Diabetes Prevention Program attendance is associated with improved patient activation: Results from the Prediabetes Informed Decisions and Education (PRIDE) study

Kia Skrine Jeffers[a,*], Yelba Castellon-Lopez[f], Jonathan Grotts[b], Carol M. Mangione[b,c], Tannaz Moin[b,d], Chi-Hong Tseng[b], Norman Turk[b], Dominick L. Frosch[e], Keith C. Norris[b], Christopher C. Duke[g], Gerardo Moreno[f], O. Kenrik Duru[b]

[a] School Nursing, UCLA, Los Angeles, CA, United States of America
[b] Division of General Internal Medicine and Health Services Research, David Geffen School of Medicine, UCLA, Los Angeles, CA, United States of America
[c] Jonathan and Karin Fielding School of Public Health, UCLA, Los Angeles, CA, United States of America
[d] Veterans Affairs Greater Los Angeles Health System, Veterans Affairs Health Services Research and Development Service Center for the Study of Healthcare Innovation, Implementation & Policy, United States of America
[e] Palo Alto Medical Foundation, Palo Alto, CA, United States of America
[f] Department of Family Medicine, David Geffen School of Medicine, UCLA, Los Angeles, CA, United States of America
[g] Altarum Institute, Ann Arbor, MI, United States of America

ARTICLE INFO

ABSTRACT

The Diabetes Prevention Program (DPP) is a 12-month behavior change program designed to increase physical activity and improve dietary patterns among patients at risk for Type 2 diabetes, in order to facilitate modest weight loss and improve cardio-metabolic profiles. It is unknown whether baseline patient activation is related to increased DPP uptake, and whether DPP attendance leads to subsequent improvement in patient activation. We analyzed data from 352 adult participants in the Prediabetes Informed Decisions and Education (PRIDE) trial of shared decision-making (SDM) in diabetes prevention, collected from November 2015 through September 2017. PRIDE participants completed baseline and 4-month follow-up surveys, including the Altarum Consumer Engagement (ACE) Measure™ of patient activation. We tracked DPP attendance over 8 months using data from partnering DPP providers. In multivariate models, we measured whether self-reported baseline activation was associated with DPP "uptake" (1+ session attended) or DPP "attendance" (9+ sessions). We also examined whether DPP attendance was associated with change in activation at 4-months follow-up. We did not find an association between baseline activation and DPP uptake or attendance. However, we did find that DPP attendance was associated with an increase in the overall ACE score (6.68 points, 95% CI 1.97–11.39, $p = 0.005$) and increased activation in 2 of the 3 ACE subscales (Commitment and Informed Choice). Our finding of increased patient activation with DPP attendance suggests a mechanism for the improved health outcomes seen in DPP real-world translational studies. This work has important implications for diabetes prevention and other behavior change programs.

1. Introduction

The Centers for Disease Control and Prevention (CDC) estimates that 86 million Americans have prediabetes, which increases their risk of Type 2 diabetes, heart disease, and stroke (Diabetes Report Card, 2017). Lifestyle change strategies such as the Diabetes Prevention Program (DPP) can prevent or delay diabetes for these individuals, with effects that last for a decade or more (Lancet Diabetes Endocrinol., 2015;

Knowler et al., 2002). The DPP is a 12-month intensive program focused primarily on improving diet, exercise, and problem-solving skills. DPP participants meet as a group for at least 16 weekly "core" sessions that promote behavior change, followed by at least 6 monthly "maintenance" sessions to reinforce the new behaviors. The National DPP (NDPP) has delivered this lifestyle change curriculum to over 30,000 participants across the United States, with 36% achieving the intended 5% weight loss goal (Ely et al., 2017). DPP participants also tend to
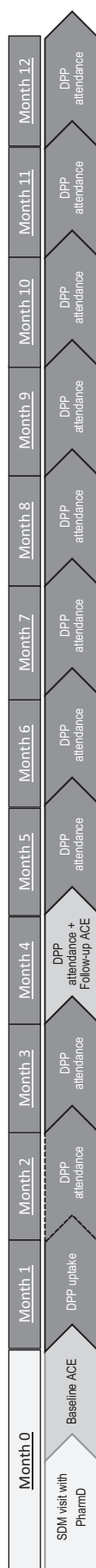
Fig. 1. Study timeline.

have lower systolic and diastolic blood pressure and lower total cholesterol one year after starting the program (Mudaliar et al., 2016). Given these successes, there are ongoing efforts to expand program reach to include a greater percentage of the 86 million Americans with prediabetes by adding the DPP as a covered Medicare benefit and by expanding the availability of DPP providers, both in-person and online (PPHF, 2012; Medicare Program, 2016).

