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Use and Impact of Type 2 Diabetes Prevention Interventions

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Abstract

Introduction: RCTs have found that type 2 diabetes can be prevented among high-risk individuals by metformin medication and evidence-based lifestyle change programs. The purpose of this study is to estimate the use of interventions to prevent type 2 diabetes in real-world clinical practice settings and determine the impact on diabetes-related clinical outcomes.

Methods: The analysis performed in 2020 used 2010–2018 electronic health record data from 69,434 patients aged ≥18 years at high risk for type 2 diabetes in 2 health systems. The use and impact of prescribed metformin, lifestyle change program, bariatric surgery, and combinations of the 3 were examined. A subanalysis was performed to examine uptake and retention among patients referred to the National Diabetes Prevention Program.

Results: Mean HbA1c values declined from before to after intervention for patients who were prescribed metformin (−0.067%; $p<0.001$) or had bariatric surgery (−0.318%; $p<0.001$). Among patients referred to the National Diabetes Prevention Program lifestyle change program, the type 2 diabetes postintervention incidence proportion was 14.0% for nonattendees, 12.8% for some

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attendance, and 7.5% for those who attended ≥4 sessions (p<0.001). Among referred patients to the National Diabetes Prevention Program lifestyle change program, uptake was low (13% for 1–3 sessions, 15% for ≥4 sessions), especially among males and Hispanic patients.

Conclusions: Findings suggest that metformin and bariatric surgery may improve HbA1c levels and that participation in the National Diabetes Prevention Program may reduce type 2 diabetes incidence. Efforts to increase the use of these interventions may have positive impacts on diabetes-related health outcomes.

INTRODUCTION

An estimated 88 million U.S. adults have prediabetes, which puts them at an increased risk for developing type 2 diabetes and other serious health conditions, including heart disease and stroke.[1,2] Studies have found that type 2 diabetes disproportionately impacts racial and ethnic minority communities and low-income populations in the U.S.[3,4]

Encouragingly, findings from RCTs show that prediabetes can be reversed and that type 2 diabetes can be prevented or delayed among high-risk individuals by metformin medication, evidence-based lifestyle change programs (LCPs), or bariatric surgery.[5-10] LCPs are widely recommended for diabetes prevention owing to the strong evidence base showing that they are effective in preventing type 2 diabetes and because LCPs are often provided at little or no out-of-pocket costs for patients.[11-15] However, relatively little is known about how findings from these RCTs translate into type 2 diabetes prevention and improvement in related cardiometabolic outcomes in clinical practice settings and how varying levels of real-world participation in these interventions—individually or in combination—impact health outcomes.[16,17]

The Centers for Disease Control and Prevention (CDC) National Diabetes Prevention Program (NDPP) has become the largest LCP in the U.S. with a focus on diet and physical activity to reduce weight.[18] However, patient retention with the NDPP has been low, especially among members of ethnic/racial minority populations and younger individuals.[19]

The purpose of this descriptive study using electronic health record (EHR) data was to examine the use and impact of the 3 type 2 diabetes prevention interventions on HbA1c, BMI, and diabetes onset among diverse, lower-income patients at elevated risk for type 2 diabetes in real-world clinical settings, overall and by demographic subgroups.

METHODS

The study used the Longitudinal Epidemiologic Assessment of Diabetes Risk (LEADR) database of standardized EHR data for >2 million unique patients from 2010 to 2018. The LEADR database is designed to examine patient-level risk factors for type 2 diabetes among U.S. adults and includes information on demographic, socioeconomic, and clinical characteristics; laboratory results; medical procedures; diagnoses; and prescribed medications. Patients included in the LEADR database are those aged ≥18 years as of 2010, with ≥4 clinical encounters across ≥24 months, and with no indication of type 2 diabetes within 12 months of cohort entry nor type 1 diabetes at any time.[20]

Study Population

The subset of the LEADR database for this study was 270,973 adult patients from 2 large healthcare systems, MetroHealth in Ohio and Denver Health in Colorado, selected because these systems were able to provide a data flag to identify patients referred to the NDPP. This flag was not in the LEADR database because such referral information is not routinely collected in the EHR. Each health system serves large populations of uninsured, Medicaid, and other vulnerable patients and is thus considered a safety-net provider by their state. More specifically, the proportion of adult patients on Medicaid is approximately 35% for MetroHealth and 44% for Denver Health.

