

# Diabetes Prevention Interventions in Latin American Countries: a Scoping Review

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**Abstract** Public policies, population health initiatives, and targeted behavioral change interventions for individuals at risk for developing diabetes are all essential for diabetes prevention in Latin American countries (LACs). This scoping review examines (1) the current evidence on diabetes prevention policies and interventions in LACs to identify components of effective diabetes prevention models in those countries and (2) effective diabetes prevention interventions targeting Latino populations in the USA to explore possible lessons from these interventions for LACs. Diabetes prevention programs in LACs evaluated to date consist of short-term health professional-led face-to-face behavioral counseling sessions. Intervention components of US-based programs for Latinos

that might benefit diabetes prevention programs in Latin America include (1) deployment of community health workers (“promotoras”) for diabetes screening and delivery of lifestyle modification programs, (2) multiple modes of program delivery beyond face-to-face sessions, (3) information technology to automate and enhance program delivery, (4) leveraging of pre-existing familial relationships to engage in and sustain lifestyle modifications, and (5) innovative environmental change strategies such as collaborations with local food stores and markets to promote healthy behaviors.

**Keywords** Diabetes · Prevention · Randomized controlled trials · Latin America · Scoping review

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## Introduction

The number of adults with diabetes has quadrupled worldwide in the last four decades to 422 million, due in large part to growing obesity, consumption of calorie-dense foods, and sedentary behaviors [1]. While the highest national prevalences of diabetes are now in Oceania, the Middle East, and northern Africa, Latin American countries (LACs) have among the fastest growing populations of adults with diabetes in the world. Between 1980 and 2008, the average body mass index (BMI) of Latin Americans increased twice as fast as global averages [2]. By 2035, in South and Central America, rates of diabetes are projected to increase by 60 %, or from 24.1 million to 38.5 million people [2]. This can be compared to a 37 % predicted increase in North America and the Caribbean. Mexico and Chile are now among the nations with the highest overweight and obesity rates in the world—over 70 % in both countries [3, 4]. Brazil has the fourth highest prevalence of diabetes in the world: nearly 12 million people (or roughly 10 % of the Brazilian population) have diabetes [1, 5, 6]. The costs associated with this growing epidemic are substantial. The annual cost of diabetes worldwide is estimated at \$825 billion, with nearly 60 % of the global cost borne by low- and middle-income countries (LMICs) [1]. A 2005 study in Mexico found an increase in costs of diabetes care of 14 % (or \$6,738,939) just over a 2-year period [7].

This dramatic increase in diabetes has been attributed to the epidemiologic, socioeconomic, and demographic changes that have occurred in LACs over recent decades [4]. While the rate of economic development has been uneven across the region, overall economies in LACs have improved, with a reduction in poverty and increased urbanization [4]. Although these trends have brought many benefits, they also have been accompanied by changes in physical activity levels and diet that have contributed to the increase in diabetes. Argentina, for example, now has one of the lowest rates of physical activity in the world [2], and a transition across the region to more processed foods high in salt, sugar, and fat has contributed to increased obesity [8]. A 2013 article in *The Economist* highlights these socioeconomic shifts that have caused diabetes rates to skyrocket, noting that Peru has the highest density of fast food restaurants worldwide, Mexicans consume the most carbonated sugar drinks in the world, and Brazil has experienced a fivefold increase in the consumption of junk food over the last 30 years [9]. Similar patterns are observed among Hispanics living in the USA, who have a disproportionately higher rate of diabetes and its complications than non-Hispanics in the USA [10, 11].

A range of effective diabetes prevention programs have been developed and tested in high-income countries (HICs). Interventions such as the Diabetes Prevention Program (DPP) in the USA and the Finnish Diabetes Prevention Study (DPS) found that among adults with impaired glucose tolerance,

rates of progression to diabetes were decreased with increased physical activity and moderate weight loss (7 % of body weight) [12–17]. The DPP has been adapted for different real-world settings within the USA including YMCA's, African American Churches, community hospitals, community health-care facilities, and other community organizations. More recently, programs designed to increase the DPP's reach have developed delivery strategies that include automated telephone systems, online programs, and DVDs [18–30]. Multiple intervention delivery formats, providers, and platforms that incorporate the necessary behavioral strategies in DPP-adapted interventions have been found effective as long as they incorporate the necessary behavior change content and communication approaches. Whether similar progress can be achieved in LACs is a critically important question. Specifically, it is important to identify the types of diabetes prevention interventions that have been found feasible and effective in LACs to achieve weight reduction, improved diet, and increased physical activity. In particular, social, economic, and cultural differences between LACs and HICs must be taken into account as these may influence the outcomes of lifestyle change programs that have been developed in the USA, Western Europe, and other industrialized countries.

There have been several excellent reviews recently examining components of effective models of diabetes care in low- and middle-income countries, including in LACs [31, 32]. However, to our knowledge, no similar reviews have been conducted of diabetes prevention programs in Latin America that identify the characteristics of effective initiatives. Accordingly, we conducted a scoping review of the state of evidence on effective diabetes prevention interventions conducted in LACs, including both randomized controlled trials (RCTs) as well as quasi-experimental designs. We supplemented this review by examining effective diabetes prevention interventions targeting Latino populations in the USA to explore possible lessons from these interventions for LACs. The principal aim of our scoping review was to identify key lessons and suggest fruitful directions for future research on interventions to prevent diabetes in Latin America.

