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REVIEW

A Systematic Review of Community Health Center Based Interventions for People with Diabetes

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Abstract

Community health centers (CHCs) focus on serving socioeconomically disadvantaged populations with heightened chronic disease burden, making CHCs an ideal setting for implementing diabetes care programs that target vulnerable populations. We aimed to synthesize evidence concerning the effects of CHC interventions in people with diabetes. To do this, four electronic databases were searched, including PubMed, EMBASE, CINAHL, and Scopus, and hand searches of reference collections were undertaken to identify intervention trials published in English. We screened 892 unique titles and abstracts. Two reviewers then independently evaluated 221 full-text articles. We discovered 29 articles met our eligibility criteria for inclusion. We found 27 unique studies with two companion articles. Seventeen studies were randomized controlled trials and the majority had a higher proportion of female and racial/ethnic minorities in the study sample. CHC interventions often involved either one-on-one or group education sessions supplemented by a phone follow-up that were delivered by health providers, nutritionists, or community health workers. CHC interventions using education sessions combined with follow up via phone generally resulted in significant improvements in hemoglobin A1C, while sole telephone-based education studies showed no significant improvements. CHC interventions had no significant effects on physical activity in all six studies that examined the outcome. Overall, we found that CHC interventions were in general effective in improving glucose control when using face-to-face interactions in low-income, underserved, and racial and ethnic minority patients with diabetes. Evidence was limited, however, in regards to other outcomes which suggests the need for continued evaluations of CHC intervention models.

Keywords Community health center · Diabetes · Intervention · Systematic review

Introduction

The health status of a population is inextricably linked to social and economic conditions. In the United States (U.S.), we face unique challenges fueled by decades of inequity that require culturally appropriate health and social interventions. For example, African Americans are more than twice as likely to die from diabetes [1]. Diabetes, which is both an antecedent and moderating factor for cardiovascular disease, is the leading cause of death in the U.S.

Community health centers (CHCs)—previously referred to as neighborhood health centers—are community-based clinics that provide primary healthcare services to people with limited access to health care [2]. Currently, there are more than 1300 CHCs in the nation, that serve more than 27 million patients, 92% of whom are low-income and 62% of whom are racial/ethnic minorities [3]. Serving

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socioeconomically disadvantaged populations with heightened disease burden makes CHCs an ideal setting for implementing chronic care programs for vulnerable populations suffering from diabetes.

A number of systematic reviews were published that addressed diabetes interventions in primary care and community settings, but not CHCs. Previous systematic reviews found that theory-based lifestyle interventions (e.g., health belief model, transtheoretical model, Precede–Proceed model, theory of empowerment, social cognitive theory) [4], social network interventions [5], or interventions using community health workers [6, 7] or peers [8], and mHealth [9] were effective in improving hemoglobin A1C (HbA1C) among individuals with diabetes. Additionally, motivational interviewing by general practitioners [10] and nurse-led self-management support interventions [11] resulted in a significant improvement in HbA1C in patients with diabetes. Community pharmacist-led interventions did not report statistically significant effects of interventions on diabetes [12].

There is growing attention to the social determinants of health in order to better understand and act on the upstream socioeconomic drivers of poor health outcomes and higher economic costs for diabetes [13]. Given that CHCs serve as primary care homes for the nation's most vulnerable populations [3], a comprehensive systematic review on CHC interventions to control diabetes among vulnerable populations is needed. To this end, the purpose of this study is to synthesize the evidence on CHC interventions. Specifically, we examined the characteristics of CHC interventions and the outcomes in people with diabetes. Our review systematically extends the previous efforts by providing an understanding of: (1) what constitutes CHC interventions (type and contents); (2) who delivers CHC intervention; and (3) how CHC interventions achieve desired effects.

Methods

Search Strategy

Following consultation with a health science librarian, four databases were searched. PubMed, EMBASE, CINAHL, and Scopus were searched using MESH and Boolean search techniques. Search terms included: "Community Health Centers" OR "community health center" OR "satellite center" OR "satellite centers" "neighborhood health centers" AND "Chronic Disease" OR "Diabetes Mellitus" OR "chronic disease" OR "chronic diseases" OR "chronic illness" OR "chronically ill" OR "chronic illnesses". Truncations of these words were also used in the electronic searches. See Appendix for specific terms used for each database.

Selection of Studies

The search was conducted in January 2018. A total of 1657 references were retrieved from the electronic searches and imported into the Covidence software. Of these, 765 duplicates were removed, and 892 studies were forwarded to title and abstract screening. Two reviewers independently conducted an initial screening of titles and abstracts for relevance to diabetes. After title and abstract review, 671 articles were excluded because they were irrelevant. Also, conference abstracts had limited information on study characteristics and thus were also excluded. 221 abstracts were identified for full review. Two reviewers independently evaluated full-text articles to determine eligibility. Articles were included in this review if the study was: about diabetes mellitus, published in the English language and involved participants who were 18 years and older. Additionally, only intervention studies that were conducted within a CHC setting in the U.S., and studies that reported patient outcomes were included. Subsequently, 192 articles were excluded for the following reasons: wrong study design (n = 68), abstract only (n = 33), wrong intervention (n = 25), wrong study population (n = 24), supplement (n = 21), wrong outcomes (n = 12), wrong setting (n = 4), wrong patient population (n = 3), wrong language (n = 2). All references were screened at every stage by two independent reviewers. Disagreements were resolved through consensus. Twenty-nine articles met the inclusion criteria. Figure 1 provides details of the selection process.

Data Extraction

Relevant data were extracted by four trained research assistants using a standardized data extraction form developed by the authors. The following data were extracted from the included studies: first author, year, study design, sample, recruitment methods, retention rate, setting, study outcomes and measurement, main findings, intervention type, modality and dose, control or comparison condition, and interventionist. An independent research assistant reviewed extracted data to check accuracy. Any discrepancies were resolved through discussions among all research assistants and authors.

Quality Appraisal

Each study was evaluated for its quality, based on published quality rating scales. Specifically, we used the quality rating scales published by the Joanna Briggs Institute for experimental and quasi-experimental studies [14]. The total quality rating scale score ranged from 0 to 13 for experimental

