

## Racial-Ethnic Inequity in Young Adults With Type 1 Diabetes

Shivani Agarwal,<sup>1</sup> Lauren G. Kanapka,<sup>2</sup> Jennifer K. Raymond,<sup>3</sup> Ashby Walker,<sup>4</sup> Andrea Gerard-Gonzalez,<sup>5</sup> Davida Kruger,<sup>6</sup> Maria J. Redondo,<sup>7</sup> Michael R. Rickels,<sup>8</sup> Viral N. Shah,<sup>5</sup> Ashley Butler,<sup>7</sup> Jeffrey Gonzalez,<sup>1,9</sup> Alandra S. Verdejo,<sup>2</sup> Robin L. Gal,<sup>2</sup> Steven Willi,<sup>10</sup> and Judith A. Long<sup>8,11</sup>

<sup>1</sup>Fleischer Institute for Diabetes and Metabolism, New York-Regional Center for Diabetes Translational Research, Division of Endocrinology, Albert Einstein College of Medicine, Bronx, NY 10461; <sup>2</sup>Jaeb Center for Health Research, Tampa, FL 33647; <sup>3</sup>Children's Hospital Los Angeles, Los Angeles, CA 90027; <sup>4</sup>University of Florida, Gainesville, FL 32611; <sup>5</sup>Barbara Davis Center for Diabetes, University of Colorado Anschutz Medical Campus, Aurora, CO 80045; <sup>6</sup>Henry Ford Medical Center, Detroit, MI 48235; <sup>7</sup>Baylor College of Medicine, Texas Children's Hospital, Houston, TX 77030; <sup>8</sup>Institute for Diabetes, Obesity & Metabolism, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA 19104; <sup>9</sup>Ferkauf Graduate School of Psychology, Yeshiva University, Bronx, NY; 10461 <sup>10</sup>Children's Hospital of Philadelphia, Philadelphia, PA 19104; and <sup>11</sup>Corporal Michael J. Crescenz VA Medical Center, Philadelphia, PA 19104

**ORCID number:** 0000-0003-4506-3702 (S. Agarwal).

**Context:** Minority young adults (YA) currently represent the largest growing population with type 1 diabetes (T1D) and experience very poor outcomes. Modifiable drivers of disparities need to be identified, but are not well-studied.

**Objective:** To describe racial-ethnic disparities among YA with T1D and identify drivers of glycemic disparity other than socioeconomic status (SES).

**Design:** Cross-sectional multicenter collection of patient and chart-reported variables, including SES, social determinants of health, and diabetes-specific factors, with comparison between non-Hispanic White, non-Hispanic Black, and Hispanic YA and multilevel modeling to identify variables that account for glycemic disparity apart from SES.

**Setting:** Six diabetes centers across the United States.

**Participants:** A total of 300 YA with T1D (18-28 years: 33% non-Hispanic White, 32% non-Hispanic Black, and 34% Hispanic).

**Main Outcome:** Racial-ethnic disparity in HbA1c levels.

**Results:** Non-Hispanic Black and Hispanic YA had lower SES, higher HbA1c levels, and much lower diabetes technology use than non-Hispanic White YA ( $P < 0.001$ ). Non-Hispanic Black YA differed from Hispanic, reporting higher diabetes distress and lower self-management ( $P < 0.001$ ). After accounting for SES, differences in HbA1c levels disappeared between non-Hispanic White and Hispanic YA, whereas they remained for non-Hispanic Black YA (+ 2.26% [24 mmol/mol],  $P < 0.001$ ). Diabetes technology use, diabetes distress, and disease

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Abbreviations: ACE, Adverse Childhood Experiences; CGM, continuous glucose monitoring; SDOH, Social Determinants of Health; SES, socioeconomic status; YA, young adult.

self-management accounted for a significant portion of the remaining non-Hispanic Black–White glyceemic disparity.

**Conclusion:** This study demonstrated large racial-ethnic inequity in YA with T1D, especially among non-Hispanic Black participants. Our findings reveal key opportunities for clinicians to potentially mitigate glyceemic disparity in minority YA by promoting diabetes technology use, connecting with social programs, and tailoring support for disease self-management and diabetes distress to account for social contextual factors. (*J Clin Endocrinol Metab* 105: e2960–e2969, 2020)

**Key Words:** type 1 diabetes, young adults, healthcare disparities, inequity, social determinants of health

Incidence of type 1 diabetes is increasing in the United States, especially among Hispanic and non-Hispanic Black (Black) young adults (YA), ages 18 to 25 years (1–3). Minority YA groups exhibit some of the highest HbA1c levels, rates of hospitalizations, psychiatric comorbidity, and mortality among all age groups with type 1 diabetes, highlighting major racial-ethnic disparity in outcomes (4–9). Nevertheless, minority YA with type 1 diabetes are not well-studied, and drivers of disparities other than socioeconomic status (SES) are not clearly defined. Moreover, it is unknown whether there are potentially important differences between Black and Hispanic groups that could allow for tailoring of interventions.

