pubmed/22996145 **Objective:** To describe the methodology and baseline data of the T1D Exchange clinic registry. **Findings and Conclusions:** Participants ranged in age from <1 to 93 years with 50% female, 82% White Non-Hispanic, 50% used insulin pump, and 6% used continuous glucose monitoring (CGM). The registry provides a rich dataset and an opportunity to address numerous issues of relevance to clinicians and patients, including assessments of associations between patient characteristics and diabetes management factors with outcomes, that hopefully will lead to improvements in diabetes management and outcomes to improve the lives of individuals with type 1 diabetes.
Blackman SM, Raghinaru D, Adi S, Ebner-Lyon L, Chase P, Tamborlane WV, Schatz D, Block J, Litton J, Raman V, Foster NC, Kollman C, DuBose SN, Miller KM, Beck RW, DiMeglio LA. Insulin pump use in young children in the T1D Exchange Clinic Registry is associated with lower hemoglobin A1c levels than injection therapy. Pediatr Diabetes. 2014;15(8):564-72. http://www.ncbi.nlm.nih.gov/pubmed/24494980 **Objectives:** To characterize insulin pump use in young children (<6 years old) with type 1 diabetes. **Findings and Conclusions:** Wide variation in pump use was observed among T1D Exchange centers even after adjusting for parent education and household income, suggesting that prescriber preference is a substantial determinant of pump use. HbA1c was lower in pump versus injection users (7.9% vs. 8.5%). No difference in the occurrence of severe hypoglycemia in pump versus injection users was observed. These data suggest that metabolic control may be improved without increasing the frequency of severe hypoglycemia, but care should be taken as to the possibly increased risk of diabetic ketoacidosis.
Campbell MS, Schatz DA, Chen V, Wong JC, Steck A, Tamborlane WV, Smith J, Beck RW, Cengiz E, Laffel LM, Miller KM, Haller MJ. A contrast between children and adolescents with excellent and poor control: The T1D Exchange clinic registry experience. Pediatr Diabetes. 2014; 15(2):110-7. http://www.ncbi.nlm.nih.gov/pubmed/23957219 **Objective:** To identify differences in diabetes management characteristics amongst children categorized as having excellent (HbA1c <7.0%) versus poor (HbA1c ≥ 9.0%) glycemic control. **Findings and Conclusions:** After adjusting for demographic and socio-economic factors, diabetes management characteristics were still strongly associated with excellent versus poor control. The excellent control group was more likely to use an insulin pump, perform blood glucose monitoring > 4 times per day, miss fewer boluses, bolus before meals rather than at the time of the meal or after meal, use meal specific insulin to carb ratios, give more bolus insulin, and have lower total daily insulin per kg of body weight. Notably, frequency of severe hypoglycemia was similar between the groups while diabetic ketoacidosis was more common in the poorly controlled group. This knowledge may further inform diabetes care providers and patients about specific characteristics and behaviors that can be augmented to potentially improve glycemic control.

SUPPLEMENTARY DATA

Cengiz E, Xing D, Wong JC, Wolfsdorf JI, Haymond MW, Rewers A, Shanmugham S, Tamborlane WV, Willi SM, Seiple DL, Miller KM, DuBose SN, Beck RW. Severe Hypoglycemia and Diabetic Ketoacidosis among Youth with Type 1 Diabetes in the T1D Exchange Clinic Registry. Pediatric Diabetes. 2013;14(6):447-54. http://www.ncbi.nlm.nih.gov/pubmed/23469984

Objective: To examine the frequency of severe hypoglycemia and diabetic ketoacidosis in ages 2 to 25 years with type 1 diabetes ≥2 years.

Findings and Conclusions: Frequency of ≥1 severe hypoglycemic event associated with seizure or loss of consciousness occurred in 9.6% of 2-5 year old, 5.2% of 6-12 year olds, 6.3% of 13 -17 year olds and 6.9% of 18-25 year olds. Non-white race, no private insurance, and lower household income were all associated with higher frequencies of both severe hypoglycemia and diabetic ketoacidosis. Poor glycemic control increased the risk of diabetic ketoacidosis but did not protect against severe hypoglycemia in youth and young adults with type 1 diabetes.

Daniels M, Dubose SN, Maahs DM, Beck RW, Fox LA, Gubitosi-Klug R, Laffel LM, Miller KM, Speer H, Tamborlane WV, Tansey MJ. Factors Associated with Microalbuminuria in 7,549 Children and Adolescents with Type 1 Diabetes in the T1D Exchange Clinic Registry. Diabetes Care. 2013;36(9):2639-45. http://www.ncbi.nlm.nih.gov/pubmed/23610082

Objective: To examine factors associated with clinical microalbuminuria diagnosis in children and adolescents < 20 years of age with duration of type 1 diabetes ≥1 year.