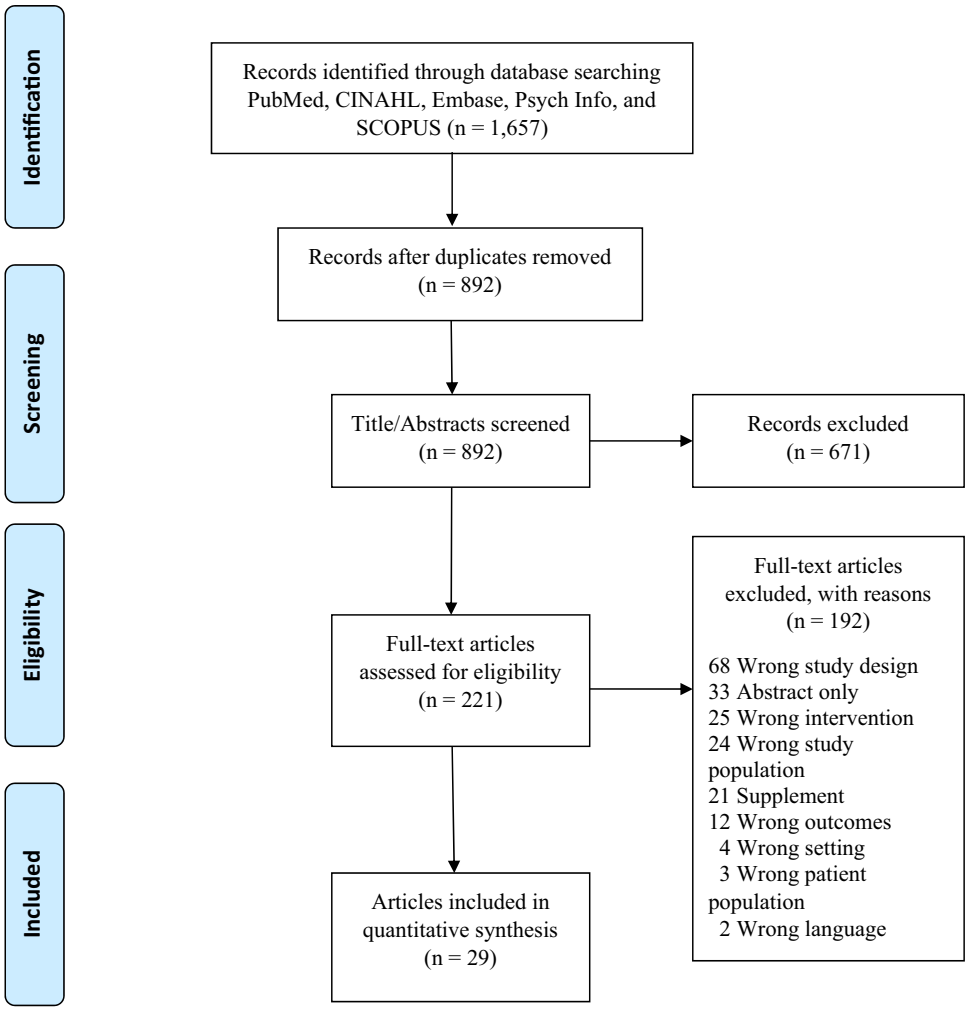

Fig. 1 PRISMA diagram

studies and from 0 to 9 for quasi-experimental studies. Zero is the lowest quality and 13 (or nine) indicates the highest quality. Based on the possible range of scores, studies with quality ratings of 0–4, 5–8, and 9 + were categorized as low, medium, and high quality for experimental studies and 0–3, 4–6, and 7 + for quasi-experimental studies, respectively. Two authors rated each study for its quality independently. Inter-rater agreement statistics using percent agreement ranged from 44 to 100% (average 73%). Any discrepancies were resolved through team discussions.

Results

Overview of Studies

Table 1 summarizes the main characteristics of the 29 articles included [15–43]. The review included 28 unique studies [15, 17–43] with one companion article [16]. The companion article [16] analyzed the cost-effectiveness of the parent study [15]. Two articles [36, 37] addressed the same intervention but with different outcomes and samples. Seventeen of the 28 studies were randomized controlled trials [15, 17–32] and the remaining studies (n = 10) were quasi-experimental [33–43]. Twenty-one studies focused solely on people with type 2 diabetes [15, 17, 19–32, 34, 39, 40, 42–44], while four studies focused on both type 1 and type 2 diabetes [18, 35, 36, 38]. One study included people with various chronic diseases including type 2 diabetes [33] and one study did not specify the type of diabetes [41].

The sample sizes ranged from 14 [18] to 10,000 [41] and the enrolled participant age ranged from 18 [37] to 89 years [33]. The majority of participants were female who consisted of 52% [24] to 89% [19] of the study samples except for a few in which female participants made up 50% or less of the sample [38, 41, 42]. Ten studies focused solely on interventions targeting Hispanic and Latino patients [20, 26–28, 31–34, 40, 42] and several studies included populations where African Americans [15, 19, 25, 35, 43] or Hispanics [37, 38] comprised more than 50% of the study sample. Other minority ethnicities included were Native Americans and Asian Pacific Islanders [19], and Native Hawaiians [30].

Table 1 Study characteristics

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Alicea-Planas (2013) [33]	Quasi-experimental (no control, pre/posttest)	N = 184 (91 intervention, 93 control group); age range 21–89 (mean = 54.1 years); 71% female; Hispanic population	Chart reviews/retention rate 87%	Inner-city urban area of Southwestern Connecticut	Self-efficacy, self-rated health/Chronic Illness Resources Survey, Chronic Disease Self-Efficacy Scale, Acculturation Scale, Health Change Plan Sheet	Self-efficacy and self-rated health scores were not significantly different from pretest to posttest by study group ($p > 0.05$)
Allen (2011) [15], (2014) [16]	RCT	N = 525 (261 intervention [mean age = 54.3 years, 72% female, 79.3% Black] and 264 enhanced usual care, EUC [mean age = 54.7 years, 71% female, 79.6% Black])	Medical record reviews/retention rate not reported	2 CHCs in Baltimore	Changes in lipids, BP, HbA1c measured at baseline and 1-year. Also, provider and lab test costs, drug costs, clinician time; dietary intake, physical activity, quality of life, resource utilization, and health care utilization	Intervention group had significantly greater improvements in all outcomes compared to usual care: LDL (decreased by 15.9 mg/dL, $p < 0.001$), total cholesterol (decreased by 19.7 mg/dL), triglycerides (decreased by 16.3 mg/dL), systolic BP (decreased by 6.2 mmHg, $p = 0.018$), and HbA1c (decrease of $\geq 0.5\%$, $p = 0.034$); total cost for 1-year of NP/CHW intervention exceeded the overall cost for physician care (per patient)

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Anderson (2010) [34]	Quasi-experimental (pre/posttest)	N = 488 out of 1783 eligible; mean age = 51.5 years, 62% female, 64.4% Hispanic	Study flyers, posters, direct mailings and referrals/retention rate not reported	A large, multisite FQHC in Connecticut	Success in goal setting and attainment; HbA1c measured at baseline, 6 months, and 12 months/number of goals set and attained (4-point attainment score based on patients' report), mean of scores for each goal (first follow-up, maximum, and average), and goal attainment (y/n)	429 (87.9%) participants set at least one goal (range 1–23). Older patients set fewer goals but had higher attainment scores; goals related to medications and healthy eating more likely to be attained; patients with depression did equally well at attaining self-management goals compared to those without depression. Patients with successful goal attainment were more likely to improve or maintain HBA1c levels of < 7.0%. Patients had an average HbA1c decrease of 0.9% per year
Anderson (2010) [17]	RCT	N = 295 (146 intervention [59% female; 27.4% white, 10.3% Black, 62.3% other], 149 control [57% female; 26.2% White, 8.1% Black, 65.8% other]); age not reported	Chart reviews used to contact participants by letter and/or telephone/retention rate 64% for intervention and 78% for control	A large, multisite FQHC in Connecticut	HbA1c, depression, BMI, blood pressure, LDL cholesterol/Patient Health Questionnaire-9	No significant differences in clinical or behavioral outcomes compared to standard care
Baker (2008) [35]	Quasi-experimental (pre/posttest)	N = 4300; mean age = 60 years; 71% female; 53% African American, 30% Hispanic, 16% white	Chart reviews/retention rate not reported	CHCs located in low income neighborhoods of a large metropolitan area	Diabetes related complications (eyes, lower extremities and cardiovascular system) via chart audits	Increased eye exams, foot exams, and controlled BP in hypertensive patients; decreased incidence of legal blindness. Long-term weight reduction or blood glucose control was not significant

