Factors Associated With Improved A1C Among Adults With Type 1 Diabetes in the United States

Halis K. Akturk,[1] Saketh Rompicherla,[2] Nicole Rioles,[2] Marisa Desimone,[3] Ruth S. Weinstock,[3] Sonya J. Haw,[4] David C. Ziemer,[4] Jane K. Dickinson,[5] Shivani Agarwal,[6] Osagie Ebekozien,[2,7]* and Sarit Polsky,[1]* on behalf of the T1D Exchange Quality Improvement Collaborative

Many adults with diabetes do not reach optimal glycemic targets, and, despite advances in diabetes management, diabetes technology use remains significantly lower in racial/ethnic minority groups. This study aimed to identify factors associated with achieving the recommended A1C target of <7% using data on 12,035 adults with type 1 diabetes from 15 centers participating in the T1D Exchange Quality Improvement Collaborative. Individuals attaining the target A1C were more likely to be older, White, have private health insurance, and use diabetes technology and less likely to report depressive symptoms or episodes of severe hypoglycemia or diabetic ketoacidosis than those with higher A1C levels. These findings highlight the importance of overcoming inequities in diabetes care.

Achieving and maintaining the recommended glycemic target (i.e., an A1C <7%) reduces risks for developing micro- and macrovascular complications of type 1 diabetes; however, many people with type 1 diabetes do not achieve this goal (1,2). A previous T1D Exchange clinic registry study showed that many adults (79%) did not achieve this A1C target (3). Use of diabetes technology, especially continuous glucose monitoring (CGM), is associated with better glycemic outcomes, including decreased severe hypoglycemia (SH) and diabetic ketoacidosis (DKA) and increased time in the target glucose range (70–180 mg/dL) (1–7). Unfortunately, racial/ethnic disparities exist in diabetes technology use, with lower use and higher A1C levels in

Non-Hispanic Blacks and Hispanics compared with Non-Hispanic Whites (8–11).

It is important to understand the factors contributing to achieving and maintaining the recommended glycemic target to improve diabetes care and to decrease inequities among people with type 1 diabetes, not just in well-controlled clinical trials but also in real-world settings. This study from the T1D Exchange Quality Improvement Collaborative (T1DX-QI) used a dataset from a large cohort of adults with type 1 diabetes in a real-world setting in the United States to evaluate the factors associated with attaining the recommended A1C target.

Research Design and Methods

The T1DX-QI was established in 2016 and includes 15 U.S. adult diabetes clinics engaged in data-sharing and quality improvement (QI) methods to drive system changes. The collaborative aims to accelerate QI interventions through shared learning and continuous review of best practices. It is the first learning health system in the United States dedicated to the care of people with type 1 diabetes. Additional information about the T1DX-QI has been published (12).

We collected electronic health record (EHR) data from 15 centers for 12,035 adults (≥18 years of age) with type 1 diabetes in the T1D Exchange EHR database who had an encounter between January 2017 and January 2022 and at least one A1C measurement. The most recent A1C

[1]Barbara Davis Center, Denver, CO; [2]T1D Exchange, Boston, MA; [3]SUNY Upstate Medical University, Syracuse, NY; [4]Grady Memorial Hospital, Atlanta, GA; [5]Teachers College Columbia University, New York, NY; [6]Albert Einstein College of Medicine–Montefiore Medical Center, Bronx, NY; [7]University of Mississippi School of Population Health, Jackson, MI

Corresponding author: Halis K. Akturk, halis.akturk@cuanschutz.edu

*Co-senior author

result during this period was used. We compared sociode-mographic attributes, self-reported depressive symptoms, episodes of DKA, episodes of SH, and diabetes device use (CGM systems and insulin pumps) by A1C level (most recent A1C <7, 7–9, or >9%). The presence of depressive symptoms was defined as having a most recent nine-item Patient Health Questionnaire (PHQ-9) score ≥5 or a seven-item General Anxiety Disorder (GAD-7) score ≥5 or a two-item PHQ-2 score >0.

These categorical data are represented as the percentage of adults with either depressive symptoms or anxiety. Means (SDs) are reported for continuous variables. P values were calculated using χ^2 tests to examine the associations between the categorical variables. A logistic regression analysis was performed, and odds ratios (ORs) are reported for factors associated with achieving the A1C target. The model was adjusted for age, race/ethnicity, insurance type, device use, and positive depression

screening record. All analyses were performed using R, v. 3.6, statistical software (R Foundation, Vienna, Austria).

This project was deemed nonhuman subject research by the Western Institutional Review Board, and all participating centers received local institutional review board approval to share aggregate data and participate in this QI project. No protected health information was transmitted outside of each clinic for this project.

