Inequities in Health Outcomes in Children and Adults With Type 1 Diabetes: Data From the T1D Exchange Quality Improvement Collaborative

Shideh Majidi,[1] Osagie Ebekozien,[2] Nudrat Noor,[2] Sarah K. Lyons,[3] Ryan McDonough,[4] Kajal Gandhi,[5] Roberto Izquierdo,[6] Carla Demeterco-Berggren,[7] Sarit Polsky,[1] Marina Basina,[8] Marisa Desimone,[6] Inas Thomas,[9] Nicole Rioles,[2] Jose Jimenez-Vega,[10] Faisal S. Malik,[11] Brian Miyazaki,[12] Anastasia Albanese-O'Neill,[13] and Nana-Hawa Yayah Jones,[14] on behalf of the T1D Exchange Quality Improvement Collaborative Study Group

Health care inequities among racial and ethnic groups remain prevalent. For people with type 1 diabetes who require increased medical access and care, disparities are seen in access to care and health outcomes. This article reports on a study by the T1D Exchange Quality Improvement Collaborative evaluating differences in A1C, diabetic ketoacidosis (DKA), severe hypoglycemia, and technology use among racial and ethnic groups. In a diverse cohort of nearly 20,000 children and adults with type 1 diabetes, A1C was found to differ significantly among racial and ethnic groups. Non-Hispanic Blacks had higher rates of DKA and severe hypoglycemia and the lowest rate of technology use. These results underscore the crucial need to study and overcome the barriers that lead to inequities in the care and outcomes of people with type 1 diabetes.

Health inequities among racial and ethnic groups persist in both children and adults. Individuals with chronic conditions such as type 1 diabetes require increased medical access and care. Yet, there are disparities in access to care and health outcomes (1). The incidence of type 1 diabetes is increasing in the United States across all populations, and most significantly among Hispanic youths, but despite the higher incidence, health disparities continue to worsen among specific racial and ethnic groups (2,3).

Mean A1C levels were found to be higher in Hispanics and non-Hispanic Blacks with type 1 diabetes compared with non-Hispanic Whites in the largest U.S. study to date, which included ∼11,000 youths and young adults in the T1D Exchange clinic network and registry (4). Non-Hispanic Blacks and Hispanics have been reported to perform fewer blood glucose checks per day than Non-Hispanic Whites (5,6). One study evaluating A1C trajectories over time in ∼16,000 youths from Australia, Europe, and the United States found that minority groups were more likely to have increasing A1C levels over time compared with Non-Hispanic Whites, specifically in the T1D Exchange and Diabetes-Patienten-Verlaufsdokumentation registries (7).

Disparities also exist in rates of acute complications such as diabetic ketoacidosis (DKA) and severe hypoglycemia, although literature in this area is more limited. One study found that Non-Hispanic Blacks were 2.5 times more likely to have at least one DKA episode in the previous 12 months compared with Non-Hispanic Whites. They were also 2.5 times more likely than Non-Hispanic Whites to have at least one severe hypoglycemic event in the previous 12 months (4). Rates of

[1]Barbara Davis Center, University of Colorado, Aurora, CO; [2]T1D Exchange, Boston, MA; [3]Baylor College of Medicine/Texas Children's Hospital, Houston, TX; [4]Children's Mercy–Kansas City, Kansas City, MO; [5]Nationwide Children's Hospital, The Ohio State University, Columbus, OH; [6]SUNY Upstate Medical University, Syracuse, NY; [7]Rady Children's Hospital, University of California, San Diego, CA; [8]Stanford University School of Medicine, Stanford, CA; [9]C.S. Mott Children's Hospital, Ann Arbor, MI; [10]Helen DeVos Children's Hospital, Grand Rapids, MI; [11]University of Washington, Seattle, WA; [12]Children Hospital Los Angeles, Los Angeles, CA; [13]University of Florida, Gainesville, FL; [14]Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Corresponding author: Shideh Majidi, Shideh.Majidi@cuanschutz.edu

mortality in diabetes are also twice as high among Non-Hispanic Blacks compared with other racial groups (8).

