



Psychosocial and diabetes risk factors among racially/ethnically diverse adults with prediabetes

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ABSTRACT

Psychosocial factors such as self-efficacy may be important in helping high-risk adults prevent diabetes. We aimed to describe psychosocial and diabetes risk factors in adults with prediabetes and evaluate if these varied by demographic characteristics. Cross-sectional data came from baseline surveys and electronic health records (2018–2021) of adults with prediabetes enrolled in a randomized study of peer support for diabetes prevention at Kaiser Permanente Northern California and Michigan Medicine. Linear regression was used to compare differences between racial/ethnic groups, adjusting for age, sex, and clinic. Of 336 participants in the study, 62% were female; median age was 57; 41% were White, 35% African American, 9% Hispanic. Mean autonomous motivation was 6.6 and self-efficacy to prevent diabetes was 6.0 (1–7 scale); mean perceived social support was 47 (12–72 scale). Hispanic adults reported higher autonomous motivation and African American adults reported higher self-efficacy compared to White adults. Hispanic and African American adults had more diabetes risk factors than White adults, including greater family history of diabetes, hypertension, sugar-sweetened beverage consumption, physical inactivity and food insecurity. In conclusion, participants reported high levels of autonomous motivation and self-efficacy at baseline, with Hispanic and African American adults reporting higher levels of some psychosocial factors related to behavior change, suggesting a significant opportunity to engage a diverse population of adults with prediabetes in diabetes prevention strategies. However, Hispanic and African American participants showed greater diabetes risk factors levels. Diabetes prevention efforts should address both to reduce diabetes incidence.

1. Introduction

Type 2 diabetes (T2DM) is a leading cause of morbidity and mortality in the U.S (Ahmad and Anderson, 2021; CDC National Health Report, 2014). Currently, 15% of adults have T2DM (Cheng et al., 2019), and if rising trends continue, it is expected that up to 1 in 3 adults could have T2DM by 2050 (Boyle et al., 2010). Furthermore, African American, Hispanic, and Asian American adults are disproportionately affected by T2DM compared to White adults (Cheng et al., 2019). In addition to the high prevalence of T2DM, there is an additional 38% of adults in the US

who have prediabetes (Cheng et al., 2019), most of whom will eventually progress to T2DM (Li et al., 2008). In adults with prediabetes, there is clear evidence that intensive lifestyle intervention programs lower incident T2DM (Cefalu et al., 2016; Jackson, 2009; Knowler et al., 2002; Ockene et al., 2012; Van Name et al., 2016). However, within studies, the effectiveness of diabetes prevention programs varies across participants (Cefalu et al., 2016; Jackson, 2009; Knowler et al., 2002). One possible reason is that individual psychosocial factors may influence the effectiveness of diabetes interventions. Prior literature has demonstrated that social support and self-efficacy are associated with improved

Abbreviations: DSS, Diabetes Social Support Scale; EHR, Electronic health records; HDL, High-density lipoprotein; KPNC, Kaiser Permanente Northern California; MM, Michigan Medicine; PCS, Perceived Competence Scale; RCT, Randomized clinical trial; TSRQ, Treatment Self-Regulation Questionnaire; UPSTART, Using Peer Support to Aid in Prevention and Treatment in Prediabetes.

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adherence to health promoting behaviors (Dennison et al., 2018; Hurdle, 2001; Issner et al., 2017; Napolitano and Hayes, 2011; Park and Gaffey, 2007; Steptoe et al., Dec 2009; Thomas et al., 2020). And in the context of T2DM management, many psychosocial factors were also studied, including autonomous and controlled motivation (Levesque et al., 2007; Williams et al., 1998), self-efficacy (Levesque et al., 2007; Williams et al., 1998; Williams and Deci, Apr 1996), perceived social support (Barrera et al., 2002; Cohen and Hoberman, 1983), and activation (Hibbard et al., Dec 2005). In prior studies among adults with T2DM, these psychosocial constructs were associated with adoption of healthy behaviors, including increased physical activity, improved diet and smoking abstinence (Ntoumanis et al., 2021; Sarkar et al., 2006), improved diabetes self-care (Rask et al., 2009; Walker et al., 2015), less diabetes distress over time (Wang et al., 2017), and improved diabetes outcomes, including glycemic control (Nakahara et al., 2006) and a reduction in HbA1c (Williams et al., 1998). However, little is known about how psychosocial factors may influence T2DM prevention among adults with prediabetes, and if these factors differ by race/ethnicity and/or socioeconomic status.

In this cross-sectional study, we described psychosocial factors and diabetes risk factors measured at baseline in an adult population with prediabetes. Study participants were enrolled in a diabetes prevention randomized clinical trial (RCT) delivered by a peer-support system. Further, we evaluated if these psychosocial factors varied by sex, race/ethnicity, and/or socioeconomic status.

