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Using path analysis to model the process of change in HbA1c among African Americans and Latinos in a community health worker diabetes intervention

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ABSTRACT

Objective: To examine which components of a culturally tailored community health worker (CHW) intervention improved glycemic control and intermediate outcomes among Latina/o and African American participants with diabetes.
Methods: The sample included 326 African American and Latina/o adults with type 2 diabetes in Detroit, MI. CHWs provided interactive group diabetes self-management classes and home visits, and accompanied clients to a clinic visit during the 6-month intervention period. We used path analysis to model the processes by which each intervention component affected change in diabetes self-efficacy, diabetes-related distress, knowledge of diabetes management, and HbA1c.
Results: The group-based healthy lifestyle component was significantly associated with improved knowledge. The group-based self-management section was significantly associated with reduced diabetes-related distress. Intervention class attendance was positively associated with self-efficacy. Diabetes self-management mediated the reductions in HbA1c associated with reductions in diabetes distress.
Conclusions: Path analysis allowed each potential pathway of change in the intervention to be simultaneously analyzed to identify which aspects of the CHW intervention contributed to changes in diabetes-related behaviors and outcomes among African Americans and Latinas/os.

Practice Implications: Findings reinforce the importance of interactive group sessions in efforts to improve diabetes management and outcomes among Latina/o and African American adults with diabetes.

1. Introduction

Community health worker (CHW) interventions have shown promise for improving glycemic control, health behaviors, and health outcomes among persons with diabetes and other chronic illnesses [20,27]; [29]; [37]; [41]. The American Public Health Association's CHW section [2] defines a CHW as someone who is a trusted member of and/or has an unusually keen knowledge and understanding of the community served. The experience, trust, and knowledge that CHWs bring to the front lines of public health enable them to serve as intermediaries between health systems and the community to facilitate access to services and improve the quality and cultural appropriateness of service delivery. In doing so, CHWs strengthen individual and community capacity by increasing health

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knowledge and self-management through outreach, community education, social support, and advocacy.

CHW interventions promote health by mitigating racial/ethnic, cultural, and access barriers between their communities and the health system [23,26,35]. These barriers are ameliorated through patient education, the identification of resources and referrals, coordination of care, and the provision of support [27]. CHW interventions are particularly effective in often marginalized communities that face challenges accessing health care [18,21,25,30,37,40,41,6].

Racial/ethnic inequities in diabetes remains a significant challenge, with a higher diabetes prevalence among Latina/o (12.7%) and African American (12.1%) adults in the United States compared to non-Latino white adults (7.4%) [7]. Compared with non-Latino white adults, African American and Latina/o adults disproportionately experience diabetes-related complications, diabetes-related mortality, and lower rates of glycemic control [11,15]. In recent years, CHW-led interventions have been shown to significantly improve glycemic control in racial/ethnic minority populations [6]; [9]; [11,12]; [16]; [32]; [33]; [37]; [41]. The REACH Detroit Partnership has conducted three cohort studies evaluating the effectiveness of its CHW-led diabetes healthy lifestyle and self-management interventions since 2000 [36,37,41]. Designed, conducted, and evaluated using community-based participatory research (CBPR) principles, these empowerment-based, culturally-tailored interventions were aimed at improving diabetes self-management among Latina/o and African American residents of Detroit [9,16]. After the intervention, participants showed significant improvement in dietary and diabetes self-management knowledge and behaviors and clinically significant improvements in HbA1c levels [37]; [41].

Despite the successes demonstrated by CHWs in promoting glycemic control among Latina/o and African American adults with diabetes, limited research examines which specific components of interventions contribute to their success. Studies that have attempted to better understand these components have been primarily descriptive and qualitative [12,21]. To our knowledge, no studies to date have systematically investigated which CHW intervention components are most effective in improving diabetes-related outcomes among racial/ethnic minority populations.

To address this gap, we identify which aspects of the REACH Detroit CHW intervention increased glycemic control among Latina/o and African American adults with type 2 diabetes. We hypothesized that specific components of our intervention led to changes in diabetes self-efficacy, diabetes-related distress, and knowledge of diabetes management, which, in turn, contributed to improvements in self-management behaviors and subsequent reductions in HbA1c levels. To test these hypotheses, we used path analysis to model the processes by which glycemic levels improved following the 6-month CHW intervention.