## Methods

### Information Sources and Search Strategy

A medical research librarian (GKR) conducted a methodical search of the literature in October 2015 and updated the search in January 2016 to identify relevant studies. Discrete searches were conducted in Medline, Scopus, CINAHL, and Embase literature databases for articles in English, Spanish, and Portuguese. Broad search strategies were created to identify potentially relevant literature that could be applicable. The primary search sought to identify intervention studies focused

on diabetes prevention in the Latin American region. A secondary search focused on identifying literature on diabetes prevention interventions targeting the Hispanic community in the USA. Search results were limited to randomized controlled trials and quasi-experimental studies published from 1995 to the present.

Searches were conducted using controlled vocabulary and keywords representing search concepts in diabetes, Latin American regions, and nonpharmacological prevention interventions. Search concepts included but were not limited to keywords and subject headings such as *preventive health, health promotion, health education, patient care models, sociological factors, exercise, community-based prevention programs, faith-based programs, peer support, patient compliance, community health, and nutrition therapy*. (See [Appendix](#) for a sample Medline search strategy using the Ovid interface). Additional studies of interest were identified by hand searches of bibliographies. Full search details are available from the authors upon request.

### Study Eligibility and Selection Criteria

Two reviewers (MH and EK) independently screened titles and abstracts for eligibility. Articles were included if (1) the intervention was conducted in South or Central America, or targeted Latino populations in the USA; (2) the intervention's objective was diabetes prevention with one or more of the following outcomes: a reduction in hemoglobin (HbA1c), fasting glucose, or weight; (3) the participants were 18 years or older and at risk for but not diagnosed with type 2 diabetes; and (4) the study utilized a randomized or quasi-experimental trial design. Studies not meeting these criteria (e.g., observational designs) were excluded.

### Data Extraction

Two reviewers used a standardized form adapted from the Cochrane Collaboration [33] to extract data from the included studies. We used the Template for Intervention Description and Replication (TIDieR) checklist and guide to identify key elements of interventions [34]: why was the intervention done; what was done (materials and procedures); who delivered the intervention; how, where, when, and how much was done in the intervention; and what tailoring or modifications were made to an existing intervention. We also extracted the following data: study design, setting, population characteristics, intervention design and duration, outcome measures, and major findings. Because our focus was identifying elements of effective interventions in Latin America, we included only interventions with statistically significant positive findings with a view toward identifying lessons for future interventions and directions for future research.

## Results

### Public Policies

Several Latin American countries are in the forefront of efforts to craft public policies that discourage consumption of processed foods and carbonated sugary beverages associated with increases in obesity and diabetes. In 2013, the Mexican government passed an excise tax on nondairy and nonalcoholic sugar-sweetened beverages (roughly a 10 % cost increase) and a sales tax on nonessential, highly energy dense foods (roughly an 8 % cost increase) [35, 36]. When this policy was enacted, Mexico had the largest per capita intake of soft drinks worldwide [36], with a 60 % increase in sugary drink consumption between 1989 and 2006 [37]. While it is too early to assess longer term effects of this measure on rates of obesity and diabetes, a 2016 evaluation found that the excise tax effectively decreased purchases of sugar-sweetened beverages by an average annual reduction of 6 %, and purchases decreased at an increasing monthly rate of up to a 12 % decline by December 2014 [36]. Chile has passed legislation that required food makers to emblazon packages with warning labels if their food is high in sugar, salt, calories, or fat and bans advertising unhealthy products to children. In 2012, Peru, Uruguay, and Costa Rica all prohibited the sale of junk food within public schools, while Ecuador has imposed food labeling using a traffic light system (with red indicating high levels of fat, salt, or sugar) [38, 39].

In addition to policies meant to reduce consumption of diabetes-promoting junk foods, there have been nationwide efforts in LACs to promote better nutrition and leisure-time physical activity. An example of this is Brazil's academic-government collaborative program initiated in 2003 that targets increasing physical activity [40]. Brazil's Ministry of Health supported the creation of a national network of researchers and practitioners organized around the creation of infrastructure to promote physical activity. The Academia da Saude (Health Academy) uses an assets-based community engagement model to provide free physical activity classes (aerobics, yoga, tai chi, dance, stretching) in 4000 municipalities across the country. An evaluation of an early implementation site found increased engagement in moderate to high levels of leisure-time physical activity among former and current intervention participants compared to similar residents who had not participated in the intervention [40]. This effort has informed new governmental initiatives in Colombia and Uruguay [41] to promote physical activity, and the model was adapted for use among Latino populations in San Diego, CA [42, 43]. An extensive evaluation of this program is underway through Project GUIA [40] (Guide for Useful Interventions for Activity in Brazil and Latin America).

