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ARTICLE HIGHLIGHTS

- This 7-year retrospective study found significant racial disparities in access and use of diabetes technologies among adults with type 1 diabetes.
- Compared with non-Black patients, Black patients were less likely to have had discussions with the diabetes care team and were less likely to receive a prescription for these technologies. These disparities persisted after adjusting for social determinants of health, glycemic control, mental health, and diabetes outcomes.
- Considering the benefits of diabetes technologies, our findings highlight the need for a standardized approach to discussing diabetes technology with all patients and incorporating their values and preferences in the decision-making process.

Racial Disparities in Access and Use of Diabetes Technology Among Adult Patients With Type 1 Diabetes in a U.S. Academic Medical Center

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OBJECTIVE

Recent studies highlight racial disparities in insulin pump (PUMP) and continuous glucose monitor (CGM) use in children and adolescents with type 1 diabetes (T1D). This study explored racial disparities in diabetes technology among adult patients with T1D.

RESEARCH DESIGN AND METHODS

This was a retrospective clinic-based cohort study of adult patients with T1D seen consecutively from April 2013 to January 2020. Race was categorized into non-Black (reference group) and Black. The primary outcomes were baseline and prevalent technology use, rates of diabetes technology discussions (CGM_{discn}, $PUMP_{discn}$), and prescribing (CGM_{rx}, $PUMP_{rx}$). Multivariable logistic regression analysis evaluated the association of technology discussions and prescribing with race, adjusting for social determinants of health and diabetes outcomes.

RESULTS

Among 1,258 adults with T1D, baseline technology use was significantly lower for Black compared with non-Black patients (7.9% vs. 30.3% for CGM; 18.7% vs. 49.6% for PUMP), as was prevalent use (43.6% vs. 72.1% for CGM; 30.7% vs. 64.2% for PUMP). Black patients had adjusted odds ratios (aORs) of 0.51 (95% CI 0.29, 0.90) for CGM_{discn} and 0.61 (95% CI 0.41, 0.93) for CGM_{rx}. Black patients had aORs of 0.74 (95% CI 0.44, 1.25) for $PUMP_{discn}$ and 0.40 (95% CI, 0.22, 0.70) for $PUMP_{rx}$. Neighborhood context, insurance, marital and employment status, and number of clinic visits were also associated with the outcomes.

CONCLUSIONS

Significant racial disparities were observed in discussions, prescribing, and use of diabetes technology. Further research is needed to identify the causes behind these disparities and develop and evaluate strategies to reduce them.

Continuous glucose monitors (CGM) and insulin pump (PUMP) devices have been demonstrated to improve clinical outcomes in patients with type 1 diabetes (T1D). In addition to better glycemic control and quality of life, use of diabetes technologies is associated with decreased frequency of severe hypoglycemia and diabetic ketoacidosis

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(DKA) (1). Recognizing these clinical benefits, the American Diabetes Association (ADA) *Standards of Medical Care in Diabetes* have, over the past decade, progressively expanded the indications and strength of recommendations for use of diabetes technologies in patients with T1D. In 2022, CGMs became standard of care for all patients with T1D, and automated insulin delivery systems are recommended to all adults with T1D who are capable of safely using them (2).

Despite recent advancements in diabetes technologies, there has not been substantial progress in reducing disparities for most diabetes-related outcomes (3). In fact, racial disparities in diabetes technology use appear to have widened over the last decade (4). Black patients with T1D are half as likely to receive PUMP and CGM (5,6); however, they have a threefold increased risk of hospitalizations with DKA and hypoglycemia (7), 1.5% higher A1C (8), and a twofold increased risk of death compared with non-Hispanic White patients (9). Health care disparities in T1D start early in life, and substantial disparities in technology use are documented among children and adolescents (5,10,11). Although a few studies have focused exclusively on adults (12), there is limited information on the overall pattern of technology disparities in adults with T1D. Several studies in adults (12,13), which generally have involved small numbers of participants or examined a limited number of social determinants of health, suggest that disparities may mirror those found among children and are only partially explained by socioeconomic status (SES) and insurance status. Significant research gaps remain in understanding the causes of these racial disparities.

In this retrospective study, we sought to evaluate racial differences in discussions and prescribing of CGM (CGM_{discn}; CGM_{rx}) and PUMP ($PUMP_{discn}$; $PUMP_{rx}$) technology among a large cohort of adult patients with T1D in a real-world clinical setting over a 7-year period, while accounting for social determinants of health, mental health issues, substance use, glycemic control, and diabetes outcomes. Understanding the mediators of such disparities may inform strategies to reduce or eliminate them. In view of reported racial and ethnic disparities in the treatment of diabetes, we hypothesized that diabetes technology discussions and prescribing rates would be lower for Black patients compared with non-Black patients with T1D.