2. Materials and Methods

2.1. Sample

Eligible participants had physician-diagnosed type 2 diabetes, did not have severe diabetes complications, and were age 18 or older from REACH Detroit Partnership cohorts 1 and 2 (Fig. 1). All participants lived in either East or Southwest Detroit and received medical care from at least one of three partnering health care organizations (one federally qualified health center and two Detroit health systems). To reach the minimum recommended sample size of 200 for path analysis, data from participants who received the intervention in the two cohorts (cohort 1: 180 participants; cohort 2: 146 participants) were combined, resulting in a combined sample size of 326 [37,41].

The cohort 1 study involved a nonrandomized, one group pre-post design. All cohort 1 participants participated in a six-month CHW intervention [41]. Cohort 2 involved a randomized design with an immediate intervention group and a delayed intervention group that received the same intervention 6-months after baseline [37]. We used data from pre-intervention to 6-months post-intervention for both the immediate (T1, T2) and delayed groups (T2, T3). For both cohorts, interviews and lab measurements were conducted pre-intervention, at 6-months (immediately post-intervention), and at 12-months (6-months post-intervention). Data were collected between 2002 and 2004 and between 2005 and 2007 for cohorts 1 and 2, respectively.

2.2. Journey to Health Intervention

In the intervention delivered to both cohorts, trained CHWs conducted three activities: (1) Journey to Health/El Camino a la Salud diabetes education classes that included two intervention sections: Healthy Lifestyle and Diabetes Self-Management; (2) two home visits, of approximately 60 min each, to address participants' specific self-management goals; and (3) one clinic visit with the participant and his or her primary care provider [9]. The CHWs were recruited from the same communities in which the intervention participants resided and were of similar racial/ethnic backgrounds as participants and received core-competency-based CHW training and diabetes-specific training [36].

Intervention activities were conducted in English or Spanish based on participant preferences. The diabetes education classes used the Journey to Health culturally-tailored curriculum of five healthy lifestyle sessions, followed by six diabetes self-management sessions, conducted every two weeks for two hours. These sessions were based on patient empowerment principles, allowing for significant interaction among participants and emphasizing coaching participants in setting short-term action steps ("action planning") to meet longer-term health goals [3]. If individuals missed the group session, CHWs conducted an individual session with the participant to review the missed material. During home visits, CHWs assisted participants in setting behavioral goals and supporting their progress. CHWs also helped participants improve their patient-provider communication skills and facilitated referrals to other service systems [37].

2.3. Measures

2.3.1. Six-Month Outcome Variables

Hemoglobin A1c, abstracted from patient records, was the primary 6-month post-intervention outcome measure. Other outcome measures were based on self-reported survey responses. Knowledge of diabetes management was measured with the validated question, "How well do you understand how to manage your diabetes?," with responses ranging from *not at all* (1) to *very well* (5) [10]. Diabetes self-efficacy, an estimate of participant empowerment, was measured with the 17-item Perceived Competence for Diabetes Scale [42]. Example items include worrying about the possibility of serious diabetes-related complications and feeling that you are failing in managing diabetes. Responses were recoded and ranged from *not a problem* (1) to *a very serious problem* (6). Diabetes-specific psychological distress was measured using the Problem Areas in Diabetes (PAID) scale [31]. Six questions assessed self-management behaviors from the Summary of Diabetes Self-Care Activities (SDSCA) scale [39]. The SDSCA scale is an average of the responses to the six questions that encompass taking recommend diabetes medication doses, following a healthful eating plan, and testing blood sugar as often as the doctor recommended. While diabetes distress and self-efficacy had high Cronbach alpha scores above 0.87, the pre- and post- diabetes self-management scores had alphas under 0.50.

