Successfully Managing Diabetes in a Community Setting

Evidence From the YMCA of Greater Richmond Diabetes Control Program

Purpose

The purpose of this study was to describe how a community-academic partnership developed and implemented a shared goal of evaluating the impact of a large community-based diabetes self-management program on diabetes care and mental health outcomes.

Methods

Data came from the YMCA of Greater Richmond Diabetes Control Program (DCP), a 12-week, group-format self-management program led by lay health coaches. Adults with type 2 diabetes (N = 312) completed baseline assessments of sociodemographic characteristics, diabetes history, and mental health. Four outcomes were assessed pre- and post-DCP on 141 participants who completed the program: hemoglobin A1C

Supplemental material is available online with this article.

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Briana Mezuk, PhD

William Thornton, MBA

Shawnita Sealy-Jefferson, PhD

Joshua Montgomery, MPH

Jana Smith, BS

Evanise Lexima, BS

Maria Jose Mejia Ruiz, MSPH

Jeannie B. Concha, PhD

From Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, Michigan (Dr Mezuk); Institute for Social Research, University of Michigan, Ann Arbor, Michigan (Dr Mezuk); Division of Epidemiology, Virginia Commonwealth University School of Medicine, Richmond, Virginia (Dr Mezuk, Mr Montgomery, Ms Lexima); Community Health Office, YMCA of Greater Richmond, Richmond Virginia (Mr Thornton, Ms Smith, Ms Mejia Ruiz); College of Public Health, Ohio State University, Columbus, Ohio (Dr Sealy-Jefferson, Dr Concha); and College of Health Sciences, University of Texas–El Paso, El Paso, Texas (Dr Concha).

Correspondence to Briana Mezuk, PhD, Center for Social Epidemiology and Population Health, Department of Epidemiology, University of Michigan School of Public Health, Suite 2649B, 1415 Washington Heights, Ann Arbor, MI 48109, USA (bmezuk@umich.edu).

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(A1C), weight, depressive symptoms (Patient Health Questionnaire–8), and glucose monitoring. The team worked with a Community Advisory Board throughout the research process.

Results

The DCP had wide geographic reach, including lower-income neighborhoods. The average age of the participants was 53.9 years, 71.4% were female, and 69% were African American. During the DCP, A1C declined from 8.4% to 7.6% ($P < .001$), but weight was unchanged (229.2 vs 227.9, $P < .282$). During the DCP, the proportion of participants with clinically significant depressive symptoms declined from 32.4% to 15.5% ($P < .001$), and frequency of glucose monitoring significantly increased.

Conclusions

The YMCA of Greater Richmond DCP has wide reach into underserved populations throughout the metropolitan area. This program is effective at improving diabetes self-management and mental health. Findings have implications for supporting academic-community partnerships to address diabetes disparities.

Approximately 1 in 10 US adults has diabetes, a proportion that is projected to triple by 2050.[1] Diabetes costs more than US$245 billion annually, nearly half of which is due to direct health care costs.[2] Diabetes self-management education and support are a central component of diabetes care,[3] and numerous randomized controlled trials have demonstrated that diabetes self-management programs (DSMP) are an effective means of improving glycemic control and reducing health care costs.[4-6] However, there is a substantial translation gap between these efficacy trials and the implementation of DSMPs in the general population, particularly for socially disadvantaged groups.[7,8]

There are persistent disparities in diabetes outcomes by race/ethnicity and socioeconomic status (SES).[9] For example, African Americans and Hispanics with diabetes are more likely to have poor glycemic control[10] and to develop end-stage renal disease[11] relative to non-Hispanic whites. These disparities mirror those seen in access to diabetes care, including DSMPs. Such programs are designed to support self-management behaviors and to improve knowledge about diabetes as a disease and emphasize the importance of appropriate nutrition and physical activity goals. However, only 57% of US adults with diabetes have ever attended a DSMP, a proportion that is even lower for individuals with low SES.[12,13]

While most insurance providers, including Medicaid and Medicare Part B,[14] reimburse for diabetes self-management education and support (DSME/S) programs offered in health care settings (eg, by nurses or certified diabetes educators), payers generally do not reimburse for programs offered by lay health workers. This is critical because most DSME/S programs offered in health care settings are brief (ie, individual sessions are billed in 30-minute increments; group sessions are generally 3 to 6 hours in total length; the number of sessions allowed is limited by reimbursement for both individual and group visits).[14] While these programs can link participants to community resources that can aide with self-management (eg, gym memberships, child care, cooking demonstrations), most emphasis is placed on diabetes education, medication adherence, and nutrition, rather than providing tangible resources to support self-management.[15,16] Thus, even when DSME/S programs are accessible to socially disadvantaged populations, they generally do not address the social and structural constraints to program engagement often faced by lower-resource groups.