RESEARCH DESIGN AND METHODS

Study Design and Subjects

This was a retrospective electronic medical record (EMR)-based cohort study of adult patients aged ≥18 years with T1D who were consecutively treated at one of four diabetes clinics of the Johns Hopkins Comprehensive Diabetes Center located in Baltimore, Maryland, between 1 April 2013 and 1 January 2020. The start date of the study coincided with the implementation of the electronic medical record system (EpicCare), which was used throughout the study period. Patients with a diagnosis of T1D were identified using ICD-10 Clinical Modification codes (E10.xxx) from the encounter diagnosis, problem list, and past medical history. Historical ICD-9 codes were automatically converted to ICD-10 codes in the EMR. Exclusion criteria were absence of insulin requirement following pancreas transplant for T1D and absence of hemoglobin A1C measurement during study period. The study was approved by the Johns Hopkins University School of Medicine Institutional Review Board, which waived the need for informed consent.

Outcomes

This study evaluated four outcomes in relation to race (Black vs. non-Black) for each of the two diabetes technologies (CGM and PUMP): *1*) technology use at baseline (i.e., active use at the first clinic visit), *2*) provider-patient discussions surrounding the technology among patients who were technology naive (i.e., never previously used the technology at the first visit), *3*) technology prescribing for patients who had received a discussion surrounding the technology (i.e., incident users), and *4*) prevalent technology use (combination of baseline and incident technology users). The proportion of each of these outcomes was reported for Black and non-Black patients.

Technology discussion (CGM_{discn}; $PUMP_{discn}$), assessed in the naive cohort, was defined as any documentation indicating that a discussion had occurred, including provision of information surrounding the technology and different devices, requirements to begin using the technology, the process for using the device, insurance requirements, cost, and advantages/disadvantages. Technology prescription (CGM_{rx}; $PUMP_{rx}$) was defined as a prescribed order for the device through a commercial pharmacy or documentation that an order was or would be sent to a durable medical equipment (DME) company, as well as documented initial use during the study period (i.e., incident use). Technology prescriptions were assessed in patients who had documented discussions regarding the technology (i.e., all patients who were prescribed the technology also had a documented discussion). Technology use was assessed at the initial study visit. Patients were classified as technology naive, previous technology users, and active technology users. Prevalent technology use, therefore, consisted of both active and new technology users, assessed cross-sectionally throughout the study period. Assessing for sustained use of the technology through manual medical record review was beyond the scope of this study. Supplementary Fig. 1 is a detailed study flowchart summarizing the eligibility criteria and analytical cohorts.

Outcomes were ascertained through manual medical record review by two independent reviewers (medical student and endocrinology fellow), and discordances were adjudicated by a third reviewer (endocrinology attending). CGM_{rx} was defined as a medication order for any component of a CGM device (sensor, transmitter, reader, etc.) or documentation that a CGM was being ordered through a DME company. We used the built-in search functionality of our EMR, which can query the entire electronic record using keywords. For CGM, the following keyword terms were used: "continuous glucose monitor," "CGM," "Dexcom," and "Libre." A screenshot of a CGM report or tracing also served as evidence of CGM use. Medtronic hybrid closed-loop PUMPs use Medtronic sensors; if the patient was noted to be using a Medtronic pump in "auto mode," it was assumed that they were using a CGM. The keyword "pump" was used to query EMR for pump outcomes. $PUMP_{rx}$ was defined as a medication order for any component of a PUMP device (pump, pods, personal diabetes manager, cartridges, insulin, etc.), documentation that a pump was being ordered or prescribed, or inclusion of a PUMP

report (Medtronic CareLink, Tandem t:connect, or Omnipod Glooko reports).

Independent Variables

We collected clinical and demographic information from a combination of automated data extraction from EpicCare, our hospital's EMR, and manual medical record review using Research Electronic Data Capture (REDCap) (14,15), an electronic data capture tool hosted at Johns Hopkins University. Extracted variables included demographics (age, sex, race, ethnicity) and social determinants of health (primary language, marital status, employment status, insurance type, Area Deprivation Index [ADI], diabetes duration), mental health issues (anxiety/depression), substance use (current tobacco smoking and illicit drug use), diabetes outcomes (A1C; hospitalizations with DKA, hyperosmolar hyperglycemic syndrome [HHS], or hypoglycemia; microvascular and macrovascular complications), and number of diabetes clinic visits. We used the 2018 version of the ADI to measure patients' neighborhood SES via linked ZIP Codes (16). ADI consists of 17 measures of education, employment, housing quality, and poverty originally extracted from long-form U.S. Census data. Race was classified as Black/African American (Black) or non-Black (White/Caucasian, unknown, or other races). Details surrounding data sources, definitions, and timing of assessment for these variables can be found in Supplementary Table 1.

It is important to highlight that our independent variables were assessed at different time points, including at the time of the first clinic visit (age, sex, race, ethnicity, diabetes duration, primary language, marital status, employment categories, ADI, insurance), cross-sectionally over the entire study period (smoking, substance use, anxiety/depression, hospitalization with DKA/HHS, hospitalizations with hypoglycemia, microvascular complications, macrovascular complications, and number of diabetes clinic visits), and on or near the date of the first clinic visit (first A1C). All of the cross-sectional variables were treated as binary variables (current use vs. nonuse; yes/no) with the exception of number of diabetes clinic visits (discrete variable). We considered that most variables assessed at the time of the first clinic visit were unlikely to change significantly over time, and a cross-sectional approach was used to increase the sensitivity of clinical documentation (e.g., smoking or substance use), capture rare events (e.g., hospitalizations for hypoglycemia), or assess patient engagement in care longitudinally (e.g., number of clinic visits).