Findings and Conclusions: Microalbuminuria was present in 4.4% of 7,549 participants, with a higher frequency associated with longer diabetes duration, higher mean HbA1c, older age, female gender, higher diastolic blood pressure, and lower body mass index. Since age and diabetes duration are important non-modifiable factors associated with microalbuminuria, the importance of routine screening is underscored to ensure early diagnosis and timely treatment of microalbuminuria.

Maahs DM, Hermann JM, DuBose SN, Miller KM, Heidtmann B, DiMeglio LA, Rami-Merhar B, Beck RW, Schober E, Tamborlane WV, Kapellen TM, Holl RW. Contrasting the clinical care and outcomes of 2,622 children with type 1 diabetes less than 6 years of age in the United States T1D Exchange and German/Austrian DPV registries. Diabetologia. 2014. [ePub ahead of print]. doi:10.1007/s00125-014-3272-2. http://www.ncbi.nlm.nih.gov/pubmed/24893863

Objective: To compare treatment modalities and clinical outcomes between the T1D Exchange clinic registry and DPV (Germany and Austria registry) among participants with type 1 diabetes < 6 years of age.

Findings and Conclusions: Insulin pump use was more frequent (74% v 50%) in DPV than the T1D Exchange. Mean HbA1c was lower in DPV (7.4%) than the T1D Exchange (8.2%), being lower for both among pump users and among injection users. Frequency of severe hypoglycemia did not differ between registries whereas frequency of diabetic ketoacidosis was higher in the T1D Exchange.

Miller KM, Beck RW, Bergenstal RM, Goland RS, Haller MJ, McGill JB, Rodriguez H, Simmons JH, Hirsch IB. Evidence of a Strong Association Between Frequency of Self-Monitoring of Blood Glucose and Hemoglobin A1C Levels in T1D Exchange Clinic Registry Participants. Diabetes Care. 2013;36(7):2009-14. http://www.ncbi.nlm.nih.gov/pubmed/23378621

Objective: To evaluate the relationship between number of self-monitoring blood glucose (SMBG) measurements per day and HbA1c levels across a wide age range of children and adults.

Findings and Conclusions: After adjusting for confounding factors, a higher number of SMBG measurements per day were strongly associated with a lower HbA1c level, with the association being present in all age groups and in both insulin pump and injection users. It is important for insurers to consider that reducing restrictions on the number of test strips provided per month may lead to improved glycemic control for some patients with type 1 diabetes.

SUPPLEMENTARY DATA

Miller KM, Xing D, Tamborlane WV, Bergenstal RM, Beck RW. Challenges and Future Directions of the T1D Exchange Clinic Network and Registry. J Diabetes Sci Technol 2013;7(4): 963-69. http://www.ncbi.nlm.nih.gov/pubmed/23911177

Objective: To outline the challenges encountered during the establishment of the T1D Exchange clinic registry.

Findings and Conclusions: Collecting the data and maximizing data quality within the T1D Exchange required considerable effort. Even with these efforts, certain data elements are difficult to capture in a meaningful way. A standard type 1 diabetes module used by all electronic health records could be developed based on the data collection instruments developed for the T1D Exchange clinic registry.

Nambam B, DuBose SN, Nathan BM, Beck RW, Maahs DM, Wadwa RP, Tamborlane WV, Foster NC, Miller KM, Haller MJ. Therapeutic Inertia: Underdiagnosed and Undertreated Hypertension (HTN) in Children Participating in the T1D Exchange Clinic Registry. Pediatric Diabetes. 2014. Doi:10.1111/pedi.12231. http://www.ncbi.nlm.nih.gov/pubmed/25330905

Objective: To determine the frequency of a hypertension diagnosis and treatment for hypertension in youth with type 1 diabetes.

Findings and Conclusions: Hypertension was diagnosed in only 1% (113/9362) of participants; yet, elevated blood pressure was recorded at one of two visits in 17% and at both visits in 4%. Hypertension is likely under diagnosed and undertreated in pediatric diabetes clinics. The relatively low proportion of hypertensive children receiving ACE-I therapy and reaching blood pressure goals likely identifies an important area for improving care in children with type 1 diabetes.

Simmons JH, Chen V, Miller KM, McGill JB, Bergenstal RM, Goland RS, Harlan DM, Largay JF, Massaro EM, Beck RW. Differences in the Management of Type 1 Diabetes among Adults Under Excellent Control Compared with Those Under Poor Control with the T1D Exchange Clinic Registry. Diabetes Care. 2013;36(11):3573-7. http://www.ncbi.nlm.nih.gov/pubmed/24026543

Objective: To identify characteristics and diabetes management techniques in adults with type 1 diabetes differentiating those under excellent glycemic control (HbA1c $< 6.5\%$) from those with poorer control (HbA1c $\geq 8.5\%$).