Results

Of the 12,035 adults with type 1 diabetes in the T1D Exchange EHR database, 23% had an A1C <7%, 44.5% had an A1C of 7–9%, and 32.5% had an A1C >9%. Characteristics of these adults by A1C are shown in Table 1. Those with an A1C >9% were significantly younger and more likely to be Non-Hispanic Blacks, experienced more DKA and SH events, and had more depressive symptoms

TABLE 1 Characteristics of Adults With Type 1 Diabetes (N = 12,035) Grouped by A1C

Characteristic	Patients With A1C <7% (n = 2,774 [23%])	Patients With A1C 7–9% (n = 5,363 [44.5%])	Patients With A1C >9% (n = 3,898 [32.5%])	P
Age, years	33.4 ± 15.8	31.8 ± 16	26.6 ± 12.2	<0.001
Age-group, years				<0.001
19–25	1,215 (44)	2,976 (55)	2,778 (71)	
26–49	1,034 (37)	1,448 (27)	801 (21)	
≥50	495 (18)	939 (18)	319 (8)	
Female sex	1,366 (49)	2,694 (50)	1,884 (48)	0.1
Race/ethnicity				<0.001
NH White	2,170 (78)	4,054 (76)	2,303 (59)	
NH Black	125 (5)	364 (7)	787 (20)	
Hispanic	140 (5)	367 (7)	335 (9)	
Other	339 (12)	578 (11)	473 (12)	
Health insurance type				<0.001
Public	498 (18)	1,157 (22)	1,144 (29)	
Private	1,650 (59)	2,693 (50)	1,479 (38)	
Other	626 (23)	1,513 (28)	1,275 (33)	
CGM used	1,827 (66)	2,944 (55)	1,425 (37)	<0.001
Insulin pump use	1,380 (50)	2,464 (46)	1,030 (26)	<0.001
CGM and insulin pump use	1,132 (41)	1,766 (33)	612 (16)	<0.001
Patients with DKA event	148 (5)	515 (10)	860 (22)	<0.001
Patients with SH event	100 (4)	270 (5)	291 (7)	<0.001
BMI, kg/m^2	27 ± 5.8	27.7 ± 5.9	26.6 ± 6.2	<0.001
Overweight or obesity	583 (21)	1,309 (24)	678 (17)	<0.001

Data are mean ± SD or n (%). NH, non-Hispanic.

(P <0.001 for all). They also had lower BMIs, were less likely to have private health insurance, and were less likely to use CGM and insulin pump therapy compared with individuals with an A1C <7% (P <0.001 for all).

Table 2 shows the factors associated with attainment of an A1C <7% in adults with type 1 diabetes. Use of diabetes technology (CGM and/or insulin pump therapy) and having private health insurance were associated with greater achievement of A1C <7% (ORs 1.28 and 1.47, respectively), while Non-Hispanic Black and Hispanic race/ethnicity (ORs 0.46 and 0.52, respectively) and screening positive for depressive symptoms (OR 0.60) had negative correlations with an A1C <7%.

Figure 1 shows A1C achievement by age-group. In all age-groups (19–25, 26–49 and ≥50 years), most of the patients had A1C of 7–9%. In the 19- to 25-year-old age-group, 17.4% had an A1C <7%; among those 26–49 years of age, that proportion was 31.5%, and among those ≥50 years of age, it was 28.2%. Younger adults were much more likely than older adults to have an A1C >9%, a pattern that has been observed in earlier studies as well (3).

Figure 2 shows A1C achievement by race/ethnicity. Most non-Hispanic Whites (47.5%) and Hispanics (43.6%) had an A1C of 7–9%, whereas most non-Hispanic Blacks (61.7%) had an A1C >9%. The percentage of people not attaining the A1C target of <7% was highest among non-Hispanic Blacks (90.2%), followed by Hispanics (83.4%) and non-Hispanic Whites (74.6%).
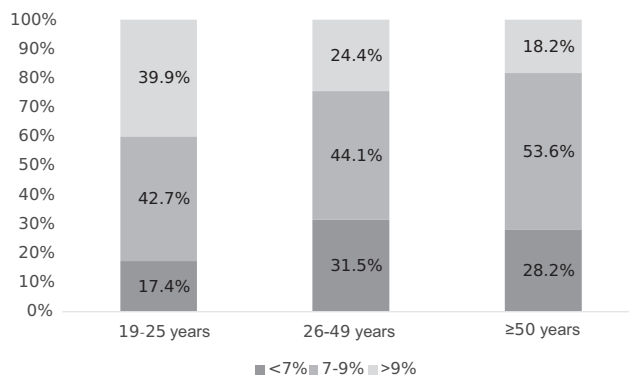
Discussion

The findings from these analyses of real-world data collected by the T1DX-QI demonstrate associations

FIGURE 1 A1C distribution by age.

between the achievement of the recommended A1C target and race/ethnicity, health insurance coverage, DKA and SH events, depression, and diabetes technology use.