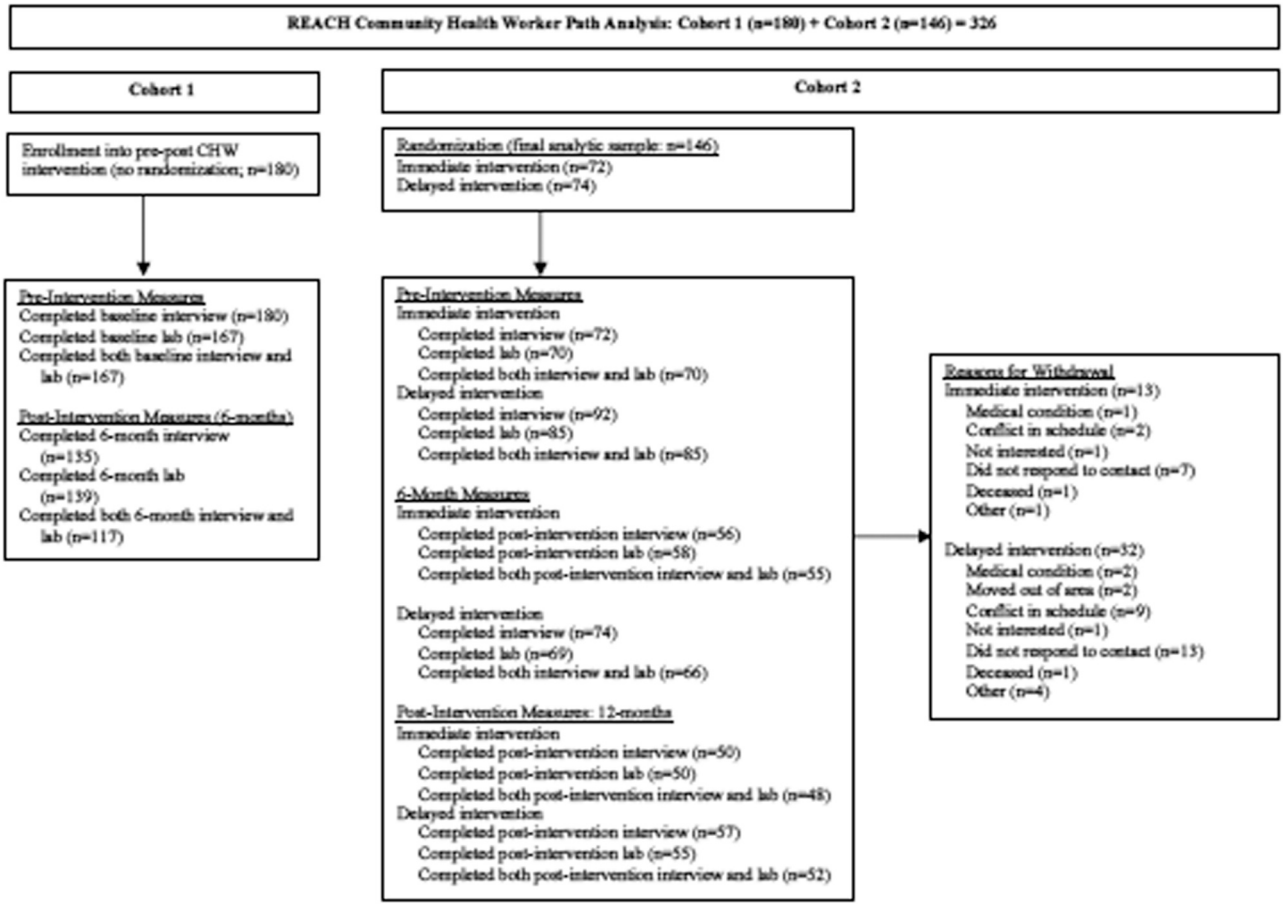

Fig. 1. Study Participant Flow Diagram, REACH Detroit Community Health Worker Intervention, Cohorts 1 and 2.

In cohort 1, self-efficacy and knowledge of diabetes management were assessed at baseline and 12-months, but not 6-months. In cohort 2, these were measured at all three time points. Neither the mean knowledge (mean: 3.93 vs. 4.06, respectively; p = 0.14) nor self-efficacy (mean: 76.12 vs. 76.28, respectively; p = 0.83) scores changed significantly from 6-months to 12-months for cohort 2 in the intervention group**.** Thus, we estimated the 6-month knowledge and self-efficacy scores in cohort 1 by using the 12-month values.