The YMCA is a main site for the National Diabetes Prevention Program (NDPP) dissemination effort.[17,18] Part of the appeal of partnering with the YMCA for the NDPP is that the mission of the YMCA organization ("Strengthening community")[19] complements the public health model of health promotion. There are more than 10 000 YMCA locations in the United States, providing accessibility to millions of Americans. The YMCA also has tangible resources (eg, gyms, on-site childcare, community events, partnerships with other community groups) that can address some of the social and structural barriers that may hinder the engagement of socially disadvantaged populations in diabetes programs. However, community-based organizations such as the YMCA often have limited staffing and/or expertise to evaluate the health programs they offer to empirically demonstrate the impact their programming has on local communities; such evidence is increasingly needed to support sustained investment in these types of programs by philanthropic

donors.[20] To address this gap, collaborative community-based participatory research (CBPR) partnerships between community organizations and researchers can be leveraged to support the exchange of expertise, test novel ideas about interventions based on the experiences of those delivering these programs, and inform the implementation and dissemination of DSMPs in a sustainable manner.[21]

Purpose

The purpose of this study was to describe how a community-academic partnership developed and implemented a shared goal of evaluating the impact of a large community-based DSMP on diabetes care and mental health outcomes. This program serves an economically- and racially-diverse urban and suburban population. This evaluation is embedded within the RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance) framework for evaluating the public health impact of interventions.[22-24] The main research questions are: (1) What is the reach of the program in terms of geography, demographic characteristics, and diabetes clinical history? and (2) What is the effectiveness of the program on reducing weight and hemoglobin A1C (A1C), promoting diabetes self-management behaviors, and improving mental health? These questions were addressed using a CBPR approach between researchers, public health students, YMCA wellness staff, and a Community Advisory Board (CAB).

Methods

Description of the Community-Engaged Partnership

The YMCA of Greater Richmond serves an estimated 177 000 people annually, in a metropolitan population of approximately 1.2 million, in its 3 core program areas: youth development, social responsibility, and healthy living. Beginning in 2013, researchers began meeting with leaders of the YMCA of Greater Richmond Community Health Office, which leads this chapter's programming on diabetes. These meetings occurred every 1 to 2 months and, with one exception, occurred at the YMCA offices. Over the course of 2 years, the group identified relative strengths and limitations and developed a shared goal of conducting a rigorous evaluation of the YMCA DSMP. In support of this shared goal, in 2015, a formal internship agreement was established between the YMCA and the Masters of Public Health (MPH) program at Virginia Commonwealth University (VCU); this agreement built a personnel and service-learning infrastructure by allowing MPH students to earn credit toward their degree by volunteering with the diabetes program team through internship (180 contact hours) and practicum (90 contact hours) experiences. All students who participated in the practicum/internship were cross-trained as YMCA volunteers.

In 2016, the team was awarded pilot funding through the VCU Council on Community Engagement; part of this funding was used to establish a CAB. At the time, the CAB consisted of 8 individuals representing a range of constituents, including people with diabetes (type 1 and type 2, some of whom were also alumni from the DSMP); health care providers (ie, registered nurses, pharmacists), including some whom work for a federally-qualified health center; representatives from health insurance companies; and representatives from local departments of health. The membership of the CAB has changed over time. The research team met with the CAB on a quarterly basis at the YMCA offices to discuss the research process and preliminary findings from the evaluation, how to increase awareness about the DSMP, outlets for disseminating the research findings (to both scientific and general population audiences), and means to support the long-term sustainability of this research collaboration. The latter element is a particularly important component of CBPR as a tool for implementation science, because without a focus on financial sustainability at the outset, these efforts often stagnate after funding is complete.

Description of the YMCA of Greater Richmond Diabetes Control Program

The YMCA of Greater Richmond's Diabetes Control Program (DCP) began in 2013 and serves approximately 160 adults each year. The DCP is 12 weeks long and is led by lay health coaches in a group format (up to 15 individuals per group).[25] DCP classes are 90 minutes long and are held at 16 YMCA locations throughout the Richmond area spanning both rural and urban areas and at 8 non-YMCA locations (eg, public housing complexes, community centers, churches) that are in lower-income areas to serve those communities. The DCP curriculum was developed by the YMCA staff with the support of community partners and is based on publicly available

Table 1

Overview and Weekly Schedule of the YMCA of Greater Richmond Diabetes Control Program (DCP) Curriculum

Week	Topic	Activity
1	Program overview and introductions	Pre-DCP survey Pre-DCP A1C
2	Taking control of diabetes	Food journal and physical activity–tracking tools[a]
3	Physical activity and you	
4	Being physically active	Group workout during class
5	Learning how to make healthy nutrition choices	
6	Navigating the grocery store	Grocery store tour (including gift card)
7	Managing blood sugar	
8	Learning to prepare healthier foods	Cooking demonstration
9	Understanding depression and stress	
10	Limiting diabetes #1: Preventing complications related to cardiovascular disease, vision, kidneys, and nerves	
11	Being physically active	Group workout during class
12	Limiting diabetes #2: Preventing complications related to sexual health and dental health	Post-DCP survey Post-DCP A1C

[a]Food journals and physical activity–tracking tools, including weigh-ins during class, are used each week of the program.

materials from the Mayo Clinic, the American Heart Association, the National Diabetes Education Program, Centers for Disease Control and Prevention, the American Diabetes Association (ADA), and the YMCA of the United States. This curriculum was independently evaluated and endorsed by 2 registered dietitians, including 1 certified diabetes educator.