After excluding 46,756 patients who did not have ≥1 BMI value in the data, the source population was 224,217 patients. From there, the sample was restricted to include patients who were at high risk for developing type 2 diabetes using the following criteria: (1) *overweight* defined as BMI ≥25 kg/m^2 for non-Asian persons and BMI ≥23 kg/m^2 for Asian persons (or BMI ≥24 kg/m^2 for non-Asian persons and BMI ≥22 kg/m^2 for Asian persons if before March 2018, when guidelines were updated) and at least 1 of the following: (1a) prediabetes (i.e., HbA1c=5.7–6.4% [39–46 mmol/mol]), fasting plasma glucose of 100–125 mg/dL, or a diagnosis code of prediabetes (International Classification of Diseases, Ninth Revision=790.2x or ICD-10=R73.03); (1b) previous gestational diabetes; or (1c) score ≥3 of the following risk factors (as a proxy for commonly used prediabetes risk questionnaires): obesity (BMI ≥30 kg/m^2), high blood pressure, family history of type 2 diabetes, male sex, or age ≥50 years. The risk factor score (or count) was used to replicate, as close as possible from the available data, the criteria established by CDC for patient eligibility to receive the NDPP.[21] Patients who met the overweight inclusion criteria only but who were referred to the NDPP LCP were also included in the sample. BMI and laboratory measurements during pregnancy were not used. There were 69,434 patients who met the eligibility criteria for study inclusion. The distribution of eligibility criteria can be found in Appendix Figure 1 (available online). A patient's time in the study starts at the date of their first appearance in the data and ends with the date of last encounter or diagnosis of type 2 diabetes.

Measures

Patients were categorized into 8 mutually exclusive intervention groups on the basis of their EHR data before type 2 diabetes onset. The intervention groups were: (1) no intervention, (2) metformin (prescribed with no other antidiabetic medications), (3) LCP: 1 session, (4) LCP: 2–5 sessions, (5) LCP: ≥6 sessions, (6) bariatric surgery, (7) metformin and ≥1 LCP session, and (8) bariatric surgery and metformin.

Prescriptions for metformin medication not prescribed during pregnancy were found in the EHR drug file. Metformin that was used in combination with another antidiabetic agent was excluded. LCP use was categorized into the number of sessions, which included visit observations in the EHR (not during pregnancy) for (1) NDPP LCP, (2) weight control education, (3) counseling for diabetes risk factor reduction, (4) medical nutrition therapy, (5) type 2 diabetes prevention education, and (6) health and behavior intervention. When there were a gap ≥6 months between 2 LCP sessions, the second session date was set as the start of a new program, not a continuation of the original program. For analysis, we used the latest program that had ≥3 months of follow-up time. Observational Medical Outcomes Partnership codes were also used to find laparoscopic gastric restrictive procedures and other bariatric surgeries from the EHR procedure files.

Within the LEADR database, *diagnosed* or *undiagnosed type 2 diabetes* was defined using the following criteria: (1) 2 diagnosis codes of type 2 diabetes or unspecified diabetes ≥14 days apart or (2) prescription for metformin or glucagon-like peptide-1 agonists and diagnosis of diabetes on any encounter (activities <14 days apart) or (3) prescription for an antidiabetic agent or (4) HbA1c ≥6.5% (48 mmol/mol) or (5) fasting plasma glucose >126 mg/dL or (6) 2 random blood glucose >200 mg/dL or (7) 1 random blood glucose >250 mg/dL. Detailed definitions of diabetes and prediabetes used in this study are provided in Appendix Table 1 (available online).