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Batik (2008) [18]	RCT with delayed intervention	N = 14; mean age = 73.6 years for immediate intervention and 71.9 years for delayed intervention; 72% female; 80.6% non-Caucasian	PCP referrals/retention rate not reported	Southeast Seattle (2 CHCs, senior center, and the UW's Health Promotion Research Center)	Physical activity level, HbA1c/rapid assessment of physical activity completed upon enrollment and at 6 months following enrollment	No significant change in mean HbA1c; There was an increased activity level of participants at follow-up visit, but level was not statistically significant
Berry (2016) [19]	Cluster RCT	N = 80 (40 intervention and 40 control); age range 32–65 (mean = 51 years), female 89%; 77.4% non-Hispanic Black, 17.9% non-Hispanic White, 2.4% bilingual Hispanic, 1.2% Asian Pacific, 1.2% American Indian	Chart reviews/retention rate 88% for intervention and 83% for control	An inner-city CHC in Raleigh, North Carolina	HbA1c, fasting lipid panel, diabetes self-management/Stanford diabetes self-management questionnaire	Experimental group significantly decreased their HbA1c ($p = .001$) and triglycerides ($p = .033$), LDL did not change significantly for the experimental group. Among self-management behaviors the experimental group's self-reported opinion of their general health improved significantly ($p = .001$)
Christian (2008) [20]	RCT	N = 310 (155 intervention [mean age = 53.4 years, 68% female, 50% Hispanic], 155 control [mean age = 53 years, 65% female, 50% Hispanic])	Diabetes registries reviews/retention rate 90% for intervention and 85% for control	Colorado (Denver Health clinic and Pueblo Community Health Center)	Lipids, HbA1c, physical activity, weight change, energy	59% of the intervention patients experienced reductions in HbA1c level, but reduction was not significant
Culica (2007) [36] (2008) [37]	Quasi-experimental (pre/posttest, no control)	N = 162; 92 completed 12 consecutive months; mean age 48 years, 66% female; 78% Mexican Americans, 15% African Americans, 6% Caucasians, 1% Asians	Referred from clinic/retention rate 60% over 12 months	Dallas, TX (Central Dallas Ministries Community Health Services)	HbA1c, BMI, and BP at 6- and 12-month postintervention	The mean HbA1c was not changed significantly from baseline to 6 months, but it was significantly reduced at 12 months when compared with baseline HbA1c (8.4% to 7. 5%, $p < 0.01$). The BMI and mean BP at baseline did not change significant at 6 or 12 months

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Davidson (2000) [38]	Quasi-experimental	N = 181 (89 intervention [mean age = 54.8 years, 52% female] and 92 control [mean age = 51.8 years, 46% female]); Intervention: 69.7% Hispanic, 14.6% African-American, 14.6% Caucasian; Control: 64.1% Hispanic, 17.4% African-American, and 15.2% Caucasian	No data/retention rate not reported	Venice Family Clinic, California	HbA1c, LDL, triglycerides/chart audit	HbA1c fell significantly in the control group (− 0.8% SD = ± 0.2%; p < .001); LDL and triglyceride outcomes not assessed due to few patients with uncontrolled cholesterol
Faridi (2008) [21]	RCT	N = 30 (15 intervention [mean age = 55.3 years, 60% female] and 15 control [mean age = 56.7 years, 67% female]); Ethnicity data not reported	No data/retention rate not reported	Two CHCs in Connecticut	HbA1c, BMI, BP, physical activity, diabetes self-care, self-efficacy/ Glucometer readings and BMI, pedometers, Yale Physical Activity Scale, Diabetes self-efficacy Scale, Diabetes Self-care Activities	HbA1c improved (− 0.1%, SD = 0.3%), but no statistical significance; diabetes self-care activities did not significantly change except for foot care (p = 0.0406); statistically significant change in self-efficacy for the intervention group was observed (− 0.5, SD = 0.6, p = 0.0080) compared to the control (0.0, SD = 1.0, p = 0.8340) Physical activity did not have statistical significance
Grant (2003) [22]	RCT	N = (62 intervention, 58 control); female: intervention = 34, Control = 40 intervention Mean: 64, Control Mean: 69; 90% White	Ambulatory billing claims and structured chart review/retention rate not reported	Academically affiliated CHC in Boston, MA	Medication adherence/ self-reported medication adherence	No significant difference between intervention and control group self-report of medication use barriers or rates of medication adherence

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Gilmer (2005) [39]	Quasi-experimental (used historical controls)	N = 348 (188 intervention [mean age = 51 years, 70% female] and 160 historical control [mean age = 52 years, 58% female]); 37% Latino, 27% non-Latino White, 19% Asian, 13% other, 4% African American	Physician referrals for the intervention group; chart reviews for the control group/retention rate 91% for intervention	17 CHCs in San Diego County, CA	HbA1c, BP, cholesterol, and disease management costs/service claims with diabetes management services at $111.52 (50 min initial nurse visit; $53.40 for 25 min follow-ups), $30.32/$15.16 (initial/follow-ups with dietitian), $20.24 (2 h group class), and $95 (administrative fee)	Participants had significant reduction in HbA1c (0.8%, $p < 0.001$), systolic (5.4 mmHg; $p = 0.001$) and diastolic (8.0 mmHg; $p < 0.001$) BP, total cholesterol (28.1 mg/dL; $p<0.001$), and LDL cholesterol (15.6 mg/dL; $p<0.001$); Pharmacy expenditures ($3157 intervention vs. $1618 control), disease management expenditures ($507 intervention). In 1st year of management total costs higher ($5,711 intervention vs. $4365 control; $p<0.001$)
Gregg (2007) [23]	RCT	N = 81 (43 intervention [mean age = 51.9 years, female 49%] and 38 control [mean age = 49.8 years, female 58%]); 32.6% Caucasian, 30.2% Hispanic, 9.3% African American, 16.3% Asian-Pacific Islander, 2.3% Native American, 4.7% Arabic, 4.7% other	PCP referral/retention rate 84% for intervention and 79% for control	CHC in San Francisco	HbA1c, diabetes self-management, acceptance, mindfulness, and values at 3 months/diabetes self-management measured by three items on exercise, diet, and glucose monitoring; acceptance, mindfulness, and understanding of diabetes and satisfaction with treatment	After 3 months, the intervention group saw significantly increased self-management scores ($p = .043$), meditation coping strategies ($p = .011$); no significant trend in HbA1c ($p = .081$),or understanding of diabetes ($p = .16$) compared to control
Hargraves (2012) [24]	RCT	N = 1415 (494 intervention [mean age = 54.9 years, female 53%] and 921 control [mean age = 52.5 years, female 51%]); 35.5% White, 26.2% Hispanic, 19.8% Black, 8.9% other	Chart reviews at CHC/retention rate not reported	12 CHCs in Massachusetts (6 control and 6 intervention)	HbA1c, LDL SBP, diabetes management, self-management goals/self-assessment ratings; encounter forms that charted goals, confidence in achieving goals; patient registries	No significant clinical changes in diabetes performance measures (BP, HbA1c) after intervention; self-management goal increased for black patients from 57.4 to 85.3% ($p < .01$) and Hispanic patients from 51.9 to 77.1% ($p < .01$)