The program relies on weekly tracking of food intake and physical activity to monitor carbohydrate consumption and to reach 150 minutes of moderate-vigorous physical activity per week. This emphasis on diet and physical activity is complemented by several DCP activities, including a grocery store tour (where participants receive a $40 store gift card), a hands-on cooking demonstration, group workouts, and free access to a personal trainer and YMCA gym facilities. Additional details of the curriculum and the program schedule are provided in Table 1. The classes are facilitated by laypersons who complete a 1-day training workshop on delivering the DCP curriculum to become "lifestyle coaches"; lifestyle coaches are trained to build rapport with participants and to make reminder/follow-up phone calls to support engagement with the program. Coaches are observed by a member of the training team at least once during the program as part of quality assurance.

Recruitment into the DCP comes from 2 main sources. The YMCA recruits individuals directly through conducting diabetes risk assessments at health fairs, on-site at YMCA branches, and online. They also foster relationships with local health care providers who refer patients to the program. These referral networks are the primary avenue for recruiting program participants. Consistent with its value of being "open to all," the YMCA offers financial assistance for participants who are unable to afford the full cost of the DCP. During the period of study, the maximum participant cost to enroll in the program was $429 (the total cost is $1000, but the YMCA subsidizes more than half this cost for all participants). Moreover, through YMCA financial assistance, less than 5% of participants paid the full cost, and 52% paid less than $20. Half of all DCP participants have family incomes less than 100% of the federal poverty guidelines.

Analytic Sample

The analysis of the reach of the DCP is limited to 312 participants who completed self-administered, paper/pencil surveys from January 2015 to February 2017. These surveys were created by the YMCA staff with support from researcher partners and students. Surveys took approximately 20 minutes to complete, were self-administered with help from DCP coaches, and were completed during the first session (pre-DCP) and session 11 or 12 (post-DCP). Analysis of the effectiveness of the DCP is limited to the 141 DCP participants who completed a post-DCP survey and provided both pre and post A1C samples. The survey data were linked to attendance, weight, and A1C records. MPH students, who were cross-trained as YMCA volunteers, conducted this data linkage. All data were deidentified before being transferred to researchers for analysis.

This study was approved by the Institutional Review Board at VCU (HM20003645). This study was approved for a waiver for informed consent for research because all DCP participants provided consent for the YMCA to share their information with researchers for the sole purpose of evaluating the program.

Measures

Age, sex, race/ethnicity (categorized as white, black, and other), education (categorized as <high school/GED, high school diploma/GED, trade/vocational school, and college/university), and employment status (categorized as employed, retired, disabled, and unemployed/not in the labor force) were assessed by self-report. Number of classes attended (range, 0-12) was assessed from DCP records. Perceived social support for diabetes management from fellow group members (only assessed post-DCP) were assessed using 5 items (eg, members of my group encourage or reassure me about my diabetes) each assessed on a 4-point Likert-type scale ranging from *strongly agree* to *strongly disagree.* These 5 items were averaged to create an overall score (range, 1-4; Cronbach's $\alpha = .66$). "Readiness" for making lifestyle changes at the beginning of the DCP was indexed by having participants rate their willingness to engage in 7 health behaviors (eg, adopt a healthy diet, increase physical activity, quit smoking) each measured on a 5-point Likert-type scale ranging from *no interest* to *already doing this*. These responses were averaged to create an overall score (range, 1-5; Cronbach's $\alpha = .76$). Diabetes history was measured by self-report and included age of diabetes onset and duration of diabetes. Participants also reported their satisfaction with their diabetes care providers by assigning them a grade from "A" to "F," including an option to indicate *not receiving care for diabetes*.