Findings and Conclusion: Excellent control was associated with more frequent self-monitoring of blood glucose (SMBG), giving mealtime boluses before a meal rather than at the time of or after a meal, performing SMBG before giving a bolus, and less frequently missing an insulin dose. Frequency of severe hypoglycemia was similar between groups while diabetic ketoacidosis was more common in the poorly-controlled group. Diabetes self-management related to insulin delivery, glucose monitoring, and lifestyle tend to differ comparing adults with type 1 diabetes under excellent control and those under poorer control. Future studies should focus upon modification of diabetes management skills in adult type 1 diabetes patients with suboptimal glycemic control

Trief PM, Xing D, Maahs D, Foster NC, Maahs DM, Kittelsrud J, Olson BA, Young LA, Peters AL, Bergenstal RB, Miller KM, Beck RW, Weinstock R. Depression in Adults in the T1D Exchange clinic registry. Diabetes Care. 2014;37(6):3573-7. http://www.ncbi.nlm.nih.gov/pubmed/24855157

Objective: To determine the frequency of depression and factors associated with depression among adults with type 1 diabetes.

Findings and Conclusions: Adults with probable major depression (ranged from 5% to 10% depending on definition used) had worse clinical outcomes than those not depressed. HbA1c was higher in the depressed vs. not depressed groups ($8.4\pm1.7\%$ vs. $7.8\pm1.4\%$). Occurrence of ≥ 1 episode of diabetic ketoacidois (11% vs. 4%) and ≥ 1 severe hypoglycemic event (18% vs. 9%) in the past 3 months was higher among depressed participants. Whether identification and treatment of depression improves diabetes outcomes requires study. Depression is common in type 1 diabetes and better identification and treatment of this co-morbid condition is needed.

SUPPLEMENTARY DATA

Weinstock RS, Xing D, Maahs DM, Michels A, Rickels MR, Peters AL, Bergenstal RM, Harris B, DuBose SN, Miller KM, Beck RW. Severe Hypoglycemia and Diabetic Ketoacidosis in Adults with Type 1 Diabetes: Results from the T1D Exchange Clinic Registry. J Clin Endocrinol Metab. 2013;98(8):3411-9. http://www.ncbi.nlm.nih.gov/pubmed/23760624

Objective: To determine frequency of and factors associated with the occurrence of severe hypoglycemia (seizure or loss of consciousness) and diabetic ketoacidosis in adults with type 1 diabetes.
Findings and Conclusions: Severe hypoglycemia was strongly associated with diabetes duration, with 18.6% of those with diabetes >40 years having an event in the past 12 months. Frequency of severe hypoglycemia was lowest in those with HbA1c levels of 7.0% to 7.5%, being higher in those with HbA1c levels <7.0% or >7.5%. Frequency of diabetic ketoacidosis increased with higher HbA1c levels, with 21.0% of those with HbA1c >10.0% having an event in the past 12 months. Diabetic ketoacidosis, most common in those with HbA1c >10.0%, should be largely preventable. In contrast, severe hypoglycemia, most frequent with diabetes ≥40 years duration, cannot be abolished given the limitation of current therapies. To reduce severe hypoglycemia in adults with longstanding diabetes, consideration should be given to modifying HbA1c goals, particularly in patients with very low HbA1c levels.

Wong JC, Foster NC, Maahs DM, Raghinaru D, Bergenstal RM, Ahmann AJ, Peters AL, Bode BW, Aleppo G, Hirsch IB, Kleis L, Chase P, DuBose SN, Miller KM, Beck RW, Adi S. Real-time continuous glucose monitoring (CGM) among participants in the T1D Exchange clinic registry. Diabetes Care. 2014;37(10):2702-9. http://www.ncbi.nlm.nih.gov/pubmed/25011947

Objective: To assess the frequency of continuous glucose monitor (CGM) use, factors associated with its use, and the relationship of CGM with diabetes outcomes.
Findings and Conclusions: Nine percent of participants used CGM (6% of children <13 years, 4% of adolescents 13-17 years, 6% of young adults 18-25 years, and 21% of adults ≥26 years). CGM use was more likely with higher education, higher household income, private health insurance, longer duration of diabetes, and use of insulin pump. CGM use was associated with slightly lower HbA1c in children (8.3% vs 8.6%) and adults (7.7% vs 7.9%). Only 27% of users downloaded data from their device at least once per month. Among participants who used CGM at baseline, 41% discontinued within one year. CGM use in the T1D Exchange is uncommon but associated with lower HbA1c in some age groups especially when used more frequently. Factors associated with discontinuation and infrequent use of retrospective analysis of CGM data should be considered in developing next-generation devices and education on CGM use.

