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Original Article

Susana Alvear Durán, MD, MPH, Galo Sanchez-del-Hierro, MD, PhD, Diego Gomez-Correa, MD, Andrés Enriquez, MD, Enver Sanchez, MD, Melissa Belec, DO, MPH, Sharon Casapulla, EdD, MPH, Mario J. Grijlava, PhD and Jay H. Shubrook*, DO

A pilot of a modified diabetes prevention program in Quito, Ecuador

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Abstract

Context: Diabetes has become a global noninfectious pandemic with rates rapidly rising around the globe. The major drivers of this increase in type 2 diabetes are obesity, an increase in processed foods, and a decrease in physical activity. In the United States, the National Diabetes Prevention Program (NDPP) has proven to be an effective lifestyle intervention to delay or prevent new-onset type 2 diabetes. However, there is limited evidence that such a lifestyle program will work in a South American community.

Objectives: This pilot program aims to determine if a modified version of the Centers for Disease Control and Prevention (CDC) Diabetes Prevention Program (DPP) would be feasible in an Ecuadorian population. The goals of this pilot program were a 7% weight loss, >150 min of physical activity per week, and a reduction of fat calories to yield a reduced risk of type 2 diabetes. This program was led by family medicine physicians and was offered to people with prediabetes in Quito, Ecuador.

Methods: The program was modified to include only the first half of the DPP curriculum, which included a schedule of 16 classes in the first 6 months. Further, the program was provided in Spanish and modified to be more culturally specific to this population. Participants were recruited from the faculty and staff of Pontifical Catholic University of Ecuador (Pontificia Universidad Católica del Ecuador [PUCE]) in Quito. Outcomes measured included A1c reduction, weight loss, increase in physical activity minutes, and progression to type 2 diabetes mellitus (T2DM).

Results: The sample included 33 people with prediabetes. The mean age of the participants was 52 years (range, 41–66 years), the mean body mass index (BMI) was 27.6 kg/m^2 (range, 21.0–40.3 kg/m^2), and the mean HbA1C was 6.2% (range, 5.7–6.4%). The attendance was 97.8% at 6 months. The mean weight loss was 3.4 kg per participant (range, 1.5 kg weight gain to 8.3 kg weight loss); in percentage points, this was a mean weight loss of 3.6% (range, 2.3% gain to 11.8% weight loss). Three-fourths of the participants lost weight (78.3%). The majority of participants (75.8%) met the target physical activity level of 150 min per week, and all participants increased their physical activity levels from baseline. No participants progressed to type 2 diabetes during this study.

Conclusions: The DPP 6 month pilot was effective in this population with prediabetes in Ecuador. The largest changes were made in physical activity time. Holding the program at worksites and providing lunch were key factors in the very high retention rate in this study.

***Corresponding author: Jay H. Shubrook,** DO, Professor, Touro University California, Vallejo, CA, USA, E-mail: jshubroo@touro.edu
Susana Alvear Durán, MD, MPH, Facultad de Medicina, Center for Research on Health in Latin America, Pontifical Catholic University of Ecuador, Quito, Ecuador. https://orcid.org/0000-0003-2422-5063
Galo Sanchez-del-Hierro, MD, PhD, Facultad de Medicina, Center for Research on Health in Latin America, Pontifical Catholic University of Ecuador, Quito, Ecuador; and Department of Primary and Interdisciplinary Care, Faculty of Medicine and Health Sciences, University of Antwerp, Wilrijk, Belgium. https://orcid.org/0000-0002-4358-3563
Diego Gomez-Correa, MD, Family Practice Resident, Facultad de Medicina, Hospital Vozandes Quito, Pontifical Catholic University of Ecuador, Quito, Ecuador
Andrés Enriquez, MD **and Enver Sanchez,** MD, Family Practice Resident, Facultad de Medicina, Hospital Un Canto a la Vida, Pontifical Catholic University of Ecuador, Quito, Ecuador
Melissa Belec, DO, MPH, Family Practice Resident, University of Minnesota – North Memorial, Minneapolis, MN, USA
Sharon Casapulla, EdD, MPH, Department of Primary Care, Office of Rural and Underserved Programs, Diabetes Institute, Infectious and Tropical Disease Institute, Heritage College of Osteopathic Medicine, Ohio University, Athens, OH, USA
Mario J. Grijlava, PhD, Department of Biomedical Sciences, Infectious and Tropical Disease Institute, Heritage College of Osteopathic Medicine, Ohio University, Athens, OH, USA; and Center for Research on Health in Latin America, School of Biological Sciences, Pontifical Catholic University of Ecuador, Quito, Ecuador

Keywords: cultural competency; diabetes prevention; prediabetes; translation; type 2 diabetes.