The 4 main outcomes were diabetes self-management, indicators of mental health (depressive symptoms and perceived stress), weight, and glycemic control. Diabetes self-management was indicated by frequency of blood glucose monitoring in the past week (range, 0-7 days) and assessed pre- and post-DCP. Depressive symptoms in the past 2 weeks (eg, feeling tired or having little energy, sleeping problems, low mood) were assessed using the 8-item Patient Health Questionnaire. Items are assessed on a 4-point Likert-type scale (*not at all* to *nearly every day*), which were summed for a total score range of 0 to 24 (Cronbach's $\alpha = .90$). Depressive symptoms were examined both as a continuous variable and as a dichotomous variable of <10 versus ≥10 to indicate clinically significant symptoms.[26] Perceived stress during the past month (eg, How often have you been upset because of something that happened unexpectedly?) was assessed using the Perceived Stress Scale[27]; items were assessed on a 5-point Likert-type scale ranging from *never* to *very often* and summed to create an overall score (range, 0-36; Cronbach's $\alpha = .82$). Weight (in pounds) was assessed using a digital scale at each DCP session; only the initial and final weights are used in this analysis. Glycemic control was assessed using A1C, a metric of average blood glucose in the past 30 to 90 days. Pre-DCP A1C was assessed using A1CNow+ (Chek Diagnostics, Polymer Technology Systems, Inc, Indianapolis, IN), a point-of-care (POC) device, at the first DCP session. In a small number of participants, pre-DCP A1C was obtained through medical records for those who provided Health Insurance Portability and Accountability Act approval for their health care providers to share that information with the YMCA. Post-DCP levels of A1C were all measured by the POC device. This POC device has 98% concordance with clinical assessments.[28] A1C was examined both as a continuous variable and as a dichotomous variable of ≤9% versus >9% to indicate poor glycemic control, consistent with ADA guidelines.[29]

Analysis

Descriptive characteristics were estimated using measures of central tendency and proportions. Average

changes in glucose monitoring, mental health, weight, and A1C over the course of the DCP were estimated by subtracting postvalues from prevalues, so positive values are preferable (ie, lower A1C, fewer depressive symptoms) except for glucose monitoring, for which negative values are preferable (ie, more frequent checking). Average change in the outcomes was estimated overall and by each DCP coach (n = 18 coaches). The statistical significance of these changes was evaluated using paired *t* tests for continuous variables and X^2 tests for categorical variables. Finally, a series of linear and logistic regression models were fit to assess the whether (1) readiness for change, (2) number of classes attended, and (3) perceived social support from DCP peers predicted these outcomes. These analyses were limited to the 148 participants who completed the program; some models are based on smaller samples due to missing data on covariates, as indicated in the tables. Adjusted R^2 was used to quantify the explanatory power of linear regression models, and the C-statistic was used to quantify the explanatory power of logistic regression models.

Consistent with the principles of CBPR, the analytic plan was developed by both YMCA staff and researchers; however, all data analysis was conducted by non-YMCA members of the research team. Data were discussed by team members at monthly meetings over a 9-month period and with the CAB at quarterly meetings, which informed the specific questions addressed and the presentation and interpretation of results. Preliminary results were also shared at academic and community-based public forums during this period, which provided an opportunity to incorporate feedback from these audiences. All analyses were conducted using STATA (v11), and all *P* values refer to 2-tailed tests.

Results

Table 2 shows the baseline descriptive characteristics of DCP participants from 2015 to 2017, overall and stratified by completion status. Most participants were in their mid-50s, most were female, and about two-thirds were black. Approximately 40% were working at least part-time. Average age at diabetes diagnosis was 46 years, and 55% of participants had been living with diabetes for at least 5 years at the time they joined the DCP. Engagement in the DCP was high, with 75% of participants attending at least 8 of 12 classes. Supplemental Figure S1 plots attendance over the 12-week program and shows that attendance declined over the course of the program with the exception of week 6, in which participants took a tour of a local grocery store and received a $40 gift card to shop there.

As noted above, of the 312 participants who began the DCP, only 141 (45.2%) completed the program and provided both pre- and post-DCP A1C tests. Table 2 shows the differences in characteristics for participants who completed the DCP versus those who did not. Participants who completed the program were slightly older, had higher education, and were more likely to rate their diabetes health care team highly but otherwise did not differ from those who did not complete the program in terms of demographic characteristics, duration of diabetes, mental health, initial weight, and initial A1C.

Figure 1 illustrates the geographic reach of the DCP in the Richmond metropolitan area. This map shows that the program draws from urban, suburban, and rural areas and that most DCP participants live in lower-income zip codes. The effectiveness of the DCP on mental health, glycemic control, weight, and glucose-monitoring outcomes is shown in Figure 2. The bars in this figure show change in the average values of these outcomes, and the lines show the variability in these changes by lifestyle coach. There were significant improvements in both depressive symptoms and perceived stress from pre- to post-DCP. The mean number of depressive symptoms declined from 6.6 to 4.3 (n = 111, *t*-score = 5.3, $P < .001$), and the proportion of participants with clinically significant depressive symptoms declined from 32.4% to 15.5% over the course of the program (n = 111, $X^2 = 15.6$, $P < .001$). Similarly, perceived stress scores declined from 16.2 to 14.6 (n = 111, *t*-score = 3.06, $P < .003$). Average bA1C declined from 8.4% to 7.6% over the program (n = 141, *t*-score = 5.3, $P < .001$). At the beginning of the DCP, more than a quarter (27.0%) of participants had poor glycemic control (defined as A1C >9%), but only 14.9% had poor control post-DCP (n = 141, $X^2 = 33.5$, $P < .001$). Unexpectedly, weight did not significantly decline during the program (average of 229.2 lb pre-DCP vs 227.9 lb post-DCP, n = 141, *t*-score = 1.08, $P = .282$). Finally, the frequency of glucose monitoring increased from an average of 3.7 days per week to 4.1 days per week (n = 144, *t*-score = −2.1, $P < .036$).