2. Research design and methods

2.1. Study sample

This study uses cross-sectional baseline data from the Using Peer Support To Aid in Prevention and Treatment in Prediabetes (UPSTART) study collected between 2018 and 2021. UPSTART objectives and design were previously described (Heisler et al., 2020). Briefly, UPSTART is a parallel, two-armed, randomized controlled pragmatic clinical trial among 351 adults with prediabetes at Kaiser Permanente Northern California (KPNC) and Michigan Medicine (MM). UPSTART eligibility criteria included patients aged 18–85 with BMI ≥ 25 kg/m² (≥ 23 kg/m² for Asian Americans who develop diabetes at a lower BMI (Hsu et al., 2015, Rodriguez et al., 2021)) and at least one HbA1c between 5.7 and 6.4% in the previous 3 months. Participants were identified using electronic health records (EHR) data. Those who enrolled were randomized to one of two arms, stratified by Hispanic ethnicity and baseline HbA1c ($\leq 6\%$ or $> 6\%$). The three study health centers (Oakland Medical Center, Ypsilanti Health Center, and East Ann Arbor Health and Geriatrics Center) serve socioeconomically diverse populations with significant numbers of Hispanic and African American populations.

2.2. Ethics approval and consent to participate

Informed consent was obtained for experimentation with human subjects and the work described has been carried out in accordance with the Declaration of Helsinki. UPSTART was reviewed and approved by KPNC (November 20, 2018 IRB 1301009) and the University of Michigan (August 31, 2017 IRB HUM00135745).

2.3. Measurements

A complete list of demographic and clinical characteristics included in UPSTART was described elsewhere (Heisler et al., 2020). The following demographic characteristics were self-reported in an online survey: race/ethnicity (White, African American, Hispanic, Asian American, including native Hawaiian and Pacific Islander, or multiracial/other); annual household income, and education. At baseline, weight, height and waist circumference were measured and BMI calculated. Due to protocol modifications in consequence of the SARS-

CoV-2 pandemic, participants enrolled in late 2020 and early 2021 did not have waist circumference measured ($n = 50$). KPNC obtained HbA1c from the EHR within 3 months prior to the baseline visit while MM measured HbA1c in the clinic during the baseline visit. Age, gender, smoking history, blood pressure, high-density lipoprotein (HDL) cholesterol, and family history of diabetes were obtained from the EHR within 365-days prior to baseline.

2.4. Psychosocial factors

Using constructs stemming from self-determination theory (Ryan and Deci, Jan 2000), which centers around motivations to change behavior, we measured autonomous and controlled motivation, self-efficacy to prevent diabetes, perceived social support and activation (see Appendix Table 1 for descriptions of these psychosocial measures and list of questions included). We calculated Cronbach's alpha as a measure of internal consistency for each psychosocial factor within our UPSTART cohort.

Motivation was assessed using 11 measures adapted from the Treatment Self-Regulation Questionnaire (TSRQ) (Levesque et al., 2007; Williams et al., 1998). The TSRQ for diabetes measures reasons for following a diabetic diet and for exercising regularly. We included 11-items from this version and slightly adapted the wording to focus on diabetes prevention. Participants rated statements using a 7-point Likert scale ranging from "Not at all true" (1) to "Very true" (7). Responses to these 11 measures were used in two separate subscales. If all questions were answered, a score was calculated. Otherwise, the score was reported as missing. Four measures asked about Autonomous Motivation, or intrinsic reasons for preventing diabetes (Cronbach's alpha = 0.77). The remaining 7 measures asked about Controlled Motivation, or extrinsic reasons for preventing diabetes (Cronbach's alpha = 0.78). High scores indicated high motivation on both.

Self-efficacy to prevent diabetes was measured using an adapted version of the Perceived Competence Scale (PCS). (Williams et al., 1998; Williams and Deci, 1996) The PCS assesses management of glucose levels among patients with diabetes; we adapted the wording of the 4 questions to focus on diabetes prevention instead of glucose control. Participants assessed feelings of competence to prevent diabetes across 4 questions with a 7-point Likert scale ranging from "Not at all true" (1) to "Very true" (7). We averaged responses if all individual questions were answered and created a continuous score, with high scores indicating high self-efficacy (Cronbach's alpha = 0.91).

Perceived social support was assessed using an adapted version of the Diabetes Social Support Scale (DSS) (Barrera et al., 2002). The DSS measures social support specific to diabetes care management; we adapted the questionnaire to focus on diabetes prevention instead of diabetes management. Participants were asked if they agreed with 12 statements (6 positive, 6 negative) using a 6-point Likert-scale ranging from "Strongly disagree" (1) to "Strong agree" (6). The responses to the 6 negative statements were reversed and the total score was created by summing the 12 responses (12–72 scale). If < 3 out of the 12 individual responses were missing, we imputed missing responses with the median response from the other questions ($n = 9$, 2.7%). If more were missing, a score was not calculated. A high score indicated high social support (Cronbach's alpha = 0.89).

Patient activation was measured using the validated short form Patient Activation Measure-13 survey (Hibbard et al., 2005). Patients were asked if they agreed with 13 statements using a 4-point Likert-scale ranging from "Strongly disagree" (1) to "Strongly agree" (4). Scores were summed and converted to a continuous 100-point scale. If < 3 of the 13 individual responses were missing, we imputed missing responses with the median response from the other questions ($n = 12$, 3.6%). If more were missing, a score was not calculated. Higher scores indicated high patient activation (Cronbach's alpha = 0.87).