Type 2 diabetes mellitus (T2DM) has become a noninfectious pandemic. Rates are presently noted to be especially high in the United States, China, and India [1]. However, there are also significant increases in Latin America and other developing parts of the world. The prevalence of T2DM is projected to increase to 9.5% in Latin America by 2030 [1, 2]. In 2018, diabetes mellitus (all types combined) was the second leading cause of mortality for Ecuadorians, including the second leading cause of death for women and the fourth leading cause of death for men [3].

Effective treatment and prevention of T2DM are issues that must be addressed by primary care physicians to combat the rising prevalence of the disease. The three most important risk factors for death and disability among Ecuadorians are high fasting glucose levels, elevated body mass index (BMI), and diet-related risks [4]. These diet-related risks include a high intake of sodium, a low intake of whole grains, and a low intake of fruits [5].

The increasing risk for and prevalence of T2DM in Ecuador has been demonstrated in several studies. These studies have shown increased rates of obesity, metabolic syndrome, and prediabetes among different populations, including those in different geographic regions, differing socioeconomic classes, and among all ages [6–8]. For example, in 2013, the prevalence of metabolic syndrome in the urban population of Guayaquil, Ecuador was 45%, the prevalence of increased abdominal waist circumference was 69%, and the prevalence of prediabetes was 46% [6]. Further, in the urban population of Quito, Ecuador, 63% of inhabitants were overweight and 15.6% had metabolic syndrome [8]. The prevalence of diabetes in Ecuador in the general population is 2.7%. However, in the age group between 60 and 64 years, it is 15.2%. In the coastal zone of Ecuador, the prevalence is higher, and it is higher in women [9].

Prevalence rates of T2DM are increasing, and these rates are associated with greater threats of complication due to generally poor glycemic control in Latin America as a whole [1, 10–12]. Low rates of medication use, low rates of adherence to treatment regimens, poor diet, and lack of physical activity are also major contributing factors [11, 12].

Prediabetes (defined by an HbA1c 5.7–6.4%, fasting glucose 100–125 mg/dL, or random glucose 140–199 mg/dL) often precedes diabetes and is defined by glucose readings above normal but below the diagnostic criteria for diabetes [13]. Interventions targeting diet and physical activity in people with prediabetes can delay or prevent the onset of diabetes [14]. The Diabetes Prevention Program (DPP) is a lifestyle intervention program that decreased the progression from prediabetes to diabetes by 58–71% [15]. In a 10 year follow-up study of the DPP, there was a 49.4% reduction in the onset of diabetes diagnoses [16]. After 10 years, DPP participants maintained higher levels of physical activity than controls [17]. In addition, many participants reverted from prediabetes classification to normal glucose levels, which substantially reduces cardiovascular disease risk [16, 17].

Obesity is a strong risk factor for prediabetes and diabetes [18]. Therefore, it is important to implement interventions to target obesity because it is a modifiable risk factor and has myriad other health consequences [19]. Prior studies of lifestyle intervention programs in patients with impaired glucose tolerance have demonstrated increased effectiveness in preventing T2DM utilizing weight loss and physical activity vs. metformin or other medications [20, 21]. Furthermore, these programs have been shown to prevent or reduce the complications of diabetes for more than 10 years after the program ends [16, 22]. Over a period of 15 years, lifestyle intervention programs demonstrated a 27% decrease in the development of diabetes compared to an 18% decrease for metformin [22]. An extensive review of the literature also supports the cost-effectiveness of lifestyle intervention programs in preventing diabetes [17, 23, 24]. The DPP from the Centers for Disease Control and Prevention (CDC) has been a widely implemented lifestyle intervention program in the United States.

There are similar diabetes prevention programs in China, Finland, and Spain [25–27]. However, few studies have attempted to implement this protocol in other countries, particularly in Latin America.

Ecuador's rising rates of metabolic syndrome are similar to those of the United States, 31.2 vs. 33% [28, 29]. By 2015, the comparative prevalence of T2DM by age between Ecuador and the United States was 9.2% vs. 10.8%, and in 2018, T2DM prevalence was 5.5 vs. 10.8% [1]. These rates have also been linked to a sedentary lifestyle and a diet high in excess sugars [30, 31]. Given these similarities, this study examines the feasibility of a modified DPP in a university setting in Quito, Ecuador to prevent new-onset T2DM, to increase participant physical activity, and to alter dietary habits. Specifically, this pilot was designed to investigate if a modified DPP program would be able to be implemented in another language in another country and modified to be accepted in another culture while providing similar benefits to its participants.