Statistical Analysis

Normality of data was assessed using tests of skewness and kurtosis. Medians and interquartile ranges are reported as all continuous measures were nonnormally distributed. Statistical significance between races was determined by χ^2 tests or Fisher exact tests, as appropriate, for categorical variables and Wilcoxon rank sum test for continuous variables.

To explore the independent association of race and other factors with diabetes technology use, we conducted univariable and multivariable logistic regression analyses for two of the four technology outcomes (discussion and prescribing) in the technology-naive cohort. We focused our regression analyses on the naive cohort only, since it was not possible to ascertain the timing of technology initiation and other time-dependent patient or provider characteristics for technology nonnaive patients (e.g., diabetes duration at time of the first visit was not equivalent to diabetes duration at time of technology initiation).

Independent variables in the models were selected based on clinical relevance, findings from prior studies, and significant results in the univariate analyses. Independent variables included age, sex (reference: female), race (reference: non-Black) and ethnicity (reference: not Hispanic or Latinx), diabetes duration (years), marital status (reference: married), employment status (reference: employed), ADI scores by quintile (reference: quintile 1—least disadvantaged neighborhood), insurance type (reference: private insurance), total number of diabetes clinic visits, other diabetes technology use (i.e., CGM use if PUMP user; PUMP use if CGM user), current tobacco smoking, substance use, anxiety/depression, first A1C value, microvascular and macrovascular complications, hospitalizations with DKA/HHS, and hospitalizations for hypoglycemia. The variance inflation factor was calculated to test the multicollinearity between the variables. This was <5 for all covariates, suggesting a low level of multicollinearity. A two-sided $P = 0.05$ was used as the threshold of statistical significance. Analyses were conducted using Stata 17 software (StataCorp LLC, College Station, TX).

Sensitivity Analysis by Study Period

Over the 7-year study period, diabetes technologies were rapidly evolving, particularly with respect to ease of use (i.e., fingerstick calibration for CGM) and indications (i.e., broader eligibility criteria for insurance coverage). Major changes in CGM technology and coverage occurred in 2017, potentially expanding their use. Therefore, to account for these secular trends, we conducted a sensitivity analysis in which the CGM outcomes were evaluated in two cohorts based on the date of the patient's first encounter (2013–2016 and 2017–2020) (17).

RESULTS

Patient Characteristics by Race

Table 1 shows the characteristics of the study cohort stratified by race. We identified 1,258 adults with T1D (19.2% Black), with a median age of 36 years and median diabetes duration of 17 years, who were seen in our clinics over the 7-year study period.

There were significant racial differences with respect to SES, health care utilization, and diabetes outcomes. Compared with non-Black patients, Black patients were in the most deprived ADI score quintiles (73% vs. 39.7% in the 3rd–5th quintiles), had lower rates of employment (50.6% vs. 59.7%), higher rates of disability (13.7% vs. 3.5%), lower rates of private health insurance coverage (61.0% vs. 82.4%), and were less likely to be married (28.6% vs. 51.1%). They had fewer diabetes clinic visits (six vs. seven), more hospitalizations for DKA/HHS (10.4% vs. 2.4%) and hypoglycemia (9.5% vs. 2.0%), higher A1C levels (9.0% vs. 7.5% for first A1C; 8.7% vs. 7.4% for last A1C), and higher prevalence of microvascular complications (53.1% vs. 36.5%). Black patients had a higher prevalence of substance use (7.9% vs. 2.4%) and anxiety/depression (18.7% vs. 13.0%).

Technology Outcomes by Race

Figure 1 shows the rates of diabetes technology use, discussions, and prescribing