2.5. Other diabetes risk factors

Hypertension was defined as $\geq 130/\geq 80$ mmHg regardless of medications. Low HDL cholesterol was defined as < 40 mg/dL in men and < 50 mg/dL in women. Family history of diabetes included any family relatives and any type of diabetes, and smoking history was categorized as current, former, never smoker, or unknown. Soda or sugary drink consumption were measured using an adapted questionnaire (Centers for Disease Control and Prevention (CDC), 2017). Physical activity was measured using an adapted questionnaire (Shephard, 1997). And food insecurity was ascertained using one item from the United States Department of Agriculture Household Food Security Survey (Bickel et al., 2000). Participants who responded “Sometimes true” or “Often true” to if they were “worried whether our food would run out before we got more to buy more” in the last 12 months were categorized as food insecure.

2.6. Statistical analysis

Descriptive statistics for demographic, clinical, behavioral and psychosocial characteristics were presented as means for continuous variables, medians for variables with non-normal distributions, or proportions for categorical variables. We reported unadjusted baseline differences in demographic, clinical, and psychosocial characteristics by race/ethnicity using Chi-Square, ANOVA, or Kruskal-Wallis tests for categorical, continuous, and non-normally distributed continuous variables respectively. Pearson or Spearman’s correlations were used to analyze the linear relationship between income level and clinical and psychosocial characteristics. And multivariate regressions were used to evaluate differences in psychosocial measures by race/ethnicity adjusting for age, sex, and clinic. Differences between White adults and other groups were determined to be significant if $P < 0.05$, using Dunnett’s adjustment for multiple comparisons. In separate exploratory models, we included income level and its interaction with race/ethnicity and considered it significant if $P < 0.05$ using nested likelihood ratio tests. A test for trend for the association of outcomes of interest and race/ethnicity by income group, education category, or sex was tested with the use of linear regression, adjusting for age, sex and clinic and considered significant if $P < 0.05$. Likewise, in separate models we included education and sex and their interaction with race/ethnicity. However, we found no significant interactions and these models were not included. Adjusted population marginal means were estimated using the LSMEANS option in PROC GLM. All statistical analyses were performed in 2021 with SAS 9.4 (SAS Institute, Cary NC).

2.7. Missing data

About 4% (15/351) of participants had one or more missing variables. We evaluated the nature of the missingness (Allison, 2001) and found that missingness was not associated with measured covariates and assumed the data were likely missing completely at random. Only participants with complete data were included in our models ($n = 336$). To evaluate correlations by income group (Table 3) and associations with income level and race interactions (Table 4), we further removed participants with missing or refused to report income responses ($n = 30$).

3. Results

This study includes 336 participants with prediabetes with 138 White (40%), 116 African American (37%), 31 Hispanic (9.2%), 29 Asian American/Hawaiian/Pacific Islander (8.6%), and 22 multi-racial or other adults (6.5%). Sixty-nine participants were at East Ann Arbor, 170 at Ypsilanti Health Clinic and 97 at KPNC Oakland Medical Center. Characteristics are shown in Table 1 by race/ethnicity. Median age differed significantly among race and ethnicity groups: 61.5 [52.0–68.0] for White, 54 [42.5–62] for African American, 53 [44–62] for Hispanic,

50 [46–58] for Asian American, and 53.5 [34–60] for Multiracial ($P < 0.01$ overall). The proportion of women also differed significantly among race and ethnicity groups (overall $P < 0.01$). The proportion of women were 51% for White, 74% for African American, 71% for Hispanic, 52% for Asian American and 59% for Multiracial adults. Education levels also differed significantly among race and ethnicity groups (overall $P < 0.01$). The proportion with college education or more were 64% for White, 41% for African American, 36% for Hispanic, 83% for Asian American and 50% for Multiracial adults. The BMI and waist circumference distributions also differed significantly among race and ethnicity groups (overall $P < 0.01$ for both). Lastly, the prevalence of hypertension, low HDL cholesterol, family history of diabetes, high sugar sweetened beverage consumption, low exercise and food insecurity, was high in all groups.

Psychosocial differences at baseline are presented by race/ethnicity in Table 2. Mean autonomous motivation was 6.5–6.8 on a 1–7 scale in all racial/ethnic groups and was slightly higher among Hispanic adults (6.8; 95% CI: 6.6–7.1), compared to White adults (6.5; 6.4–6.6). Mean range of controlled motivation was 2.5–3.3 on a 1–7 scale and was slightly lower among multi-racial/other adults (2.5; 2.0–3.0) compared to White adults (3.3; 3.1–3.5). Similarly, self-efficacy to prevent diabetes for all groups had a mean range of 5.7–6.3 on a 1–7 scale, and was slightly higher in African American adults (6.1; 5.9–6.4) and multi-racial/other adults (6.3; 5.9–6.8) compared to White adults (5.7; 5.5–5.9). Perceived social support was similar across groups (mean range 45.0–49.5 on a 12–72 scale). Lastly, activation scores were similar in all groups (mean range 65.5–72.4 on a 0–100 scale). We also evaluated mean differences in psychosocial variables by sex and found that women had lower controlled motivation (2.7; 2.5–3.0) compared to men (3.2; 2.9–3.5), and higher activation (70.9; 68.4–73.4) compared to men (66.7; 63.6–69.9) and these differences were similar across racial/ethnic groups (results not shown).