Because socioecologic factors are associated with increased prediabetes and other diabetes risks, the Social Vulnerability Index (SVI) linked to each patient's ZIP code was included in the analysis.[22] The SVI provides a ranking on the basis of 15 area-level social factors such as poverty, lack of vehicle access, and crowded housing. Patient characteristics included age, sex, self-reported race/ethnicity, the Charlson–Devo comorbidity index,[23] and a self-reported family history of diabetes recorded in the EHR. Detailed definitions of overall SVI and the Charlson–Deyo comorbidity index are provided in Appendix Table 2 (available online).

Statistical Analysis

The changes in group-level mean HbA1c and BMI were calculated among patients who had these values both during the baseline (before intervention start date) and follow-up (after the middle of intervention time), resulting in 2 subsamples. For this analysis, there were 3 timeframes: (1) baseline, (2) first half of the intervention period, and (3) follow-up (Appendix Figure 2, available online). A follow-up timeframe including the second half of the intervention period allowed for the metformin group, with a longer or ongoing duration of intervention, to also have a follow-up timeframe necessary to find at least 1 HbA1c and BMI measurement after the intervention. Paired *t*-tests were used to assess significant changes ($p<0.001$) between baseline and follow-up in mean HbA1c and BMI values by group.

Using NDPP referral data and distinct Observational Medical Outcomes Partnership codes for NDPP LCP in the LEADR database, data from a subset of patients who were referred to the NDPP LCP were analyzed to assess their uptake, volume of use, and overlap with metformin or bariatric surgery. Referred patients were invited to attend ≥22 in-person classes (offered in English and Spanish) for more than 12 months (following CDC guidelines) free to all patients regardless of their insurance status. One clinic allowed patients to attend NDPP LCP classes indefinitely. Virtual sessions and online delivery (e.g., application based) of NDPP LCP had not yet been implemented at the 2 health systems during the study timeframe. Initially, this subanalysis applied CDC's current definition of a NDPP LCP participant who completed the program as someone who had ≥3 sessions during months 1–6 and had a span ≥9 months between the first and last session. However, using this requirement, the resulting sample was only 2% of referred patients. Therefore, a relaxed criterion was used to find high-use LCP patients: (1) ≥4 sessions attended within any span or (2) within ≥9-month span. The remaining patients who attended at least 1 LCP session were categorized as partial LCP. Patients without 1 session were categorized as no LCP attendance. Independent sample *t*-tests for continuous variables and chi-squared statistics for frequencies were used to determine significant differences ($p<0.001$) between group means.

All analyses used SAS, version 9.4. Because the LEADR database did not contain personal identifying information, the study was exempt from IRB full committee approval after review from the Colorado Multiple IRB.

RESULTS

Table 1 shows the demographic and clinical characteristics of the 69,434 adults in the analysis, overall and by intervention group. Two-fifths of the sample (39.5%) were non-Hispanic White persons, 33.2% were non-Hispanic Black persons, and 18.4% were Hispanic persons. The sample of patients was 50% female and had a mean of 5.9 years of EHR data. A total of 9% of patients (n=6,151) received an intervention that included metformin, LCPs, and/or bariatric surgery, the most common being metformin (4%), followed by LCP (1 session [2%]).

The LCP groups included a significantly lower percentage of non-Hispanic White patients than the no intervention group. The majority of the sample (67.6%) met study inclusion eligibility by being overweight and having prediabetes. The intervention groups all had significantly higher percentages of patients with prediabetes (range: 84.1%–100%) and higher mean BMI values (range: 38.1–51.9 kg/m^2) during the study period than the no intervention group with 65.9% for prediabetes and 34.9 kg/m^2 for mean high BMI.