One area of diabetes care that has improved diabetes management is the advancement of technology, including insulin pumps and continuous glucose monitoring (CGM) systems. However, use of these advanced diabetes technologies varies by population. Both the T1D Exchange and the SEARCH for Diabetes in Youth registries reported that Non-Hispanic White youths are more likely to use an insulin pump than their Black and Hispanic counterparts (4,9,10). The T1D Exchange registry found that Non-Hispanic White youths were 1.9 times more likely than Non-Hispanic Black youths and 3.6 times more likely than Hispanic youths to use an insulin pump. This finding is particularly important because it is known that insulin pump therapy can contribute to lower A1C levels (11), and Non-Hispanic Black and Hispanic youths are more likely to have higher A1C levels (4,7). Agarwal et al. (12) recently found that insulin pump use was one variable that helped account for the difference in A1C levels between Black and White young adults with type 1 diabetes. Studies of CGM use among racial and ethnic groups are very limited. One study showed that, among youths <13 years of age, Non-Hispanic Whites were more likely than Hispanics to use CGM, but this difference was not seen in older children or adults (13).

Although there have been multiple studies evaluating A1C differences among racial and ethnic groups, there are limited population studies, and none have examined inequities in acute complication rates and technology use. This study uses a dataset with a large cohort of individuals with type 1 diabetes in a real-world setting to examine racial and ethnic differences in glycemic control, acute complications rates, and technology use.

Research Design and Methods

Participants

The T1D Exchange Quality Improvement Collaborative (T1DX-QI) was established in 2016 and is comprised of 34 U.S. diabetes clinics engaged in data-sharing and quality improvement (QI) methods to drive systems changes. The T1DX-QI aims to accelerate QI interventions through shared learning and continuous review of best practices and is the first learning collaborative in the United States dedicated to the care of people with type 1 diabetes. Additional

information about the T1DX-QI has been previously described (14).

This project was deemed nonhuman subject research by the Western Institutional Review Board, and each clinic received approval from its respective institutional review board. De-identified data from each site were provided to a centralized site to be analyzed. The T1D Exchange served as the coordinating center. Data were combined and analyzed from eight T1DX-QI clinics: the Barbara Davis Center for Diabetes (pediatric and adult practices), Texas Children's Hospital, Children's Mercy–Kansas City, Nationwide Children's Hospital, SUNY Upstate Medical University (pediatric and adult centers), and Cincinnati Children's Hospital Medical Center. Data from January 2018 to November 2020, representing 19,226 youths and adults with type 1 diabetes, were included. The coordinating center developed a data definition specification with 125 electronic medical record (EMR)-sourced elements that benchmarked nine clinical measures across the collaborative.

Variables

Race/ethnicity was classified as either non-Hispanic White, non-Hispanic Black, Hispanic (including Hispanic Black), or "other." The latter category was composed of individuals who identified as Asian, American Indian or Alaskan Native, or Native Hawaiian and individuals for whom race/ethnicity status was unknown or not reported. Insurance status was categorized as public (including Medicare and Medicaid), private (including private and military insurance), or "other" (including insurance status reported as other or unknown). Device use was categorized as users or nonusers based on whether patients were noted in the EMR to be using a CGM system or insulin pump at their most recent clinic visit. Clinical outcomes included A1C levels, DKA, and severe hypoglycemia events. A1C values recorded for each patient from the most recent clinic visit were used in this analysis. DKA and severe hypoglycemia events were defined as categorical variables, with patients reporting at least one event within the study time period being classified as having had a DKA or severe hypoglycemia event. An event was considered DKA if acidosis was severe enough to require correction in an emergency room or hospitalization. Severe hypoglycemia was defined as hypoglycemia requiring treatment or care from another person. Information on demographic data, race/ethnicity, insurance status, A1C levels, DKA events, severe hypoglycemia events, insulin pump use,

and CGM use was obtained by each site via data-sharing with the coordinating center from its EMR system.