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Koonce (2015) [25]	RCT	N = 160 (81 intervention [mean age = 54 years, 57% female] and 79 control [mean age = 53 years, 62% female]); 51% African American, 27% White, Other 1%	Chart reviews conducted at CHC/retention rate 75% for intervention and 85% for control group at 6-week follow-up	CHC in Nashville, TN	Diabetes knowledge, health literacy, and numeracy at 2 and 6 weeks/modified version of Diabetes Knowledge Test and Subjective Numeracy Scale, health literacy measured by three-question assessment by Chew et al.	Intervention group had increased knowledge at 2 weeks (2.66; $p < 0.001$), and at 6 weeks (increase in knowledge by 2.46 points; $p < 0.001$); Control group had no significant change in diabetes knowledge at both follow-ups
Mauldon (2006) [40]	Quasi-experimental Pre/posttest study (no control)	N = 16; age range 32–64 years (median = 50), female 56%; Latino patients	Recruitment by PCPs or a center's health educator; self-referral via program flyers throughout center/ retention rate 94%	Southern Connecticut CHC	HbA1c, total cholesterol, diabetes knowledge, psychosocial distress/ diabetes mellitus-related health belief instrument, Diabetes Knowledge Questionnaire, Problem Areas in Diabetes, language-based acculturation scale	HbA1c significantly reduced from at 3 and 6 months (2.08% reduction, $p = .001$). HbA1c continued to decrease from 3 to 6 months but this decrease was not statistically significant. Total cholesterol decreased, but changes were not statistically significant. Overall, diabetes knowledge improved ($p = .003$, raw score increase from 16 to 18 out of 24); Psychosocial distress did not improve significantly

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Page (2015) [41]	Quasi-experimental (pre/post; no control)	N = 7664 participants in registry receiving regular care at baseline, increased to 8589 at 12 months; age range 18–70+ years, female 33% to 70% across the seven sites; 46.3% Hispanic or Latino, Non-Hispanic 53.1%	Centralized nurses and patient care coordinators reached out to 10,000 patients at the FQHCs/retention rate not reported	7 FQHCs in South Florida, Miami-Dade County	Compliance with scheduled appointments and exams/total number of patients in registry and number of patients completing diabetic care visits, exams, or screenings	Compliance with eye exams increased 5.6%, diabetic foot exams increased 10.9%, dental exams increased 1.4%, urine protein exams increased 4.4%, creatinine screenings increased 1.9%, HbA1c tests increased 2.4%, and colorectal cancer screenings increased 44.6% ($p < 0.05$ for all tests). There was no change in compliance with LDL tests
Philis-Tsimikas (2011) [26]	RCT	N = 207 (104 intervention [female 66%] and 103 control [female 75%]); age range 21–75 years; Mexican Americans	Provider referrals, chart reviews, and waiting-room demonstrations/retention rate 66.5% for intervention and 84.5% for control	FQHC in San Diego	HbA1c, BP, lipids, BMI at baseline, 4 months, and 10 months	Reduction in HbA1c ($p = 0.02$) and diastolic BP ($p = 0.04$) statistically significant between groups. Intervention group had significant improvement from baseline: HbA1c (− 1.7%, $p = 0.001$) and HDL cholesterol (+1.4 mg/dL, $p = 0.01$) at 4 months and HbA1c (− 1.5%, $p = 0.01$) and total cholesterol (− 7.2 mg/dL, $p = 0.02$) at 10 months. No significant changes in the control group

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Rosal (2005) [27]	RCT	N = 25 (15 intervention and 10 control); age range 45–82 years (mean = 62.6), female 80%, low literate or illiterate Spanish speaking patients	Participants recruited from CHC, senior center, and a community database/retention rate 92% overall (intervention and control)	Community room near the CHC and elder center where participants were recruited	Feasibility, HbA1c, physical activity, and psychosocial variables/Audit of diabetes knowledge, Audit of Diabetes dependent Quality of Life, Insulin Management of Self-Efficacy Scale, Center for Epidemiological Studies—Depression Scale (all administered in Spanish)	Participants averaged 7.8 intervention sessions out of 10. Significant decrease in HbA1c for intervention group at 3 months (− 0.8%) and 6 months (− 0.85%) and increased physical activity compared to control (p = 0.11). Statistically significant differences in depression at 3 months (p = 0.006) and 6 months (p = 0.047). Intervention participants showed an increase in self-monitoring of blood glucose, but it was not significant
Rosal (2011) [28]	RCT	N = 252 (124 intervention and 128 control); age range 18–65+ years (33% in 55–64 years), female 77%; Latino	Letters to patients referred by PCPs/retention rate 18% for follow-up (attended ≥ 4 of 8 monthly sessions)	CHCs in Massachusetts	HbA1c, lipids, diabetes knowledge, dietary quality, blood glucose self-monitoring, patient exercise at baseline, 4 and 12 months/diabetes knowledge, 17-item self-efficacy for dietary and physical activity change (created by research team)	Significant decrease in HbA1c at 4 months: intervention: − 0.88, control: − 0.35 (p < 0.01), but no statistical significance at 12 months: intervention: − 0.46, control: 0.20 (p = 0.293); Significant increase in diabetes knowledge at 12 months (p = 0.001), self-efficacy, (p = 0.001), blood glucose monitoring (p = 0.02) and dietary quality (p = 0.01)
Scott (2006) [29]	RCT	N = 149 (76 intervention [female = 58%] and 73 control [female = 64%]); age range = 18–69 years; mean = not reported; 56.6% Caucasian, 34.2% Hispanic, 5.3% African American, 1.3% Native American	PCP referred patients to clinical pharmacist or nurse/retention rate 84% for intervention and 92% for control	Pharmacy at the Siouxland CHC, Sioux City, Iowa	HbA1c, weight, BMI, BP, LDL at baseline, 3 6, and 9 months; quality-of-life measures/Diabetes Quality of Life questionnaire	HbA1c levels fell significantly (p < 0.05) from baseline to 9 months in control and intervention groups; a 1.0% difference in the HBA1c levels between the groups (95% CI 0.08–1.78; p < 0.05)

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Seol (2017) [42]	Quasi-experimental (pre/posttest; no control)	N = 30, age range 26–81 years (mean = 50), 50% female; 76.7% Hispanic	PCP referrals/retention rate 60%	FQHC in Northwestern suburbs of Chicago	HbA1c, adherence to scheduled 3 and 6 months follow-up visits, self-management compliance/take-home diabetes record	At 3 months, of 17 patients mean HbA1c was reduced from 9% at baseline to 7.8% (p = .008); at 6 months, of 18 patients, HbA1c was reduced, but not statistically significant 9% to 8.3% (p = .161)
Sinclair (2013) [30]	RCT	N = 82 (48 intervention [female 63%] and 34 control [female 61%]), mean age = 53 years; Native Hawaiian, Filipino, and Pacific Islander patients	Flyers and word of mouth/retention rate 71% for intervention and 91% for control	Two CHCs in Hawaii	HbA1c, weight, diabetes self-management at baseline and 3 months/diabetes care profile, summary of diabetes self-care attitudes, and problem areas in diabetes	Significant decrease in diabetes-related stress (p = 0.04); Significant decrease in HbA1c (p < 0.0001), and diabetes understanding (p < 0.0001)
Two Feathers (2005) [43]	Quasi-experimental (pre/posttest, no control)	N = 151; mean age = 58.5 years, female 79%; 64% African American, 36% Latino	Physician referrals/retention rate 74% for completion of post survey, 60% for post clinical measures	Two hospitals and 1 CHC in Detroit, MI	Quality of life, self-care, HbA1c, weight, total cholesterol, BP/problem Areas in Diabetes scale revised, Diabetes Self-Care Activities questionnaire	Females 18–59 knowledge improved the most; HbA1c improved significantly from baseline (p < 0.001) but other measures (total cholesterol, BP, weight) did not improve significantly
Vincent (2007) [31]	RCT	N = 17 (9 intervention and 8 control); age range = 37–69 years (mean = 56), female 71%; Mexican American patients	Flyers in clinics, provider referrals, and chart reviews/retention rate: 100% for intervention and 80% for control	CHC in Tucson, Arizona	Diabetes knowledge, self-efficacy, self-management behaviors, HbA1c, BMI/Diabetes Knowledge Questionnaire (Spanish version, 8-item Self-efficacy for Diabetes Scale (Spanish version), Summary of Diabetes Self-Care Activities	For intervention group significant decrease in weight (p = .03) and BMI (p = .03); No statistically significant change in self-efficacy scores, diabetes knowledge, blood glucose, and HbA1c