Table 1—Characteristics of the study population, stratified by race

Variable	Full cohort (*N* = 1,258)	Non-Black (*n* = 1,017)	Black (*n* = 241)	*P* value*
Age at study entry, years	36 (26, 52)	36 (25, 53)	36 (27, 46)	0.240
Male sex	608 (48.3)	505 (49.7)	103 (42.7)	0.053
Race				—
White/Caucasian	933 (74.2)	—	—	
Black/African American	241 (19.2)	—	—	
Other	78 (6.2)	—	—	
Unknown	6 (0.5)	—	—	
Ethnicity				0.100
Not Hispanic or Latino	1,206 (95.9)	970 (95.4)	236 (97.9)	
Hispanic, Latinx, or other	52 (4.1)	47 (4.6)	5 (2.1)	
Diabetes duration, years	17 (7, 27)	18 (7, 27)	15 (6, 24)	0.022
Weight, kg	76.2 (65.8, 88.4)	76.5 (66.4, 89.1)	74.7 (63.8, 85.6)	0.026
BMI, kg/m^2	25.8 (23.3, 29.5)	25.8 (23.3, 29.3)	25.8 (23.0, 29.9)	0.890
Primary language English	1,249 (99.3)	1,008 (99.1)	241 (100.0)	0.140
Marital status				<0.001
Married	588 (46.7)	519 (51.0)	69 (28.6)	
Single	556 (44.2)	412 (40.5)	144 (59.8)	
Divorced/separated/widowed	90 (7.2)	64 (6.3)	26 (10.8)	
Other/unknown	24 (1.9)	22 (2.2)	2 (0.8)	
ADI state rank (quintiles)				<0.001
First (1, 2): least disadvantaged	226 (18.0)	209 (20.6)	17 (7.1)	
Second (3, 4)	203 (16.1)	178 (17.5)	25 (10.4)	
Third (5, 6)	207 (16.5)	170 (16.7)	37 (15.4)	
Fourth (7, 8)	205 (16.3)	153 (15.0)	52 (21.6)	
Fifth (9, 10): most disadvantaged	168 (13.4)	81 (8.0)	87 (36.1)	
Missing	249 (19.8)	226 (22.2)	23 (9.5)	
Employment status				<0.001
Employed	729 (57.9)	607 (59.7)	122 (50.6)	
Not employed	217 (17.2)	155 (15.2)	62 (25.7)	
Student	90 (7.2)	83 (8.2)	7 (2.9)	
Disabled	69 (5.5)	36 (3.5)	33 (13.7)	
Retired	103 (8.2)	88 (8.7)	15 (6.2)	
Unknown	50 (4.0)	48 (4.7)	2 (0.8)	
Insurance type				<0.001
Private	985 (78.3)	838 (82.4)	147 (61.0)	
Medicare	181 (14.4)	128 (12.6)	53 (22.0)	
Medicaid	64 (5.1)	32 (3.1)	32 (13.3)	
Other	28 (2.2)	19 (1.9)	9 (3.7)	
Current tobacco smoking	152 (12.1)	117 (11.5)	35 (14.5)	0.200
Substance use disorder	43 (3.4)	24 (2.4)	19 (7.9)	<0.001
Anxiety/depression	177 (14.1)	132 (13.0)	45 (18.7)	0.022
Number of A1C measurements	7 (3, 13)	7 (3, 12)	8 (4, 15)	<0.001
A1C, %	7.8 (7.0, 8.9)	7.6 (6.9, 8.5)	9.1 (8.1, 10.5)	<0.001
First A1C in study period, %	7.8 (6.8, 9.1)	7.5 (6.7, 8.7)	9.0 (7.8, 10.9)	<0.001
Last A1C in study period, %	7.6 (6.7, 8.7)	7.4 (6.6, 8.4)	8.7 (7.6, 10.3)	<0.001
Hospitalizations with DKA/HHS**	49 (3.9)	24 (2.4)	25 (10.4)	<0.001
Hospitalizations with hypoglycemia**	43 (3.4)	20 (2.0)	23 (9.5)	<0.001
Macrovascular complications	124 (9.9)	97 (9.5)	27 (11.2)	0.440
Microvascular complications	499 (39.7)	371 (36.5)	128 (53.1)	<0.001
Number of diabetes clinic visits	6.5 (3, 11)	7 (3, 12)	6 (3, 10)	0.033
Endocrinology fellow	0 (0, 0)	0 (0, 0)	0 (0, 1)	<0.001

Continued on p. 60

Table 1—Continued

Variable	Full cohort (*N* = 1,258)	Non-Black (*n* = 1,017)	Black (*n* = 241)	*P* value*
Endocrine faculty (adult/pediatric)	3 (1, 6)	3 (1, 7)	2 (0, 4)	<0.001
Advanced diabetes practitioners	2 (0, 5)	2 (0, 5)	2 (0, 5)	0.850
DSMT (CDCES, pharmacist, RN)	0 (0, 0)	0 (0, 0)	0 (0, 1)	<0.001

Data are presented as median (interquartile range) or as *n* (%). CDCES, certified diabetes care and education specialist; DSMT, diabetes self-management training; RN, registered nurse. **P* value for comparison by racial groups. **Number of patients with one or more hospitalizations.

stratified by race. Significant racial disparities were observed for all outcomes. Black patients were less likely to have CGM_{use} at initial study visit (baseline CGM_{use} 7.9% vs. 30.3%, $P < 0.001$) and throughout the study period (prevalent CGM_{use} 43.6% vs. 72.1%, $P < 0.001$). Among CGM-naive patients, Black patients were less likely to have CGM_{discn} (79.6% vs. 91.7%, $P < 0.001$) and subsequent CGM_{rx} (50.0% vs. 68.4%, $P < 0.001$).