2.3.2. Independent Variables

Class attendance indicated the number of Journey to Health sessions that participants attended in either a group or one-on-one format, and ranged from 0 to 11. As 44% of participants attended at least one intervention class through a one-on-one session with the CHW, two intervention format variables were created that accounted for the intervention section (i.e., Healthy Lifestyles or Diabetes Self-Management) and format (e.g., group or one-on-one). The Healthy Lifestyles group session variable was dichotomized as participants who participated in all of the Healthy Lifestyles classes in the group format only (1) and those who completed >1 of the classes in one-on-one format (0). Similarly, the Diabetes Self-Management group session variable was dichotomized as those who only engaged with this curriculum using the group format (1) and participants who received any one-on-one sessions (0). The CHW-accompanied doctor visits variable was dichotomized as participants who were accompanied for at least one visit (1) and those who were not (0). Due to insufficient measurement for the home visit component of the intervention from cohort 1, we excluded the home visit variable from the model. Covariates included age, gender, race/ethnicity, high school education, cohort, and treatment group (e.g., immediate or delayed group).

2.4. Analysis

Exploratory data analysis techniques were used to assess the distribution of variables. Unadjusted means and percentages were calculated for sociodemographic and participation measures for the combined cohorts 1 and 2 (n = 326). The unadjusted means of the outcomes at pre-intervention, post-intervention, and the change scores with 95% confidence intervals were calculated. Change scores were computed by subtracting the pre-intervention means from the post-intervention means. The p-values for the change scores were estimated by *t*-test.

The path analysis tested the fit of our theoretical model that hypothesized that changes in self efficacy, diabetes-related distress, and knowledge of diabetes management would lead to change in self-management behaviors and subsequent reductions in HbA1c 6-months following the intervention (Fig. 2). We included as indicators in the post-intervention equations for self-efficacy, diabetes-related distress, and knowledge of diabetes management: class attendance, intervention section (e.g., Healthy Lifestyles or Self-Management), intervention format (group versus individual), and whether participants were accompanied to >1 doctor appointment by a CHW. The post-intervention self-management behavior equation includes pre-intervention behaviors, post-intervention self-efficacy, diabetes-related distress, and knowledge of diabetes management. Post-intervention HbA1c is modeled as a function of post-intervention self-management behaviors, adjusting for covariates.

The path analysis was estimated using Full Information Maximum Likelihood (FIML), which utilizes all available variables [43]. To confirm the assumption that data were missing at random [19], we conducted an independent *t*-test to determine whether pre-test intervention means differed as a function of post-intervention missing data. None of the pre-intervention means differed significantly by whether the post-intervention values were missing, indicating that missing at random was a reasonable assumption. The goodness of fit of our model was evaluated with the Joreskorg-Sorbom Adjusted Goodness of Fit Index (AGFI) for absolute fit [14,17], Bentler's Comparative Fit Index (CFI) for incremental fit [5], Steiger-Lind Root Mean Square Error of Approximation (RMSEA) for a parsimony index [38], and the Standardized Root Mean Square Residual (SRMR) for predictive fit of the model [13]. A likelihood ratio test (LRT) was used to examine the effect of removing demographics and treatment group, class attendance, class format, and doctor visits from the model. The Akaike Information Criteria (AIC) was used to compare models that were not nested as recommended [1]. The model was run with SAS Proc CALIS, version 9.4.

3. Results

3.1. Sample Demographic and Participation Characteristics

Table 1 summarizes the participant characteristics and intervention participation. The average age of participants was 54.7 years (Range: 22–90 years). Forty-two percent identified as Latina/o and 58% identified as African American. Seventy-two percent identified as women and 54% were high school graduates. On average, participants attended 7 out of 11 intervention classes: 56% attended all healthy lifestyles classes in group format and 51% attended all diabetes self-management classes in group format. Participants received an average of one CHW-accompanied doctor visit, with 51% of participants receiving at least one CHW-accompanied doctor's visit. Following the intervention, scores in knowledge of diabetes management, diabetes self-efficacy, and diabetes self-management behavior all significantly improved (Table 2). There was no significant decrease in diabetes distress. Participants' HbA1c dropped significantly, with an average of a 0.7% decline from pre- to post-intervention.