Young adults are at a critical inflection point of newfound independence both in life and in disease self-management (10). As a result of competing financial, social, educational, and geographic shifts, YA infrequently interface with health care and may miss key interventional opportunities to prevent complications in adulthood (5, 11, 12). In general, YA experience deleterious short- and long-term outcomes (13–17). Minority status adds to this increased baseline risk. Prior literature notes that biological differences in glycation of hemoglobin between Black and non-Hispanic White (White) groups may account for apparent disparities in glyceemic control. However, the estimated contribution of biological differences to glyceemic control only accounts for a small proportion of the observed disparities between racial-ethnic minority and White groups (18). Thus, disparities may largely stem from social contextual factors, but this remains understudied.

The Social Determinants of Health (SDOH) model describes a set of factors that affect the health of individuals and communities beyond personal choices that are a product of their life experiences, physical, social, and economic environments (19, 20). Social determinants are multilevel and include factors such as individual and neighborhood poverty level, literacy, educational attainment, food security, and adverse childhood experiences, among others. Although it is well-established that SDOH greatly influence health outcomes in minority and low SES populations (19, 21), several gaps remain

in the literature: (1) studies of YA minority populations with type 1 diabetes are scarce and could show different results compared with adults or youth given their unique developmental needs; (2) existing research does not examine the effect of multiple coincident SDOH and other disease-specific factors, which limits identification of potentially more modifiable drivers of disparities; and (3) little to no research directly compares Hispanic and Black groups, which could help guide intervention approaches.

We designed this study to more fully describe minority YA with type 1 diabetes and identify factors other than SES that account for disparity in glyceemic control. We used a targeted, inclusive approach to recruit a diverse and economically vulnerable national population of YA, equally representing Black, Hispanic, and White racial-ethnic groups. We collected an array of patient-reported and chart-extracted variables related to SES, SDOH, and disease-specific variables to capture relevant risk factors. The primary objectives of this study were to (1) describe and compare SES, SDOH, diabetes management factors, and HbA1c levels among Black, Hispanic, and White YA and 2) determine what more modifiable factors may be driving disparities besides SES. Because minorities and YA are very difficult to recruit in research studies, utilization of one-time data capture provided a unique and in-depth view of social determinants of health and inequity that is not otherwise possible in this depth.

## Materials and Methods

### Study design and participants

The Young Adult Racial Disparities in Type 1 Diabetes study involved one-time cross-sectional data collection. This design was chosen to facilitate recruitment and data capture of minority YA with type 1 diabetes, who are severely underrepresented in clinical research studies (22).

Six Type 1 Diabetes Exchange clinic network sites in different urban geographical regions across the United States were selected to participate based on clinic estimates of YA and minority (Black and Hispanic) type 1 diabetes patients. The sites included: (1) Pediatric centers: Children's Hospital of Los Angeles (Los Angeles, CA), University of Florida (Gainesville,

FL), and Baylor Texas Children's Hospital (Houston, TX); (2) Adult centers: Henry Ford Health System (Detroit, MI); and (3) Combined pediatric-adult centers: Children's Hospital of Philadelphia-University of Pennsylvania (Philadelphia, PA) and Barbara Davis Center for Diabetes (Aurora, CO). Sites enrolled all participants outside of their existing Type 1 Diabetes Exchange registries to promote inclusion of minority YA who may not usually participate in research. Additional site information is available in the supplement (23).

Participants were included if they were 18 to 25 years old and had a clinical diagnosis of type 1 diabetes for at least 6 months, English-reading ability, and presence of at least 1 HbA1c value in the past 12 months. Participants were excluded if they were taking glucocorticoids, were currently pregnant, had a developmental disability that would preclude procedural requirements of independently filling out survey measures, or were of a self-reported race-ethnicity other than the prespecified racial-ethnic groups.

## Procedures

Recruitment and enrollment occurred between November 2017 and October 2018. A sample size of 300 young adults was calculated based on power calculations to detect at least 0.5% difference in HbA1c levels. This sample size also enabled adequate power (>90%) to detect meaningful differences in most of the measures. We used recruitment targets to ensure equal representation of White, Black, and Hispanic participants, and made efforts to recruit participants who did not show to regularly scheduled visits. The Type 1 Diabetes Exchange acted as the coordinating center for all study-related matters. Each site individually recruited, consented, and enrolled participants with their own study staff. Written informed consent was obtained before collecting any study-specific information. We maintained regular meetings between Type 1 Diabetes Exchange study staff, site study staff, site principal investigators, and the main principal investigator to ensure consistent procedures across sites. The coordinators were instructed periodically to maintain enrollment logs and submit completed logs at study completion. This study was approved by a central institutional review board at the Jaeb Center for Health Research.