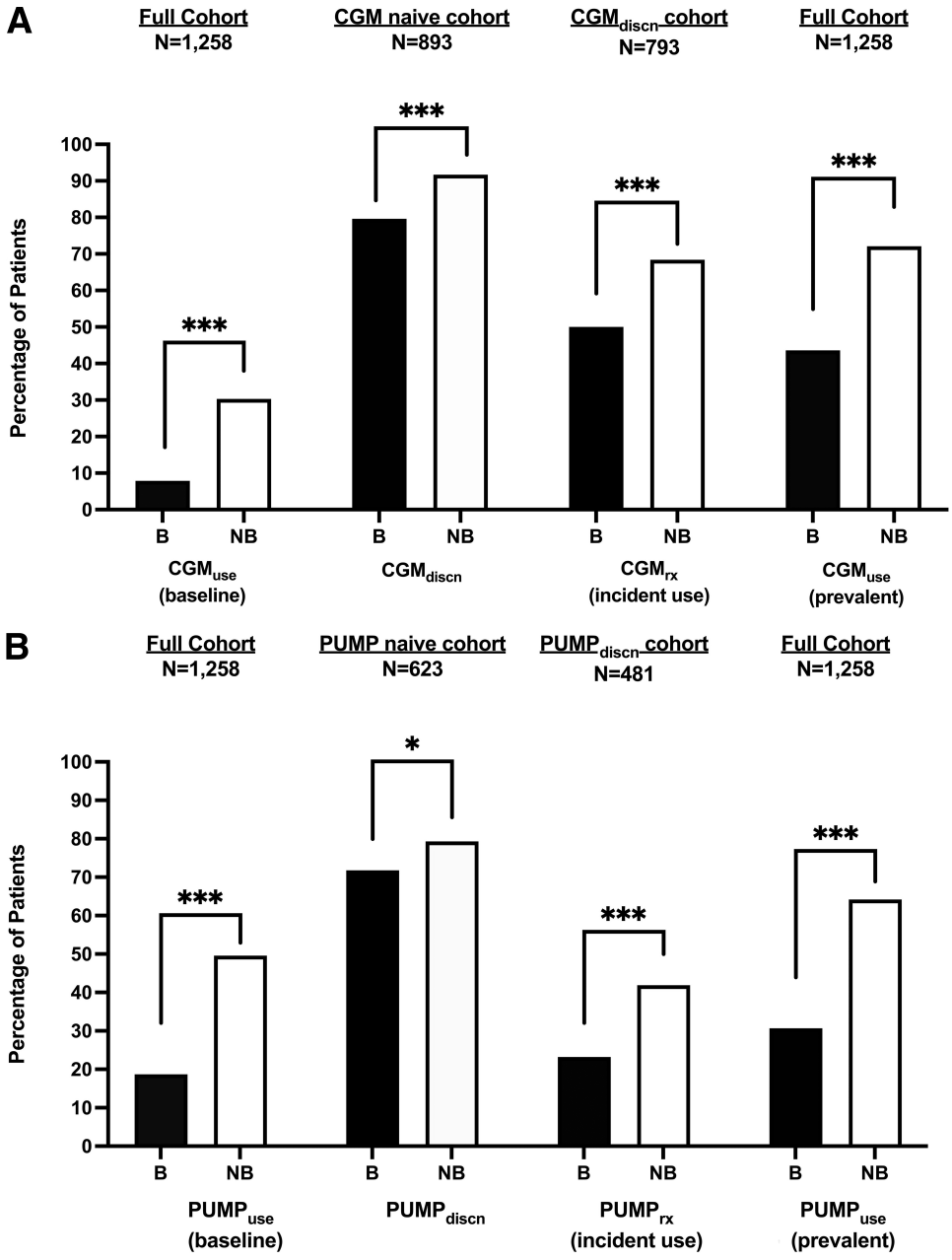

Figure 1—Comparison of diabetes technology outcomes among Black vs. non-Black patients. *A*: CGM outcomes by race. *B*: PUMP outcomes by race. *$P < 0.05$; ***$P < 0.001$.

Similarly, Black patients were less likely to have $PUMP_{use}$ at the initial study visit (baseline $PUMP_{use}$ 18.7% vs. 49.6%, $P < 0.001$) and throughout the study period (prevalent $PUMP_{use}$ 30.7% vs. 64.2%, $P < 0.001$). Among PUMP-naive patients, Black patients were less likely to have $PUMP_{discn}$ (71.8% vs. 79.5%, $P = 0.04$) and subsequent $PUMP_{rx}$ (23.2% vs. 41.9%, $P < 0.001$).

Association of Race and CGM Outcomes

Figure 2 shows the association between patient characteristics and CGM_{discn} and CGM_{rx}. In the CGM-naive cohort, the unadjusted odds of CGM_{discn} and CGM_{rx} among Black patients were 0.35 (95% CI 0.23, 0.54) and 0.46 (95% CI 0.33, 0.65), respectively. The adjusted odds of CGM_{discn} and CGM_{rx} among Black patients were 0.51 (95% CI 0.29, 0.90) and 0.61 (95% CI 0.41, 0.93), respectively. Other variables associated with CGM_{discn} and CGM_{rx} after adjustment were $PUMP_{use}$, marital status, higher ADI category, and number of diabetes clinic visits. The odd ratios for the full regression model are reported in the Supplementary Tables.

In our sensitivity analyses, the association between race and CGM_{discn} was only significant in the early period (2013–2016), whereas race was only significantly associated with CGM_{rx} in the later period (2017–2020) (Supplementary Tables 4 and 5).