Only 15% of patients (n=10,374) had available HbA1c results for comparisons before and after intervention. As shown in Table 2, the group-level changes in HbA1c percent values for the 3 LCP groups were not significant. There was a significant decrease (improvement) in the mean HbA1c percent value among patients in the metformin group (−0.07%), the bariatric surgery group (−0.32%), and the bariatric surgery and metformin group (−0.41%). In comparison, those receiving no intervention had a significant increase (worsening) in HbA1c (0.08%). For BMI change, 80.0% of patients (n=55,627) had available pre—post values. Bariatric surgery patients had a significant decrease in mean BMI (−8.07). No intervention patients had a significant increase in mean BMI (0.42). Among the metformin and LCP groups, mean BMI did not significantly change. More detailed information about the patient subsamples used for the HbA1c and BMI change analyses can be found in Appendix Table 3 (available online).

Among 4,753 patients referred to the NDPP, 72% (n=3,417) had no LCP attendance, 13% (n=627) had partial-use LCP, and 15% (n=709) had high-use LCP (Table 3). The patients in either of the 2 LCP-use groups were significantly ($p<0.001$) more likely to be female, have a family history of diabetes in the EHR, have higher BMI, have a less favorable comorbidity index, and be non-Hispanic Black than the patients with no attendance. On average, the high-use LCP group was significantly older than the partial LCP group (age 47.2 vs 44.5 years). Across racial/ethnic groups, no LCP attendance was found to be highest among Hispanic patients. For example, 56% of the referred patients were Hispanic; yet, they represented 60% of the no LCP attendance, which was a significantly higher representation than in the partial LCP and high-use LCP groups (50% and 42%, respectively.) Furthermore, the high-use LCP type 2 diabetes incidence proportion was significantly lower than no LCP attendance (7.5% vs 14.1%; $p<0.0001$) and lower than partial LCP (7.5% vs 12.8; $p=0.0013$). Comparisons of type 2 diabetes incidence proportions among more detailed LCP session group levels can be found in Appendix Table 4 (available online).

DISCUSSION

Only 9% of patients at elevated risk for type 2 diabetes used any kind of prevention intervention (metformin, LCP, bariatric surgery, or a combination of the 3). The most commonly used intervention was metformin, followed by 1 LCP session. Notable differences in LCP use were found across demographic and clinical subgroups. For example, attendance at any LCP was disproportionately lower among Hispanic patients, consistent with previous reports.[24] In addition, as shown in Table 1, patients prescribed metformin or any level of LCP were more likely to have prediabetes than those who received no intervention, suggesting that the health systems were successfully targeting patients in greatest need of prevention services. NDPP LCP use was lower among men than among women.

Evidence of statistically significant glycemic improvement was found among the patients who received standalone metformin or bariatric surgery. Although not statistically significant, glycemic improvement was also found among patients with ≥6 LCP sessions. Clinically, these findings support the use of these interventions to control HbA1c among patients diagnosed with prediabetes.

BMI increased significantly among patients who received no intervention. However, BMI did not change in the metformin and LCP groups. Because the time between intervention mid-date and the study end (i.e., follow-up) averaged 2–3 years for the metformin and LCP groups, it is possible that any immediate weight loss resulting from these interventions was not sustained long-term, as observed in previous studies.[14]

Among patients referred to the NDPP, the group of patients who attended ≥4 sessions of any LCP or attended for ≥9 months had a lower incidence proportion of type 2 diabetes than patients with no and partial attendance. These findings, coupled with the lack of weight loss and significant HbA1c reduction among the LCP groups, suggest that LCPs may improve health and/or body composition regardless of body size and preliminarily address the question of whether a delay or prevention of type 2 diabetes is possible in the absence of weight loss or significant HbA1c reduction.[25-27] Overall and relevant to practice, among patients at-risk for type 2 diabetes, the results suggest that metformin and/or LCPs may help to stop further risk progression.