Statistical Analysis

A1C was analyzed as a continuous variable. DKA and severe hypoglycemia were treated as categorical variables, with patients classified as having had an event if at least one event was recorded in the EMR or reported by patients during clinic visits between January 2018 and November 2020. Data for continuous variables was reported as mean ± SD, and those for categorical variables were reported as frequency and percentage. χ^2 tests were applied to determine the associations between race/ethnicity groups and categorical covariates, whereas differences in mean A1C levels were examined using a t test. Multivariable regression models were used to examine the association between A1C and race/ethnicity while adjusting for potential confounders, including age and insurance status. All analyses were performed using R version 3.5.2 statistical software.

Results

In this cohort of 19,226 individuals, 73.5% (n = 14,124) were non-Hispanic White, 7.5% (n = 1,435) were non-Hispanic Black, 8.7% (n = 1,685) were

Hispanic, and 10.3% (n = 1,982) were listed as "other." There were no differences in median age or sex among groups (Table 1). Non-Hispanic Blacks and Hispanics were more likely than non-Hispanic Whites to have public insurance (P <0.01).

A1C was significantly different among groups (P <0.001) (Table 2), even after adjusting for age and insurance status (Table 3). Non-Hispanic Blacks had the highest mean A1C (10.3%), followed by Hispanics (9.2%), individuals in the "other" group (8.5%), and non-Hispanic Whites (8.3%) (Figure 1). Rates of acute complications were significantly different among groups (P <0.001), with non-Hispanic Black individuals having higher rates of both DKA severe hypoglycemia events (Table 2).

Insulin pump and CGM use also varied among groups (P <0.001). Non-Hispanic Whites were more likely to use an insulin pump and CGM system than other groups. Non-Hispanic Blacks had the lowest rates of insulin pump (41%) and CGM system (17%) use (Table 1).

Discussion

This is the largest study in the literature looking at health inequities in youths and adults with type 1 diabetes confirms the persistence of health disparities among

TABLE 1 Distribution of Patient and Diabetes Characteristics Across Race/Ethnic Groups (N = 19,226)

	Non-Hispanic White (n = 14,124)	Non-Hispanic Black (n = 1,435)	Hispanic (n = 1,685)	Other* (n = 1,982)
Age, years†	23 ± 15	19 ± 11	18 ± 9	21 ± 13
Age-group, years†				
0–12	1,709 (21)	181 (23)	291 (23)	400 (28)
13–18	2,931 (36)	404 (51)	629 (50)	506 (35)
19–25	1,542 (19)	404 (51)	199 (16)	195 (14)
26–49	1,375 (17)	46 (6)	122 (9)	268 (19)
50+	577 (7)	20 (2)	19 (2)	63 (4)
Male sex	7,330 (52)	722 (50)	809 (48)	1,028 (52)
Insurance†				
Public	2,450 (17)	583 (41)	828 (49)	546 (28)
Private	8,108 (58)	480 (33)	734 (44)	1,192 (60)
Other/unknown	3,566 (25)	372 (26)	123 (7)	244 (12)
CGM use†,‡	5,526 (40)	244 (17)	618 (37)	1,067 (55)
Pump use†,‡	8,315 (60)	578 (41)	938 (56)	1,438 (74)

Data are mean ± SD or n (%). *"Other" includes Asian (n = 191), American Indian or Alaska Native, Native Hawaiian or other Pacific Islander (n = 1,011), or responses recorded as unknown (n = 780). †P <0.001. ‡Data were available on a subset of the total population (non-Hispanic White n = 13,852, Non-Hispanic Black n = 1,403, Hispanic n = 1,672, and other n = 1,944).