Association of Race and Pump Outcomes

Figure 3 shows the association between patient characteristics and PUMP outcomes. In the pump-naive cohort, the unadjusted odds of $PUMP_{discn}$ and $PUMP_{rx}$ among Black patients were 0.67 (95% CI 0.45, 0.99) and 0.42 (95% CI 0.26, 0.67), respectively. The adjusted odds of $PUMP_{discn}$ and $PUMP_{rx}$ among Black patients were 0.74 (95% CI 0.44, 1.25) and 0.40 (95% CI 0.22, 0.70), respectively. Other variables associated with $PUMP_{discn}$ and/or $PUMP_{rx}$ after adjustment were sex, CGM_{use}, employment status, and the number of diabetes clinic visits. The odds ratios for the full regression model are reported in the Supplementary Tables.

CONCLUSIONS

This study of adults with T1D found that Black patients had lower CGM and PUMP use, which is likely mediated by the lower frequency of discussions and prescribing of these technologies. Our findings in adults are consistent with studies involving younger patients with T1D (5,10,11). For all the diabetes technology outcomes we assessed (with the exception of $PUMP_{discn}$), a strong negative association was observed with race, and there was only slight attenuation after adjustment for available social determinants of health and diabetes outcomes.

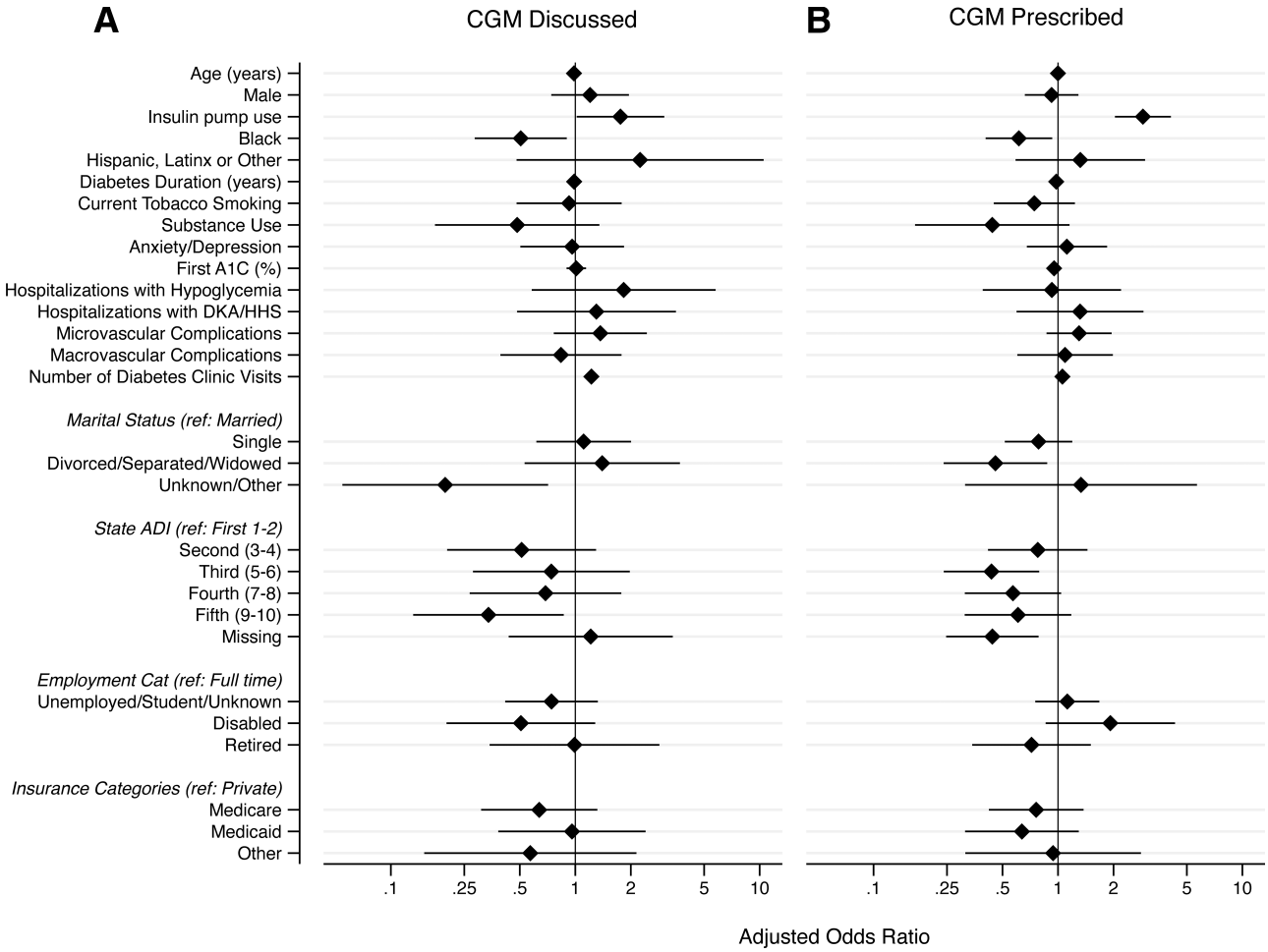

Figure 2—Association of patient characteristics and CGM_{discn} in CGM-naive cohort ($n = 893$) (*A*) and CGM_{rx} in the CGM_{discn} cohort ($n = 793$) (*B*). Data displayed represent point estimates and 95% CIs derived from multivariable regression.