Table 1
Demographics and Participation (n = 326), REACH Detroit.

Characteristic	Mean (95% CI) or no. (%)
Race/Ethnicity, no. (%)	
Latina/o	136 (41.7%)
African American	190 (58.3%)
Gender, no. (%)	
Women	236 (72.4%)
Men	90 (27.6%)
Age, years, mean (95% CI)	54.7 (53.3, 56.2)
High School Graduate, no. (%)	176 (54.0%)
Doctor Visits[a], mean (95% CI)	1.1 (0.9, 1.2)
Healthy Lifestyles Group Class Attendance[b], no. (%)	184 (56.4%)
Self-Management Group Class Attendance[c], no. (%)	167 (51.2%)
Number of Intervention Classes, mean[d] (95% CI)	7.1 (6.6, 7.6)

[a] Number of client doctor visits accompanied by a community health worker.
[b] Percentage of clients who attended all Journey-to-Health classes in group format.
[c] Percentage of clients who attended all Self-Management classes in group format.
[d] Total of 11 classes possible.

3.2. Path Analysis Results

3.2.1. Diabetes Knowledge

The coefficients and standard errors for the path analysis are displayed in Fig. 2. All post-intervention outcomes were significantly related to their pre-intervention values. Higher post-intervention knowledge of diabetes management was associated with the number of intervention classes attended and attending the healthy lifestyle classes in group format. As indicated by the significant path coefficient from intervention class attendance to post-intervention knowledge, for each intervention class attended, the average increase in knowledge was 0.03. Participants who received the healthy lifestyles classes in group format had a 0.25 greater increase in measured knowledge compared to those who attended one-on-one sessions. Therefore, if a participant attended 10 classes and each class was in group format, the average post-intervention increase in knowledge would be 0.55, which is approximately half a point on a four-point scale.

3.2.2. Diabetes Distress

Attending the self-management classes in group format was associated with a −5.86 ($p < 0.01$) average decrease in diabetes distress score. This corresponds to approximately a 25% reduction in diabetes distress from its pre-intervention mean of 23.9. A decrease in diabetes-related distress was associated with improved self-management behavior ($p < 0.05$).

3.2.3. Self-Efficacy

Post-intervention self-efficacy increased an average of 1.38 ($p < 0.001$) for each intervention class attended. If a participant attended 10 classes, average self-efficacy increased by an average of 13.8 on a 100-point scale.

3.2.4. HbA1c

Post-intervention HbA1c levels were significantly associated with post-intervention self-management behaviors and gender. A one-unit increase in self-management behaviors was associated with a 0.55 ($p < 0.001$) drop in post-intervention HbA1c. While there was no pre-intervention difference in HbA1c by gender ($p = 0.11$), on average men had post-intervention HbA1c levels that were 0.42 units lower than women. A reduction in post-intervention diabetes distress was a significant predictor of increased post-intervention diabetes self-management behavior, which mediated reductions in HbA1c.

3.3. Model Fit Results for the REACH Detroit Partnership's Theoretical Model

The model explained 97% of the generalized covariance among the predictors and outcomes (AGFI score: 0.971). The model also had a good predictive fit (SRMR: 0.046) and an appropriate amount of parsimony (RMSEA: 0.067, 95% confidence interval: 0.053, 0.081). Lastly, the intervention model was a 94% improvement over the null model (CFI: 0.935). The LRT results indicated the effect of removing demographics, treatment group, and doctor visits were small, where treatment group indicates whether the intervention was conducted from baseline to 6-months or from 6-months to 12-months, not whether a participant received the intervention. In contrast, class attendance and group versus one-on-one format were critical components of the model. Specifically, the group class format was significantly associated with increased knowledge and lower diabetes distress. Whereas the high alpha scores in diabetes distress and diabetes self-efficacy indicated a single construct, the low alpha scores in self-management suggested this variable might be better represented with individual components instead of a composite score. Further, the medication adherence component of self-

Table 2
Unadjusted Six-Month Outcomes, Mean (95% CI), REACH Detroit.