We ran additional exploratory models to test whether there were race/ethnicity and income interactions. Pearson or Spearman correlations between clinical and psychosocial characteristics and annual household income level are presented in Table 3. We found significant and negative linear correlations between income level and all clinical variables; however, there were no significant correlations between income and the psychosocial measures of interest (Table 3).

The adjusted means of HbA1c, anthropometric measures and psychosocial characteristics by race/ethnicity and annual household income levels are presented in Table 4. Association trends or interactions were not significant for autonomous motivation or self-efficacy. Controlled motivation and perceived social support were inversely associated with income in the combined sample, but the associations did not reach statistical significance (P for trend = 0.06, and 0.07, respectively). And lastly, activation was not associated with income in the combined sample, but we found activation was negatively associated with income among White adults (P for trend = 0.05), but positively associated with income among African American adults (P for trend < 0.01).

4. Discussion

In this cross-sectional study of adults ages 18–85 with prediabetes enrolled in a peer-support diabetes prevention RCT, we found that at study enrollment, participants had high levels of autonomous motivation and self-efficacy, and intermediate levels of controlled motivation, perceived social support and activation. We also found racial/ethnic minority groups had similar psychosocial measures compared to White adults, though Hispanic adults had slightly higher autonomous motivation and African American adults had slightly higher self-efficacy compared to White adults.

This study adds to the limited body of literature of psychosocial characteristics in adults with prediabetes. Prior studies only included one or two of these measures (autonomous and controlled motivation,

Table 1
UPSTART participant demographic, clinical and psychosocial baseline characteristics by race/ethnicity.

Characteristics	Combined (N = 336)	White (N = 138, 41%)	African American (N = 116, 35%)	Latino/Hispanic (N = 31, 9.2%)	Asian American/HI/Pacific Islander (N = 29, 8.6%)	Multiracial, or Other (N = 22, 6.5%)	P value
Demographics							
Age, years	57.0 [46.5–65.0]	61.5 [52.0–68.0]	54.0 [42.5–62.0]	53.0 [44.0–62.0]	50.0 [46.0–58.0]	53.5 [34.0–60.0]	<0.01 ^a
Female sex	62	51	74	71	52	59	<0.01 ^b
Annual household income							<0.01 ^b
\$0–\$55,000	38	25	56	39	21	36	
\$56,000–100,000	24	28	22	19	14	27	
>\$100,000	30	38	15	32	52	23	
Refused	7	4.3	6.9	9.7	14	14	
Missing	1.8	4.3	0	0	0	0	
Education							<0.01 ^b
Less than college	43	32	59	65	10	46	
College or more	54	64	41	36	83	50	
Missing	2.7	4.3	0	0	6.9	4.5	
Clinical							
HbA1c, %	5.9 [5.8–6.1]	5.9 [5.7–6.0]	5.9 [5.8–6.1]	5.9 [5.7–6.2]	5.9 [5.7–6.1]	6.0 [5.7–6.1]	0.15 ^a
HbA1c, mmol/mol	41 [40–43]	41 [39–42]	41 [40–43]	41 [39–44]	41 [39–43]	42 [39–43]	0.15 ^a
BMI, kg/m ²	33.0 [29.3–37.3]	33.1 [29.3–36.1]	34.5 [30.5–40.2]	31.3 [29.2–35.7]	27.4 [25.9–31.5]	33.3 [29.8–38.1]	<0.01 ^a
Overweight ^d	28	28	19.8	32	55	27	<0.01 ^b
Obese ^e	72	72	80	68	45	73	<0.01 ^b
Waist circumference ^f , cm	111.3 (17.7)	113.9 (17.5)	111.6 (17.5)	106.6 (13.1)	95.4 (11.9)	118.6 (22.2)	<0.01 ^c
>88 (women)	91	93	92	91	67	89	0.14 ^b
>102 (men)	75	86	74.1	56	40	63	0.02 ^b
Missing	15	17	8.6	3.2	35	23	
Hypertension ^g	18	19	23	7.1	7.4	15.8	0.17 ^b
Low HDL cholesterol ^h	36	41	23	40	50	33	0.04 ^b
Family history of diabetes							0.05 ^b
Yes	44	38	53	39	41	46	
No	47	53	40	39	48	55	
Unknown/non- response	8.9	8.7	6.9	22.6	10.3	0	
Behavioral							
SSB consumption	6.0 [0.0–22.5]	4.0 [0.0–14.9]	15.4 [4.0–34.7]	2.0 [0.0–12.9]	1.0 [0.0–5.0]	7.2 [4.0–43.0]	<0.01 ^a
Missing	0.6	0.7	0.9	0	0	0	
Exercise, min/week	90 [15–180]	90 [30–180]	60 [0–135]	135 [0–225]	60 [20–160]	110 [60–150]	0.01 ^a
Missing	0.6	0	1.7	0	0	0	
Smoking history							0.02 ^b
Current	6.3	3.6	6.9	9.7	3.4	18	
Former	22	30	19	19	0	18.2	
Never	68	64	68	65	93	59	
Unknown/non- response	4.5	2.9	6.0	6.5	3.4	4.5	
Psychosocial							
Autonomous motivation	6.8 [6.3–7.0]	6.8 [6.3–7.0]	7.0 [6.3–7.0]	7.0 [6.8–7.0]	6.8 [6.5–7.0]	7.0 [6.8–7.0]	0.02 ^a
Controlled motivation	3.0 [2.0–4.0]	3.1 [2.3–4.1]	2.7 [1.9–3.7]	3.0 [2.0–4.0]	3.1 [2.0–4.0]	2.4 [1.4–3.6]	0.06 ^a
Self-efficacy	6.0 [5.0–7.0]	6.0 [5.0–7.0]	6.5 [5.3–7.0]	6.3 [5.3–7.0]	6.3 [5.5–7.0]	6.8 [5.8–7.0]	0.04 ^a
Perceived social support	46.7 (11.5)	46.7 (11.1)	46.7 (11.6)	46.8 (9.6)	44.6 (12.9)	49.7 (13.9)	0.64 ^c
Activation	67.6 (13.7)	66.1 (11.6)	67.0 (14.9)	69.8 (14.8)	70.7 (13.6)	72.9 (16.1)	0.64 ^c
Social determinants of health							
Food insecurity	17	10	22	13	14	36	<0.01 ^b