In order to improve population health, the NDPP must not only expand recruitment among eligible participants with prediabetes but also retain enrolled participants over time. This will require comprehensive study of facilitators and barriers to DPP recruitment and retention, including patient-level factors such as patient activation. Patient activation has been defined as an individual's willingness and ability to assume responsibility for their health and health care, with the knowledge, skills and confidence to take independent actions in this regard (Hibbard et al., 2004). In observational studies, greater baseline activation has been linked to lower weight and lower blood pressure at 2–3 years of follow-up in prediabetes patients receiving usual care, although these studies did not assess whether participants were engaged in behavior change programs (Sacks et al., 2017; Greene et al., 2015). Patients who have prediabetes and greater activation at baseline may have higher levels of DPP uptake as well as more consistent program attendance than less activated patients, but this relationship has not yet been evaluated.

In addition, little is known about the underlying self-regulatory mechanisms that may be triggered by participation in the DPP and lead to behavioral change (Maindal et al., 2010). The DPP has a demonstrated "dose-response" effect whereby participants who attend more group sessions have better physiologic outcomes on average (Ely et al., 2017). However, it is not clear whether consistent attendance is also associated with increased patient activation. Given the paucity of evidence in this area, there is a need to examine the role of correlates of behavior change such as patient activation.

We analyzed data from the intervention arm of the Prediabetes Informed Decisions and Education (PRIDE) study of shared decision making for diabetes prevention in overweight adults with prediabetes. We hypothesized that among study participants who expressed an initial interest in joining the DPP, those with higher levels of baseline activation would be more likely to follow through with starting the DPP (program "uptake") and also be more likely to continue attending DPP group sessions over time (program "attendance") than participants with lower activation at baseline. We also hypothesized that consistent DPP attendance would be associated with an increase in activation from baseline to follow-up.

2. Methods

PRIDE was a cluster randomized controlled trial of shared decision-making (SDM) for diabetes prevention in a single academic health system (the University of California, Los Angeles, or UCLA) that enrolled participants from November 2015 through September 2017. This paper analyses data from participants in 10 primary care sites that were assigned to the study intervention arm. As part of the PRIDE study, all participants met in-person with a trained clinical pharmacist for a one-time SDM visit lasting 45–60 min. During this visit, the pharmacist and the participant together went over an online decision aid for diabetes prevention, which was designed to help patients consider two evidence-based strategies to prevent Type 2 diabetes–the DPP and metformin. The decision aid was produced by Healthwise™, a non-profit health content organization with the mission of helping people make better health decisions. At the conclusion of the SDM visit, patients declared a commitment to join the DPP, start metformin, take both actions, or continue usual care. Patients were provided with contact information for DPP programs at UCLA and/or YMCA of Metropolitan Los Angeles. Study participants completed a baseline survey immediately after their SDM visit and completed a second survey 4 months after the SDM visit.

The timing of the second survey was chosen so that study participants would have an opportunity to initiate their chosen diabetes prevention strategy/ies, and in the case of the DPP attend multiple core sessions of their 12-month program before follow-up assessment (Fig. 1). The UCLA Institutional Review Board approved this study.

The PRIDE study was limited to patients with prediabetes who were eligible for both the DPP and metformin. Inclusion criteria were: 1) baseline hemoglobin A1c from 5.7 to 6.4%, 2) age 18–74, 3) English or Spanish-speaking, 4) overweight (BMI > 24 kg/m² if non-Asian, BMI > 22 kg/m² if Asian), and 5) adequate renal function to start metformin (estimated glomerular filtration rate > 45 ml/min/1.73m²). Patients with diabetes, defined as any recorded A1c value of ≥ 6.5%, ICD-9 billing code of 250.xx, or use of antiglycemic medication, were excluded. Because SDM was central to this trial, patients with current or past participation in the DPP or with current use of metformin were also excluded since they had already selected one of these prevention strategies. Patients with anorexia, bulimia, active pregnancy, non-skin cancer being actively treated with cytotoxic chemotherapy or radiation, dementia, end-stage congestive heart failure, or end-stage liver disease as determined by a physician study investigator (OKD) were also excluded. Potential study participants were identified in the electronic health record (EHR) and recruited by introductory letter followed by a telephone call. Primary care physicians in the intervention clinics were also invited to directly refer eligible patients to the study through the EHR.