Table 1 (continued)

First author (year) [References]	Study design	Sample	Recruitment/retention	Setting	Outcomes/measurement	Main findings
Welch (2011) [32]	RCT	N = 39 (21 intervention [mean age = 54.4 years, 68% female] and 18 control [mean age = 57.5 years, 61.9% female]); Hispanic patients	CHC diabetes registry/ retention rate 84% for intervention and 85.7% for control	CHC in Springfield, MA	HbA1c, SBP, satisfaction/ Diabetes Treatment Satisfaction Questionnaire	Intervention HbA1c improved from baseline to 12-month follow up versus control (− 1.6% vs. − 0.6%; p = 0.01). Also, intervention met more clinical goals at follow-up: SBP (intervention 55% met goal vs. control 28% met goal), foot screening (intervention 86% met goal vs. control 72% met goal), and eye screening (intervention 91% vs. control 78%). Diabetes treatment satisfaction increased for the intervention group (p = .06)

Studies' recruitment methods included reviewing medical records or billing claims [15, 20, 22, 26, 32, 39], household mailings [17, 28, 34, 40], and primary care provider referrals [17, 21, 24, 25, 27, 28, 30, 31, 34, 35, 40, 41, 43]. Retention rates were reported in 20 studies [17, 19, 20, 23, 25–30, 32, 33, 37, 39–43]. Of the studies, retention rates ranged from 18% retention over 8 months for both the control and intervention together in one study [28] to 100% for the intervention group over 12 weeks in another [31].

Characteristics of CHC Interventions

Table 2 describes detailed characteristics of CHC interventions included in the review. The CHC interventions varied greatly in terms of type and modality of the interventions. Twelve studies used one-on-one education sessions [15, 24, 25, 27–29, 32, 33, 37–39, 43] with three of the studies incorporating follow-up telephone calls to answer patients' questions [15, 29, 39]. One CHC intervention [33] incorporated individual education sessions into the patient's routine clinic visits, while the remaining individual education sessions were independent of routine visits to their primary care provider. Four interventions used group education sessions [19, 28, 29, 31] with the education sessions ranging from 1 to 12 sessions [28]. Five CHC interventions [17, 18, 21, 22, 44] used the telephone as the main method of communication with one intervention sending daily text messages following a one-day workshop [21]. In addition, three studies included telephone calls as a method of follow-up with participants [15, 24, 29]. Other intervention methods included one diabetic complication screenings [35], and a 1-day workshop that focused on mindfulness as a way to improve one's management of diabetes [23].

The main focus of the CHC interventions also varied. Clinical variables were measured as outcomes in numerous studies with 22 studies using HbA1C as a primary outcome [15, 17–21, 23, 24, 26, 27, 29–32, 34, 36–40, 42, 43] and eleven studies including cholesterol as an outcome [15, 17, 19, 20, 24, 26, 28, 29, 38–40]. Thirteen studies used diabetes knowledge as an outcome by educating patients about diabetes self-management topics (diet, exercise smoking cessation, and stress) [17, 19, 23–25, 31, 32, 34, 36, 38, 39, 42, 43]. Other studies included medication management [15, 19, 22, 29], goal setting and achievement [20, 33, 34], and depression screenings [34] as part of their interventions.

Additionally, two studies [18, 43] focused on increasing physical activity levels and one study [23] taught mindfulness techniques as a way to improve one's self-management of diabetes. Adjusting education to the appropriate health literacy levels [17, 25, 34, 42] and bilingual and bicultural education [27, 28, 33, 34, 36, 40, 45] were incorporated into several studies. Furthermore, two studies [27, 28] culturally tailored group education

Table 2 Characteristics of CHC interventions

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Alicea-Planas (2013) [33]	Individual clinic visits focused on goal-setting, creating action plans, and evaluating goal achievements	Initial routine primary care visit with 1 follow-up visit to assess goals and complete surveys. Created a "healthy change" action plan as part of routine visit, set small goals, identified facilitators and barriers to achieving goals	Usual care	RNs, License Practical Nurses
Allen (2011) [15], (2014) [16]	In-person and telephone medication counseling	Nurse practitioners (NPs) delivered information about lifestyle modifications, managed medications; community health workers (CHWs) reinforced education over 1 year period	Enhanced usual care (enhanced by feedback regarding CVD risk factors)	NPs and CHWs
Anderson (2010) [34]	Individual education sessions	Six individual one-on-one sessions every 1–2 weeks; quarterly follow-up sessions over 3-year period. Self-management tools (didactic handouts and behavior change pamphlets) provided in English and Spanish at 6th grade level; Patients identified behavior change areas and set measurable goals	No Control	Bilingual certified diabetes educators (CDE)
Anderson (2010) [17]	Telephone education	Weekly, biweekly, or monthly calls over 1 year period based on pre-determined risk stratification. Education materials provided in English and Spanish at 4th grade reading level; materials included clinical assessment, self-management education (diet, exercise, stress, smoking cessation, readiness, goals), medication adherence, glucose monitoring; incorporated depression screening and mental health treatment on-site	Usual care	Nurses received training about diabetes self-management intervention education
Baker (2008) [35]	Protocols providing recommendations for care of diabetes complications	Implemented protocols among all 9 CHCs into routine care for increased use of focused diabetic related screenings (eyes, lower extremities, cardiovascular system)	No control	Physicians, nurses, dieticians, and social workers
Batik (2008) [18]	Phone support program	Motivational telephone calls provided by older adult volunteers; encouraged 6 months commitment	Referred to local activity resources and exercise handouts	Project coordinator

Table 2 (continued)

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Berry (2016) [19]	Group education sessions	Five diabetes group visit sessions every 3 months over 15 months. Group education visits tailored to low-income patients; focused on understanding diabetes self-management techniques (foot care, glucose monitoring, BP and lipids, nutrition and exercise, and complications of diabetes)	Five individual sessions every 3 months over 15 months; Included a review of medications, diabetes self-management education, and a medical examination	Physician, NP, community health center director, nurse, nutrition educator, clergy member, exercise educator
Christian (2008) [20]	Motivational interviewing based on computer assessment to tailor patient packet	Participants completed computer-based assessment of motivational readiness to receive tailored feedback report, which the patient reviewed and made dietary or physical activity goals. Goal sheets reviewed at 3, 6, and 9 months follow-up visits	Standard education packets about diet and exercise	19 physicians who completed a 30-h training session on patient lifestyle change, goal sheets, and motivational interviewing counseling
Culica (2007) [36] (2008) [37]	Individual education sessions	Three one-to-one education visits (60 min) focused on diabetes knowledge and self-management skills; 4 follow-up quarterly assessments by CHW (30–60 min) over 12 months period (seven total patient contact hours)	No control	Trained bilingual CHW
Davidson (2000) [38]	Algorithm-based management program	Patients received diabetes management based on algorithm designed by pharmacist	Usual care	Pharmacists, diabetologist
Faridi (2008) [21]	"NICHE" (Novel Interactive Cellphone technology for Health Enhancement) training workshop and text-message support	1 day NICHE training workshop and supportive text-messages about diabetes self-management behavior and diabetic tools (glucometer, pedometer)	Usual care	Training facilitated by nurses taught how to use NICHE for patients with type 2 diabetes

Table 2 (continued)