Another notable example of population-based policy intervention for preventing diabetes is the Agita São Program. The

program was initiated in 1996 with support from the Sao Paulo State Health Secretariat and represents collaboration among multiple government, research, and community organizations. The goal of Agita São Paulo is to promote moderate physical activity most days of the week, with a special focus on students, workers, and the elderly [44–46]. The program uses social marketing, social adaptation, and nonpaid media to reach a large population regarding the benefits and target levels of physical activity. Based on earlier successes, the program has expanded throughout Brazil and to at least 11 other Latin American countries. In addition, the program was used as a model in 2000 to create the Physical Activity Network of the Americas/Red de Actividad Física de las Americas with support from the Pan-American Health Organization and U.S. Centers for Disease Control [41]. This “network of national networks” promotes regular physical activity through the integration and dissemination of policies throughout the region and helps LAC nations implement evidence-based physical activity strategies building on findings from member networks [47].

### Diabetes Prevention Interventions in Latin American Countries

The peer-reviewed literature includes only a very small number of RCTs or quasi-experimental evaluations of diabetes prevention programs targeting adults at high risk for diabetes but not necessarily with prediabetes in Latin American countries. There were no studies modeled on the United States DPP. Five randomized controlled trials reported positive effects on study outcomes of fasting glucose, A1c, and/or body weight (see Table 1 for descriptions) [48–52]. Of these, three were conducted among patients receiving care within health-care facilities. Two studies were conducted in community settings, with only one targeting a disadvantaged ethnic minority, i.e., low-income Amerindian women in Peru [52]. All but one intervention consisted of weekly or monthly face-to-face individual and/or nutritional counseling conducted by nutritionists. Two of these interventions also included encouragement to engage in physical activity. Four of the studies had intervention periods of 6 months, with only one having an intervention period of 12 months. The program targeting Amerindian women focused exclusively on promoting physical activity. Physical activity sessions were conducted by a physiotherapist in an outside park with a concrete surface, with participants randomized to two different frequencies of group sessions teaching traditional folk and modern aerobic dancing [52]. One study specified that the nutritionists leading the sessions were trained in motivational interviewing-based approaches and that the fidelity of the nutritionists to these approaches was high [48]. Another counseling intervention conducted in the northeast Brazilian city of Sao Luis, Maranhão, specified that an emphasis of the intervention

was to promote a low-glycemic index Brazilian diet readily available in the Northeast (e.g., daily beans, manioc, local fruits, and vegetables).

These interventions provide encouraging preliminary evidence about the effectiveness of relatively low-intensity face-to-face counseling interventions led by trained health professionals. However, follow-up in all but one study was relatively short term, with no data on whether gains were maintained after 6 months. Moreover, only two trials sought to extend preventive efforts beyond formal health-care settings into community settings, only two sought to promote both healthy diets and physical activity, and only one intervention targeted a low-income ethnic and cultural minority population. None of the interventions used nonhealth professionals to deliver the programs, a significant limitation for low-resource settings and facilities within LACs. Moreover, none tested delivery modes beyond face-to-face sessions that may further reduce costs and extend the reach of programs.

### Possible Lessons for Models for Diabetes Prevention in Latin America from US-Based Programs

A 2014 review of evaluations of community-based diabetes prevention programs in the USA identified 46 high-quality evaluations [27]. Twenty-three of the evaluated programs included both an emphasis on healthy diet and physical activity (9 RCTs and 14 non-RCTs). Of the RCTs, two of the nine trials [25, 53] resulted in relatively large relative risk reductions (RRRs) in developing diabetes compared to other studies (−24 and −19 %), whereas the remaining seven trials had RRRs of −5 % or less. Studies that adhered most closely to the DPP standards were generally the most effective. The authors emphasized that most of the successful programs were group based, making them more feasible for communities with modest resources to adopt. Programs that focused only on promoting dietary changes or physical activity rather than both, as was the case in most of the Latin American interventions evaluated to date, were far less successful in promoting the necessary changes to reduce the risk for diabetes.

Whereas none of the US programs included in the abovementioned review had significant numbers of Latino adults, our review of diabetes prevention interventions targeting Latino adults in the USA suggested a number of intervention components that might also benefit diabetes prevention programs in Latin America. In particular, the interventions we identified in our review (see Table 2) illustrate the potential usefulness of (1) community health workers (“promotoras”) for diabetes screening [54] and delivery of lifestyle modification programs [55–59], (2) multiple modes of program delivery beyond face-to-face sessions [60], (3) information technology to automate and enhance program delivery [61], (4) leveraging of pre-existing familial relationships to engage in and sustain lifestyle modifications [62],