We measured patient activation using the Altarum Consumer Engagement™ (ACE) score at both baseline and follow-up. The ACE Measure can be licensed free-of-charge for non-commercial purposes. The PRIDE survey included 12 items from the original 21-item ACE Measure, as shown in Table 1 (Duke et al., 2015). The shortened 12-item survey has been validated and the individual items are grouped into 3 subscales (Commitment, Informed Choice, and Navigation). Commitment refers to patients' commitment to "everyday health behaviors"; Informed Choice refers to patients' "preference for learning about health"; Navigation refers to patients' "experience and savvy using healthcare" (Duke et al., 2015). Each item was administered as a 5-level Likert scale, with response options of *strongly disagree, disagree, neither agree nor disagree, agree,* or *strongly agree.* The 3 subscale scores range from 5 to 25, with a higher score representing greater activation. Because the ACE Measure used in the PRIDE survey was reduced from 21 to 12 items and one of the original 4 subscales was omitted, the total activation score is computed by adding together the subscale scores and multiplying that sum by 4/3; the possible range of this total score is

therefore 20–100. The baseline survey also assessed self-reported income and included the 8-item Patient Health Questionnaire (PHQ) as a screener for symptoms of depression (Kroenke et al., 2001). The cutoff for depression was a score of 10.

DPP uptake and attendance were primarily obtained from DPP program records of the UCLA and the YMCA. We defined DPP "attendance" as participating in 9 or more of the 16 weekly sessions because prior work has indicated that people who attended at least 9 sessions were likely to lose ≥ 5% of their body weight (Centers for Disease Control and Prevention, n.d.). We defined "uptake" as attending between 1 and 8 sessions. Participants who attended DPP within 8 months of their SDM visit with the clinical pharmacist were included in this analysis, as we assumed that participants would have completed their 16 core weekly sessions by then. We identified 13 participants who indicated on the follow-up survey that they had attended the DPP but were missing from the attendance records. We called these participants individually to determine how many DPP sessions they attended, and used this information to fill in missing data from the DPP provider attendance records. We obtained additional study variables from the EHR, including age, gender, race/ethnicity, and body mass index (BMI).

2.1. Statistical analysis

We examined bivariate associations using the Fisher's exact test for categorical variables and ANOVA for continuous variables. We conducted multivariate logistic regressions to test the first hypothesis, examining whether participants with greater activation at baseline would be more likely to 1) start the DPP (program uptake) and 2) attend 9 or more DPP group sessions over time (program attendance) than participants with lower activation at baseline. We also performed multivariate linear regressions to test the second hypothesis, examining whether participants who attended 9 or more DPP sessions (program attendance) had a greater change in follow-up activation at 4 months than participants who attended 8 or fewer DPP sessions. In both sets of models, we included a random effect to account for clustering by primary care clinic. We conducted separate regressions for the overall ACE score and the 3 subscales, and each regression controlled for age, gender, race/ethnicity, BMI, income, and symptoms of depression. We imputed missing data for the change in ACE scores for patients who did not complete the 4-month survey, using multiple imputation by chained equations (van Buuren and Groothuis-Oudshoorn, 2011). For participants missing self-reported income, we assigned the median income for their zip code of residence, obtained from the 2016 American Community Survey 5-year estimate (American Community Survey, 2016). For the main analyses, we assumed that patients without data on DPP uptake and attendance (e.g., they were absent from the attendance records and they did not complete the follow-up survey) did not attend any DPP sessions. In sensitivity analyses, we imputed DPP uptake (yes/no) and DPP attendance (yes/no) for these participants with missing attendance information. We ran a second sensitivity analysis dropping participants who did not complete the 4-month follow-up survey and therefore were missing ACE scores (e.g., complete case analysis). All analyses were conducted using the R Statistical Computing Environment (R Core Team; Vienna, Austria).