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Grant (2003) [22]	Telephone-based education	Phone intervention completed at baseline and 3 months with average phone call time of 18.5 min. Phone interview from pharmacist included 13-item questionnaire for medication reconciliation and self-reported medication adherence; After interview, pharmacist immediately provided drug-specific education via phone, arranged for social services or nutrition consult as needed, and emailed the patient's PCP a summary of medication discrepancies, barriers, and assistance with follow-up appointments	Usual care	Pharmacist
Gilmer (2005) [39]	Individual and group management program	8 weekly self-management education sessions taught by promotora; 1 visit (50 min) with a nurse; 2–4 additional visits (25–50 min) with a dietitian; as indicated telephone reminders prior to appointments and for questions. Promotoras focused on providing culturally specific peer education participant's primary language	Usual care	Nurse-led team (RN/CDE, bilingual medical assistant, and bilingual dietician). RN and CDE were trained by an endocrinologist. Promotoras completed 4-month competency-based training and mentoring program; completed series of classes as a patient and instructed a series with a seasoned educator
Gregg (2007) [23]	Mindfulness workshop	1-day meditation workshop designed to teach mindfulness techniques for people with diabetes and diabetes self-management education (diabetes disease process, diet, exercise, glucose monitoring, prevention, and treatment of complications)	Received education on diabetes and were not taught mindfulness techniques	Diabetes educator
Hargraves (2012) [24]	Individual, group, and telephone sessions	48-h training program, 18-h onsite training, and on-going training; Implemented CHWs with extensive training into diabetes self-management individual, group, and telephone encounters	Usual care	CHWs, nurses dietitians, medical assistants

Table 2 (continued)

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Koonce (2015) [25]	Tailored diabetes education sessions	Participants selected preferred learning styles; All participants were provided with 5th grade level diabetes education material tailored to specific learning styles and participants with higher health literacy were given 8th grade level supplements	Usual care	EBL knowledge management team* **Unclear what EBL stands for or who made up the team, however*
Mauldon (2006) [40]	Group education sessions	6 weekly, 3 h cognitive behavioral educational group sessions in Spanish and culturally tailored; Breakfast and lunch provide with the opportunity to sample familiar cuisine prepared in healthier way according to ADA guidelines; Curriculum came from ADA *Taking Control* developed by Philadelphia's Health Promotion Council	No control	Health educator, co-investigator, bilingual research assistants
Page (2015) [41]	Telephone-based education and appointment reminders	One telephone call 7 days prior to appointment. Specifically, centralized team of nurses and health technicians called patients 7 days prior to scheduled appointments and conducted motivational reminder conversations; During call, they reviewed status of self-management and referrals acknowledge patient progress, listened to questions, provided motivation, and helped patient create a list of questions to ask during upcoming visit; relayed call information to patient care teams	No control	Nurses, health technicians
Philis-Tsimikas (2011) [26]	Education sessions and support groups	Eight weekly, 2 h diabetes self-management classes and 2 h monthly support groups led by peer educator. Peer educator identified as a "promotora" and had traits of a natural leader to lead diabetes education series; Peer educators then co-taught two series of classes with trainer and two series under trainer observation	Routine care at home clinic	Clinical trials assistant, trained over 3-month period. Peer educators (promotoras) spent 40 h learning education curriculum, behavior modification techniques, group instruction and meditation

Table 2 (continued)

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Rosal (2005) [27]	Individual and group education sessions	Initial 10 h individual session followed by 10 weekly 2.5 to 3-h group sessions, two 15-min individual sessions that occurred immediately before a group session during the 10-weekly sessions. Culturally tailored intervention (soap opera with group discussion, group cooking and meals, self-monitoring demonstrations, quick quizzes, modeling, cognitive reframing, family support, stress management, label reading, visual aids, supermarket tour, step counters, goal setting, problem solving, group games, feedback opportunities)	Received lab results and given a diabetes self-management booklet	Nutritionist, nurse, and intervention assistant (all bilingual); Trained with a detailed intervention manual in theoretical and delivery models, intervention goals, consoling skills, and diabetes materials use
Rosal (2011) [28]	Individual and group education sessions	Year-long program: 12 weekly education sessions utilizing culturally tailored sessions (use of soap operas, video games, focus on making traditional foods healthier) with follow-up phase of 8 monthly sessions; initial individual 1 h home visit, 2.5 h group sessions at community settings (YMCA, senior center, Latino center)	Received lab results	Nutritionist, health educator, trained lay individual investigators
Scott (2006) [29]	Individual and group sessions, telephone follow-ups	Over 3-month period, intervention group received an individual appointment every two weeks, group-sessions, and telephone follow-ups. Each group meeting was guided by topics chosen by the participants plus medication reviews conducted at each appointment; recommendations to providers were made by the pharmacist or physician. The pharmacist provided other therapeutic interventions (e.g., initiating aspirin therapy, administering influenza vaccinations, referring patients for therapeutic shoes, and managing medications for hypertension and dyslipidemia)	Nurse-managed and restricted to solely collecting data with no additional education	Pharmacist-led team with dietitian and nurse all present during group-sessions

Table 2 (continued)

First author (year) [References]	Type	Modality and dose	Control/comparison	Interventionist
Seol (2017) [42]	Individual clinic visits	Three patient-provider encounters: initial clinic visit, 3 months follow-up, 6-month follow-up; Mean time of each visits was 16 min (initial visit), 11 min (3-month follow-up), 15 min (6-month follow-up). Diabetes education tools (Lifestyle Change Card for activity recommendations, target blood glucose range, and diet recommendations, serving sizes; take-home diabetes record) were used to communicate visually desired HbA1c levels for low health literacy patients	No control	Nurse practitioner and medical assistants
Sinclair (2013) [30]	Group education sessions	Twelve 1-h group meetings; Culturally adapted diabetes curriculum for Hawaiian natives using local food, terminology, and storytelling to convey ADA clinical guidelines	Usual care	Peer educators trained by research staff during 4-h group training with a facilitator's manual; research staff supervised the initial two intervention meetings
Two Feathers (2005) [43]	Group education sessions	Five 2-h group meetings delivered every 4 weeks in two community locations. CHWs led approach taking into account culturally relevant intervention; Participants encouraged to bring family members	No control	Ten family health advocates trained by research staff
Vincent (2007) [31]	Group education sessions	Eight weekly 2-h group sessions. Education sessions focused on didactic content (pathology, complications, treatment, self-management strategies, and self-monitoring) and group support as participants were encouraged to bring a support person to the sessions	Usual care (10 to 15 min encounter with physician or nurse practitioner two to four times per year) and education given at clinic visit	Nurse researcher; research assistant
Welch (2011) [32]	Individual education sessions	Seven 1-h diabetes education (diet, medications, exercise) sessions over 12-month period. Participants also received eye screening; to manage medications the nurse contacted the PCP directly as needed	Usual care	Nurse, dietician (both certified diabetes educators) and bilingual clinic support staff

sessions to include making traditional foods healthier and created Latin American styled soap opera dramas to convey diabetes-specific education in a familiar format. In addition, one study utilized physical activity [18] and three studies set behavior change goals [20, 33, 34] as the main methods of diabetes management. One of the goal setting studies [20] had patients create goals after completing a computer-based assessment of their motivational readiness. Then patients planned ways to achieve these goals with their healthcare provider and reviewed their goals at 3, 6, and 9-month follow-up visits.

The included studies used a variety of control or comparison conditions. For example, thirteen studies [17, 21, 22, 24–26, 29–33, 38, 39] provided routine care for their control group, whereas five studies enhanced their patient's usual care with diabetes education packets [15, 18–20, 27]. One of the studies using enhanced usual care [27] also gave their control group their lab results. Seven studies had no control group [35–37, 40–43].