Table 3 shows the relationship between readiness for change, class attendance, and social support from DCP classmates with glycemic control, depressive symptoms,

Table 2

Baseline Characteristics of Participants in the Greater Richmond Area YMCA's Diabetes Control Program (DCP): 2015 to 2017

		Program Completion Status		
	All Participants	Completed	Did Not Complete	X^2 or *z*-Score, *P* Value[a]
n	312	141	171	
Age, y, mean (SD)	53.9 (10.9)	55.1 (10.4)	52.8 (11.3)	1.78, $P = .076$
Female, n (%)	212 (71.4)	103 (74.1)	109 (69.0)	0.946, $P = .331$
Race/ethnicity, n (%)				
White	52 (24.4)	27 (27.0)	25 (22.1)	2.89, $P = .235$
Black	147 (69.0)	64 (64.0)	83 (73.5)	
Other	14 (6.6)	9 (9.0)	5 (4.4)	
Education, n (%)				
<High school/GED	15 (5.3)	3 (2.3)	12 (7.9)	7.83, $P = .050$
High school diploma/GED	100 (35.1)	43 (32.3)	57 (37.5)	
Trade/vocational school	38 (13.3)	16 (12.0)	22 (14.5)	
College/university	132 (46.3)	71 (53.4)	61 (40.1)	
Employment status, n (%)				
Full or part-time employment	122 (41.8)	58 (43.0)	64 (40.8)	2.26, $P = .521$
Retired	42 (14.4)	23 (17.0)	19 (12.1)	
Disabled	69 (23.6)	30 (19.7)	39 (24.8)	
Unemployed/not in the labor force	59 (20.2)	24 (15.8)	35 (22.3)	
Age at diabetes diagnosis, mean (SD)	46.1 (11.8)	47.3 (11.1)	45.0 (12.3)	1.43, $P = .153$
Duration of diabetes, n (%)				
Less than 1 y	42 (19.5)	21 (20.8)	21 (18.4)	1.84, $P = .605$
1 to <5 y	53 (24.7)	28 (27.7)	25 (21.9)	
5 to 10 y	45 (20.9)	18 (17.8)	27 (23.7)	
10 y	75 (34.9)	34 (33.7)	41 (36.0)	
"Grade" for doctor, n (%)				
A	146 (52.0)	62 (47.0)	84 (56.4)	11.95, $P = .035$
B	72 (25.6)	43 (32.6)	29 (19.5)	
C	43 (15.3)	19 (14.4)	24 (16.1)	
D or F	12 (4.3)	7 (5.3)	5 (3.4)	
Not receiving care	8 (2.9)	1 (0.8)	7 (4.7)	
A1C, mean (SD)	8.38 (2.2)	8.36 (2.5)	8.4 (2.0)	0.16, $P = .876$
Poor glycemic control,[b] n (%)	80 (26.9)	38 (27.0)	42 (26.9)	0.00, $P = .996$
Clinically significant depression,[b] n (%)	72 (32)	34 (32.4)	38 (31.7)	0.01, $P = .909$
Weight, lb, mean (SD)	231.1 (56.0)	229.8 (57.9)	232.3 (54.4)	0.38, $P = .704$
Perceived stress score, mean (SD)	16.6 (6.9)	16.0 (7.0)	17.1 (6.9)	1.23, $P = .220$
Number of DCP classes attended, mean (SD)	8.8 (2.9)	10.2 (1.6)	7.3 (3.4)	6.76, $P < .001$
Attend 8 or more classes, n (%)	200 (74.6)	131 (94.2)	69 (53.5)	58.7, $P < .001$

[a]"Completed" is defined as providing both a pre- and post-DCP A1C sample. Some estimates made on <141 participants due to missing data: age (n = 134), gender (n = 139), race/ethnicity (n = 100), education (n = 133), employment (n = 135), age of diagnosis (n = 105), duration of diabetes (n = 101), doctor grade (n = 101), weight (n = 138), depression (n = 105), perceived stress (n = 107), attendance (n = 139). *P* values from X^2 tests for categorical variables and *t* tests for continuous variables comparing characteristics of those who completed the YMCA DCP to those who did not.

[b]Poor glycemic control indicated by A1C >9%. Clinically significant depression indicated by Patient Health Questionnaire–8 score ≥10.