3. Results

Of the 515 PRIDE participants who provided informed consent and met with the pharmacist between November 2015 and September 2017, 352 (68%) chose the DPP with or without metformin and completed the survey at both baseline and 4-months follow-up. Of the 352 participants in the analytic sample, we imputed change in ACE score for 66 (19%) who did not complete the follow-up survey and we imputed PHQ baseline values for 2 patients. We also used zip code median income for 59 (17%) patients with missing self-reported income. As shown in Table 2, among the 352 patients who chose to attend the DPP at their

Table 1
Altarum Consumer Engagement (ACE) measure.

Patient instructions: on a scale from 1 to 5, tell us if you agree with the statement.

Commitment
1. I can stick with plans to exercise and eat a healthy diet.
2. Even when life is stressful, I know I can continue to do the things that keep me healthy.
3. When I work to improve my health, I succeed.
4. I handle my health well.

Informed choice
1. When choosing a new doctor, I look for official ratings based on patient health.
2. I compare doctors using official ratings about how well their patients are doing.
3. When choosing a new doctor, I look for information online.
4. I spend a lot of time learning about health.

Navigation
1. I have lots of experience using the healthcare system.
2. I feel comfortable talking to my doctor about my health.
3. I have brought my own information about my health to show my doctor.
4. Different doctors give me different advice, it's up to me to choose what's right for me.

Response choices included 1 = Strongly disagree; 2 = Somewhat disagree; 3 = Neutral; 4 = Somewhat agree; and 5 = Strongly agree

Table 2
Characteristics of study sample (*n* = 352) By DPP attendance.

	Attended 0 DPP classes (*n* = 203)	Attended 1–8 DPP classes (*n* = 51)	Attended ≥9 DPP classes (*n* = 98)	*p*-Value
Variable				
Days from SDM consult to DPP start, mean (SD)	NA	73.1 (47.3)	50.2 (47.9)	**0.003**
Gender				**0.01**
Male	97 (47.8%)	16 (31.4%)	31 (31.6%)	
Female	106 (52.2%)	35 (68.6%)	67 (68.4%)	
Race/ethnicity				0.536
White	77 (37.9%)	19 (37.3%)	43 (43.9%)	
Hispanic	34 (16.7%)	13 (25.5%)	23 (23.5%)	
Asian	43 (21.2%)	9 (17.6%)	14 (14.3%)	
Black	38 (18.7%)	9 (17.6%)	16 (16.3%)	
Other	11 (5.4%)	1 (2%)	2 (2%)	
Age, mean (SD)	56.1 (11.7)	53.6 (12)	58.6 (9.6)	**0.044**
BMI, mean (SD)	30.4 (5.2)	31.6 (5.5)	31 (5.3)	0.331
Income (pt reported)				0.758
< $65,000	63 (31%)	12 (23.5%)	26 (26.5%)	
$65,000 to under $85,000	39 (19.2%)	9 (17.6%)	24 (24.5%)	
$85,000 to under $150,000	51 (25.1%)	15 (29.4%)	27 (27.6%)	
≥$150,000	50 (24.6%)	15 (29.4%)	21 (21.4%)	
Weight (lbs), mean (SD)	190.7 (39.7)	193.8 (42)	188.5 (35)	0.881
A1C (%), mean (SD)	6 (0.2)	5.9 (0.2)	6 (0.2)	0.143
Baseline ACE - commitment domain, mean (SD)	17.9 (3.1)	17.2 (3.4)	17.1 (3.9)	0.223
Baseline ACE - informed choice domain, mean (SD)	15.1 (4.2)	14.4 (4.3)	14.2 (4.6)	0.197
Baseline ACE - navigation domain, mean (SD)	17.4 (3.3)	17.7 (3.8)	17.5 (2.9)	0.911
Baseline ACE - total score, mean (SD)	67.2 (10.8)	65.7 (11.1)	65 (11.6)	0.342
Baseline PHQ-8, median (IQR)	3 (1–5)	4 (2–7)	2 (0–6)	0.148
Baseline PHQ-8 categories				**0.03**
No evidence of depression	189 (93.1%)	43 (84.3%)	84 (85.7%)	
Major depression	14 (6.9%)	8 (15.7%)	9 (9.2%)	
Severe major depression	0 (0%)	0 (0%)	3 (3.1%)	

Total possible score for each ACE subscale was 5–25 at baseline and also at follow-up, higher scores = greater activation.
Bold values are statistically significant.

SDM visit, 203 (58%) attended no sessions, 51 (14%) attended 1–8 sessions, and 98 (28%) attended 9 or more sessions. Participants who attended 9 or more sessions waited an average of 50 days to start their first DPP session, as compared with an average of 73 days for participants who only attended 1–8 sessions (*p* = 0.003 for difference).