**Table 1** Table of diabetes prevention randomized controlled trials in Latin American countries (RCTs)

Authors, year [ref]	Participant inclusion criteria	Who delivered, how, and where	Intervention components, duration, and dose	Comparison group	Main results
Assunção et al., 2010 [48]	241 adults 20 years old or older with BMI >24.9 kg/m <sup>2</sup> who receive care at primary and secondary health-care units in an urban public health system and were referred by nutritionists as having previously sought treatment to lose weight	Trained nutritionists provided face-to-face individual consultations in both groups; fidelity to protocol by nutritionists was assessed and was high	24 weekly sessions over 6 months using motivational interviewing-based approaches and (a) individualized monthly dietetic prescriptions, (b) guidance on choosing and substituting foods, and (c) encouragement to consume fruits, vegetables, and low-fat foods, and engage in physical activity Same duration and number of consultations in both groups	RCT with usual care control group that also received “usual care” nutritional consultations	At 6 months follow-up, there were no differences between groups in weight loss. In the group receiving MI-based counseling and a structured curriculum, participants had significantly improved fasting glycemia compared to the comparison group (-3.4 vs. +4.4, $p < 0.01$ ), decreased consumption of sweet foods (-44.2 vs. -11.2 g, $p < .01$ ) and sodium (-371.5 vs. +33 mg, $p = 0.03$ ), and increased time in physical activity (+88.4 vs. -38.7 min/week, $p < 0.01$ )
Lima et al., 2013 [49]	206 adults 20 years or older with hypertension but not diabetes in two public primary care health units that assist patients with hypertension in an urban area of São Luis, Maranhão, Brazil	Nutritionists provided counseling in monthly face-to-face individual sessions to the experimental group and the control group received standard care counseling in clinic visits	Monthly face-to-face counseling over 6 months on principles of DASH and glycemic levels of common foods. Encouraged increased intake of fruits, vegetables, low-fat dairy products, beans, and manioc products and discouraged salt, meats and meat products, and sugar-sweetened beverages	2-group RCT of 6-month intervention with monthly planned menus and nutritional counseling promoting low-glycemic index Brazilian diet with principles of DASH-Na diet vs. standard care counseling focused on salt intake reduction	After 6 months, mean differences in fasting glucose between the experimental and control groups were -7.0 ( $p < 0.01$ ), -0.2 for HbA1c ( $p < 0.01$ ), -28.6 for triglycerides ( $p < 0.01$ ), and -23.8 for LDL-c ( $p < 0.01$ )
Pimentel et al., 2010 [50]	51 adults with impaired glucose tolerance and at least 1 other risk factor for T2DM (overweight or obesity, visceral adiposity, family history, low serum HDL), high serum TGs, or self-reported sedentary lifestyle in Lins, a southeast Brazilian city recruited through public health campaigns	Team of nutritionists provided individual and group nutritional counseling	Individual and group nutritional counseling: discussion-format group sessions twice a month and individual sessions once a month. The intervention included written and oral instructions to improve diet quality, for example, consumption of more vegetables, fruits, whole grains, and less saturated fats	2-group RCT of 12-month intervention providing individual and group nutritional counseling compared to usual care	After 12 months, the intervention group showed a significant decline in body weight (-3.4 %), body mass index (-5.7 %), fasting glycemia (-14 %), and glycated hemoglobin in the control group
Sartorelli et al., 2005 [51]	104 adults aged 30–65 who did not have diabetes but had BMI of 24–35 kg/m <sup>2</sup> and were patients at primary health-care center in Sao Jose do Rio Preto, SP, Brazil	A single nutritionist conducted all counseling at the primary care center	3 individual face-to-face nutritional counseling over 6 months aimed at increasing intake of fruits, vegetables, and olive oil; reducing saturated fats and improving physical activity. Participants received a diet prescription and were encouraged to walk at least 30 min a day	2-group RCT of individual nutritional counseling over 6 months and usual care control group. Both groups received written diet information and 30-min group session on benefits of diet and physical activity	After 6 months, the intervention participants achieved significantly greater weight loss (-3.1 %), decreased waist circumference (-1.9 cm), total cholesterol (-12.3 %) and LDL cholesterol (-15.5 %) compared to the control group. Reductions in weight and waist circumference were maintained at 12 months

Table 1 (continued)

Authors, year [ref]	Participant inclusion criteria	Who delivered, how, and where	Intervention components, duration, and dose	Comparison group	Main results
Lindgarde et al., 2007 [52]	76 low-income Amerindian women with fasting glucose below the diabetes range in Peru	Structured exercise sessions supervised by a physiotherapist and took place outdoors on a square with concrete surface	Participants were randomly assigned to receive either 1 group exercise training session per week or 3 group training sessions per week for 6 months. Sessions consisted of warm up and then traditional folk and modern aerobic dances for 60 min	Randomized comparison between two interventions but no control group	In both groups, plasma glucose decreased, waist circumference decreased, and V02max increased significantly (all $p < 0.05$ ). These effects were more pronounced in the more intensive group ( $p = 0.019$ ). The number of sessions attended independently contributed to reduction of glucose concentrations. There was no change in body weight

and (5) innovative environmental change strategies such as collaborations with local food stores and markets to promote healthy behaviors [63].

An essential first step for diabetes prevention is early identification of vulnerable populations at high risk for diabetes. Thompson et al. conducted a single-group quasi-experimental study among Latino migrant workers in rural Virginia and found that community health workers could use noninvasive diabetes and CVD screening tools to identify individuals at risk for diabetes or CVD as accurately as registered nurses. If more rigorous studies corroborate these findings, it would suggest that nonhealth professional outreach workers can be an effective and cost-saving strategy for providing population-based diabetes screening in much of Latin America, where resources are limited and health-care workers are scarce and overburdened. Moreover, the program's use of risk scoring tools that do not require use of serum testing to evaluate risk makes the program more feasible and less expensive for dissemination in LACs.