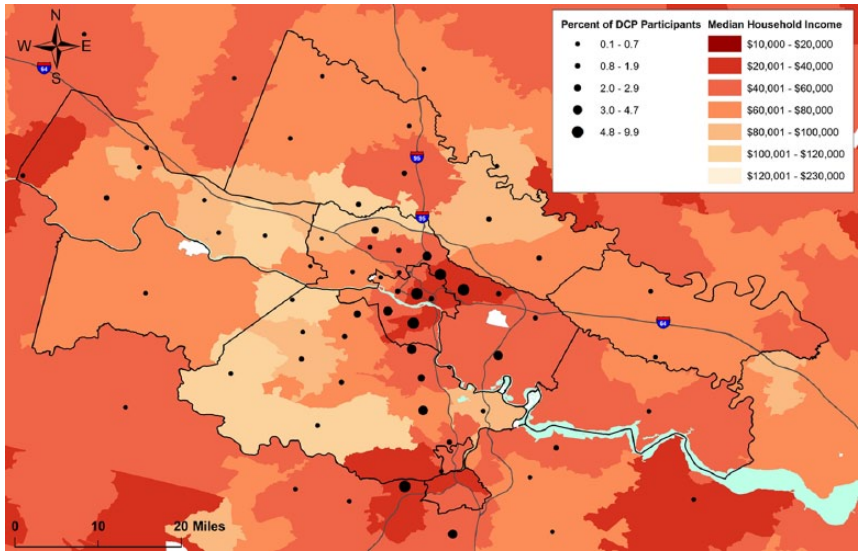

Figure 1. Geographic reach of the Greater Richmond Area YMCA's Diabetes Control Program (DCP) overlaid with median household income. Map of the Richmond, Virginia, metropolitan area. Median household income by zip code indicated by color intensity. Percentage of DCP participants (n = 312) who live in each zip code indicated by the black dots.

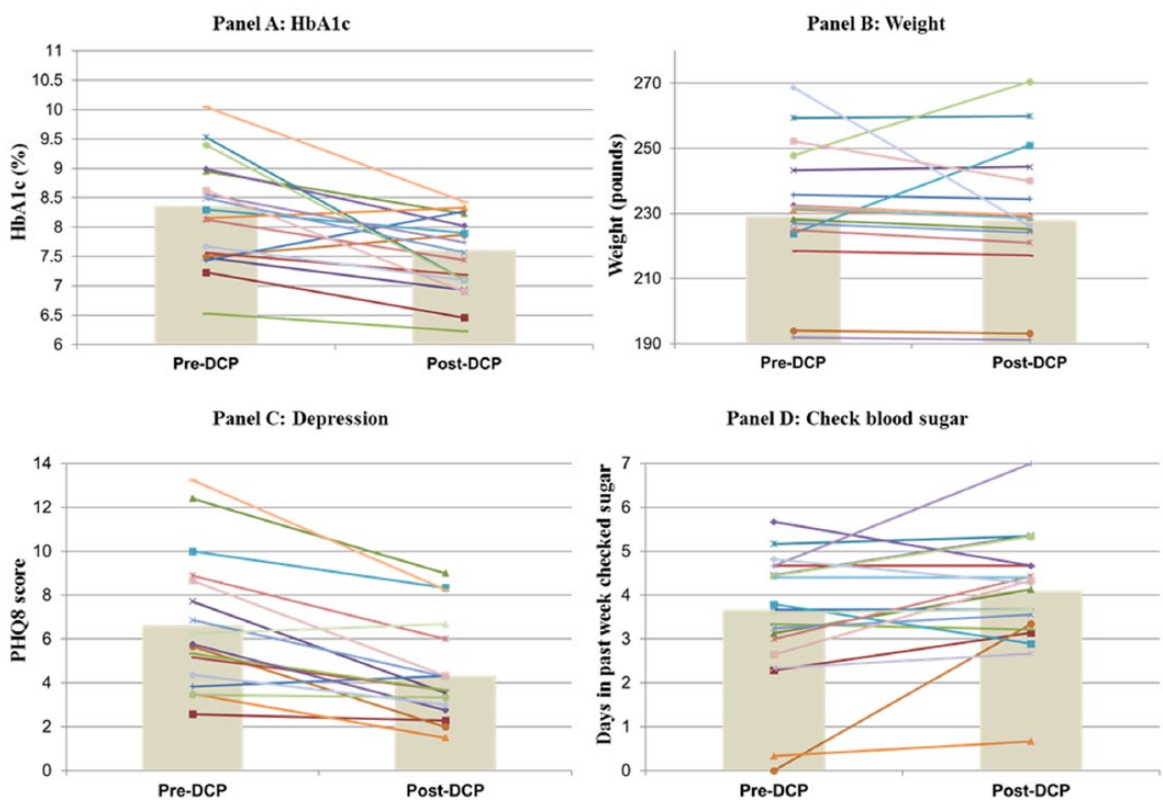

Figure 2. Average change in A1C, weight, depression, and glucose monitoring over the course of the YMCA Diabetes Control Program (DCP). Bars represent the overall average change pre-DCP to post-DCP among those who completed the program. Lines indicate the average change for individual coaches. (A) Hemoglobin A1C (%; n = 141). (B) Weight (lb; n = 141). (C) Depressive symptoms (Patient Health Questionnaire–8; n = 111). (D) Frequency of blood glucose monitoring (days per week, out of 7; n = 141).