The subanalysis of NDPP referrals showed that <1 in 4 patients referred to the program attended a session, and only 15% had ≥4 visits. These findings support the national effort to increase the awareness, promotion, and health insurance coverage of cost-effective LCPs such as the NDPP.[15,28,29] Because the NDPP LCP classes included in the analysis were held in-person and offered to patients free of charge in safety-net settings, attendance in this study may have been impeded by barriers such as lack of transportation and child care.[30] Thus, patient-centered adaptations are needed to address disparities in attendance among specific populations.[2,19] Virtually delivered sessions, which are common in the NDPP, may help to address socioeconomic barriers to in-person attendance. Other promising strategies to improve retention include introductory presessions, engaging a patient's household member(s) in the program, establishing a provider referral network, special population tailoring (e.g., culture- and gender-specific adaptions), and nonmonetary incentives (e.g., gym memberships).[31-33] More research and updated policies are also needed to increase provider referrals to diabetes prevention interventions for at-risk patients.[16]

Limitations

This study has limitations. The health systems used in this analysis were deidentifiable to the analysts, preventing an analysis of results by health system or provider. The systems represent a convenient sample from the larger LEADR database. The 2 health systems have relatively high levels of continuity over time, especially among the Medicaid population. However, a reliable, overall rate of patient churn during the study period was not available. Thus, the findings may not be representative of patient and provider patterns throughout all regions of the U.S. Physical and sedentary activity levels and perceived overall health were unavailable.[34] Overall, more nuanced factors that may be associated with participation and outcomes such as perceived self-efficacy, partner/social support for healthy habits, and barriers to attending visits, such as lack of transportation or work conflicts, cannot readily be captured through EHR-based studies. Piloted LCP programs were not captured in the EHR data, which may produce a small amount of mis-classification in the no-intervention group. The study was not able to examine bariatric surgery groups by LCP use. Despite being a requirement for bariatric surgery, only 15% of bariatric patients had documented LCP visits, suggesting that LCP may not be coded separately in the EHR. The metformin estimates do not exclude women with a history of polycystic ovary syndrome. In addition, patients who are prescribed metformin may not adhere to their prescribed medication. Descriptive statistics were used instead of modeling methods because the study was designed to focus on uptake and group-level incidence proportions rather than to examine individual type 2 diabetes risk. Thus, caution should be taken when interpreting the diabetes incidence proportions among the intervention groups owing to confounding by selection bias and indication (i.e., more intervention prescribed for those at greater risk).[35] Future real-world (nonrandomized) studies should explore various approaches to examining the comparative effectiveness of different type 2 diabetes interventions, such as propensity score analysis, to address the effects of confounding by indication.

CONCLUSIONS

This observational study found that the use of type 2 diabetes prevention services was low overall. In particular, among patients referred to attend free NDPP LCPs, men and Hispanic patients were engaging less than women and non-Hispanic patients. The study found that patients prescribed metformin and those who had bariatric surgery appeared to have decreased HbA1c levels. Patients who participated in LCP sessions, especially those with more intensive participation, appeared to have a lower incidence proportion of type 2 diabetes than patients who were referred but did not attend LCP, suggesting that the success of LCPs relies on uptake and retention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Patient Characteristics Among Study Eligible Population by Intervention Grouping