In five of the evaluated interventions delivered exclusively by community health workers, or "promotoras," positive intervention effects were demonstrated immediately after the interventions [54–57, 59]. In three of the interventions, community health workers delivered culturally tailored community-based versions of the DPP for groups of Spanish-speaking Latinos [56, 57, 59], and in one RCT, **community health workers** (CHWs) in one arm provided supplemental support to participants beyond an adapted DPP program delivered by health educators [58]. Ruggiero et al. and Ockene et al. explicitly described the use of community-based participatory research (CBPR) methods to work with community stakeholders to translate the DPP and adapt it to provide culturally specific information on diabetes risk and strategies to improve diet and physical activity. The use of CBPR methods is critically important in both US and LAC settings to gain buy-in from key stakeholders, ensure the cultural appropriateness of programs, and increase the likelihood that programs found to be effective will be disseminated and maintained over the long term. Despite their positive findings, these studies had limitations. All of the trials except that of Rosas et al. [58] did not examine whether gains in outcomes were maintained beyond the end of the intervention period, and Rosas et al. found that weight loss gains achieved during the intervention at 6 months were not sustained at the end of the intervention at 12 or 24 months. Moreover, one promising intervention, the evaluation of Ruggiero et al. of the culturally adapted 1-year intensive DPP program did not include a control group. These interventions had promising initial results, however, that need to be built on in larger scale rigorous evaluations that also examine whether gains are maintained among both Latino populations in the USA and in LACs. The use of community health workers and other lay outreach workers will be crucial in LACs to effectively extend diabetes

**Table 2** US Latino diabetes prevention randomized controlled trials and quasi-experimental studies

Authors, year [ref]	Participant inclusion criteria	Who delivered, how, and where	Intervention components, duration, and dose	Comparison group	Main results
Thompson et al., 2015 [54]	66 Latino migrant farmworkers in 10 housing complexes for migrant farmworkers in Nelson County, VA	8 community health workers and 3 RNs did the screening, took blood pressure, weighed, took abdominal circumference, calculated body mass index, and completed diabetes and CVD risk screening tools	Screening for CVD and diabetes by both CHWs and RNs and results were then compared. Those at risk (diabetes risk score of 5 or greater and/or CVD risk score >10%) were referred for health care and provided educational materials. Referred individuals were called by the screening CHW 2 weeks after completion of the screen	Single-group quasi-experimental study	No significant difference between diabetes risk scores of CHWs and RNs. Using RN evaluation as the gold standard, estimated sensitivity of CHW's diabetes risk assessment of the farmworkers was 94%. Specificity was 92%. Similarly, there were no significant differences in CVD risk scores
Duggan et al., 2014 [55]	Latino men and women (N = 320) 18 years or older with A1c >6% in Lower Yakima Valley, WA	CHWs delivered individual sessions in participants' homes in a rural area where more than 60% of the population is Latino and low income. Sessions were once a week and lasted 1 h each	5 weekly sessions providing information on diabetes, self-management of diabetes, healthy dietary and physical activity behaviors, complications of diabetes	2-arm parallel RCT in which the control received a delayed educational curriculum	The immediate intervention group at 3 months achieved a significant improvement in A1c compared to the delayed group
Vincent et al., 2014 [56]	58 adults in the Tucson, AZ, metropolitan area of Mexican origin older than 25 years old who had ADA risk assessment score $\geq 10$ , a BMI $\geq 25$ kg/m <sup>2</sup> , and random blood glucose between 100 and 199 mg/dl	5-month-long program with intensive phase of 8 weekly 2-h sessions, followed by maintenance phase of 3 monthly 1-h sessions. Both phases delivered by bilingual and bicultural promoters in community rooms of churches. Study participants attended the intervention or control sessions on Sunday afternoons after church services	A culturally tailored community-based group of Diabetes Prevention Program for Spanish-speaking adults of Mexican descent	2-arm parallel cluster RCT in which 1 site received intervention and the other received an attention control condition. The attention control group received 5 months of educational sessions composed of 8 weekly 2-h sessions followed by 3 monthly 1-h sessions on general information on health promotion	Intervention participants had lower weight, smaller waist circumference, lower BMI, and greater diet self-efficacy than the attention control group. Intervention participants had a mean weight loss of 6.2 lb or approx. 3% of mean baseline body weight and waist circumference decreased by mean of 1.56 at conclusion of a 5-month intervention
Ruggiero et al., 2011 [57]	69 Latino adults with screening glucose value in normal to prediabetes range with no current diagnosis of diabetes and BMI >24.9 kg/m <sup>2</sup> in 3 neighborhoods with large Latino populations in southwest Chicago	Bilingual, bicultural CHWs led 16 sessions over 24 weeks followed by 6 monthly maintenance sessions. Sessions were delivered in small group format in Spanish in community settings. It used CBPR methods to translate the DPP intervention and recruited participants through community health screenings	Community health worker-led, culturally tailored adaptation of the DPP's 1-year intensive lifestyle program delivered in community settings with limited resources. The program provided culturally specific information on diabetes risk and program and supplemental educational materials	Single-group prospective study	At 6 months, 20% of the sample achieved a 7% weight loss goal, and at 12 months, 16% achieved a 7% weight loss goal. At 6 months, 29% achieved 5% weight loss, and at 12 months, 30% achieved 5% weight loss. Weight/BMI, waist circumference, body fat, and IPAQ scores had change scores from baseline to end of core program (6 months) in the expected direction at the $p < 0.05$ level
Rosas et al., 2015 [58]	207 Spanish-speaking Latino adults with a BMI of 30-60 and one or more heart disease risk factors who received care at the Fair Oaks Clinic, a satellite community health center of San Mateo County, CA, health system and resided in the neighborhood	Health educators led 12 2-h group sessions and 4 individual sessions over the 12-month intensive phase and 3 group sessions and 1 individual session in the 12-month maintenance phase. Participants randomized to CM + CHW received the above intervention plus 5 CHW home visits during the intensive phase and 2 CHW home visits during the maintenance phase to provide additional support. Participants in	Interventions based on the DPP model were delivered over 12 months. Fidelity to intervention was rigorously assessed and was high	3-arm randomized controlled trial comparing case management by a health educator, case management by a health educator with additional support from a community health worker (CHW), and usual care	At 6 months, mean weight loss in the CM + CHW arm was modest but greater than in the CM-alone and usual care arms (-2.9 kg compared with -1.6 kg and -0.9, respectively, $p < 0.05$ ). By 12 and 24 months, differences across groups were no longer statistically significant, and participants in all arms regained lost weight