After consent and enrollment, participants completed questionnaires through REDCap on a tablet or computer. All language in the consent and survey was in English and at or below a ninth-grade reading level. The survey took 15 to 40 minutes to complete, and participants were compensated for their time. Given the sensitive and private nature of certain questions, YA participants completed the survey in a private room without other family members and could opt out of any questions. Site study staff extracted additional data from participant medical charts. All study data were managed and stored by a central team at the Type 1 Diabetes Exchange.

## Measurements

This study evaluated an extensive list of potential SES, SDOH, and disease-specific variables that might explain observed racial-ethnic disparities in glycemic control in YA with type 1 diabetes. We organized variables in the following domains: (1) SES, (2) treatment regimen, (3) care setting, (4) psychosocial factors, and (5) self-management. Measures are included elsewhere (23).

## Main measures

**Race-ethnicity.** Race-ethnicity was self-reported using the U.S. Census 2000 questionnaire. We only included Black and White races in this study because our a priori hypotheses were based on prior literature examining these groups. We also could not ensure sufficient recruitment of other races at the selected sites to ensure adequate representation. For ethnicity, most Hispanic participants purposely declined to identify their race. This trend is in line with other studies (24, 25). Therefore, participants designated themselves as non-Hispanic White, non-Hispanic Black, or Hispanic.

**Glycemic control.** Study staff provided all HbA1c values recorded for each participant within the past 12 months (both point-of-care HbA1c and laboratory tests). For these analyses, we report and use the mean recorded HbA1c value for each participant and calculate disparity as the difference in mean HbA1c levels between White and Black, White and Hispanic, and Black and Hispanic participants.

## Other variables of interest

**Socioeconomic status.** We used multiple patient-reported and chart-extracted measurements to maximize our ability to accurately capture SES. Measures included insurance type, highest education attained, household income, neighborhood poverty, social status, and food insecurity. We extracted insurance information from the medical chart and categorized it at the site level into a binary variable: private or public/other/none. We asked participants to report their highest education level and annual household income. We assessed neighborhood poverty level by using 5-digit ZIP codes and available census tract data from the U.S. Census (26). We assessed social status by using the Hollingshead Index, which is a self-reported measure containing 15 questions that evaluates education and job type for each gainfully employed person in the household (27). Last, we used the short form of the U.S. Department of Agriculture Food Security Scale to measure household food security (28).

**Treatment regimen and care setting.** We extracted information from participant medical charts on current insulin pump use and continuous glucose monitor (CGM) use in the past. We categorized care settings into 3 groups: pediatric, adult, or combined pediatric-adult diabetes centers.

**Psychosocial factors.** Participants completed the Adverse Childhood Experiences (ACE) questionnaire to elicit information on childhood abuse, neglect, and family/household dysfunction, among other experiences (29). We used ACE as a categorical variable given prior work reflecting a dose-response relationship between 0, 1 and 4, and > 4 ACEs and diabetes incidence/control (30). All categories  $\geq 1$  were collapsed given few participants with scores > 1. Participants also completed the Diabetes Distress Scale, which is an assessment of diabetes-related emotional stress and is associated with glycemic control (31).

**Disease self-management.** Participants completed several measures of disease self-management: (1) the Diabetes Self-care Inventory (revised), a self-report measure of perceived

adherence to diabetes self-care recommendations (32); (2) the Diabetes Numeracy Test 5, which contains 5 math problems for type 1 diabetes self-management (33); and (3) the Single Item Literacy Screener, which measures health literacy (34).

### Data analysis

SES, treatment regimen, care setting, psychosocial factors, and self-management variables were compared between each pair of race-ethnicity groups (Black, Hispanic, White) using a Fisher's exact test or Wilcoxon rank-sum test, as appropriate. These comparisons used available cases only. Missing data were minimal for most variables and is reported in the tables.

HbA1c was compared between race-ethnicity groups in a linear regression model adjusted for age, sex, and diabetes duration. Because HbA1c was somewhat right skewed, the model was fit with robust linear regression using MM estimation. Robust regression was chosen instead of a transformation because it was important to be able to interpret the regression coefficients on the original scale.

To examine how measures of SES, treatment regimen, care setting, psychosocial factors, and self-management might account for any observed racial-ethnic disparity in HbA1c, we first added each measure individually to the regression model. To examine the effect of the measures when considered together, we sequentially added them to the model in groups in the following order: SES, treatment regimen, care setting, psychosocial variables, and self-management. Variables were added in groups rather than 1 at a time because it was expected that many of them would be highly correlated with each other, so it would be impossible to accurately estimate the individual contribution. The order of variables was chosen to assess the contribution of other factors to disparity after adjustment for well-known structural risk factors, such as SES. Missing data were handled using Rubin's multiple imputation so that all participants were included in every model.