Wood JR, Miller KM, Maahs DM, Beck RW, DiMeglio LA, Libman IM, Quinn M, Tamborlane WV, Woerner SE. Most youth with type 1 diabetes in the T1D Exchange clinic registry do not meet American Diabetes Association or International Society for Pediatric and Adolescent Diabetes clinical guidelines. Diabetes Care. 2013;36(7):2035-7. http://www.ncbi.nlm.nih.gov/pubmed/23340893

Objective: To assess the proportion of youth with type 1 diabetes under the care of pediatric endocrinologists in the U.S. meeting targets for HbA1c, blood pressure, BMI, and lipids.
Findings and Conclusions: American Diabetes Association HbA1c targets of <8.5% for <6 years old, <8.0% for 6-<13 years old, and <7.5% for 13-<20 years old were met by 64%, 43%, and 21% of participants, respectively. The majority met targets for BP and lipids, and two-thirds met BMI goal of <85th%. Despite advances in technologies and strategies for care, achieving HbA1c targets remains a significant challenge for the majority of youth in the T1D Exchange registry. Moreover, a large number of youth with diabetes already have additional vascular disease risk factors at a young age. This analysis suggests further transformations to improve pediatric diabetes care are needed to prevent future complications of diabetes.

SUPPLEMENTARY DATA

Supplementary Table 2. Comparison of Enrollment Characteristics in Participants With and Without a Recent Annual Update Among 22,265 Participants with Diabetes Duration of ≥ 1 Year at Enrollment*

	2-5 yrs old		6 - 12 yrs old		13 - 17 yrs old		18 - 25 yrs old		26 - 49 yrs old		≥50 yrs old	
	Yes Annual Update N=154	No Annual Update N=522	Yes Annual Update N=4061	No Annual Update N=1282	Yes Annual Update N=3213	No Annual Update N=2364	Yes Annual Update N=1689	No Annual Update N=1998	Yes Annual Update N=2553	No Annual Update N=1647	Yes Annual Update N=1810	No Annual Update N=972
Age at Enrollment years - mean±SD	4.1±1.0	4.1±1.0	9.6±1.9	9.7±1.9	14.7±1.4	15.3±1.3	20.4±2.2	20.2±2.1	37.4±6.9	36.9±7.1	60.0±7.5	60.3±8.1
Gender: Female - *N(%)*	42%	42%	48%	49%	50%	50%	48%	47%	55%	52%	52%	54%
Race/Ethnicity- *N(%)*												
White Non-Hispanic	81%	77%	78%	75%	78%	76%	84%	80%	90%	87%	95%	93%
Black Non-Hispanic	5%	6%	6%	8%	5%	7%	3%	6%	4%	5%	2%	3%
Hispanic or Latino	7%	10%	11%	9%	11%	9%	9%	10%	3%	5%	1%	1%
Other	6%	6%	6%	7%	5%	6%	4%	4%	3%	3%	1%	2%
Use of Insulin Pump	50%	47%	58%	56%	56%	52%	56%	50%	61%	60%	58%	59%
Use of Continuous Glucose Monitoring	4%	6%	4%	3%	3%	3%	5%	4%	15%	15%	15%	15%
HbA1c - mean±SD	8.2±1.0	8.3±1.0	8.3±1.2	8.4±1.3	8.7±1.6	8.9±1.8	8.3±1.6	8.7±1.9	7.7±1.3	7.9±1.5	7.6±1.1	7.7±1.2

*Participants pregnant at the time of enrollment or annual update and who have a history of pancreas or islet cell transplant were excluded