Data are mean (SD), median [interquartile range], or percent. UPSTART, Using Peer Support to Aid in Prevention and Treatment in Prediabetes; BMI, body mass index; HTN, hypertension; HDL, high-density lipoprotein; SSB, sugar-sweetened beverage.

^a P value for Kruskal-Wallis tests for non-normally distributed continuous variables.

^b P value for Chi-Square tests for categorical variables.

^c P value for ANOVA tests for normally distributed continuous variables.

^d Overweight BMI 25–29.9 kg/m², or 23–27.4 among Asian American, Native Hawaiian, or Pacific Islander participants.

^e Obese BMI ≥ 30 kg/m², or ≥ 27.5 among Asian American, Native Hawaiian, or Pacific Islander participants.

^f Waist circumference was not measured in 50 adults due to protocol modifications as a result of the SARS-CoV-2 pandemic.

^g Defined as ≥ 130/≥80 mmHg regardless of hypertension medications.

^h Defined as < 40 mg/dL in men, <50 mg/dL in women.

Table 2
Adjusted^a mean (95% CI) of clinical diabetes risk factors and psychosocial characteristics by race/ethnicity.

Characteristic	Combined (n = 336)	White (n = 138)	African American (n = 116)	Latino/Hispanic (n = 31)	Asian American/HI/Pacific Islander (n = 29)	Multi-Racial, or Other (n = 22)
HbA1c, %	5.9 (5.9, 6.0)	5.9 (5.9, 5.9)	6.0 (5.9, 6.0) ^b	6.0 (5.9, 6.0)	6.0 (5.9, 6.0)	6.0 (5.9, 6.1)
HbA1c, mmol/mol	41 (41, 42)	41 (41, 41)	42 (41, 42) ^b	42 (41, 42)	42 (41, 42)	42 (41,43)
BMI, kg/m ²	34.2 (33.4,34.9)	34.3 (33.2, 35.4)	34.9 (33.6, 36.2)	32.4 (30.1, 34.7)	28.3 (25.9, 30.6) ^b	33.6 (31.0, 36.3)
Waist circumference ^c , cm	111.3 (109.2,113.4)	114.4 (110.7, 118.1)	112.5 (108.6, 116.5)	108.2 (101.7, 114.7)	95.8 (88.1, 103.5) ^b	118.3 (109.9, 126.6)
Autonomous motivation	6.6 (6.5,6.6)	6.5 (6.4, 6.6)	6.6 (6.4, 6.7)	6.8 (6.6, 7.1) ^b	6.6 (6.4, 6.8)	6.7 (6.4, 6.9)
Controlled motivation	3.0 (2.9,3.2)	3.3 (3.1, 3.5)	3.0 (2.7, 3.2)	3.2 (2.7, 3.6)	3.1 (2.6, 3.5)	2.5 (2.0, 3.0) ^b
Self-efficacy	6.0 (5.9,6.1)	5.7 (5.5, 5.9)	6.1 (5.9, 6.4) ^b	6.0 (5.6, 6.4)	6.1 (5.7, 6.5)	6.3 (5.9, 6.8) ^b
Perceived social support	46.7 (45.5,48.0)	46.6 (44.5, 48.6)	46.3 (43.9, 48.7)	46.5 (42.3, 50.7)	45.0 (40.7, 49.4)	49.5 (44.6, 54.4)
Activation	67.6 (66.1,69.1)	65.5 (63.1, 67.9)	65.8 (63.0, 68.6)	69.2 (64.3, 74.2)	71.3 (66.2, 76.4)	72.4 (66.7, 78.1)

^a Values are least square means for each characteristic, adjusted by age, sex and clinic.

^b Different from White ($P < 0.05$), adjusted for multiple comparisons using Dunnett method.

^c Waist circumference was not measured in 50 participants due to protocol modifications as a result of the SARS-CoV-2 pandemic; $N = 286$.