We adjusted 2-sided *P* values and 95% confidence intervals for multiple comparisons in all analyses to control for the false discovery rate using the adaptive Benjamini-Hochberg procedure. We used SAS software, version 9.4 (SAS Institute Inc., Cary, NC), for analyses.

## Results

### Participant characteristics

Three hundred diverse YA with type 1 diabetes participated in the study per recruitment targets: 33% White (*n* = 100), 32% Black (*n* = 97), and 34% Hispanic (*n* = 103) (Table 1). Participants exhibited a wide range of socioeconomic indicators, with one-half on public insurance or without insurance, and more than one-half reporting annual household incomes of less than \$50,000 (Table 1). Mean HbA1c for the sample was 9.0% (75 mmol/mol). Fewer than one-half of participants were using an insulin pump at the time of the survey (43%, *n* = 129) or had ever used a CGM (45%, *n* = 135). There was a roughly even distribution of participants from pediatric, adult, and combined pediatric-adult care settings (Table 1).

### Racial-ethnic comparisons

Mean  $\pm$  SD HbA1c for Black YA was  $10.7 \pm 2.4\%$  ( $93 \pm 26$  mmol/mol), for Hispanic YA was  $9.3 \pm 2.2\%$  ( $78 \pm 24$  mmol/mol), and for White YA was  $8.5 \pm 1.8\%$  ( $69 \pm 20$  mmol/mol). Adjusting for age, sex, and diabetes duration, Black participants had HbA1c levels 2.26 percentage points (24.7 mmol/mol) higher than White participants (*P* < 0.001) (Tables 2 and 3). Hispanic participants had HbA1c 0.64 percentage points (7.0 mmol/mol) higher than White participants, but this was not statistically significant (*P* = 0.15).

Compared with White participants, both Black and Hispanic participants had significantly worse socioeconomic indicators with lower annual household income, lower attained education, lower social status, and higher neighborhood poverty (Table 1). In addition, far fewer minority participants were on insulin pump treatment (18% Black, 39% Hispanic, vs 72% White, *P* < 0.001) or had ever used a CGM (28% Black, 37% Hispanic, vs 71% White, *P* < 0.001) (Table 1).

Compared with White and Hispanic participants, Black YA reported the higher neighborhood poverty levels, lower social status, higher food insecurity, more adverse childhood experiences, higher levels of diabetes distress, and lower diabetes self-management scores (*P* < 0.001 for all) (Table 1). In addition, Black YA had the lowest insulin pump use, despite similar rates of public insurance as Hispanic YA (Table 1).

### Explanation of racial-ethnic disparity in glycemic control

When examining each variable's effect on glycemic control after adjusting for age, sex, and diabetes duration (Table 2), all variables were associated with glycemic control in Black but not Hispanic YA. In multivariate sequential modeling after controlling for SES factors (model 2, Table 3), Hispanic YA appeared more like White participants in terms of glycemic control. Meanwhile, Black YA continued to have stark disparity in HbA1c levels, with diabetes technology use, care setting, diabetes distress, and self-care exerting the greatest influence on Black-White glycemic disparity (Table 3, Fig. 1).

## Discussion

We performed this study in a diverse national population of YA with type 1 diabetes to describe disparities, examine the effect of variables other than SES on glycemic control, and compare differences between minority groups. Black and Hispanic YA exhibited lower SES, much lower diabetes technology use, and higher