SUPPLEMENTARY DATA

Supplementary Table 3. Insulin types in Pump Users and Injection Users

	Overall	2-5 yrs old	6 - 12 yrs old	13 - 17 yrs old	18 - 25 yrs old	26 - 49 yrs old	≥50 yrs old
Pump Users	**N=9530**	**N= 146**	**N=2131**	**N=2810**	**N=1555**	**N=1625**	**N=1263**
Glulisine	296 (3%)	5 (3%)	63 (3%)	57 (2%)	38 (2%)	79 (5%)	54 (4%)
Lispro	4017 (42%)	65 (45%)	880 (41%)	1081 (38%)	612 (39%)	789 (49%)	590 (47%)
Aspart	4952 (52%)	72 (49%)	1120 (53%)	1577 (56%)	847 (54%)	739 (45%)	597 (47%)
Humulin R or Novolin R	18 (<1%)	0	0	3 (<1%)	1 (<1%)	7 (<1%)	7 (<1%)
Injection Users	**N=6281**	**N=87**	**N=1136**	**N=2008**	**N=1277**	**N=940**	**N=833**
Short/Rapid Acting							
Glulisine	116 (2%)	1 (1%)	11 (1%)	32 (2%)	24 (2%)	32 (3%)	16 (2%)
Lispro	3181 (51%)	51 (59%)	587 (52%)	979 (49%)	631 (49%)	488 (52%)	445 (53%)
Aspart	2622 (42%)	28 (32%)	487 (41%)	862 (43%)	554 (43%)	380 (40%)	331 (40%)
Humalin R or Novolin R)	49 (1%)	0	0	3 (0%)	4 (<1%)	18 (2%)	24 (3%)
U500 Human R Regular	3 (<1%)	0	2 (<1%)	0	0	0	1 (1%)
Long Acting							
Detemir	562 (9%)	14 (16%)	127 (11%)	159 (8%)	107 (8%)	78 (8%)	77 (9%)
Glargine	5203(83%)	68 (78%)	917 (81%)	1664 (83%)	1069 (84%)	791 (84%)	694 (83%)
Degludec	2 (<1%)	1 (1%)	0	0	1 (<1%)	0	0
Intermediate Acting							
Humalin N (NPH)	219 (3%)	3 (3%)	52 (5%)	67 (3%)	27 (2%)	31 (3%)	39 (5%)
Novolog N (NPH)	157 (2%)	2 (2%)	35 (3%)	39 (2%)	24 (2%)	31 (3%)	26 (3%)
Premix							
Humalog 50/50	18 (<1%)	0	4 (<1%)	6 (<1%)	6 (<1%)	2 (<1%)	0
Humalog 75/25	49 (1%)	0	5 (<1%)	25 (1%)	16 (1%)	2 (<1%)	1 (<1%)
Humalin 50/50	3 (<1%)	0	1 (<1%)	2 (<1%)	0	0	0
Humalin 70/30	37 (1%)	0	7 (1%)	20 (1%)	8 (1%)	1 (<1%)	1 (<1%)
Novolin 70/30	21 (<1%)	0	1 (0%)	15 (1%)	2 (<1%)	1 (<1%)	2 (<1%)
Novolog 70/30	41 (1%)	0	6 (1%)	15 (1%)	11 (1%)	4 (<1%)	5 (1%)

SUPPLEMENTARY DATA

Appendix 1.

A listing of the T1D Exchange Clinic Network sites with participating principal investigators (PI), co-investigators (I) and coordinators (C) ordered by the number of participants recruited per site as of August 1, 2012 is included below:

Philadelphia, PA Children's Hospital of Philadelphia (n=1451) Steven Willi (PI); Terri Lipman (I); Tammy Calvano (C); Olena Kucheruk (C); Pantea Minnock (C); Chau Nguyen (C) **Aurora, CO Barbara Davis Center for Childhood Diabetes** (n=1440) Georgeanna Klingensmith (PI); Carolyn Banion (I); Jennifer Barker (I); Cindy Cain (I); Peter Chase (I); Sandy Hoops (I); Megan Kelsy (I); Georgeanna Klingensmith (I); David Maahs (I); Cathy Mowry (I); Kristen Nadeau (I); Jennifer Raymond (I); Marian Rewers (I); Arleta Rewers (I); Robert Slover (I); Andrea Steck (I); Paul Wadwa (I); Philippe Walravens (I); Philip Zeitler (I); Heidi Haro (C); Katherine Manseau (C) **Syracuse, NY SUNY Upstate Medical University** (n=1301) Ruth Weinstock (PI); Roberto Izquierdo (I); Umair Sheikh (I); Patricia Conboy (C); Jane Bulger (C); Suzan Bzdick (C) **New York City, NY Naomi Berrie Diabetes Center, Columbia University P&S** (n=1249) Robin Goland (PI); Rachelle Gandica (I); Lindsay Weiner (I); Steve Cook (C); Ellen Greenberg (C); Kevin Kohm (C); Sarah Pollack (C) **Ann Arbor, MI University of Michigan** (n=927) Joyce Lee (PI); Brigid Gregg (I); Meng Tan (I); Kimberly Burgh (C); Ashley Eason (C) **Aurora, CO University of Colorado/Denver, Barbara Davis Center for Childhood Diabetes** (n=897) Satish Garg (PI); Aaron Michels (I); Lisa Myers (C); **Indianapolis, IN Riley Hospital for Children, Indiana University School of Medicine** (n=859) Linda DiMeglio (PI); Tamara Hannon (I); Donald Orr (I); Christy Cruz (C); Stephanie Woerner (C) **Boston, MA Children's Hospital Boston** (n=836) Joseph Wolfsdorf (PI); Maryanne Quinn (I); Olivia Tawa (C) **Portland, OR Harold Schnitzer Diabetes Health Center at Oregon Health and Science University** (n=793) Andrew Ahmann (PI); Jessica Castle (I); Farahnaz Joarder (I); Chris Bogan (C); Nancy Cady (C); Jennifer Cox (C); Amy Pitts (C); Rebecca Fitch (C); Brad White (C); Bethany Wollam (C) **Atlanta, GA Atlanta Diabetes Associates** (n=742) Bruce Bode (PI); Katie Lindmark (C); RaShonda Hosey (C) **Buffalo, NY University Pediatric Associates** (n=673) Kathleen Bethin (PI); Teresa Quattrin (I); Michelle Ecker (C) **Los Angeles, CA Children's Hospital Los Angeles** (n=605) Jamie Wood (PI); Lily Chao (I); Clement Cheung (I); Lynda Fisher (I); Debra Jeandron (I); Francine Kaufman (I); Mimi Kim (I); Brian Miyazaki (I); Roshanak Monzavi (I); Payal Patel (I); Pisit Pitukcheewanont (I); Anna Sandstrom (I); Marisa Cohen (C); Brian Ichihara (C); Megan Lipton (C) **Grand Rapids, MI Helen DeVos Children's Hospital Endocrinology and Diabetes** (n=576) Ayse Cemeroglu (PI); Yaw Appiagyei-Dankah (I); Maala Daniel (I); Daniel Postellon (I); Michael Racine (I); Michael Wood (I); Lora Kleis (C); **Seattle, WA University of Washington, Diabetes Care Center** (n=569) Irl Hirsch (PI); Anthony DeSantis (I); DC Dugdale (I); R Alan Failor (I); Lisa Gilliam (I); Carla Greenbaum (I); Mary Janci (I); Peggy Odegard (I); Dace Trence (I); Brent Wisse (I); Emily Batts (C); Angela Dove (C); Deborah Hefty (C); Dori Khakpour (C); Jani Klein (C); Kristen Kuhns (C); Marli McCulloch-Olson (C); Christina Peterson (C); Mary Ramey (C); Marissa St. Marie (C); Pam Thomson (C); Christine Webber (C) **Idaho Falls, ID Rocky Mountain Diabetes & Osteoporosis Center, PA** (n=557) David Liljenquist (PI); Mark Sulik (PI); Carl Vance (PI); Tiffany Coughenour (I); Chris Brown (C); Jean Halford (C); Andrea Prudent (C); Shanda Rigby (C); Brandon Robison (C) **Morristown, NJ BD Diabetes Center at Goryeb Children's Hospital** (n=542) Harold Starkman (PI); Tymara Berry (I); Barbara Cerame (I); Daisy Chin (I); Laurie Ebner-Lyon (I); Frances Guevarra (I); Kristen Sabanosh (I); Lawrence Silverman (I); Christine Wagner (I); Marie Fox (C) **Stanford, CA Stanford University School of Medicine, Division of Pediatric Endocrinology** (n=525) Bruce Buckingham (PI); Avni Shah (I); Kimberly Caswell (C); Breanne Harris (C) **Minneapolis, MN International Diabetes Center/Park Nicollet Adult Endocrinology** (n=514) Richard Bergenstal (PI); Amy Criego (I); Greg Damberg (I); Glenn Matfin (I); Margaret Powers (I); David Tridgell (I); Cassie Burt (C); Beth Olson