Table 3

Correlates of Improvements in Glycemic Control, Depressive Symptoms, and Glucose Monitoring in the YMCA of Greater Richmond Diabetes Control Program (DCP)[a]

Outcome: A1C						
Relative Odds of Poor Glycemic Control (A1C >9%) Post-DCP						
	Model 1 OR (SE)	**Model 2 OR (SE)**	**Model 1 OR (SE)**	**Model 2 OR (SE)**	**Model 1 OR (SE)**	**Model 2 OR (SE)**
Readiness for change	0.52 (0.21)[b]	0.31 (0.19)[b]	—	—	—	—
Number of DCP classes attended	—	—	1.15 (0.14)	1.20 (0.26)	—	—
Perceived social support from DCP peers	—	—	—	—	0.63 (0.31)	1.67 (1.34)
N	109	68	148	93	132	79
C-statistic	0.84	0.87	0.84	0.86	0.82	0.84
Outcome: Depressive Symptoms						
Relative Odds of Clinically Significant Symptoms (PHQ score ≥10) Post-DCP						
	Model 1 OR (SE)	**Model 2 OR (SE)**	**Model 1 OR (SE)**	**Model 2 OR (SE)**	**Model 1 OR (SE)**	**Model 2 OR (SE)**
Readiness for change	0.34 (0.15)[c]	0.08 (0.08)[c]	—	—	—	—
Number of DCP classes attended	—	—	0.89 (0.08)	0.59 (0.15)[c]	—	—
Perceived social support from DCP peers	—	—	—	—	0.41 (0.23)	0.22 (0.18)[b]
N	114	70	123	74	122	73
C-statistic	0.87	0.84	0.85	0.84	0.84	0.88
Outcome: Frequency of Glucose Monitoring						
Change in Number of Days per Week of Monitoring Glucose at Post-DCP						
	Model 1 β (SE)	**Model 2 β (SE)**	**Model 1 β (SE)**	**Model 2 β (SE)**	**Model 1 β (SE)**	**Model 2 β (SE)**
Readiness for change	0.15 (0.31)	0.28 (0.38)	—	—	—	—
Number of DCP classes attended	—	—	0.03 (0.11)	0.06 (0.15)	—	—
Perceived social support from DCP peers	—	—	—	—	–0.81 (0.47)[b]	–0.35 (0.68)
n	115	70	144	94	135	86
Adjusted R^2	0.01	0.22	0.00	0.12	0.02	0.14

Abbreviations: OR, odds ratio; PHQ, Patient Health Questionnaire; SE, standard error.
[a]Model 1: unadjusted. Model 2: adjusted for age, sex, race/ethnicity, education, and employment status.
[b]$P < .10$.
[c]$P < .05$.

and glucose monitoring among those who completed the program. For each predictor, models show the crude and adjusted estimates. Readiness for change was marginally associated with lower odds of poor glycemic control post-DCP (odds ratio [OR]: 0.31, $P < .10$); however, neither number of classes attended nor social support from DCP classmates was associated with this outcome. Both attending more classes (OR: 0.59, $P < .033$) and

social support from fellow group members (OR: 0.22, $P < .07$) were associated with decline in clinically significant depression symptoms post-DCP. There were no significant predictors of change in glucose monitoring pre- to post-DCP. Weight was not examined as an outcome since it did not change during the DCP.

Discussion

Using the framework of RE-AIM, the primary findings from this study are that (1) the YMCA DCP has meaningful reach into low-income and racial/ethnic minority communities in the Richmond area and (2) this program is effective at producing improvements in glycemic control and mental health that are clinically meaningful. The success of this collaboration among YMCA staff, public health students, the CAB, and academic researchers reflects several core principles of CBPR: building on the strengths and resources within this community, partnering in a collaborative and equitable way throughout the research process, integrating knowledge and expertise for the benefit of all partners, engaging in transparent dissemination of findings by all partners, and committing to a long-term and sustainable research project.[30] Socially disadvantaged populations have limited access to high-quality health care, including diabetes education,[3] and the economic costs of these disparities are staggering.[31] This community-based DSMP is both effective and accessible, and it provides a model for other community-based organizations to follow as they attempt to address race/ethnic and SES inequities in diabetes self-management.