**Table 2** (continued)

Authors, year [ref]	Participant inclusion criteria	Who delivered, how, and where	Intervention components, duration, and dose	Comparison group	Main results
Ockene et al., 2012 [59]	312 Spanish-speaking Latino adults 25 years or older from Lawrence, MA, with BMI $\geq 24$ kg/m <sup>2</sup> , and 30% or greater likelihood of being diagnosed with diabetes over the next 7.5 years	usual care consisted of routine primary care follow-ups The intervention was delivered by trained Spanish-speaking individuals with post-high school education from the community. Individual sessions were conducted in the participants' homes, and group-based sessions were conducted at a community site to which participants had easy access	A community-based, literacy, sensitive, and culturally tailored lifestyle intervention adapted from the DPP. The intervention consisted of 3 individual (the first one was 1 h and the last two were 30 min) and 13 group sessions (the first one was 1.5 h and the rest were 1 h) over a 1-year period. Additional individual sessions were scheduled when patients missed group sessions and were willing to schedule a makeup session. Fidelity was assessed and was high	2-arm parallel RCT comparing the lifestyle intervention and usual care	At 1 year of the intervention, compared to the usual care group, the intervention group had a modest but significant weight reduction (-2.5 vs. 0.63 lb, $p = 0.04$ ) and a clinically meaningful reduction in HbA1c (-0.10 vs. -0.04 %, $p = 0.009$ ). The HbA1c changes were equal to those seen in the DPP at the 1-year time point, although mean weight loss in DPP at 1 year was much greater
Albright et al., 2005 [60]	72 low-income women attending vocational training courses at 7 San Francisco Bay Area adult education sites serving multiethnic population. They were between 18 and 65, free of diagnosed CAD or T2DM, and had no conditions limiting light to moderate intensity exercise	Class-based curriculum was offered during regular school hours, such as lunch time, lab periods, or independent study times. Health educators who were ethnically matched taught the classes. In home-based phone + mail counseling condition, a health educator provided brief, structured counseling on a weekly basis for the first 4 weeks, biweekly during the next 8 weeks, and then monthly for the remaining period (a total of 14 calls over 10 months). Each call lasted from 10 to 15 min each Automated and delivered by mail	8 weekly 1-h face to face classes designed to inform and motivate women to become more physically active then random assignment to 10 months of either home-based telephone counseling for physical activity (PA) plus information and feedback via mailed newsletters (phone + mail counseling condition) or just the mailed newsletters (mail support condition). Sessions included behavior change strategies for PA and discussions related to motivational readiness for PA change	2-arm parallel RCT comparing 2 forms of follow-up after face-to-face sessions	After 10 months of intervention, women in the phone + mail counseling condition had significantly greater increases in estimated total energy expenditure compared to women in the mail support condition ( $p < 0.05$ ). Those in the mail-only group had similar initial increase in physical activity after the face-to-face skill-based course but did not maintain this increase, relapsing to their baseline PA levels after 10 months
Marcus et al., 2013 [61]	266 inactive low-income, less-acculturated Spanish-speaking Latino adults in Providence, RI	Delivered by facilitator from same ethnic community 16-week intervention consisting of (1) 4 group meetings attended by both mother and daughter; (2) 8 biweekly home visits with both mother and daughter led by the lifestyle community coach and followed up with in-between home visit phone calls; weekly weigh-ins; personalized inventory of health habits; goal setting for diet and exercise, tailored to fit the family's lifestyle and socioeconomic situation; coaching sessions at participants' homes; support materials on nutrition and diet; referral to community-based exercise and fitness programs	Computer expert system-driven, culturally and linguistically adapted, individually tailored, print interventions based on transtheoretical model and social cognitive theory delivered by mail	2-arm, parallel RCT comparing a 6-month tailored physical activity intervention condition or wellness contact control. The control condition received Spanish-language pamphlets on heart-healthy behaviors besides physical activity	The intervention group at 6 months reported significantly more minutes/week of moderate to vigorous physical activity compared to the control group (mean difference = 41.36, $p < 0.001$ ). This difference was corroborated by accelerometer readings (tho = 0.44, $p < 0.01$ ). The mean increase in PA in intervention was 70 min/week Intervention participants lost significantly more weight at 16 weeks ( $p < 0.003$ ) compared with the control participants. Furthermore, intervention participants also were more likely to be eating foods with lower glycemic load ( $p < 0.001$ ) and less saturated fat ( $p = 0.004$ ) at 16 weeks. Intervention participants also reported a significant increase in health-related social support and social control and a decrease in undermining
Sorkin et al., 2014 [62]	89 pairs of Latina women with type 2 diabetes and their daughters with BMI $\geq 25$ kg/m <sup>2</sup> recruited from two federally qualified health centers in California	Delivered by facilitator from same ethnic community 16-week intervention consisting of (1) 4 group meetings attended by both mother and daughter; (2) 8 biweekly home visits with both mother and daughter led by the lifestyle community coach and followed up with in-between home visit phone calls; weekly weigh-ins; personalized inventory of health habits; goal setting for diet and exercise, tailored to fit the family's lifestyle and socioeconomic situation; coaching sessions at participants' homes; support materials on nutrition and diet; referral to community-based exercise and fitness programs	A culturally tailored lifestyle diet and exercise intervention using the DPP implemented in partnership between health center and community and incorporating family members, in particular focused on mother-daughter pairs	2-arm parallel RCT: minimal intervention control received information sent home on benefits of diet and exercise for diabetes management (mothers) and diabetes prevention (daughters); usual care; data collection and weigh-ins at the beginning and end of study	Intervention participants also reported a significant increase in health-related social support and social control and a decrease in undermining