Characteristics	Entire sample	No intervention	Metformin	LCP:1 session	LCP:2–5 sessions	LCP:≥6 sessions	Bariatric surgery	Metformin and LCP	Bariatric surgery and metformin
Number of patients	69,434	63,283	2,681	1,482	950	543	250	203	42
% of sample	100	91	4	2	1	1	<1	<1	<1
Patient age	49.3	49.5	**47.9**	**46.3**	**46.4**	48.2	**41.5**	**43.7**	**33.1**
High-risk eligibility criteria met, %									
OW + prediabetes	67.6	65.9	**86.2**	**84.1**	**86.0**	**88.6**	**86.8**	**97.0**	**100**
OW + risk score ≥3	50.6	51.9	**43.3**	**35.7**	**37.0**	**28.2**	**25.2**	**29.1**	**4.8**
OW + National DPP referral	6.4	5.0	5.8	**19.3**	**32.3**	**64.3**	5.2	**37.0**	9.5
OW+ gestational diabetes	0.2	<1	<1	0.0	<1	0.0	0.0	0.0	0.0
Patient female sex, %	50.0	48.2	**64.9**	**66.5**	**71.4**	**79.2**	**82.4**	**80.3**	**90.5**
Highest BMI value (kg/m^2) during study, %	35.4	34.9	**38.1**	**39.6**	**44.1**	**47.2**	**49.6**	**43.5**	**51.9**
Family history of diabetes, %	46.6	46.7	44.8	43.7	46.3	**32.6**	**66.0**	39.9	59.5
Risk score (range: 0–5), %	2.3	2.4	2.3	**2.1**	**2.2**	**1.9**	**2.1**	**2.0**	**1.7**
Race/ethnicity, %									
Non-Hispanic White	39.5	40.4	**33.1**	**25.4**	**28.0**	**30.6**	44.4	**22.2**	33.3
Non-Hispanic Black	33.2	32.8	32.7	**44.8**	**42.0**	28.9	37.6	38.9	38.1
Hispanic	18.4	17.7	**24.4**	**23.7**	**24.4**	**37.8**	10.4	**33.0**	9.5
Other or multiracial	2.7	2.7	2.9	2.0	2.1	1.3	**0.0**	1.5	**0.0**
Missing/unknown/refused	6.2	6.3	6.9	**4.2**	**3.5**	**1.5**	7.6	4.4	19.1
Social vulnerability index[a]	0.56	0.55	**0.58**	**0.59**	**0.60**	0.57	0.56	0.60	0.60
Charlson comorbidity index[b]	2.4	2.3	2.4	**2.8**	**2.9**	2.4	2.5	2.7	3.7
Study years[c]	5.9	5.9	**5.3**	**7.0**	**7.1**	**8.0**	**6.9**	**7.1**	**7.5**

Note: Boldface indicates a statistically significant difference (p<0.001) in comparison with the no-intervention group using chi-square for percentages and t-test for means.

CCI, comorbidity index; DPP, Diabetes Prevention Program; LCP, lifestyle change program; OW, overweight.

[a]Lower Social Vulnerability Index scores are better and indicate more desirable social determinants of health. Range: 0–1.

[b]Lower CCI scores are better. CCI range: 0–25.

[c] Time between the first encounter in the data and the last encounter or type 2 diabetes onset in the data.

Table 2.

Changes in HbA1C (n=10,374) and BMI (n=55,627) Before and During/After Intervention

Characteristics	No intervention[a]	Metformin	LCP:[c] 1 Session	LCP: 2–5 sessions	LCP: ≥6 sessions	Bariatric surgery	Metformin and LCP	Bariatric surgery and metformin
Full studysample (n)	63,283	2,681	1,482	950	543	250	203	42
Consistent patients for HbA1c analysis (n)[b]	8,144	719	567	428	287	99	103	27
Number of HbA1c results per patient (baseline)	1.3	1.9	1.9	2.1	2.3	2.0	2.1	1.9
Number of HbA1c results per patient (follow-up)	1.4	1.9	2.2	2.1	1.9	1.8	1.9	1.8
Rounded mean of HbA1c % results (baseline)	5.70	5.90	5.79	5.81	5.85	5.75	5.90	5.87
Rounded mean of HbA1c % results (follow-up)	5.78	5.83	5.81	5.81	5.81	5.44	5.91	5.45
Change in mean HbA1c %	**0.081**	**−0.067**	0.019	0.002	−0.042	**−0.318**	0.009	**−0.412**
Consistent patients for BMI analysis (n)[b]	50,530	1,878	1,335	897	530	240	176	41
Number of BMI values per patient (baseline)	6.5	11.2	14.9	16.4	16.9	29.0	13.4	18.8
Number of BMI values per patient (follow-up)	8.2	8.0	15.2	16.4	13.8	19.1	13.3	25.8
Rounded mean of BMI kg/m^2 values (baseline)	32.4	36.3	34.4	36.3	37.0	46.6	38.4	47.4
Rounded mean of BMI kg/m^2 values (follow-up)	32.9	36.5	34.6	36.8	38.0	38.6	38.9	45.0
Change in mean BMI kg/m^2	**0.415**	0.204	0.132	0.431	0.981	**−8.073**	0.435	−2.374

Note: Boldface indicates statistical significance (p<0.001) using paired t-tests comparing baseline with follow-up means for each group.