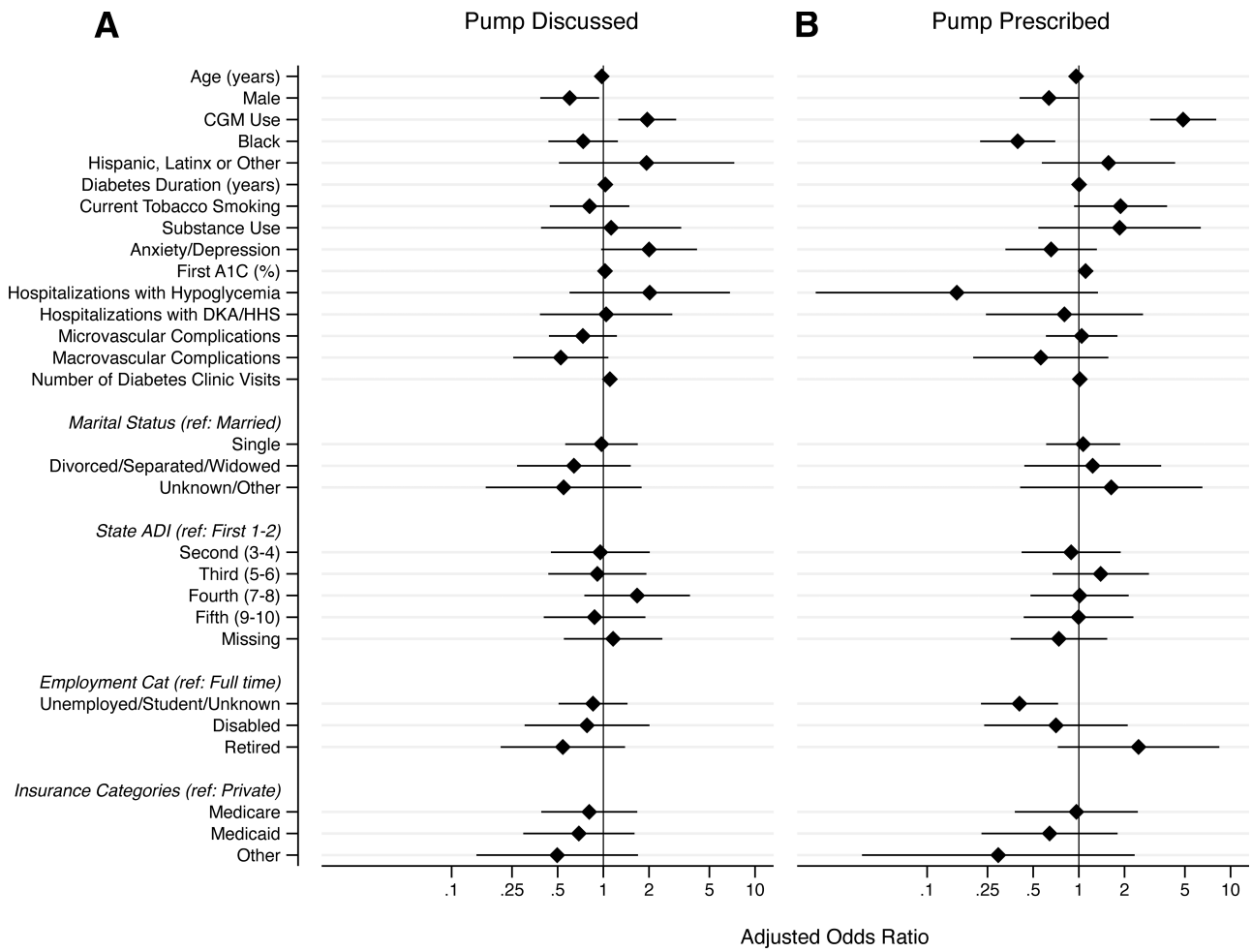

Figure 3—Association of patient characteristics and $PUMP_{discn}$ in the PUMP-naive cohort (n = 623) (*A*) and $PUMP_{rx}$ in the $PUMP_{discn}$ cohort (n = 481) (*B*). Data displayed represent point estimates and 95% CIs derived from multivariable regression.

Although previous studies have explored disparities in the overall use of diabetes technologies, to our knowledge, this is the first study to evaluate the outcomes of clinical discussions and prescribing of diabetes technologies in adult patients with T1D.

In our cohort, Black adults fared worse than non-Black patients for nearly all health-related measures that we examined, in alignment with previous studies (8,18). We identified social risk factors, including low socioeconomic position (as indicated, for example, by employment status), marital status, living in a deprived neighborhood, health insurance coverage, and differences in health care utilization (hospitalization rates, number of diabetes clinic visits) as influencing health care equity. Our findings mirror those found among children that cite SES (educational level, household income, and occupation), Medicare and Medicaid health insurances, and health literacy as barriers to medical care and access to diabetes devices (19–22). Although our study did not measure income and educational level, we used the ADI, which incorporates education, employment, housing quality, and poverty measures (16).