TABLE 2 Distribution of Clinical Outcomes Across Race/Ethnicity (N = 19,226)

Clinical Outcomes	Non-Hispanic White (n = 14,124)	Non-Hispanic Black (n = 1,435)	Hispanic (n = 1,685)	Other (n = 1,982)
DKA*†	248 (8)	49 (28)	68 (12)	54 (7)
Severe hypoglycemia*†	26 (0.8)	7 (5.1)	3 (0.6)	3 (0.4)

Data are n (%). *P <0.001. †Data were available on a subset of the total population (non-Hispanic White n = 13,852, Non-Hispanic Black n = 1,403, Hispanic n = 1,672, and other n = 1,944).

people with type 1 diabetes. Higher A1C levels were seen in non-Hispanic Blacks and Hispanics compared with non-Hispanic Whites, which is consistent with other reports (4,7,10). There may be a variety of reasons for these differences; one previous study found that diabetes technology use, diabetes distress, and differences in self-management accounted for differences in A1C levels between Black and non-Hispanic White young adults with type 1 diabetes (12). There are also data suggesting that A1C overestimates the mean glucose concentration in African Americans, but this difference is small and cannot fully explain the differences seen in A1C between groups (15). Acute complications such as DKA and severe hypoglycemia were also significantly higher in the non-Hispanic Black group, which is similar to previously reported T1D Exchange data in 2015 from youth with type 1 diabetes (4). Higher A1C levels are associated with DKA episodes, and decreased diabetes self-management is associated with severe hypoglycemia, both of which are seen more frequently in non-Hispanic Blacks with type 1 diabetes (4). The results of this study highlight the importance of addressing health inequities as a key strategy to improving clinical outcomes.

TABLE 3 Linear Regression Model Examining the Association Between A1C Level and Race/Ethnicity, Age, and Insurance Status

	Coefficient (95% CI)*	Coefficient (95% CI)†
Race/ethnicity		
Non-Hispanic White	—	—
Non-Hispanic Black	1.9 (1.8–2.0)‡	1.6 (1.5–1.8)‡
Hispanic	0.9 (0.8–1.0)‡	0.6 (0.5–0.7)‡
Other	0.1 (0.03–0.3)‡	0.1 (−0.01–0.2)‡
Age	—	−0.02 (−0.03 to −0.02)
Insurance		
Public vs. private	—	0.73 (0.64–0.81)
Other vs. private	—	0.57 (0.47–0.67)

*Unadjusted. †Adjusted for age and insurance status as covariates.
‡P <0.001.

Few studies have assessed the use of diabetes technology among diverse racial and ethnic groups. Our study found that non-Hispanic Blacks were the least likely to be using an insulin pump or CGM system, consistent with previous findings (4,9,13,16). Willi et al. (4) looked at patients <18 years of age and also found that insulin pump use was significantly more likely in non-Hispanic Whites than in Hispanics and that Hispanics were more likely than non-Hispanic Blacks to use an insulin pump (4).

Further investigation into potential reasons for this disparity in technology use is needed, especially given that technology use has been found to improve diabetes management (11,17,18). Socioeconomic factors are often discussed as potential reasons, but Willi et al. (4) found that differences in insulin pump use between non-Hispanic Blacks and non-Hispanic Whites persisted
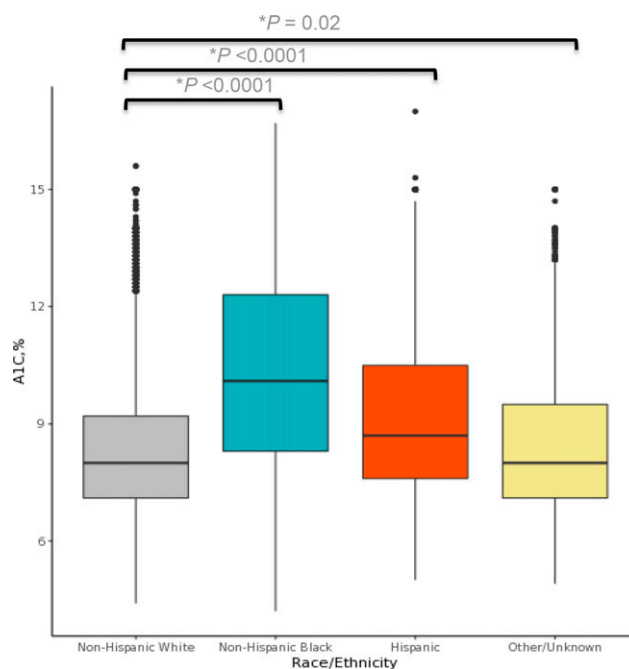