The study sample was multiethnic, mostly female, and most participants were obese (Table 2). In multivariate analyses, associations between baseline activation for the total ACE score or any of the three ACE subscales with DPP uptake (Table 3) and DPP attendance (Table 4) were not statistically significant. Higher income was associated with greater odds of DPP uptake in all models. Older age was associated with greater odds of DPP attendance in all models but no other covariates were significantly associated with DPP attendance (data not shown). We did not find statistically significant differences in PHQ scores at baseline or for DPP uptake or attendance.

As shown in Table 5, we found a significant association between DPP attendance and an increase in follow-up activation on the overall ACE score (6.71, 95% CI 2.01–11.41, *p* = 0.005), the commitment subscale (1.93, 95% CI 0.59–3.27, p = 0.005), and the informed choice subscale (1.97, 95% CI 0.09–3.85, *p* = 0.04), but not the navigation subscale (1.15, 95% CI -0.16-2.46, *p* = 0.084). We found a similar association between DPP attendance and a change in activation in the

Table 3
Baseline ACE scores and DPP uptake.

Predictor variable	OR of DPP uptake (95% CI)	p-Value
ACE total baseline (divided by 10)	0.88 (0.72–1.09)	0.239
ACE commitment baseline (divided by 10)	0.65 (0.32–1.33)	0.242
ACE informed choice baseline (divided by 10)	0.68 (0.4–1.16)	0.161
ACE navigation baseline (divided by 10)	1 (0.5–2.01)	0.989

Adjusted for age, gender, race/ethnicity, income, BMI, depression.

complete case analysis limited to the 286 participants with complete ACE score data.

4. Discussion

In this study of individuals who participated in a diabetes prevention SDM intervention and declared a commitment to start the DPP, our hypothesis of an association between baseline activation and program uptake and attendance was not supported. However, study participants who attended 9 or more DPP sessions reported greater increases in activation at follow-up. This suggests that the relationship between greater DPP session attendance and reinforcement of change in diet and activity behaviors among DPP participants is tied to an increase in activation that develops during the first 16 weeks of the program. This increase in activation is likely related to both individual decisions to change and group dynamics and the social milieu among the cohort of DPP participants.

In particular, we found an association between DPP session attendance and improvement in 2 of the 3 subscales we measured, Informed Choice and Commitment. We did not find an association between attendance and change in the Navigation subscale. Our findings are consistent with the goals of the DPP curriculum and have strong face validity. The core sessions of the DPP curriculum focus on learning about health, including which foods and food preparation methods are healthiest (National Center for Chronic Disease Prevention and Health Promotion Division of Diabetes Translation, n.d.). This content is likely to help patients become more activated in terms of making informed choices. The DPP curriculum also emphasizes the personal responsibility and behavioral strategies required to maintain behavior change, such as avoiding tempting situations and staying motivated, which should increase patient commitment (National Center for Chronic Disease Prevention and Health Promotion Division of Diabetes Translation, n.d.). The DPP curriculum does not address navigation through a complex healthcare system, so it is unsurprising that we

Table 4
Baseline ACE scores and DPP adherence.

Predictor variable	OR of DPP adherence (95% CI)	p-Value
ACE total baseline (divided by 10)	0.87 (0.7–1.1)	0.247
ACE commitment baseline (divided by 10)	0.62 (0.28–1.35)	0.23
ACE informed choice baseline (divided by 10)	0.7 (0.39–1.26)	0.234
ACE navigation baseline (divided by 10)	0.92 (0.43–2)	0.842

Adjusted for age, gender, race/ethnicity, income, BMI, depression.

found no association between DPP attendance and the Navigation subscale.

Few studies have examined the role of baseline individual patient activation or similar measures as predictors of uptake and/or attendance to behavior change programs. The Inter99 study examined associations between baseline self-efficacy for healthy diet/exercise or baseline perception of self-care with uptake or attendance to a group counseling program among patients at high risk for coronary heart disease (Toft et al., 2007). Patients who reported unhealthy dietary habits were somewhat more likely than those with average or healthy dietary habits to sign up for the program, but were also more likely to drop out before the program ended.