**Table 1. Participant Characteristics**

	Overall N = 300	NH White N = 100	NH Black N = 97	Hispanic N = 103	NH White vs. NH Black	NH White vs. Hispanic	Hispanic vs. NH Black
Demographic variables							
Age (yrs) – median (Q1, Q3)	20 (19, 22)	21 (20, 23)	21 (19, 22)	20 (19, 20)			
Female	166 (55%)	59 (59%)	54 (56%)	53 (51%)			
Diabetes duration (yrs) – median (Q1, Q3)	10 (7, 14)	12 (9, 16)	10 (7, 15)	10 (6, 13)			
Socioeconomic status							
Insurance (public/none)	155 (52%)	22 (22%)	55 (57%)	78 (76%)	<0.001	<0.001	0.018
High school education or less	29 (10%)	24 (24%)	64 (66%)	72 (70%)	<0.001	<0.001	0.64
Annual household income <\$50 000	171 (61%)	31 (33%)	70 (74%)	70 (74%)	<0.001	<0.001	0.69
% Poverty in census tract – median (Q1, Q3)	16 (9, 25)	9 (6, 18)	22 (14, 33)	19 (12, 27)	<0.001	<0.001	0.042
Hollingshead Index – median (Q1, Q3)	43 (32, 53)	50 (38, 58)	41 (31, 51)	35 (24, 47)	<0.001	<0.001	0.040
Food insecurity	66 (22%)	14 (14%)	28 (29%)	24 (23%)	0.014	0.19	0.42
Treatment regimen							
Insulin pump	129 (43%)	72 (72%)	17 (18%)	40 (39%)	<0.001	<0.001	0.011
CGM ever	135 (45%)	70 (71%)	27 (28%)	38 (37%)	<0.001	<0.001	0.18
Care setting							
Pediatric	111 (37%)	25 (25%)	15 (15%)	71 (69%)			
Adult	67 (22%)	31 (31%)	34 (35%)	2 (2%)			
Combined	122 (41%)	44 (44%)	48 (49%)	30 (29%)			
Psychosocial factors							
≥ 1 adverse childhood experience	173 (58%)	47 (47%)	69 (71%)	57 (55%)	<0.001	0.36	
D0.040 diabetes distress – median (Q1, Q3)	1.8 (1.3, 2.7)	1.7 (1.2, 2.5)	2.0 (1.5, 3.0)	1.7 (1.3, 2.5)	0.023	0.89	0.07
Self-management							
Diabetes Self-care Inventory – mean (SD)	3.4 (0.7)	3.5 (0.5)	3.2 (0.8)	3.5 (0.7)	0.006	0.84	0.040
Diabetes numeracy – median (Q1, Q3)	4 (3, 5)	5 (4, 5)	4 (2, 5)	4 (2, 5)	<0.001	<0.001	0.74
Health nonliterate	40 (13%)	7 (7%)	11 (11%)	22 (21%)	0.33	0.028	0.06

Abbreviations: CGM, continuous glucose monitor; NH, non-Hispanic; Q, quarter.

Mean and standard deviation were reported for variables with an approximately normal distribution and the median, 25th, and 75th percentiles were reported for variables with skewed distributions.

*P* values are calculated from a Wilcoxon rank-sum test or a Fisher's exact test, as appropriate. *P* values have been adjusted for multiple comparisons to control the false discovery rate.

Missing data: income 18 (6%), % poverty in Census Tract 6 (2%), Hollingshead Index 43 (14%), CGM use ever 1 (<1%), diabetes self-care 1 (<1%), hospitalizations 2 (<1%). All other variables have no missing data.

HbA1c levels than White YA. Across the board, Black YA had the lowest scores on all variables, most significantly for self-reported psychosocial and self-management factors. After accounting for SES, Hispanic YA were similar to White YA exhibiting no difference in glycemic control, whereas Black YA continued to have much higher HbA1c levels than White YA. The variables that contributed most to the remaining Black–White glycemic disparity after SES were diabetes technology use, diabetes distress, and diabetes self-management. Our findings indicate that increased effort to encourage and facilitate insulin pump and CGM use among Black and Hispanic YA may be one avenue to mitigate racial-ethnic inequity. Our results also demonstrate that clinicians may be able to improve HbA1c levels among Hispanic YA by directly addressing social needs, whereas Black YA may need further support with tailored reeducation and behavioral interventions that target diabetes distress and self-care.

To our knowledge, this study is the first in YA designed to test how multiple patient-reported and chart-extracted

variables account for racial-ethnic disparity in glycemic control. We used targeted recruitment to enable equal representation and comparison of Black and Hispanic groups. Our results demonstrated that SDOH composed the largest portion of glycemic disparity; however, we were also able to identify clear modifiable factors that account for remaining inequity, such as diabetes technology use, diabetes distress, and self-management. We also demonstrated key differences between Black and Hispanic YA, which may help target and tailor appropriate interventions. An unexplained disparity of 0.7% in HbA1c levels remained after accounting for all variables, most of which can be explained by biologic differences in hemoglobin glycation between Black and White populations, accounting for approximately 0.5% in HbA1c (18).

Although it was expected that Black and Hispanic YA had significant disparity in economic variables compared with White YA, the degree to which both groups had lower diabetes technology use was surprising. This is especially poignant given that participants were cared for in subspecialized diabetes centers and resided in