Table 3
Correlations between each characteristic and annual household income level^a.

Characteristic	Income	P value
HbA1cb	-0.150	<0.01
BMI ^b , kg/m ²	-0.241	<0.01
Waist circumference ^c , cm	-0.174	<0.01
Autonomous motivation ^b	-0.028	0.62
Controlled motivation ^b	-0.099	0.08
Self-efficacy ^b	-0.053	0.36
Perceived social support ^c	0.060	0.30
Activation ^c	-0.001	0.98

^a Income levels: \$0–55,000, \$56,000–\$100,000, >\$100,000.

^b Spearman's correlation computed.

^c Pearson's correlation computed.

self-efficacy, perceived social support and activation), and none included all five measures. For instance, in a prior study by our group among University of Michigan employees identified to have prediabetes during a workplace screening, we found higher levels of motivation and identifying as White were associated with behavior modification 3 months after their screening (Kullgren et al., 2016). These behaviors included attempting to lose weight, increasing exercise, asking their doctor about metformin or attending a Diabetes Prevention Program. Aside from this US based study, a few additional studies that evaluated motivation, self-efficacy, or social support among populations with prediabetes were conducted outside of the US. In a 2007 Australian study among adults volunteering to be part of an intervention, investigators found that Anglo-Australian adults had higher levels of self-efficacy in relation to exercise, compared to Chinese-Australians (Hackworth et al., 2007). However, in their study, Anglo-Australian adults had a higher BMI and more cardiometabolic syndrome than Chinese-Australians. This higher diabetes risk may have explained the higher likelihood in engaging in physical activity compared to Chinese-Australians. And more recently in a cross-sectional study done in Uganda among adults with prediabetes or T2DM, investigators found autonomous motivation was associated with vigorous physical activity (De Man et al., 2020). And lastly, in a longitudinal study in Finland, women had higher baseline levels of social support compared to men, and low social support in young adulthood was associated with a higher risk of prediabetes about 11 years later among women (Serlachius et al., 2017).

In contrast to the limited body of literature evaluating race/ethnic differences in psychosocial characteristics among adults with prediabetes, more work was done in adults with diagnosed T2DM. However, these were limited to social support and self-efficacy and have mixed results. For instance, a study found White adults had higher levels of

social support compared to African American and Hispanic adults (Misra and Lager, 2009); by contrast in the present study we found no race/ethnicity or income differences in perceived social support. In a diabetes self-management trial, investigators found that at baseline, social support was higher in African American adults compared to White adults, and self-efficacy in diabetes self-management was similar between these two groups (Hausmann et al., 2010). By contrast in the present study, we found self-efficacy was higher among African Americans. Similar to the present study, using NHANES 2005–2006 data of adults with diabetes, investigators found no differences in social support among White, Hispanic or African American adults (Rees et al., 2010). And lastly, among California adults with diabetes participating in the 2009 California Health Interview Survey, Asian American adults had lower levels of self-efficacy compared to White adults with African American and Hispanic adults falling in between these groups (Kim et al., 2015). These trends were similar in our study.

Within populations with T2DM, extensive work evaluating the association between these five psychosocial measures in relation to behavior modifications over time were conducted, but these did not examine differences by race/ethnicity. For example, a recent meta-analysis of interventional studies found that increases in autonomous motivation were positively associated physical activity changes, and to a lesser extent dietary behaviors and smoking abstinence (Ntoumanis et al., 2021). Likewise, in other studies, higher self-efficacy was positively associated with diabetes self-care (Walker et al., 2015), less diabetes distress over time (Wang et al., 2017), better adherence with subsequent improved glycemic control (Nakahara et al., 2006), and improved management including a healthier diet, more exercise and self-monitoring of blood glucose and foot care (Sarkar et al., 2006). Moreover, social support influenced adherence and glycemic control through self-efficacy (Nakahara et al., 2006). Lastly, research showed activation was positively associated with healthy behaviors, a higher likelihood of performing self-management behaviors and higher medication adherence (Mosen et al., 2007), and with higher rates of self-care behaviors and ease in managing diabetes (Rask et al., 2009). In our current study we are unable to examine the association between psychosocial measures and diabetes outcomes over time, but that is an objective of future work.

Diabetes risk factors were common in our study population. Like prior studies, racial/ethnic minority groups had more risk factors compared to White adults. In particular, we found African American adults had increased diabetes risk factors and behavior change barriers compared to White adults, including a higher BMI distribution, lower income levels and educational attainment, higher family history of diabetes, higher sugary beverages consumption, fewer exercise, and higher food insecurity. Having higher self-efficacy and autonomous

Table 4
Clinical diabetes risk factors and psychosocial characteristic means^a by race/ethnicity and annual household income level.