Demographic predictors of program attendance have been more widely studied. A meta-analysis of 27 behavioral interventions for weight loss between 2004 and 2015 found that 17 of the 27 did not identify any significant baseline predictors distinguishing between participants who were adherent to the program and those who were not (Lemstra et al., 2016). Of the remaining studies, several found that older age, higher income, and/or greater education were associated with greater attendance, while having more children at home, tobacco use, past negative experiences with physical activity, and incompatibility with job hours were each associated with lower attendance in at least one study (Lemstra et al., 2016). Our findings of increased DPP uptake among higher income adults and increased DPP attendance among older adults is consistent with these prior reports. Overall, however, there is limited evidence that patient demographics or baseline activation are consistently associated with uptake or attendance to behavior change programs.

Our findings of increased activation at follow-up among DPP participants who attended 9 or more sessions align with results from the European ADDITION-DK study (Maindal et al., 2011). This randomized controlled trial delivered 2 individual counseling interviews and 8 group sessions to intervention patients ($n = 322$) with prediabetes or diabetes within a period of 3 months, and measured change in patient self-regulation at 12 months. Intervention participants reported increased internal motivation to adopt healthy diet and exercise patterns, and also reported greater perceived competence to eat a healthy diet than controls (Maindal et al., 2011). At 3-year follow-up, intervention participants had greater increases on the Patient Activation Measure (PAM) than controls (Maindal et al., 2011). In the subgroup with prediabetes, intervention patients had lower total cholesterol levels at 3-year follow-up and there was a trend toward lower systolic and diastolic blood pressure but no change in hemoglobin A1c (Maindal et al., 2014).

Similar to the present study, there is evidence from population-level analyses that change in patient activation over time is associated with global health outcomes. Greene and colleagues examined data from a US health system that collected PAM scores for > 10,000 patients during primary care visits in 2010 and again in 2012 (Greene et al., 2015). They found that changes in patient activation accounted for > 50% of the variation in health outcomes and health-related costs at 2 year follow-up. Compared to patients with no change in activation, patients who became more activated had better outcomes and lower costs over time, while those who became less activated had worse outcomes and higher costs. Similarly, a recent study using the ACE measure found that DPP-enrolled patients with high ACE Commitment scores improved their HbA1c over time, while those with lower scores did not (Wardian et al., 2018). Because greater activation is associated with improved outcomes, additional studies should assess ways in which activation can be enhanced among DPP participants in community settings, particularly in the critical early weeks of the program.

Numerous challenges remain in optimizing both recruitment and retention in real-world DPP delivery, which is an important area for future research. Almost all published DPP translation studies focus only on actual program enrollees, and provide no information on the broader target population initially referred to or contacted about the program (Aziz et al., 2015). Ways to optimize recruitment and retention are particularly critical for on-the-ground DPP providers. As insurance reimbursement for DPP delivery is often linked to patient participation metrics, the ability to predict patient participation may be helpful to community-based DPP providers attempting to balance group sizes and start dates, while at the same time helping them identify patients who may benefit from additional efforts to enhance attendance before and during the program (Fitzpatrick et al., 2017).

In planning for the retention of participants throughout the 12-month program, community-based DPP providers might also consider looking beyond engaging individual participants, by focusing on broader influences that may synergistically enhance attendance and behavior change (Lewis et al., 2017). For example, DPP participants typically progress through the 12-month program as a group, which creates their own social network. DPP providers might leverage the influence that group members have upon one another within these networks. Two drivers of behavior change that could receive increased focus are social relevance (Centola, 2018) (e.g., the shared experience among individuals who have a similar health condition like prediabetes) and social reinforcement (Centola, 2018) (e.g., receiving messages from socially relevant individuals about health promoting behaviors that reduce diabetes risk). The DPP curriculum already includes the explicit goal of group problem solving to overcome obstacles

Table 5
Adherence and absolute change in ACE scores (baseline to 4 months).

Predictor variable	Absolute change in ACE scores (95% CI)	p-Value
Adherence to DPP (9+ sessions)	Absolute change in overall ACE score: +6.71 (2.01–11.41)	**0.005**
	Absolute change in commitment subscale: +1.93 (0.59–3.27)	**0.005**
	Absolute change in informed choice subscale: +1.97 (0.09–3.85)	**0.04**
	Absolute change in navigation subscale: +1.13 (−0.17–2.43)	0.089

Total possible ACE score was 20–100 at baseline and also at follow-up. Total possible score for each ACE subscale was 5–25 at baseline and also at follow-up. Adjusted for age, gender, race/ethnicity, income, BMI, depression.
Bold values are statistically significant.

that make it difficult to achieve behavior change targets (National Center for Chronic Disease Prevention and Health Promotion Division of Diabetes Translation, n.d.). Continued reinforcement among peers throughout the program might facilitate behavior change in ways that a DPP provider-led curriculum may not.