(C); LeeAnn Thomas (C) **Boston, MA Joslin Diabetes Center- Pediatric** (n=451) Sanjeev Mehta (PI); Michelle Katz (I); Lori Laffel (I); Joanne Hathway (C); Roxanne Phillips (C) **New Haven, CT Yale Pediatric Diabetes Program** (n=398) Eda Cengiz (PI); William Tamborlane (I); Darryll Cappiello (C); Amy Steffen (C); Melinda Zgorski (C) **Los Angeles, CA University of Southern California - Community Diabetes Initiatives** (n=365) Anne Peters (PI); Valerie Ruelas (C) **Durham, NC Duke University Medical Center - Pediatric Endocrine Division** (n=364) Robert Benjamin (PI); Deanna Adkins (I); Juanita Cuffee (C); Amber Spruill (C) **Minneapolis, MN International Diabetes Center/Park Nicollet Pediatric Endocrinology** (n=357) Richard Bergenstal (PI); Amy Criego (I); Greg Damberg (I); Glenn Matfin (I); Margaret Powers (I); David Tridgell (I); Cassie Burt (C); Beth Olson (C); LeeAnn Thomas (C) **Chicago, IL Northwestern University** (n=352) Grazia Aleppo-Kacmarek (PI); Teresa Derby (C); Elaine Massaro (C); Kimberly Webb (C) **Charlottesville, VA University of Virginia Health System** (n=342) Christine Burt Solorzano (PI); Mark DeBoer (I); Helen Madison (C) **St. Louis, MO Washington University** (n=342) Janet McGill (PI); Lori Buechler (C); Mary Jane Clifton (C); Stacy Hurst (C); Sarah Kissel (C); Carol Recklein (C) **Iowa City, IA University of Iowa Children's Hospital** (n=327) Eva Tsalikian (PI); Michael Tansey (I); Joanne Cabbage (C); Julie Coffey (C); Sarah Salamati (C) **Kansas City, MO Children's Mercy Hospital** (n=323) Mark Clements (PI); Sripriya Raman (I); Angela Turpin (I); Jennifer Bedard (C); Cyndy Cohoon (C); Aliza Elrod (C); Amanda Fridlington (C); Lois Hester (C); **Detroit, MI Henry Ford Health System** (n=316) Davida Kruger (PI); Andreana Tassopoulos **Gainesville, FL University of Florida** (n=306) Desmond Schatz (PI); Michael Clare-Salzler (I); Kenneth Cusi (I); Colleen Digman (I); Becky Fudge (I); Mike Haller (I); Collette Meehan (I); Henry Rohrs (I); Janet Silverstein (I); Sujata Wagh (I); Miriam Cintron (C); Eleni Sheehan (C); Jamie Thomas (C) **Orange, CA Children's Hospital of Orange County** (n=305) Mark Daniels (PI); Susan Clark (I); Timothy Flannery (I); Nikta Forghani (I); Ajanta Naidu (I); Christina Reh (I); Peggy Scoggin (I); Lien Trinh (I); Natalie Ayala (C); Rebeca Quintana (C); Heather Speer (C) **Columbus, OH Central Ohio Pediatrics Endocrinology and Diabetes Services** (n=303) William Zipf (PI); Diane Seiple (C) **Sioux Falls, SD Avera Research Institute** (n=281) Julie Kittelsrud (PI); Ashutosh Gupta (I); Vikki Peterson (C); Ashley Stoker (C) **San Diego, CA University of California** (n=280) Michael Gottschalk (PI); Marla Hashiguchi (C); Katheryn Smith (C) **Tampa, FL University of South Florida Diabetes Center** (n=276) Henry Rodriguez (PI); Craig Bobik (C); Danielle Henson (C) **Nashville, TN Vanderbilt Eskind Diabetes Clinic** (n=276) Jill Simmons (PI); Amy Potter (I); Margo Black (C); Faith Brendle (C) **Cleveland, OH Case Western Reserve University** (n=251) Rose Gubitosi-Klug (PI); Beth Kaminski (I); Susan Bergant (C); Wendy Campbell (C); Catherine Tasi (C) **Oklahoma City, OK University of Oklahoma Health Sciences Center Dept. of Pediatric Diabetes and Endocrinology** (n=243) Kenneth Copeland (PI); Joni Beck (I); Joane Less (C); Jill Schanuel (C); Jennifer Tolbert (C) **San Francisco, CA University of California, San Francisco Medical Center (UCSF)** (n=237) Saleh Adi (PI); Andrea Gerard-Gonzalez (I); Stephen Gitelman (I); Nassim Chettout (C); Christine Torok (C) **Seattle, WA Seattle Children's Hospital** (n=226) Catherine Pihoker (PI); Joyce Yi-Frazier (I); Susan Kearns (C) **Pittsburgh, PA Children's Hospital of Pittsburgh of UPMC** (n=217) Ingrid Libman (PI); Vicky Bills (C); Ana Diaz (C); Julie Duke (C) **Minneapolis, MN University of Minnesota** (n=204) Brandon Nathan (PI); Antoinette Moran (I); Melena Bellin (I); Shannon Beasley (C); Anne Kogler (C); Janice Leschyshyn (C); Kara Schmid (C); Anne Street (C) **Greenville, SC Greenville Hospital System Pediatric Endocrinology** (n=196) Bryce Nelson (PI); Carrie Frost (C); Erin Reifeis (C) **Houston, TX Baylor College of Medicine / Texas Children's Hospital** (n=187) Morey Haymond (PI); Fida Bacha (I); Maria Caldas-Vasquez (I); Sara Klinepeter (I); Maria Redondo (I); Rosa Berlanga (C); Teresa Falk (C); Elizabeth Garnes (C); Janette Gonzalez (C); Cecilia Martinez (C); Mariam Pontifes (C); Ronald Yulatic (C) **Ocean Springs, MS The Diabetes Center, PLLC** (n=187) Kathleen Arnold (PI); Traci Evans (I); Sharon Sellers (C) **Salt Lake City, UT University of Utah - Utah Diabetes Center** (n=181) Vandana