Throughout the studies, different interventionists were used to deliver the intervention. Providers used to deliver the diabetes education interventions included one or more of the following: physicians [19, 20, 35], nurse practitioners [15, 19, 42], registered nurses [17, 21, 24, 29, 32, 33, 35, 39], pharmacists [22, 29, 38], and dietitians [19, 24, 29, 32, 35, 39] with providers often trained as certified diabetes educators. Studies also used community health workers [15, 24, 36, 43], medical assistants [24, 32, 39–42], and peer educators [26, 39] also known as "*promotoras.*" Promotoras in these studies [26, 39] were former intervention recipients who were selected to complete a training and mentoring program and then deliver supervised education sessions while following a detailed curriculum.

Intervention fidelity was monitored in several interventions, but it cannot be detailed extensively due to the lack of reporting among all of the studies in our systematic review. Of available studies in which fidelity was discussed, one study used direct observation [40] as a method to ensure that the content for group education sessions was delivered correctly. Group education sessions also reported using protocol adherence check [28] to maintain intervention fidelity. Peer educators in two different studies [30, 39] followed scripted manuals in order for the same curriculum to be delivered to all participants. One study audio recorded classes and reviewed that all appropriate content was covered in order to ensure fidelity [26]. During individual education sessions, Allen et al. [15] confirmed fidelity by recording the number and length of patient-provider encounters, documenting protocol adherence, and conducting quality assurance assessments.

Effects of CHC Interventions

Twenty-two CHC interventions used HbA1C as a primary outcome [15, 17–21, 23, 24, 26, 27, 29–32, 34, 36–40, 42, 43]. Of the twenty-two studies that included HbA1c as an outcome, 14 studies [15, 19, 26, 27, 29, 30, 32, 34, 36–40, 43] saw statistically significant decreases in HbA1c, eight studies [17, 18, 20, 21, 23, 24, 31, 42] did not see statistically significant decreases, and one study [28] saw significant decreases at 4 months, but not at 12 months. Additionally, Sinclair et al. [30] reported significant increases in diabetes understanding ($p < 0.001$) and self-management ($p < 0.001$). Five studies that implemented both individual and group education sessions also reported significant decreases in HbA1c [19, 26, 29, 39, 40], triglycerides [19], and total cholesterol [26, 39].

The five CHC interventions that were delivered primarily over the phone [17, 18, 21, 22, 41] showed mixed effects on people with diabetes. In all four studies where clinical outcomes (i.e. HbA1c, BMI, cholesterol, weight) were measured [17, 18, 21, 22], telephone counseling exhibited no significant improvements on these outcomes. One study [41] that used the telephone to remind patients of scheduled appointments and tests seven days prior reported an increased number of patients seen in clinic and an increase in eye, foot, dental, and urine exams.

Other outcomes included diabetes goal attainment and self-efficacy. Anderson et al. [34] found that participants who achieved their goals successfully maintained or decreased their HbA1c of $< 7.0\%$ with an average decrease of 0.9 percentage points over the 3-year study period. Hargraves et al. [24] saw a significant difference ($p < .01$) in goal-setting between patients with or without a community health worker, but no statistically significant clinical outcomes were associated with goal-setting. Another study [20] that set goals after assessing a participant's motivational readiness saw reductions in HbA1c levels. Self-efficacy promotion was also mixed. Two studies (routine clinic visit and group education session) did not see significant differences in self-efficacy [31, 33], while one study [21] that used a 1-day workshop with text message reminders found significance ($p = 0.008$) in self-efficacy scores after 3-month compared to baseline.

Quality of Included Studies

Results of the quality assessments are detailed in Table 3. The average quality scores for the seventeen randomized controlled trials [15, 17–32] was 8.5 of a maximum possible score of 13 (range 3 to 10). Eight studies were rated high-quality (9 or higher) [15, 17, 20, 23, 26–28, 31], eight studies fell under the medium-quality category (scores of 5 to 8) [19, 21, 22, 24, 25, 29, 30, 32], and one had a low rating

Table 3 Study quality ratings

Items	Allen (2011) [15]	Anderson (2010) [17]	Batik (2008) [18]	Berry (2016) [19]	Faridi (2008) [21]	Grant (2003) [22]	Gregg (2007) [23]	Hargraves (2012) [24]	Koonce (2015) [25]	Philis-Tsimikas (2011) [26]	Rosal (2005) [27]	Rosal (2011) [28]	Scott (2006) [29]	Sinclair (2013) [30]	Vincent (2007) [31]	Welch (2011) [32]
1. Was true randomization used?	1	1	0	1	0	0	1	0	1	1	1	1	0	1	1	1
2. Was allocation to treatment groups concealed?	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
3. Were treatment groups similar at the baseline?	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1
4. Were participants blind to treatment assignment?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. Were those delivering treatment blind to assignment?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Were outcomes assessors blind to assignment?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (continued)

Items	Allen (2011) [15]	Anderson (2010) [17]	Batik (2008) [18]	Berry (2016) [19]	Faridi (2008) [21]	Grant (2003) [22]	Gregg (2007) [23]	Hargraves (2012) [24]	Koonce (2015) [25]	Philis-Tsimikas (2011) [26]	Rosal (2005) [27]	Rosal (2011) [28]	Scott (2006) [29]	Sinclair (2013) [30]	Vincent (2007) [31]	Welch (2011) [32]
7. Were treatment groups treated identically other than the intervention?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8. Were differences between groups in terms of their follow up adequately described and analyzed?	1	1	0	0	1	1	1	0	1	1	1	0	1	1	1	1
9. Were participants analyzed in the groups to which they were randomized?	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
10. Were outcomes measured in the same way for treatment groups?	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
11. Were outcomes measured in a reliable way?	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0

Table 3 (continued)

Items	Allen (2011) [15]	Anderson (2010) [17]	Batik (2008) [18]	Berry (2016) [19]	Faridi (2008) [21]	Grant (2003) [22]	Gregg (2007) [23]	Hargraves (2012) [24]	Koonce (2015) [25]	Philis-Tsimikas (2011) [26]	Rosal (2005) [27]	Rosal (2011) [28]	Scott (2006) [29]	Sinclair (2013) [30]	Vincent (2007) [31]	Welch (2011) [32]
12. Was appropriate statistical analysis used?	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
13. Was the trial design appropriate, and any deviations from the standard RCT design accounted for in the conduct and analysis of the trial?	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Score	9	10	3	7	8	8	9	5	8	9	9	9	8	8	9	8

Items	Alicea-Planas (2013) [33]	Anderson (2010) [34]	Baker (2008) [35]	Culica (2007) [3]	Culica (2008) [37]	Davidson (2000) [38]	Gilmer (2005) [39]	Mauldon (2006) [40]	Page (2015) [41]	Seol (2017) [42]	Two Feathers (2005) [43]
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	1	1	1	1	1	1	1	1	1	1	1
2. Were the participants included in any comparisons similar?	0	1	1	1	1	1	1	1	1	1	1
3. Were the participants included in any comparisons receiving similar treatment, other than the exposure or intervention of interest?	1	1	1	1	1	1	0	1	1	1	1
4. Was there a control group?	1	0	0	0	0	1	1	0	0	0	0
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	1	1	1	1	1	1	1	1	1	1	1

Table 3 (continued)

Items	Alicea-Planas (2013) [33]	Anderson (2010) [34]	Baker (2008) [35]	Culica (2007) [3]	Culica (2008) [37]	Davidson (2000) [38]	Gilmer (2005) [39]	Mauldon (2006) [40]	Page (2015) [41]	Seol (2017) [42]	Two Feathers (2005) [43]
6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	0	0	0	0	0	0	0	1	0	0	0
7. Were the outcomes of participants included in any comparisons measured in the same way?	1	1	1	1	1	0	1	1	1	1	1
8. Were outcomes measured in a reliable way?	1	1	1	1	1	1	1	1	1	1	1
9. Was appropriate statistical analysis used?	1	1	0	1	1	0	1	1	1	1	1
Total score	7	7	6	7	7	6	7	8	7	7	7

scale of 3 [18]. Five of the RCTs either did not apply true randomization for assignment of participants to treatment groups [8, 24, 29] or it was unclear if true randomization was used [21, 22]. There were eleven quasi-experimental studies scored [33–43] with an average quality rating of 6.9 (range 6 to 8; maximum possible score = 9). Nine studies met the criterion of high-quality (7 or greater) [33, 34, 36, 37, 39–43], while the other two were of medium-quality (both with scores of 6) [35, 38]. Only three of quasi-experimental studies had control groups [33, 38, 39].