We observed an association between an increase in participants' commitment to healthy behaviors and high attendance at DPP sessions. Our data are insufficient to capture the influence of social networks on study participants' commitment and attendance; but it is plausible that leveraging the social network within the DPP might boost patient activation and thereby aid in recruiting and retaining persons who are at risk of attrition. To our knowledge, no DPP providers are currently evaluating the relationship between social networks and participant outcomes. Our work suggests that the CDC and NDPP may want to incorporate and track factors such as social relevance and social reinforcement in program delivery and evaluation.

Our study has several limitations, including a relatively affluent sample compared to the population demographics of the health system from which participants were drawn. However, the analytic sample had good representation of both male and female patients as well as racial/ethnic diversity. There were also system-level limitations related to DPP delivery. PRIDE was a pragmatic study that referred to two community-based DPP providers as part of usual practice. There were differences in program cost for the two providers as well as likely unmeasured differences in the skills, training and experience of the DPP lifestyle coaches, which could have affected participants' experiences. Finally, as the DPP is a 12-month program, the 4-month timeframe in this study would not fully capture attendance to the entire program or any slower-developing effects of the program on patient activation.

In summary, while we did not find an association between baseline patient activation and DPP uptake or attendance, we did observe a relationship between attendance to the DPP and increased patient activation at 4 months, reflecting a greater expressed commitment to healthy behaviors. This finding suggests a potential mechanism for the weight loss results of DPP translational studies, but more work is needed in this area. As a next step, we plan to evaluate whether changes in patient activation at 4-months directly lead to study outcomes which will be collected at 1-year follow-up, including weight change and change in blood pressure. This work may have important implications for diabetes prevention.

References

American Community Survey. Bureau of the Census. Suitland, MD. https://www.census.gov/acs/www/data/data-tables-and-tools/data-profiles/2016/. Published: 2016. Accessed: September 10, 2018.

Aziz, Z., Absetz, P., Oldroyd, J., Pronk, N.P., Oldenburg, B., 2015. A systematic review of real-world diabetes prevention programs: learnings from the last 15 years. Implement. Sci. 10, 172.

Centers for Disease Control and Prevention Centers for Disease Control and Prevention Diabetes Prevention Recognition Program: Standards and Operating Procedures. https://www.cdc.gov/diabetes/prevention/pdf/dprp-standards.pdf, Accessed date: 30 March 2019.

Centola, D., 2018. How Behavior Spreads: The Science of Complex Contagions. Princeton University Press, New Jersey.

Diabetes Report Card 2017. Atlanta, GA. Centers for Disease Control and Prevention, US Dept of Health and Human Services. https://www.cdc.gov/diabetes/pdfs/library/diabetesreportcard2017-508.pdf. Published 2018. Accessed: September 10, 2018.

Duke, C.C., Lynch, W.D., Smith, B., Winstanley, J., 2015. Validity of a new patient engagement measure: the Altarum Consumer Engagement (ACE) measure. Patient 8 (6), 559–568.

Ely, E.K., Gruss, S.M., Luman, E.T., Gregg, E.W., Ali, M.K., Nhim, K., et al., 2017. A national effort to prevent type 2 diabetes: participant-level evaluation of CDC's National Diabetes Prevention Program. Diabetes Care 40 (10), 1331–1341.

Fitzpatrick, S.L., Wilson, D.K., Pagoto, S.L., 2017. Society for Health Psychology (APA Division 38) and Society of Behavioral Medicine joint position statement on the Medicare Diabetes Prevention Program. Transl. Behav. Med. 7 (2), 385–387.

Greene, J., Hibbard, J.H., Sacks, R., Overton, V., Parrotta, C.D., 2015. When patient activation levels change, health outcomes and costs change, too. Health Aff. 34 (3), 431–437.

Hibbard, J.H., Stockard, J., Mahoney, E.R., Tusler, M., 2004. Development of the Patient Activation Measure (PAM): conceptualizing and measuring activation in patients and consumers. Health Serv. Res. 39 (4 Pt 1), 1005–1026.