**Table 2. Variable Effect on Racial-Ethnic Disparity in HbA1c (%)**

Predictor	NH Black vs. NH White		Hispanic vs. NH White	
	$\beta$ (95% CI) <sup>a</sup>	<i>P</i> Value <sup>a</sup>	$\beta$ (95% CI) <sup>a</sup>	<i>P</i> Value <sup>a</sup>
<b>Race-ethnicity only</b>	2.26 (1.46-3.07)	<0.001	0.64 (-0.14 to 1.43)	0.15
<b>Socioeconomic status</b>				
Health insurance	2.13 (1.46-2.81)	< 0.001	0.48 (-0.30 to 1.26)	0.29
Highest education attained <sup>b</sup>	1.81 (1.16-2.47)	< 0.001	0.34 (-0.35 to 1.04)	0.41
Annual household income <sup>b</sup>	1.93 (1.24-2.63)	< 0.001	0.34 (-0.40 to 1.08)	0.45
% poverty in Census Tract	1.98 (1.30-2.67)	< 0.001	0.45 (-0.28 to 1.19)	0.29
Hollingshead Index	2.00 (1.34-2.65)	< 0.001	0.25 (-0.48 to 0.98)	0.59
Food insecurity	2.18 (1.50-2.86)	< 0.001	0.62 (-0.15 to 1.38)	0.15
<b>Treatment regimen</b>				
Insulin pump	1.76 (1.06-2.46)	< 0.001	0.41 (-0.31 to 1.13)	0.33
CGM use ever	2.10 (1.42-2.78)	< 0.001	0.53 (-0.22 to 1.28)	0.21
<b>Care Setting</b>				
Pediatric vs. adult/combined	2.16 (1.51-2.82)	< 0.001	0.92 (0.00-1.84)	0.05
<b>Psychosocial factors</b>				
Adverse childhood experiences	2.22 (1.53-2.90)	< 0.001	0.63 (-0.15 to 1.41)	0.15
Diabetes distress	1.97 (1.37-2.56)	< 0.001	0.58 (-0.13 to 1.29)	0.15
<b>Self-management</b>				
Diabetes Self-care Inventory	1.89 (1.29-2.49)	< 0.001	0.56 (-0.14 to 1.26)	0.15
Diabetes numeracy	2.05 (1.38-2.71)	< 0.001	0.46 (-0.27 to 1.20)	0.28
Health nonliterate	2.27 (1.43-3.11)	< 0.001	0.66 (-0.14 to 1.46)	0.15

Abbreviations: CI, confidence interval; NH, non-Hispanic.

<sup>a</sup>Each variable was added to a linear regression model adjusting for race/ethnicity, age, sex, and diabetes duration. *P* values and CI have been adjusted for multiple comparisons to control the false discovery rate.

<sup>b</sup>Education and income are considered ordinal.

states with generous insurance plans that covered diabetes technology. Our results demonstrate that the impact of diabetes technology use on glycemic control was large, even after adjustment for SES, rivaling treatment effects of new diabetes medications (35). Although prior research has highlighted racial-ethnic disparities in diabetes technology among youth with type 1 diabetes (36, 37), our results show that racial-ethnic disparities exist despite being covered for these devices. In addition, we show that Black YA had lower diabetes technology use than Hispanic YA, despite similar public insurance coverage rates and SES levels. Thus, cost may not be the only driver of racial-ethnic disparities in technology use. That more Hispanic patients were in pediatric care could have accounted for their slightly better rates of technology use over Blacks, but it does not fully explain why both minority groups had much lower use than White YA.

Implicit bias in prescribing practices must be considered. Studies evaluating prescription of statins, psychotropic medications, and opioids for pain control suggest that prescribing practices create racial-ethnic disparities (38-40). Whether societal issues for Black YA related to racism, mistrust of health care systems, and fractured support networks (41, 42) influence provider prescription practices of diabetes technology are unknown. Further, it is unknown whether cultural norms influence patient acceptance of advanced

diabetes technologies. Studies highlighting literacy barriers in technology promotional materials and minority patient preferences for quality of life over medical outcomes underscores the need to more fully explore patient factors in acceptance of diabetes technology (43, 44). As emerging technologies, such as closed loop systems, become more readily available in the near future and have clear glycemic advantage over existing treatment regimens (45, 46), more research is needed to examine minority preferences and challenges as well as patient-provider interactions surrounding technology. Moreover, more lenient eligibility criteria for use of these advanced systems and invention of more affordable technology may be necessary to prevent widening disparities (47).

We also found that Black-White disparity in glycemic control stemmed from higher levels of self-reported diabetes distress and lower self-management scores in Black YA. The exact causes of these self-reports cannot be discerned from this study, but prior studies have suggested that low social and disease-related support in low SES communities contributes to higher perceived stress and lower self-management (48). In the YA context, support for diabetes-related distress and self-management may be particularly necessary during the developmental transition to adulthood as well (10). In our study, Black YA reported lower social status and higher neighborhood poverty levels than White or Hispanic