In our study, having private health insurance was associated with achieving an A1C <7% (OR 1.47). Previous studies have shown that patients with public health insurance were more likely to be hospitalized with DKA (13,14). Health insurance coverage for diabetes technology, medications, and supplies varies among both public and private plans. High copayments, high-deductible plans, and limited formularies may act as barriers to the adoption and use of CGM and insulin pump therapy.

Previous T1D Exchange data showed that CGM use was strongly associated with lower A1C levels (10,15). Several studies have shown a correlation between lower diabetes technology use and negative diabetes outcomes among non-Hispanic Blacks and Hispanics (8–10). Despite an increase in prevalence of type 1 diabetes among racial/ethnic minorities (16), inequity persists in racial/ethnic representation in randomized clinical trials of

TABLE 2 Factors Associated With A1C <7% in Adults With Type 1 Diabetes (N = 12,035)

Characteristic	OR (95% CI)	P*
Race/ethnicity		
NH White (ref)	—	
NH Black	0.46 (0.34–0.61)	<0.001
Hispanic	0.52 (0.37–0.72)	<0.001
Health insurance		
Public (ref)	—	
Private	1.47 (1.19–1.80)	<0.001
CGM or insulin pump use	1.28 (1.09–1.49)	<0.001
Screened positive for depression	0.60 (0.49–0.72)	<0.001

*Adjusted for age, race/ethnicity, insurance type, technology use, and positive depression screening record. NH, non-Hispanic; ref, reference category.
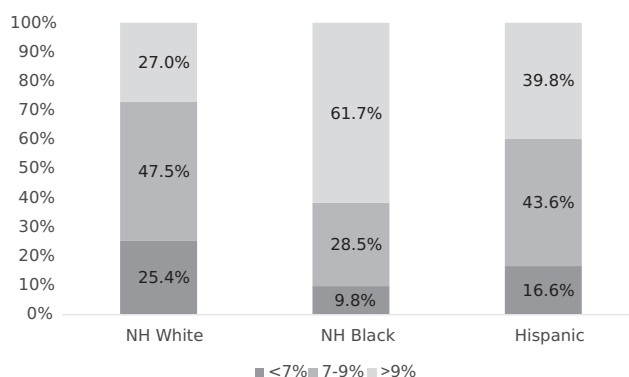

FIGURE 2 A1C by race/ethnicity. NH, non-Hispanic.

diabetes technology use in type 1 diabetes (17). Our work, and that of others, support the notion that there is a need to enroll more people from racial/ethnic minority groups in diabetes technology clinical trials. Most importantly, CGM and hybrid closed-loop insulin delivery systems should be made accessible to everyone in routine diabetes care. The incorporation of special programs that are sensitive to the cultural attitudes and lived experiences of adults living with type 1 diabetes should help more individuals use these devices and improve their glycemic profiles.

Another important finding of our study was that screening positive for depressive symptoms was negatively correlated with achievement of an A1C <7% (OR 0.6, 95% CI 0.49–0.72). The prevalence of depression among people with type 1 diabetes is two to three times higher than in the general population (18). Studies have shown that adults with comorbid depression and type 1 diabetes are less likely to achieve and maintain glycemic targets, have less interest in diabetes self-management, and are at increased risk for diabetes-related complications (19–21). It is important to both screen patients with diabetes for depression and treat depression among those affected to achieve recommended glycemic outcomes (22).

The strengths of this study include the use of a large database of racially/ethnically diverse adults from multiple centers to assess factors associated with attaining glycemic targets and the verification of diabetes technology use by EHR data rather than self-report. Limitations of this study include using academic-based diabetes centers, thus revealing findings that may not be generalizable outside of this setting, and using EHR data that are subject to documentation errors. We have incomplete glucose metrics (i.e., percentage of time in hypoglycemia and time in the target glycemic range) documented and do not know the percentage of individuals using hybrid closed-loop insulin delivery systems. Finally, data on social determinants of health were not available but are being collected for future analyses.

In summary, our results suggest that inequities in diabetes care still exist. Greater proportions of people from racial/ethnic minority groups did not reach glycemic targets when compared with non-Hispanic Whites. Having private health insurance and using advanced diabetes technology (i.e., CGM and insulin pumps) correlated with achieving an A1C <7%. Interventions are necessary to decrease racial/ethnic inequities in diabetes care among adults with type 1 diabetes.

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