Knowler, W.C., Barrett-Connor, E., Fowler, S.E., Hamman, R.F., Lachin, J.M., Walker, E.A., et al., 2002. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N. Engl. J. Med. 346 (6), 393–403.

Kroenke, K., Spitzer, R.L., Williams, J.B., 2001. The PHQ-9: validity of a brief depression severity measure. J. Gen. Intern. Med. 16 (9), 606–613.

Long-term effects of lifestyle intervention or metformin on diabetes development and microvascular complications over 15-year follow-up: the Diabetes Prevention

Program Outcomes Study. Lancet Diabetes Endocrinol. 3 (11), 866–875.

Lemstra, M., Bird, Y., Nwankwo, C., Rogers, M., Moraros, J., 2016. Weight loss intervention adherence and factors promoting adherence: a meta-analysis. Patient Prefer. Adherence 10, 1547–1559.

Lewis, M., Fitzgerald, T., Zulkiewicz, B., Peinado, S., Williams, P., 2017. Identifying strategies in multilevel interventions: the convergence strategy. Health Educ. Behav. 44 (2), 236–244.

Maindal, H.T., Kirkevold, M., Sandbaek, A., Lauritzen, T., 2010. Lifting the lid of the "black intervention box" - the systematic development of an action competence programme for people with screen-detected dysglycaemia. BMC Health Serv. Res. 10, 114.

Maindal, H.T., Sandbaek, A., Kirkevold, M., Lauritzen, T., 2011. Effect on motivation, perceived competence, and activation after participation in the "Ready to Act" programme for people with screen-detected dysglycaemia: a 1-year randomised controlled trial, Addition-DK. Scand. J. Public Health 39 (3), 262–271.

Maindal, H.T., Carlsen, A.H., Lauritzen, T., Sandbaek, A., Simmons, R.K., 2014. Effect of a participant-driven health education programme in primary care for people with hyperglycaemia detected by screening: 3-year results from the Ready to Act randomized controlled trial (nested within the ADDITION-Denmark study). Diabet. Med. 31 (8), 976–986.

Medicare Program, 2016. Revisions to payment policies under the physician fee schedule and other revisions to part B for CY 2017; Medicare Advantage Bid Pricing Data Release; Medicare Advantage and Part D Medical Loss Ratio Data Release; Medicare Advantage Provider Network Requirements; Expansion of Medicare Diabetes Prevention Program Model; Medicare Shared Savings Program Requirements. Final rule. Fed. Regist. 81 (220), 80170–80562.

Mudaliar, U., Zabetian, A., Goodman, M., Echouffo-Tcheugui, J.B., Albright, A.L., Gregg, E.W., et al., 2016. Cardiometabolic risk factor changes observed in diabetes prevention programs in US settings: a systematic review and meta-analysis. PLoS Med. 13 (7), e1002095.

National Center for Chronic Disease Prevention and Health Promotion Division of Diabetes Translation. National Diabetes Prevention Program Lifestyle Coach Facilitation Guide. (Accessed: March 30, 2019).

PPHF 2012 - National Diabetes Prevention Program: Preventing Type 2 Diabetes Among People at High Risk Financed Solely by 2012 Prevention and Public Health Funds. Funding Opportunity Announcement. Atlanta, GA. Centers for Disease Control and Prevention, US Dept of Health and Human Services. https://www.cdc.gov/diabetes/prevention/foa/foa_announcement.pdf. Published: 2012. Accessed: September 10, 2018.

Sacks, R.M., Greene, J., Hibbard, J., Overton, V., Parrotta, C.D., 2017. Does patient activation predict the course of type 2 diabetes? A longitudinal study. Patient Educ. Couns. 100 (7), 1268–1275.

Toft, U.N., Kristoffersen, L.H., Aadahl, M., von Huth Smith, L., Pisinger, C., Jorgensen, T., 2007. Diet and exercise intervention in a general population–mediators of participation and adherence: the Inter99 study. Eur. J. Pub. Health 17 (5), 455–463.

van Buuren, S., Groothuis-Oudshoorn, K., 2011. MICE: multivariate imputation by chained equations in R. J. Stat. Softw. 45 (3), 67.

Wardian, J., Bersabe, D., Duke, C., Sauerwein, T.J., 2018. Patient commitment and its relationship to A1C. Clin. Diabetes 36 (4), 295–304 (Apr).