Characteristic	Combined (n = 306)	White (n = 126)	African American (n = 108)	Latino/Hispanic (n = 28)	Asian American/HI/Pacific Islander (n = 25)	Multi-Racial, or Other (n = 19)
HbA1c, %, 0.49 ^b						
\$0–\$55,000	6.0 (6.0, 6.1)	5.9 (5.9, 6.0)	6.0 (5.9, 6.1)	6.0 (5.9, 6.2)	6.0 (5.9, 6.2)	6.0 (5.9, 6.2)
\$56,000–100,000	5.9 (5.8, 6.0)	5.9 (5.8, 6.0)	6.0 (5.9, 6.1)	5.9 (5.7, 6.1)	5.8 (5.6, 6.0)	5.9 (5.8, 6.1)
>\$100,000	5.9 (5.9, 6.0)	5.9 (5.8, 5.9)	6.0 (5.9, 6.1)	5.8 (5.7, 6.0)	6.0 (5.9, 6.1)	6.0 (5.9, 6.2)
P for trend ^d	0.01	0.31	0.67	<0.01	0.92	0.94
BMI, kg/m ² , 0.99 ^b						
\$0–\$55,000	33.6 (31.8, 35.3)	35.0 (32.7, 37.4)	35.7 (33.8, 37.5)	32.8 (29.0, 36.6)	28.8 (23.6, 34.0)	35.5 (31.0, 40.0)
\$56,000–100,000	32.8 (30.8, 34.9)	34.2 (32.1, 36.3)	34.6 (32.0, 37.1)	32.3 (27.1, 37.5)	29.9 (23.6, 36.2)	33.2 (28.1, 38.4)
>\$100,000	32.0 (30.2, 33.7)	33.7 (31.9, 35.4)	34.6 (31.5, 37.7)	32.6 (28.5, 36.6)	27.2 (23.9, 30.5)	31.7 (26.1, 37.4)
P for trend ^d	0.08	0.38	0.92	0.79	0.12	0.35
Waist circumference ^c , cm 0.99 ^b						
\$0–\$55,000	112.8 (107.7, 118.0)	116.6 (110.3, 123.0)	116.6 (111.5, 121.7)	110.9 (101.1, 120.7)	97.2 (81.2, 113.1)	122.8 (110.3, 135.3)
\$56,000–100,000	106.3 (99.8, 112.8)	110.3 (104.4, 116.3)	110.4 (103.3, 117.5)	105.2 (91.9, 118.5)	91.5 (68.7, 114.4)	114.1 (98.1, 130.2)
>\$100,000	107.1 (101.6, 112.5)	113.1 (107.8, 118.4)	109.2 (101.2, 117.3)	108.5 (97.7, 119.2)	93.2 (83.5, 102.9)	111.3 (92.6, 130.0)
P for trend ^d	0.04	0.38	0.32	0.80	0.37	0.35
Autonomous motivation, 0.69 ^b						
\$0–\$55,000	6.7 (6.5, 6.8)	6.8 (6.5, 7.0)	6.5 (6.4, 6.7)	6.8 (6.5, 7.2)	6.7 (6.2, 7.2)	6.6 (6.1, 7.0)
\$56,000–100,000	6.7 (6.5, 6.9)	6.6 (6.4, 6.8)	6.7 (6.5, 7.0)	6.9 (6.4, 7.4)	6.5 (5.9, 7.1)	6.8 (6.3, 7.3)
>\$100,000	6.6 (6.4, 6.8)	6.4 (6.3, 6.6)	6.5 (6.2, 6.8)	6.7 (6.3, 7.1)	6.6 (6.3, 6.9)	6.7 (6.2, 7.2)
P for trend ^d	0.15	0.04	0.95	0.50	0.48	0.91
Controlled motivation, 0.21 ^b						
\$0–\$55,000	3.4 (3.1, 3.8)	3.4 (2.9, 3.8)	3.1 (2.8, 3.5)	3.8 (3.0, 4.5)	4.2 (3.2, 5.1)	2.8 (1.9, 3.6)
\$56,000–100,000	2.8 (2.4, 3.1)	3.2 (2.8, 3.6)	3.1 (2.7, 3.6)	2.8 (1.8, 3.8)	2.4 (1.2, 3.6)	2.3 (1.4, 3.3)
>\$100,000	2.8 (2.4, 3.1)	3.3 (2.9, 3.6)	2.5 (1.9, 3.1)	2.5 (1.7, 3.2)	2.8 (2.2, 3.4)	2.7 (1.6, 3.8)
P for trend ^d	0.06	0.85	0.10	0.13	0.04	0.47
Self-efficacy, 0.81 ^b						
\$0–\$55,000	6.1 (5.8, 6.4)	5.8 (5.4, 6.2)	6.0 (5.7, 6.3)	5.9 (5.3, 6.5)	6.1 (5.3, 7.0)	6.6 (5.8, 7.3)
\$56,000–100,000	6.2 (5.9, 6.6)	5.9 (5.5, 6.2)	6.2 (5.8, 6.6)	6.5 (5.6, 7.3)	6.5 (5.4, 7.5)	6.2 (5.3, 7.0)
>\$100,000	6.1 (5.8, 6.4)	5.6 (5.3, 5.9)	6.4 (5.9, 6.9)	6.1 (5.4, 6.7)	6.1 (5.5, 6.6)	6.3 (5.3, 7.2)
P for trend ^d	0.46	0.34	0.17	1.00	0.28	0.33
Perceived social support, 0.47 ^b						
\$0–\$55,000	43.5 (40.3, 46.6)	44.4 (40.2, 48.6)	44.6 (41.2, 47.9)	45.9 (39.0, 52.7)	33.6 (24.3, 42.9)	48.9 (40.7, 57.0)
\$56,000–100,000	48.9 (45.3, 52.5)	49.1 (45.3, 52.8)	47.2 (42.7, 51.7)	46.3 (36.9, 55.6)	46.3 (35.0, 57.7)	55.6 (46.3, 64.9)
>\$100,000	47.5 (44.4, 50.6)	46.1 (42.9, 49.2)	49.7 (44.1, 55.3)	46.7 (39.5, 53.9)	48.3 (42.4, 54.3)	46.7 (36.6, 56.9)
P for trend ^d	0.07	0.86	0.07	0.54	<0.01	0.88
Activation, <0.01 ^b						
\$0–\$55,000	69.2 (65.7, 72.8)	69.6 (64.9, 74.4)	63.1 (59.3, 66.9)	66.7 (59.0, 74.4)	69.9 (59.4, 80.4)	76.9 (67.7, 86.1)
\$56,000–100,000	70.2 (66.1, 74.3)	64.8 (60.6, 69.1)	65.3 (60.1, 70.4)	76.3 (65.7, 86.9)	78.1 (65.3, 90.9)	66.6 (56.1, 77.1)
>\$100,000	70.0 (66.5, 73.5)	64.5 (60.9, 68.1)	79.4 (73.0, 85.7)	69.7 (61.6, 77.9)	70.5 (63.8, 77.2)	65.8 (54.3, 77.3)
P for trend ^d	0.49	0.05	<0.01	0.51	0.93	0.51