LCP, lifestyle change program.

[a]For the no-intervention group, the baseline is a person's first one-third days, and follow-up is the last one-third days of the study.

[b]Patient had at least 1 value before and after intervention.

Table 3.

Characteristics and Lifestyle Change Program Use Among Patients Referred to National Diabetes Prevention Program

Characteristics	Not referred to NDPP	Referred to NDPP	No LCP attendance among referred	Partial LCP[a] among referred	High use LCP[b] among referred
Number of patients	64,681	4,753	3,417	627	709
Number of LCP sessions	0.1	1.7	0.0	1.6	10.5
LCP duration (months)	0.0	0.7	0.0	0.4	4.6
Study time period (years)	5.8	7.9	7.9	8.0	8.0
Patient age on January 2010 (range: 20–80 years)	49.6	44.8	44.5	44.2	**47.2** [c]
Other prevention intervention use, %					
Attended an LCP other than NDPP	3.0	3.9	**0.0** [d]	23.9	**5.1** [c]
Prescribed metformin	4.1	5.3	4.5	**9.1** [c]	5.4
Bariatric surgery	0.4	0.6	0.0	1.3	2.5
T2DM follow-up incidence proportion	17.2	12.9	14.0	12.8	**7.5** [c]
How study eligibility was met, %					
Overweight and prediabetes	46.7	81.5	84.4	78.9	**70.4** [c]
Overweight, prediabetes, risk score ≥3	18.8	14.7	13.1	16.8	**20.3** [c]
Overweight and risk score ≥3	34.2	3.0	2.4	2.9	**5.6** [c]
Overweight and NDPP referral (only)	0.0	0.7	0.0	1.4	**3.7** [c]
Overweight, prediabetes, gestational	0.3	0.1	0.1	0.0	0.0
Patient female sex, %	48.6	68.0	**63.6** [d]	77.4	80.5
Family history of diabetes, %	48.6	19.2	**15.3** [d]	26.0	31.7
Social Vulnerability Index (lower is better)	0.55	0.59	0.60	0.58	0.57
Highest BMI value during the study (kg/m^2)	35.2	38.8	**34.8** [d]	48.8	48.8
Charlson comorbidity index	2.4	1.2	**1.0** [d]	2.5	2.5
Race/ethnicity, %					
Non-Hispanic White	41.0	20.0	17.7	22.5	**29.1** [c]

Characteristics	Not referred to NDPP	Referred to NDPP	No LCP attendance among referred	Partial LCP[a] among referred	High use LCP[b] among referred
Non-Hispanic Black	34.2	19.4	**16.8** [d]	25.2	26.9
Hispanic	15.6	56.2	**60.3** [d]	49.8	41.8
Other or multiracial	2.7	2.0	2.3	1.5	1.0
Missing/unknown/refused	6.5	2.4	2.9	1.0	1.2

Note: Boldface indicates statistical significance (p<0.001) using independent samples t-tests comparing means and chi-square comparing frequencies between one LCP use group with another.

Patients referred to NDPP include patients prescribed metformin or who had bariatric surgery. Values are group means or percentages.

LCP, lifestyle change program; NDPP, National Diabetes Prevention Program; T2DM, type 2 diabetes.

[a] *Partial LCP* is defined as having LCP sessions but not meeting the high-use status.

[b] *High-use LCP* is defined as 4 or more sessions of any LCP or a duration of attendance that spanned at least 9 months.

[c] Significantly different from partial LCP group and significantly different from the no LCP attendance group only.

[d] No LCP attendance is significantly different from the other 2 groups.