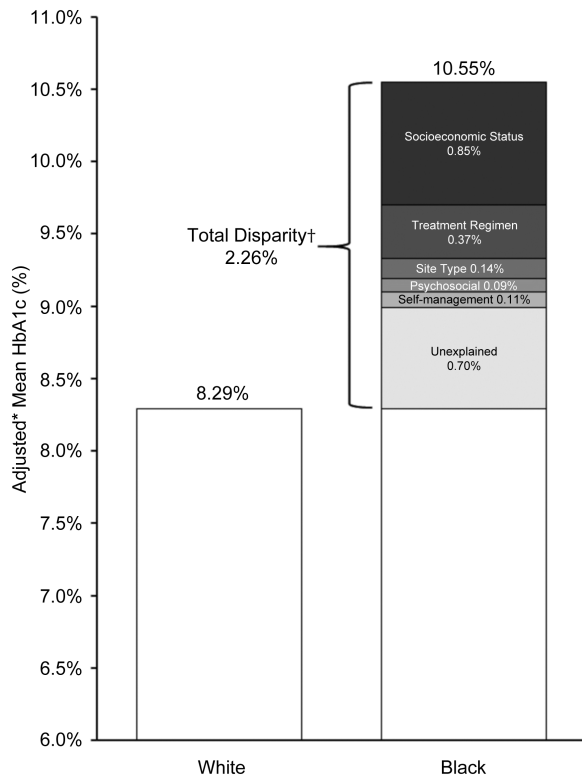
**Table 3. Multivariate Model of Race-Ethnicity and HbA1c (%)**

	Model 1 (Race-Ethnicity) <sup>a</sup>		Model 2 (Model 1 + SES) <sup>a</sup>		Model 3 (Model 2 + Diabetes Technology) <sup>a</sup>		Model 4 (Model 3 + Site Type) <sup>a</sup>		Model 5 (Model 4 + Psychosocial) <sup>a</sup>		Final Model (Model 5 + Self-management) <sup>a</sup>	
	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value	β (95% CI)	P Value
<b>Race-ethnicity</b>												
NH Black vs. NH White	2.26 (1.46-3.07)	<0.001	1.41 (0.69-2.13)	<0.001	1.04 (0.29-1.79)	0.007	0.90 (0.14-1.65)	0.019	0.81 (0.10-1.52)	0.025	0.70 (0.02-1.38)	0.044
Hispanic vs. NH White	0.64 (-0.14 to 1.43)	0.15	-0.04 (-0.78 to 0.69)	0.91	-0.17 (-0.92 to 0.58)	0.73	0.10 (-0.64 to 0.84)	0.79	0.08 (-0.62 to 0.78)	0.82	0.02 (-0.65 to 0.70)	0.94
<b>Socioeconomic status</b>												
Insurance (private vs. public/none)	-	-	0.03 (-0.57 to 0.62)	0.93	0.19 (-0.42 to 0.80)	0.55	0.19 (-0.41 to 0.80)	0.53	0.03 (-0.54 to 0.60)	0.92	0.30 (-0.25 to 0.84)	0.28
Highest attained education <sup>b</sup>	-	-	-0.62 (-1.12 to 0.13)	0.006	-0.59 (-1.08 to 0.11)	0.008	-0.61 (-1.10 to 0.12)	0.006	-0.66 (-1.15 to 0.17)	0.002	-0.55 (-1.02 to 0.08)	0.014
Annual household income <sup>b</sup>	-	-	-0.12 (-0.44 to 0.19)	0.44	-0.13 (-0.44 to 0.18)	0.40	-0.19 (-0.50 to 0.12)	0.22	-0.19 (-0.49 to 0.11)	0.21	-0.23 (-0.54 to 0.07)	0.16
% Neighborhood poverty	-	-	0.02 (-0.01 to 0.04)	0.19	0.02 (-0.01 to 0.04)	0.18	0.02 (-0.01 to 0.04)	0.16	0.01 (-0.01 to 0.03)	0.28	0.01 (-0.01 to 0.04)	0.20
Hollingshead Index	-	-	-0.02 (-0.04 to 0.01)	0.18	-0.01 (-0.04 to 0.01)	0.22	-0.01 (-0.03 to 0.01)	0.34	-0.01 (-0.03 to 0.01)	0.57	-0.01 (-0.03 to 0.01)	0.41
Food insecurity	-	-	0.48 (-0.19 to 1.15)	0.18	0.42 (-0.23 to 1.07)	0.21	0.41 (-0.22 to 1.05)	0.21	0.08 (-0.53 to 0.70)	0.79	0.23 (-0.35 to 0.81)	0.43
<b>Treatment regimen</b>												
Insulin regimen (pump vs. injections)	-	-	-	-	-0.80 (-1.53 to -0.08)	0.023	-0.72 (-1.40 to -0.04)	0.035	-0.63 (-1.25 to -0.01)	0.045	-0.44 (-1.02 to 0.14)	0.16
CGM user ever	-	-	-	-	-0.11 (-0.68 to 0.46)	0.71	-0.19 (-0.76 to 0.38)	0.51	-0.11 (-0.65 to 0.43)	0.68	-0.18 (-0.70 to 0.33)	0.49
<b>Care setting</b>												
Pediatrics vs. adult/combined	-	-	-	-	-	-	-0.82 (-1.57 to -0.08)	0.025	-0.71 (-1.38 to -0.04)	0.036	-0.71 (-1.37 to -0.05)	0.031
<b>Psychosocial factors</b>												
Adverse childhood experiences	-	-	-	-	-	-	-	-	-0.37 (-0.90 to 0.15)	0.18	-0.38 (-0.90 to 0.13)	0.17
Diabetes distress	-	-	-	-	-	-	-	-	0.62 (0.27-0.97)	<0.001	0.20 (-0.08 to 0.47)	0.18
<b>Self-management</b>												
Self-care inventory	-	-	-	-	-	-	-	-	-	-	-0.99 (-1.54 to -0.44)	<0.001
Diabetes numeracy	-	-	-	-	-	-	-	-	-	-	-0.16 (-0.35 to 0.02)	0.10
Health nonliterate	-	-	-	-	-	-	-	-	-	-	-0.49 (-1.21 to 0.23)	0.20