Raman (PI); Carol Foster (I); Mary Murray (I); Vandana Raman (I); Trina Brown (C); Hillarie Slater (C); Karen Wheeler (C) **Worcester, MA University of Massachusetts Medical School** (n=179) David Harlan (PI); Mary Lee (I); John-Paul Lock (I); Celia Hartigan (C); Lisa Hubacz (C) **Durham, NC University of North Carolina Diabetes Care Center** (n=179) John Buse (PI); Ali Calikoglu (I); Joseph Largay (I); Laura Young (I); Helen Brown (C); Vinnie Duncan (C); Michelle Duclos (C); Julie Tricome (C) **Sioux Falls, SD Sanford Research/USD** (n=178) Verdayne Brandenburg (PI); Julie Blehm (I); Julie Hallanger-Johnson (I); Dawn Hanson (C); Corliss Miller (C); Jennifer Weiss (C) **Columbus, OH The Research Institute at Nationwide Children's Hospital** (n=168) Robert Hoffman (PI); Monika Chaudhari (I); David Repaske (I); Elizabeth Gilson (C); Jesse Haines (C) **Billings, MT St. Vincent Healthcare/Internal Medicine and Diabetes** (n=165) Justen Rudolph (PI); Charles McClave (I); Doris Biersdorf (C) **Bismarck, ND Medcenter One** (n=156) Anthony Tello (PI); Julie Blehm (I); Donna Amundson (C); Rhonda Ward (C) **Philadelphia, PA University of Pennsylvania School of Medicine/Rodebaugh Diabetes Center** (n=156) Michael Rickels (PI); Cornelia Dalton-Bakes (C); Eileen Markman (C); Amy Peleckis (C); Nora Rosenfeld (C) **Cincinnati, OH Cincinnati Children's Hospital Medical Center** (n=148) Lawrence Dolan (PI); Sarah Corathers (I); Jessica Kichler (I); Holly Baugh (C); Debbie Standiford (C) **Spokane, WA Rockwood Research Center, P.S.** (n=132) Jeanne Hassing (PI); Jennifer Jones (I); Stephen Willis (I); Stephen Willis (I); Carol Wysham (I); Lisa Davis (C) **Baltimore, MD Johns Hopkins University Pediatric Endocrinology** (n=120) Scott Blackman (PI); Kimber-Lee Abel (C); Loretta Clark (C); Andrea Jonas (C); Ellie Kagan (C) **Miami, FL University of Miami, Diabetes Research Institute** (n=119) Jay Sosenko (PI); Carlos Blashke (C); Della Matheson (C) **Rapid City, SD Regional Health Clinical Research** (n=118) Rachel Edelen (PI); Thomas Repas (I); Denise Baldwin (C); Trista Borgwardt (C); Christina Conroy (C); Kelly DeGrote (C); Rod Marchiando (C); Michelle Wasson (C) **Jacksonville, FL Nemours Children's Clinic** (n=116) Larry Fox (PI); Nelly Mauras (I); Ligeia Damaso (C); Kim Englert (C) **Cleveland, OH Cleveland Clinic Department of Endocrinology, Diabetes and Metabolism** (n=111) Marwan Hamaty (PI); Laurence Kennedy (I); Michelle Schweiger (I); Pantelis Konstantinopoulos (C); Carolyn Mawhorter (C); Amy Orasko (C); Denise Rose (C) **Tallahassee, FL Tallahassee Memorial Diabetes Center** (n=108) Larry Deeb (PI); Kim Rohrbacher (C) **Findlay, OH Blanchard Valley Medical Associates** (n=100) Leroy Schroeder (PI); Amanda Roark (C) **Milwaukee, WI The Medical College of Wisconsin/ Children's Hospital of WI** (n=99**)** Omar Ali (PI); Joanna Kramer (C); Donna Whitson-Jones (C) **Nashville, TN Vanderbilt Eskind Diabetes Clinic** (n=98) Amy Potter (PI); Margo Black (C); Faith Brendle (C) **Vallejo, CA Kaiser Permanente** (n=74) Heidi Gassner (PI); Sobha Kollipara (I); Vicky Bills (C); Julie Duke (C) **Paterson, NJ St. Joseph's Children's Hospital** (n=53) Katerina Harwood (PI); Vijaya Prasad (I); Judy Brault (C)