Six-Month Outcome	Pre-Intervention	Post-Intervention	Change[a]
Diabetes Management Knowledge score[b]	3.4 (3.2, 3.5)	4.0 (3.8, 4.1)	0.6 (0.5, 0.8)**
Diabetes Distress (PAID) scale score[c]	23.9 (21.5, 26.3)	22.8 (20.2, 25.5)	-1.6 (−3.9, 0.7)
Diabetes Self-efficacy score[d]	71.8 (69.6, 74.0)	74.6 (72.0, 77.3)	4.2 (1.1, 7.3)**
Diabetes Self-management Behavior score[e]	3.0 (2.9, 3.1)	3.3 (3.3, 3.4)	0.3 (0.2, 0.4)**
Hemoglobin A1c (HbA1c)	8.4 (8.2, 8.7)	7.8 (7.5, 8.0)	-0.7 (−0.9, −0.5)**

*p < 0.05; **p < 0.01.
(range=1–5; 1 =not at all; 5 =very well).
[a] p-values from *t*-test.
[b] From theDiabetes Care Profile [26], "How well do you understand how to manage your diabetes?"
[c] Problem Areas in Diabetes scale [28], (range = 0–100).
[d] Perceived Competence for Diabetes scale [27], (range = 0–100).
[e] Summary of Diabetes Self-Care Activities (SDSCA) scale [29], (range = 1–4).