Abbreviations: CI, confidence interval; NH, non-Hispanic; SES, socioeconomic status.

<sup>a</sup>Each group of variables was added sequentially to a model of HbA1c adjusting for race/ethnicity, age, sex, and diabetes duration. P values and CI have been adjusted for multiple comparisons to control the false discovery rate.

<sup>b</sup>Education and income are considered ordinal.



**Figure 1.** Portion of the total HbA1c disparity between Black and White participants that is explained by each variable group.

YA. Whether these neighborhood and societal indicators are markers for lower overall social and disease-related support needs to be further examined.

It is notable that Hispanic YA reported equivalent diabetes distress and self-management to White YA, despite similar economic insecurity to Black YA. Hispanic participants in our study were more likely to be in pediatric care than Black participants, which may have provided them access to better safety nets. However, several studies have suggested that Hispanic populations are shielded from some of the negative effects of SES through the “barrio effect,” which involves residence in neighborhoods with shared characteristics of intact family structures, community institutions, and kinship networks (49-51). These cultural factors may be protective among Hispanic individuals and communities (50) and may have contributed to the observed differences between Hispanic and Black YA in our study. Given our results, clinicians should consider evaluating and strengthening social support among vulnerable YA, whether through family, neighborhood, peer, virtual, or other community networks. In fact, a wealth of literature underscores how resilience can be protective against the deleterious effects of SES, specifically in youth with type 1 diabetes (52-54). Pediatric care may be a favorable model to promote resilience for YA. However, even in resource-strained settings such as adult care, engaging

the multifaceted networks of YA to support strengths and promote resilience may be a unique method of mitigating racial-ethnic inequity in outcomes.

This study has several limitations. First, it is cross-sectional, thus limiting our ability to make causal inferences. We specifically chose this design to maximize recruitment and data capture, offering insight into a severely underrepresented population with the hope that any data would be value added. Second, although this is the largest study of social contextual factors and glycemic control in minority YA with type 1 diabetes to date, there may have been limited power to detect potentially important differences and moderating or mediating relationships. Third, we recruited participants from specialty diabetes centers and used English-only materials, which could have skewed the population toward a more educated, engaged, and acculturated Hispanic population. Fourth, we found that more Hispanic participants were from pediatric centers than Black participants, which may have selected for a Hispanic population that had better support because of the site of care. Nevertheless, our results showing more favorable psychosocial and outcome variables in the Hispanic group mirror other larger studies of other diseases that demonstrate protective cultural aspects (55).

This study focused on a population of high relevance and used a new approach to identify modifiable drivers of disparities in a national population of YA with type 1 diabetes. We uncovered meaningful racial-ethnic disparities in glycemic control, SDOH, and diabetes-specific factors. Our results highlight several critical priority areas to decrease racial-ethnic inequity among minority YA. These include a need to increase diabetes technology use, provide clinicians with training to address social needs with connection to existing social programs, and tailor support for diabetes self-management and diabetes distress to which leverages existing YA social networks. Overall, clinicians need to adapt current care approaches to caring for minority YA with type 1 diabetes that takes into account developmental, cultural, historical, and environmental contexts. These changes have the potential to prevent inequity from enduring into later adulthood.

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## Additional Information

**Correspondence:** Shivani Agarwal, MD, MPH, Albert Einstein College of Medicine, 1180 Morris Park Avenue, Bronx, NY 10461. E-mail: [Shivani.Agarwal@einsteinmed.org](mailto:Shivani.Agarwal@einsteinmed.org).

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