**Table 2** (continued)

Authors, year [ref]	Participant inclusion criteria	Who delivered, how, and where	Intervention components, duration, and dose	Comparison group	Main results
Ayala et al., 2013 [63]	179 adults who were recent immigrants from Mexico or Central America and customers of 4 small store “tiendas” (at least 40 participants per store) in central North Carolina. Customer eligibility criteria were as follows: at least 18 years old; lived in a community where the tienda was located; visited the tienda at least weekly; purchased some produce at that tienda at least weekly; did not visit any of the other participating tiendas; consumed less than 8 cups of fruits (F) and vegetables (V) per day	Research staff conducted (1) employee and manager trainings; (2) an 8-week food marketing campaign that included a point-of-purchase component, food demonstrations, and an audio-based media campaign; and (3) equipment to make structural changes to present F and V in ready-to-eat forms	Tienda employees and managers were trained to promote F & V sales, including how to implement a food marketing campaign and installing store equipment to promote fresh fruits and vegetables	2-arm parallel RCT randomizing 4 small Latino stores in US Mexican and Central American communities (tiendas) to a 4-month environmental change intervention or a delayed treatment control condition. Intervention assessed at the customer and tienda levels	Intervention condition participants reported consuming nearly an additional daily serving of F and V, with no increase among control participants ( $p < 0.06$ ). A group by time interaction approached significance for increased daily servings of F and V among customers at the intervention tiendas; intervention customers reported an increase in F and V intake over time. No other significant group-by-time interactions were observed on other outcomes including fruit or vegetable variety, behavioral strategies for fat or fiber or perceived barriers. In store-level analyses, a group-by-time interaction was observed for availability of fresh and canned vegetables; the intervention increased the availability of vegetables but not fruits

prevention efforts to low-income, rural, and ethnic and cultural minority populations in Latin America.

Another important consideration for extending the reach of diabetes prevention is the development and testing of alternative delivery methods that can serve as either adjuncts or substitutes for face-to-face group sessions. Albright et al. evaluated telephone outreach from a health educator plus mailed newsletters compared with mailed newsletters alone after all participants had received 8 weekly 1-h face-to-face sessions to promote physical activity. They found that the phone + mail condition resulted in significantly greater increases in estimated total energy expenditures at 10 months than the mail-alone condition. In Marcus et al.’s intervention to increase physical activity among inactive, low-income, less acculturated Latino adults, they compared a computer expert system-driven, culturally and linguistically adapted, individually tailored print intervention delivered by mail with an attention control group. After 6 months, the intervention group had significantly more minutes a week of moderate to vigorous physical activity compared to the control group [61]. Along with automated, mail-delivered programs and telephone outreach that were tested in these two interventions, there is growing evidence for the effectiveness of e-Health and mHealth interventions, such as interactive voice response (IVR) systems, online programs, email and text message outreach, and use of social media platforms such as Twitter and Facebook [64]. Incorporating such virtual forms of program delivery and outreach into diabetes prevention programs is an important area of intervention research both in programs targeting Latino populations and in LACs.

A fourth line of promising intervention research that could inform diabetes prevention efforts in LACs is exemplified by Sorkin’s family-based intervention that leverages pre-existing familial relationships to help initiate and sustain lifestyle modifications. Targeting families in diabetes prevention makes great sense for all populations as obesity tends to occur in multiple members of a family and has been associated with families’ nutritional and exercise habits. A family focus may be even more important among Latin Americans and US Latinos because strong cultural values emphasizing the importance of family relationships suggest that behavioral changes in diet and exercise will most likely occur and be maintained as a family unit. Sorkin et al. argue that the mother-daughter bond is especially important. Accordingly, in their 16-week intervention (*Unidas*), pairs of Latina women with type 2 diabetes and their daughters who are overweight or obese participate together in group meetings as well as in home visits and phone calls by a health coach. At 16 weeks, *Unidas* participants had lost more weight and improved their diet more than the control participants.