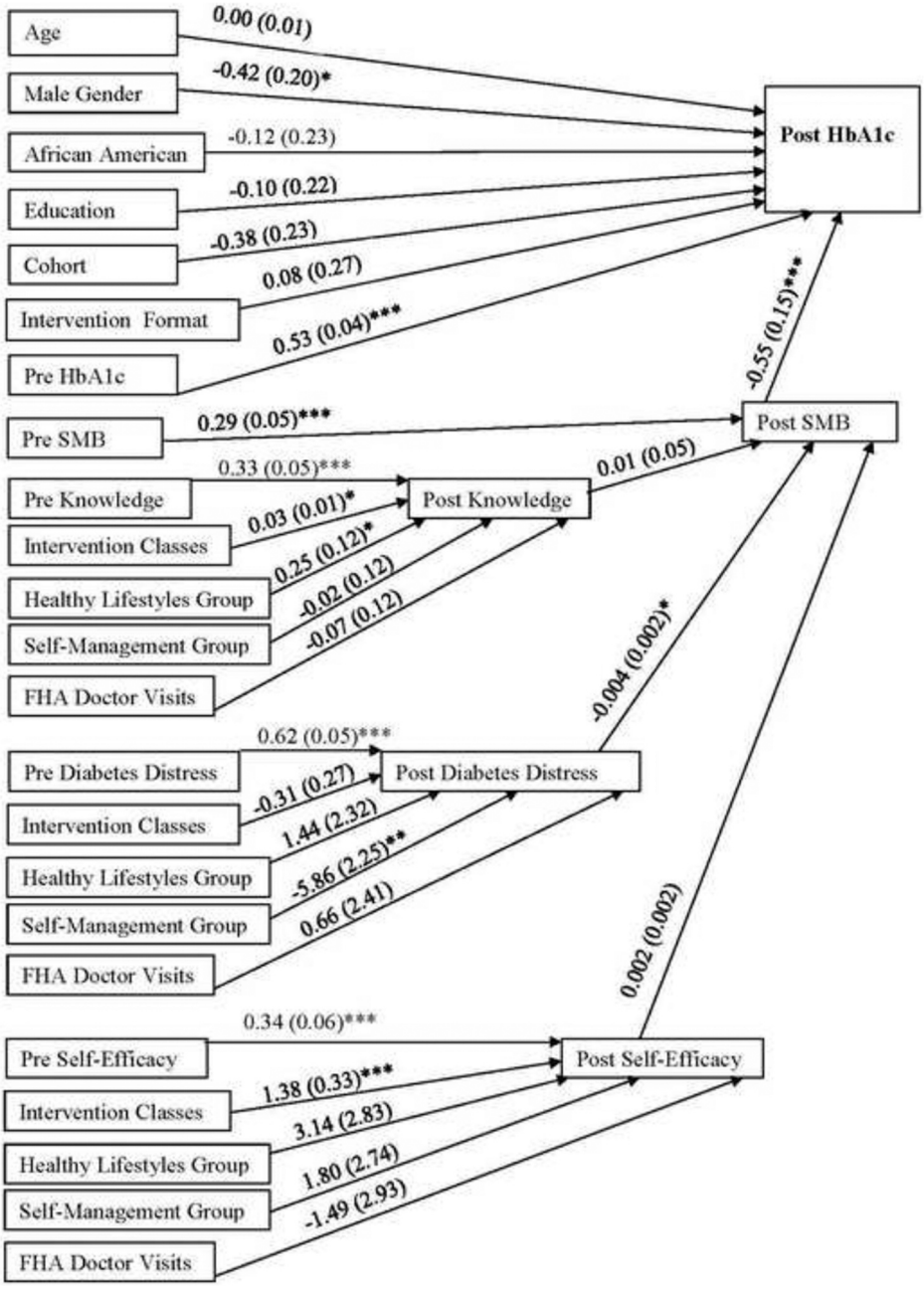

Fig. 2. Path Analysis of Process of Change in Six-Month Self-Management Behaviors and HbA1C in a CHW Intervention, REACH Detroit, 2002–2007. Notes:* indicates p < 0.05 ** indicates p < 0.01 *** indicates p < 0.001 SMB indicates diabetes self-management behavior FHA indicates Family Health Advocate.

management was near the maximum of the scale at pre-intervention and did not change during the intervention. However, the components of diabetes self-management on testing blood sugar and following a healthy diet improved significantly from pre-intervention to post-intervention. Subsequently, we examined a model for each component of diabetes self-management as separate outcomes. Based on AIC criteria, the model with the composite measure for self-management fit best.

4. Discussion and Conclusions

4.1. Discussion

In this paper modeling the process of change in HbA1c among African American and Latina/o adults with type 2 diabetes participating in a CHW-led intervention, we found differential effects of the examined intervention components. Attendance of CHW-led group classes was a significant predictor of improved intermediate outcomes such as knowledge and diabetes distress and reductions in HbA1c associated with reductions in diabetes distress were mediated by post-intervention diabetes self-management behaviors. When intervention format was significant, the group format was more beneficial than the one-on-one format.

Unlike studies of other CHW programs, this study moves beyond prior descriptions of socio-demographic and socio-cultural correlates of change in health outcomes by examining the impact of specific components of the intervention. Path analysis allowed for each potential pathway of change in the intervention to be simultaneously analyzed to identify which aspects of the CHW intervention contributed to changes in diabetes-related behaviors and health outcomes among African Americans and Latinas/os.

Diabetes self-management education and increased diabetes knowledge can also have a positive impact on mental health. Another diabetes education intervention that examined the impact on self-care, metabolic control, and emotional well-being indicated post-intervention improvements in emotional status, diabetes self-efficacy, self-esteem, and glucose control, and decreases in depression and anxiety [34]. Our findings are similar, and further distinguish the contributions of healthy lifestyle and self-management education led by CHWs and show that positive outcomes beyond HbA1c can be obtained. Attending healthy lifestyles intervention sessions in group format significantly increased knowledge of diabetes management. Additionally, participating in the group format of the self-management section significantly reduced diabetes-related distress.

Our findings are consistent with prior studies demonstrating that group-based interactive interventions that incorporate action planning are an effective method for improving diabetes knowledge and self-management skills [8]. For example, a meta-analysis of 11 randomized controlled clinical trials of group-based diabetes education programs compared to routine treatment showed significant decreases in fasting blood glucose, blood pressure, and body weight, and increases in diabetes knowledge for group-based diabetes education programs [8]. Additional benefits of a group format include increased opportunities for group participation, peer support, and collaborative relationships to provide additional social support for change [24]. The present study contributes to the literature on group-based education by demonstrating that CHW-led group education classes are more effective in improving health outcomes in type 2 diabetes compared to one-on-one classes. Using an empowerment-based, culturally-tailored curriculum with individual follow-up home and clinic visits may have contributed to the effectiveness of the group format compared to one-on-one format alone. Given our knowledge of the importance of interactive CHW-led health education classes compared to didactic approaches, it is important to improve access to community-based group classes and reduce attendance barriers.