^a Values are least square means (95% CI) for each characteristic, adjusted by age, sex and clinic and with an interaction term between race/ethnicity and annual household income level.

^b P value for likelihood ratio test of interaction between race/ethnicity and income level.

^c Missing measurements for 43 participants due to protocol modifications as a result of the SARS-CoV-2 pandemic, N = 263.

^d P value for linear trend by income level were calculated with the use of linear regression, adjusting for age, sex and clinic.

motivation and lower controlled motivation are not likely to improve diabetes outcomes unless other social and structural barriers are simultaneously and systematically addressed. Our findings reinforce the critical importance of addressing such barriers to improve health outcomes among African American and Hispanic adults.

4.1. Limitations

Our study has limitations. First, the psychosocial questionnaires were adapted from research conducted in T2DM management, and have not been previously validated among patients with prediabetes. Nevertheless, similar behaviors overlap between T2DM prevention and management and the concepts are rooted in behavior modification, thus we are confident the questionnaires were appropriate for our study population. Second, we conducted our analyses in the complete case only, though missing data was only approximately 4% of our sample. Model diagnostics showed that missing data was at random with the exception that slightly more women refused to provide their annual household income. In our race/ethnicity by income interaction models we excluded 25 participants who refused to provide their annual household income;

19/25 of whom were women. Our results may be biased, however, given that this missing data represented only 7% of our sample, we would not expect our results to qualitatively change. Third, Hispanic, Asian American and multi-racial adults included fewer participants, thus we lacked sufficient power to detect interactions between psychosocial measures and income categories. Fourth, history of diabetes included any type of diabetes among any relative, which likely overestimated the history of T2DM among first-degree relatives. Further given that adults from racial and ethnic minority groups are more likely than White adults to have undiagnosed diabetes (Cheng et al., 2019), we would expect a larger degree of underreporting among minority groups. And lastly, the literature does not provide a clear explanation for our finding that African American adults reported slightly higher levels of self-efficacy compared to White adults; we believe that this warrants additional investigation. Given that African American adults reported higher diabetes risk factors (e.g., higher levels of food insecurity, engaging in less physical activity, and consuming more sugary sweetened beverages), which may act as barriers to behavior modification, we expected lower levels of self-efficacy to be reported by this group. Evaluating the association between baseline levels of these psychosocial characteristics, or

changes over time with engagement in the peer support intervention and with changes in diabetes risk factors, and if these associations vary by race and ethnicity, are important topics for future research.

5. Conclusion

In a diverse cohort of adults with prediabetes enrolled in a diabetes prevention RCT, we found participants had high levels of autonomous motivation and self-efficacy at baseline. African American and Hispanic participants had higher reported positive psychosocial characteristics than White participants. This suggests a significant opportunity to engage a diverse population of adults in diabetes prevention strategies and reduce diabetes incidence. However, Hispanic and African American participants experienced greater diabetes risk factors and social barriers which may impede behavior change. Future diabetes prevention efforts should aim to simultaneously address such barriers while promoting positive psychosocial attributes such as autonomous motivation and self-efficacy to reduce diabetes incidence.

CRediT authorship contribution statement

Luis A. Rodriguez: Conceptualization, Methodology, Visualization, Writing – original draft. **Tainayah W. Thomas:** Conceptualization, Methodology, Writing – review & editing. **Holly Finertie:** Software, Formal analysis, Writing – original draft. **Cassie D. Turner:** Writing – review & editing. **Michele Heisler:** Conceptualization, Supervision, Funding acquisition, Writing – review & editing. **Julie A. Schmittiel:** Conceptualization, Supervision, Funding acquisition, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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