A final line of promising research represented by Ayala et al.’s RCT is to develop and test innovative approaches to change local environments to promote healthy eating choices

and physical activity [63]. While larger scale governmental action will be necessary to change regulations, taxation, and other policies to incentivize healthy eating (such as Mexico's excise tax) and physical activity, neighborhood- and community-level interventions can promote increased availability (and potentially affordability) of healthy foods through collaborations with local stores and markets. In the Ayala study, investigators randomized small Latino stores serving US Mexican and Central American communities to a 4-month environmental change intervention (see Table 2 for details) or a delayed treatment control condition. The store-based intervention was moderately effective in increasing fruit and vegetable intake of their sampled customers. The development and large-scale implementation of effective strategies to reshape the current obesogenic food and built environments in Latin American countries that are fueling the diabetes epidemic will be as or more important for preventing diabetes as initiatives focusing on improving individuals' behaviors.

## Conclusions

Our scoping review yielded several innovative governmental initiatives to stem the growing prevalence of diabetes in Latin American countries. It will be important to more rigorously evaluate the effects of policies such as Mexico's taxes on calorie-dense beverages and foods and of collaborative population-based efforts among government, research, and community organizations to promote physical activity and healthy diets such as the Academia da Saúde and Agita São Paulo programs. Our review also identified a small number of short-term trials of face-to-face health professional-led group and individual counseling sessions to promote physical activity and/or healthy diets to achieve weight loss and improved glycemia among adults at high risk for diabetes. Such efforts to test the efficacy of different curricula, counseling approaches, meeting frequencies and durations, and intervention duration of professional-led face-to-face sessions are important to inform effective lifestyle modification programs for individuals at risk for developing diabetes in LACs. Yet, even highly effective health professional-led face-to-face programs will represent only a small part of the array of interventions and broader initiatives necessary for diabetes prevention efforts in LACs.

While the DPP has been successfully adapted for diverse community settings, to be delivered by CHWs and other lay health workers, and offered through different media and platforms in the USA, we did not find published evaluations of any efforts to adapt the DPP in LACs. Such efforts will require careful consideration of the specific characteristics of different local contexts. Many individuals face substantial barriers to attending frequent in-person visits, even those in convenient community locations, and men in particular are often

underrepresented in clinic-based programs. The content of sessions will need to be adapted to be suitable for lower literacy and numeracy levels. Cultural norms that affect food and physical activity preferences and attitudes about body weight and weight loss will need to be incorporated. Environmental barriers that may affect food availability or exercise opportunities will have to be addressed. In addition to barriers, there may be unique facilitators that can support intervention delivery in LACs (e.g., the widespread use of cell phone). Consideration of the needs for sustainability and dissemination of the adapted intervention within different local contexts will be critically important. Toward this end, evaluations of new diabetes prevention interventions in LACs should incorporate frameworks such as the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) model to include essential information for scaling up and replicating effective programs [65] and utilize strategies to engage and gain buy-in from key stakeholders at all stages of intervention development, implementation, and evaluation.

Resource limitations and access barriers across LACs further represent obstacles to the widespread dissemination of effective models of diabetes prevention that rely exclusively on delivery by CHWs and other lay outreach workers. Health professionals with the skills necessary to train and supervise these lay workers are scarce, and programs that work in a controlled, research environment may be delivered unevenly on a larger scale. Fortunately, studies in multiple countries have shown that mobile health technologies can increase the scalability and potential cost-effectiveness of programs designed to address diabetes risk factors [64]. Programs have been developed using mHealth tools to assist CHWs with tablet-based guidance for patient assessment and effective communication, education, and behavioral goal setting [66]. Other programs have focused on mHealth approaches for patient monitoring and education between face-to-face encounters [67, 68] that also hold significant promise for diabetes prevention efforts. RITMOS [*Red Iberoamericana de Tecnologías Móviles en Salud*] is an international network designed to promote the development, dissemination, and sustainability of these promising approaches [69, 70]. The Pan American Health Organization (the regional representative of the WHO) is focusing attention on this topic and recently made available a mobile app to measure cardiovascular risk [71]. These regional and other national level efforts in LACs will play an important role in coming years in making sure that facilitators of diabetes prevention programs and patients at risk for diabetes have the resources they need to be effective.

The Affordable Care Act and initiatives by the Centers for Medicare and Medicaid Services (CMS) in the USA are using their "power of the purse" both to increase the cost-effectiveness of care and to restructure provider incentives in order to more effectively promote the goals of prevention and health—including the prevention of diabetes. In contrast,

public and private payment systems in Latin America are still often fee-for-service based, with few incentives for improving the quality and outcomes of diabetes prevention programs. Aligning these economic incentives will be an important part of promoting the implementation of more effective diabetes preventive programs that give health systems and communities the resources they need to do the right things, including the hiring, training, and supervising of programs for assisting individuals with weight loss, improved diet, and physical activity goals. Throughout Latin America—as in the rest of the world—a broad range of diabetes prevention programs and policies at all levels must be developed, implemented, and continuously evaluated and refined to help individuals and populations live healthier lives free from diabetes and other lifestyle-related diseases.

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#### Compliance with Ethical Standards

**Conflict of Interest** Michele Heisler, Elizabeth Kaselitz, Gurpreet K. Rana, and John D. Piette declare that they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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