This study has several limitations. These findings are most applicable to CHW interventions involving predominantly female African American and Latina/o participants with diabetes from an urban area and may not be generalizable to other contexts. Research should assess whether similar findings apply to CHW interventions conducted in rural areas, with samples that predominantly include men, and with other racial/ethnic groups. Additional limitations include the use of self-reported data for some variables and combining data from two cohorts who participated at different time periods. Thus, there may be a historical threat to validity. However, since the basic components of the intervention and its protocols were unchanged across the two cohorts, the benefit of increasing our sample size and subsequent power gained outweighs this limitation. Another limitation is the use of 12-month diabetes knowledge and self-efficacy scores as a proxy for 6-month scores for Cohort 1, even though 6-month and 12-month scores were similar for Cohort 2. Finally, participants were not randomly assigned to group or one-on-one intervention formats. Participants in one-to-one meetings may have experienced greater barriers to participating in group meetings (e.g., inadequate transportation, complex work schedules, childcare responsibilities) that could also lead to poorer diabetes outcomes. Moreover, it is possible that other pre-intervention characteristics (e.g., readiness for change, preference) play a role in shaping participation in group-based classes, which may have contributed to improvements in intervention outcomes linked with group-based class participation. Indeed, evidence indicates that more frequent participation in a diabetes CHW intervention is associated with modest reduction in HbA1c relative to the comparison group [28]. Future studies are warranted that examine the impact of participant preference and barriers to participation in group interventions, as well as identifying and studying strategies that address barriers to group intervention participation.

4.2. Conclusions

The findings from this study suggest that although interventions can demonstrate overall effectiveness in their intended outcomes, the analytic model elucidates the intervening paths, specifically the intervention shaped improvements in diabetes-related outcomes through improved knowledge, self-efficacy, and post-intervention self-management behavior and reduced distress. Such information is important in continuing to develop and refine effective CHW-led interventions to improve diabetes-related health outcomes. CHW interventions are increasingly utilized in health care systems and in communities. This study advances the literature on CHW-led diabetes interventions by demonstrating that this CHW-led interactive group-based healthy lifestyle and self-management education was effective because it affected changes in participants that, in turn, affected HbA1c.

4.3. Practice Implications

By using path analysis, this study contributes to a better understanding of which aspects of a CHW intervention are most effective in improving glycemic control. It also helps elucidate how these components influence intermediate outcomes on the path to glycemic control. This study joins literature that has contributed to the identification of CHWs as critical members of interdisciplinary health care teams [22,30,4]. The findings from the literature are clear: CHWs are an important ambassador between disenfranchised communities and health systems serving these communities. Our findings extend this literature and suggest one important role that CHWs play in these interdisciplinary teams, namely facilitation of group sessions as part of a diabetes management intervention. This

has important implications for future program design and care team roles allocation, and for improving diabetes-related outcomes in populations disproportionately burdened by diabetes and related complications. Expanding access to culturally appropriate group interventions led by CHWs has great potential for improving the health of individuals and communities and reducing health inequities. As more CHW interventions are put into place, it is important that diabetes researchers, educators, and health care organizations have a better understanding of the specific mechanisms that produce change within a CHW intervention.

CRediT authorship contribution statement

Alana M.W. LeBrón: Conceptualization, Investigation, Writing – original draft. **Nicolaus R. Espitia:** Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Edith C. Kieffer:** Funding acquisition, Conceptualization, Methodology, Writing – original draft. **Brandy R. Sinco:** Methodology, Data curation, Formal analysis, Visualization, Writing – original draft. **Jaclynn M. Hawkins:** Writing – original draft. **Emily J. Nicklett:** Writing – original draft. **Gloria Palmisano:** Writing – original draft. **Michele Heisler:** Writing – original draft. **Michael S. Spencer:** Funding acquisition, Conceptualization, Methodology, Writing – original draft, Supervision.

Declaration of Competing Interest

The authors have no competing interests to declare.

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