We postulate several potential mechanisms for the persistent racial disparities in diabetes technology outcomes, which were not directly evaluated in our study: insurance or clinical practice requirements related to diabetes self-management skills (including frequent self-monitoring of blood glucose levels, carbohydrate counting, and visits with a certified diabetes educator), fulfillment of subjective criteria regarding appropriate patient selection (i.e., willing, motivated, and capable patients), factors influencing the process of shared decision making (doctor-patient relationship and concordance between patient values and treatment choices), and provider implicit racial bias.

Throughout the study period, health insurance companies and practice guidelines required that patients have a documented history of at least four blood glucose levels per day and have completed a diabetes education program before being eligible for the devices (23,24). Although we did not measure frequency of self-monitoring of blood glucose or competency in diabetes management (e.g., carbohydrate counting, adherence to insulin regimens), we used A1C as an indicator of glycemic control, which we anticipated would correlate with diabetes self-management skills (25). Diabetes self-management skills have been described to be lower among Black patients (11) and a provider-level barrier to recommending technology (23,26,27).

It is worthwhile to mention that diabetes technologies were not standard of care across the study period, and clinical practice recommendations required providers' subjective assessment

for determining patient eligibility, such as patient's "motivation" and "interest," in addition to objective measures (i.e., hypoglycemia unawareness and glycemic control) (28). Qualitative studies in children indicated that clinicians often based treatment decisions on subjective, rather than objective, clinical criteria (26). These treatment decisions are concerning because there is a tendency to overestimate patient barriers to technology use (29,30).

The pursuit of diabetes technology also depends on shared decision making, which seeks to weigh risks and outcomes in the context of patients' preferences and values. Although we could not assess quality of clinical discussions, we relied on documented technology discussions as an indirect measure of shared decision making and found a lower frequency of this outcome among Black patients. Various factors influence patient preference in decision making, including the depth and quality of discussions, patients' health literacy levels, financial and health concerns, provider-patient trust, and respect for patient autonomy (31,32). Qualitative studies of minority patients reported that providers played the role of gatekeepers and restricted patients' autonomy; providers "discouraged and blocked" the use of technology because of "glycemic control" or "device being too complex for the patient," despite the patient's request. They also were more likely to receive partial or incomplete information regarding the benefits of technology and reported being unfamiliar with T1D and its technologies (31,32). "Judgmental" endocrinologists were reported as one barrier to attending scheduled appointments among minorities (31).

Finally, our findings cannot exclude the possibility of implicit racial bias in providers. A previous study of pediatric endocrinologists demonstrated that insurance status may be viewed as a proxy for social determinants; providers' treatment recommendations were influenced by insurance status based on clinical vignettes. Similarly, it is possible that race is inappropriately used as a proxy of social determinants of health (33,34).

The findings of this study indicate opportunities for potential strategies to address racial disparities in the use of diabetes technologies. First, our findings suggest that clinicians should have a standard approach to discussing diabetes technology with all patients, which incorporates the risks and benefits of treatment as well as the patient's values and preferences to ensure effective shared decision making (35,36). With more accurate information on a patient's personal, social, and cultural context, this may reduce provider biases and allow clinicians to better partner with the patient to make informed treatment decisions (34). Disparities that are associated with SES might be reduced through educational interventions targeted at health literacy (such as diabetes self-management training programs).

Strengths of this study are its large size, comprehensive assessment of social determinants of health and diabetes outcomes, and systematic approach to evaluating the steps proximal to diabetes technology use (i.e., discussion and prescribing).

Limitations of this study, inherent to retrospective observational data, include the possibility of unmeasured confounders, as previously described. This study was not able to evaluate race concordance between health care providers and patients as a factor influencing these outcomes, as we did not have access to provider-reported race information (37).

Another limitation is the subjective interpretation and incomplete/missing clinical documentation. To address the former, two independent reviewers manually extracted information from the medical records, and conflicts were adjudicated by a third reviewer. Our long duration of follow-up and clinical care model of alternating visits between a physician and advanced practice provider reduces the likelihood of undocumented discussions resulting from the documentation practices of individual providers. We cannot exclude the possibility of negative reporting bias, in which the decisions to document discussions regarding diabetes technologies were influenced by patient acceptance of the recommendation in the first place.

While our study was powered to detect differences by race, it was not adequately powered to detect differences by ethnicity given the underrepresentation of Hispanic/Latinx patients. The extent to which these findings generalize to community-based practices or health systems is uncertain.

Despite these limitations, this retrospective real-world study may have an advantage over prospective studies, as recruitment and consent may introduce bias in research aimed at identifying disparities.

In summary, our findings revealed marked racial disparities in diabetes technology discussions, prescribing, and use in adults with T1D. Further qualitative and well-designed prospective studies incorporating the perspectives of patients are needed to elucidate the causes behind these disparities in order to develop, implement, and evaluate strategies to reduce them. Specifically, prospective studies should assess the impact of provider type, training, and experience, racial concordance of provider and patient, quantity/quality of provider-patient discussions, patient sustained use of technologies, and ethnic disparities on technology use.

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