FIGURE 1 Difference in A1C levels across racial/ethnic groups. *t test.

across a variety of household incomes, suggesting that income status alone did not explain for this difference. In the same study, Hispanic individuals had a rate of insulin pump use similar to that of non-Hispanic Whites at the highest income level (4). Our study did not collect information on household income levels. Insurance can also play a role as a potential confounder, as non-Hispanic Black and Hispanic populations were more likely to be on public insurance, which does not cover CGM or insulin pumps in some states. Provider bias (implicit or unconscious) may also play a role in differences among groups. Although not evaluated in our study, provider bias has been reported in a variety of medical specialties (19,20).

The results of this study indicate that inequities in multiple areas of diabetes care still exist. Recent data in disparities of care during the coronavirus disease 2019 pandemic show that disparities in diabetes care persist between racial/ethnic groups and insurance statuses, such that non-Hispanic Blacks and individuals with public insurance were more likely to be hospitalized and to experience DKA (21,22), underscoring the need for increased assessment and evaluation of risk factors that lead to these inequities to further identify, address, reduce, and resolve them. Future studies should include and evaluate the potential effects of providers' implicit conscious and unconscious biases (20). Additionally, there is a need to address the lack of or inadequate insurance coverage for technology, particularly for individuals with public insurance and those with private insurance that has high deductibles, high copayments, or narrow formularies. Other potential contributors to lower rates of technology use could include limited technology literacy or access, limited English proficiency, cultural views, and low income. These barriers should be identified so that solutions to mitigate them can be developed.

Interventions are needed that specifically focus on Black and Hispanic individuals with type 1 diabetes to find ways to increase their use of technology and improve their diabetes care and management. Some interventions are currently underway, but more are needed. For example, the Novel Intervention in Children's Healthcare (NICH) program specifically targets socially and medically vulnerable adolescents with type 1 diabetes to provide more individualized and focused care on those in most need (23). The NICH program is associated with improvements in glycemic control and reduced hospitalizations (24). Additionally, a shared medical appointment clinical model for Hispanic youths and families has been developed and studied. Participation in this clinical model was associated with improvement in glycemic control and an increase in technology use (25). More interventions similar to these are needed to close the gap in diabetes care between non-Hispanic Whites and individuals of other racial and ethnic groups.

The strengths of this study include that it is the largest dataset to date to assess racial and ethnic disparities among U.S. youths and adults with type 1 diabetes. The results that were reported to the central data site were harmonized among centers so that equivalent data were being reported. However, the centers involved in this study are academic-based diabetes practices; thus, the results may not be generalizable outside of this setting. All but two centers included only pediatric populations. Additionally, the data were obtained from EMR system and may be subject to documentation inaccuracies. This limitation could be further addressed by the use of claims-based data to improve accuracy.

In summary, this study found that there are striking inequities in glycemic control, acute diabetes complications, and technology use among non-Hispanic White, non-Hispanic Black, and Hispanic people with type 1 diabetes. It is important to investigate possible etiologies for these differences and develop interventions that specifically focus on Black and Hispanic individuals to improve their diabetes management and care and decrease racial and ethnic health inequities.

AUTHOR CONTRIBUTIONS

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