In developing the DCP, the YMCA applied many of the ADA standards for implementing accessible diabetes education, including considering the target population and modes of delivering the programming and identifying resources that could be leveraged to support engagement. However, the ADA has also called for research to address knowledge gaps in the implementation of DSMPs, including (1) the influence on organizational structure on the effectiveness of programming, (2) the impact of using a structured curriculum, and (3) the training required for laypersons to effectively deliver programming.[3] These findings speak to each of these gaps. First, the YMCA has structured DCP staffing support in a manner that focuses on day-to-day program operations, supporting community partnerships, and long-term sustainability. Ensuring that each of these foci has organizational support lends to the success of the program. Second, the YMCA of Greater Richmond designed their own structured curriculum drawing on vetted publicly available sources. This curriculum is unique in its active-learning elements, specifically the cooking demonstration, grocery store shopping tour, group physical activity sessions, and access to the YMCA gym, on-site childcare, and personal training services. Participants are encouraged to implement these lessons into their daily routine through journaling to track their diet and physical activity. Dietary management can be complex for diabetes, and DCP coaches are trained to encourage participants to talk with their doctor about setting diet and physical activity goals. In addition, the YMCA Community Health Office incorporated both motivational interviewing techniques and offers structured, continuous opportunities for skill development into their lifestyle coach training sessions. Diabetes program staff observe lifestyle coaches leading classes at least once during each 12-week session, which supports quality control, curriculum fidelity and helps identify where additional skills need to be developed. Finally, by leveraging a partnership with academic researchers, this YMCA has been able to evaluate the impact of their innovative programming on the community they serve in a rigorous way that would not have been possible without this type of expertise exchange.

Of the 4 outcomes examined—A1C, mental health, self-management behaviors, and weight—all but the latter improved over the course of the DCP. It is unclear which components of the program were the drivers of these changes. Neither number of classes attended nor social support from classmates were related to A1C. However, since these relationships were estimable only among those who provided the post-DCP A1C, and this group attended more classes (an average of 10.2 vs 7.2 classes), they likely felt sufficient support from their group compared with people who did not provide the second A1C. While the DCP curriculum was not designed to explicitly address mental health, depressive symptoms improved over the course of the program. There is an established bidirectional relationship between depression and diabetes,[32] and nearly one-third of participants had clinically significant depressive symptoms at the beginning of the program. This echoes the high mental health needs identified in the Diabetes Attitudes, Wishes and Needs (DAWN) studies[33] and demonstrates that any provider of DSMPs, whether health care professional or

layperson, needs to be aware of the burden of depression when delivering self-management programming.[34] Attendance and social support were associated with improved mental health, even though they were not related to self-management behaviors or glycemic control, suggesting that there are multiple mechanisms by which engaging in the DCP improves the overall well-being of participants. These results resonated strongly with alumni of the DCP who serve on the CAB. Additional research on the primary drivers of improvements in these clinical outcomes in community-based diabetes programs is warranted.

Findings should be interpreted considering study limitations and strengths. While this analysis evaluated change in outcomes pre- to post-DCP, participants were not randomized to the program, and thus these estimates cannot be interpreted as causal. The impact of the DCP could be estimated only for those who completed the program; however, those who completed the DCP were similar to those who did not complete it on most characteristics, suggesting that the findings are not substantially biased by differential attrition. In addition to attrition, missing data on some covariates reduced the sample size available for analysis. Medication adherence, prior experience with diabetes education, and health care utilization were not assessed and should be investigated in future research. Finally, it is important to note that the DCP is an adjunct to, not a replacement for, medical care; the laypersons who facilitate these groups do not provide medical guidance and are explicitly trained to direct participants to their health care provider if they have questions about their individual medication, diet, and overall health needs. This study also has several strengths. This evaluation reflects the shared vision and knowledge across multiple stakeholders: researchers, community-based organizations, public health students, and community members. Such cross-sector collaboration is critical to addressing social disparities in health.[35] The sample was large and racially and socioeconomically diverse, and both mental health and A1C were assessed using validated instruments.

The YMCA of Greater Richmond has offered the DCP since 2013, but community-based organizations must think innovatively to keep their programming both accessible and sustainable. Traditional return-on-investment analyses assume that the costs of providing DSMPs are recouped by organizations because they reduce health care utilization costs in the future. However, this is not the case for diabetes programs provided by community organizations such as the YMCA, which instead simply pass on these cost-savings to health care organizations, which often have not paid for the program themselves. The recent decision by the Centers for Medicare and Medicaid Services to reimburse for diabetes prevention programs offered in non–health care settings opens the door for policy makers to consider extending reimbursement to community-based DSMPs as well. This study suggests that such changes could have a significant impact on race/ethnic and economic disparities in diabetes outcomes.

ORCID iD

Briana Mezuk https://orcid.org/0000-0003-1798-2285

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