Discussion

To the best of our knowledge, this is the first systematic review that provides a critical appraisal of CHC interventions targeting persons with diabetes. The included studies evaluated a variety of clinical outcomes encompassing HbA1c, blood pressure, and lipids, as well as psychosocial and behavioral outcomes such as diabetes knowledge, self-management, adherence to treatment regimen (e.g., screening for complications), goal setting, and self-efficacy. CHC interventions were generally effective in HbA1c reduction either via individual education [15, 27, 32, 36, 37], group education [30, 43] or both [19, 26, 29, 39, 40], although insignificant HbA1c reductions were also noted in nine studies [17, 18, 20, 21, 23, 24, 28, 31, 42]. CHC interventions were also effective in improving lipids [15, 19, 26, 39] and systolic blood pressure [15, 39] but only a small number of studies addressed them as study outcomes. Similarly, there was limited evidence to show that CHC interventions were effective in improving diabetes knowledge [30], self-management [30], screening for complications [41], goal attainment [20, 24, 34], and self-efficacy [21]; two studies failed to find significant changes in self-efficacy as a result of CHC intervention [31, 33].

The different type and modality of CHC interventions used in the included studies might explain why some interventions were effective in achieving study outcomes while others were not. For example, the CHC interventions primarily delivered over the phone failed to yield any improvement in clinical outcomes including HbA1c [17, 22], in comparison to other forms of educational interventions using face-to-face interactions which most often resulted in significant reductions in HBA1c [15, 19, 26, 27, 29, 30, 32, 36, 37, 39, 40, 43]. The findings suggest that CHC interventions would benefit from incorporating face-to-face education as an essential component of the intervention and that phone-based delivery be considered only as a means to supplement and not to replace the face-to-face interaction.

The majority of study participants included in the studies were racial/ethnic minorities and female. Given the demographics of patients served at CHCs, it is not surprising that

the CHC interventions involved racial/ethnic minorities as study participants, most often of Hispanic [20, 26–28, 31–34, 37, 38, 40, 42] or African American ethnicities [15, 19, 25, 35, 43]. Female patients were also overrepresented in the study samples included in the review. Recent epidemiological studies point to higher prevalence rates of type 2 diabetes in subgroups of Asian American and Pacific Islanders (e.g., Pacific Islanders, South Asians, and Filipinos) than any other racial/ethnic groups, including minorities traditionally considered high risk such as African Americans, Latinos, and Native Americans [46, 47]. Future CHC intervention research should consider targeted recruit strategies to identify and enroll more diverse and understudied groups such as Asian American and Pacific Islanders and male participants in the study sample.

Only one article [16] included in the review examined the cost-effectiveness of the CHC intervention reported in the primary study [15]. In the era of healthcare expenditure ever so rising, a cost-efficient model of diabetes care is an important avenue for future research. For example, prior reviews of community health worker intervention studies [48–51] concluded that working with CHWs is a reimbursable, alternative model of care for promoting cardiovascular risk reduction including diabetes management in low-income, racial and ethnic minority populations. One of the main aims of the U.S. Affordable Care Act (ACA) is to reduce the costs of healthcare for individuals and the government [52]. The ACA acknowledges community health workers as an important part of healthcare teams for the delivery of care, particularly among medically underserved populations and communities. Clearly, the ACA presents opportunities to include community health workers as a core component of effective CHC intervention teams.

There are methodological issues to be taken into consideration when interpreting the findings in this review. While 17 of 28 studies (61%) included in the review [15, 17, 20, 23, 26–28, 31, 33, 34, 36, 37, 39–43] were of high quality, many lacked methodological rigor, which might have led to negative findings. For example, 11 of 28 studies included in the review [33–43] used a quasi-experimental study design and seven of them [35–37, 40–43] lacked a control group, hence subject to substantial threats to internal validity. In addition, majority of the studies using an RCT design lacked any discussion regarding blinding [15, 18, 19, 21–27, 29–32], hence it was unclear whether interventionists took on multiple roles (e.g., recruitment and/or data collection responsibilities) as well as the delivery of the intervention. Study members with multiple roles would be expected to lead to disclosure of group allocation and therefore could result in bias in how the intervention is delivered and also measurement bias, hence, threatening the internal validity of the results. Finally, intervention fidelity was monitored in less than one third of the studies [15, 26, 28, 30, 39, 40] included in the review. Variability in fidelity of CHC intervention implementation could be possible explanations for non-significant effects found in some studies. Previous systematic reviews [50, 53] underscored the importance of required training and competency levels for community interventionists in relation to assigned responsibilities. There is a strong need for studies to clearly elaborate the contents and processes of interventionists training such as competency evaluation and supervision to optimize the use of this approach.

A few limitations of this review should be noted. First, it is possible that we did not find all relevant articles in the literature. To avoid this, we conducted an extensive systematic electronic search using a compressive list of MeSH terms, after a consultation with an experienced health science librarian, in addition to hand searches of references of the identified studies. We did not include grey literature such as reports from organizations and conference abstracts; this could result in publication bias for this review, but the included studies are also final (not preliminary, as conference results may be) and peer-reviewed. The CHC predominantly serves low-income, racial/ethnic minority populations. Thus, our findings may not be applicable to other populations such as mid- or high-income populations. Finally, we included only articles written in English; therefore, the findings cannot be generalized to populations for which studies are published primarily in non-English languages.

Conclusions

CHC-based health promotion is a growing trend for the care of low-income patients. CHCs have a unique role in spearheading community health promotion and may be the mechanism by which to establish close ties between healthcare providers and community members who often lack sufficient resources and support for diabetes control. CHC intervention models also support the movement from a healthcare system that focuses only on "sickness care" to one that is also "prevention-focused." Our review of 29 articles shows that CHC interventions are in general effective in promoting glucose control when using face-to-face interactions in low-income, underserved, and racial and ethnic minority patients with diabetes. There was positive but limited evidence to show that CHC interventions were effective in improving diabetes knowledge, self-management, screening for complications, goal attainment, and self-efficacy. Our findings support the use of CHC intervention for glucose control and suggest the need for more rigorous and continued evaluations of this intervention approach.

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MN. Conducted the data extraction: SM, SR, OA, KG. Analyzed the data: HRH, SM, PW. Contributed analysis: MN, MA. Wrote the paper: HRH, SM, MN, PW. Contributed to the revision process: HRH, SM, MN, PW, SR, OA, MA, KG, NM, PS.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical Approval This article does not contain any studies with human participants performed by any of the authors.

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