Methods

This study was completed at Pontifical Catholic University of Ecuador (Pontificia Universidad Católica del Ecuador [PUCE]) in the capital city of Quito and tested the translatability of DPP in a sample of 33 Ecuadorian individuals with prediabetes.

The curriculum was led by Ecuadorian family medicine physicians who completed training to become lifestyle coaches for the National Diabetes Prevention Program (NDPP). They utilized the 2012 NDPP curriculum in Spanish for their cohort [32]. The full curriculum can be found at https://www.cdc.gov/diabetes/prevention/resources/curriculum.html [32]. This curriculum is free and open to the public. For the United States' 2012 DPP, the participants met approximately 22 times over the course of the year to discuss behavior modification strategies. The participants logged their food intake over the course of a year and aimed to lose at least 7% of their body weight and to increase their physical activity to 150 min/week. These meetings can occur in person or online. In this study, the participants met face to face at the participants' workplaces for a total of 16 meetings over 6 months.

Inclusion and exclusion criteria

All employees of PUCE were invited to participate, and then those interested were screened for prediabetes by measuring HbA1c.

Characteristics of participants

In this study, the participants included 23 females (70%) and 10 males (30%) with a mean age of 52 years (range, 41–66 years). All participants were Ecuadorian. No participants reported a history of gestational diabetes. The sole exclusion criterion was a previous diagnosis of prediabetes. The mean weight of the participants at the beginning of the intervention was 71.3 kg (157 lbs), with an average BMI of 27.5 kg/m^2. All participants worked an average of 8 h a day at the PUCE campus in Quito and had access to the same cafeterias.

Recruitment and enrollment

The CDC prediabetes screening questionnaire was sent electronically to all employees of the PUCE via email [33]. Employees who volunteered to complete the survey and returned it were considered as potential participants, and those with a high prediabetes risk score as determined by the questionnaire were invited to participate in the program. After completing consent, the interested individuals were screened for prediabetes by measuring HbA1c values. The inclusion criteria included HbA1c values in the prediabetic range (5.7–6.4%) and a CDC high prediabetes risk score. The exclusion criteria were having a previous diagnosis of diabetes, a diagnosis of T2DM based on their HbA1c levels at the beginning of their intervention, and refusal to sign the informed consent. Among the 36 interested participants, 33 had HbA1c values in the prediabetic range (5.7–6.4%). The remaining three interested participants were diagnosed with T2DM based on their HbA1c levels. These individuals were started on metformin and participated in the program, but their data are not included in the data analysis. This study was approved by the Institutional Review Boards of PUCE (115-CEI-2015), Ohio University (14E359), and Touro University California (M-1715). No participants dropped out of the study. However, two participants were responsible for all missed sessions.

The participants formed three groups, and each group was led by a family physician trained in leading the DPP. The three groups were created to accommodate various work schedules. The curriculum followed the guidelines and class schedule of the DPP core sessions. The first 16 sessions were held weekly except for Christmas and the New Year's holiday, but all 16 sessions were completed within 6 months. Each session was held at noon on a weekday within the participants' workplace and lasted 90 min. Lunch was offered free of charge to facilitate attendance. Participants' HbA1c and lipid panels were analyzed before and after DPP intervention.

Tools

Height/weight: To measure weight and height, the authors utilized scales calibrated and compared with standardized equipment at the medical center of PUCE. Ultrasonic wave was utilized to measure height precisely (InLab S50; Korean); for weight, we utilized Camry scale- 9111; ISO9001.

HbA1c: An ISO-certified campus and clinical laboratory was utilized to measure HbA1c. DISERLAB is governed by the ISO 17025 standard to perform tests (operate competently and have the ability to generate valid results). It utilized automatized high-performance liquid chromatography in the measurement of HbA1c. The sample collection follows the international standards.

Statistical analysis

For the descriptive analysis of the data, the absolute frequencies (number of cases) and relative frequencies (percentages) of participants meeting goals were determined. The percentage of weight lost was calculated for each person. Microsoft Excel 2016 was utilized for the calculations.

Results

The program was well attended with low rates of attrition. Attendance ranged from 94–100%, with two participants being responsible for all missed sessions. The mean attendance over the 6 month period was 97.8%.

Changes in HbA1c

The initial HbA1c range of participants was 5.7–6.4% with a mean of 6.15%. The final mean was 5.31%. No participant progressed to T2DM during the study.

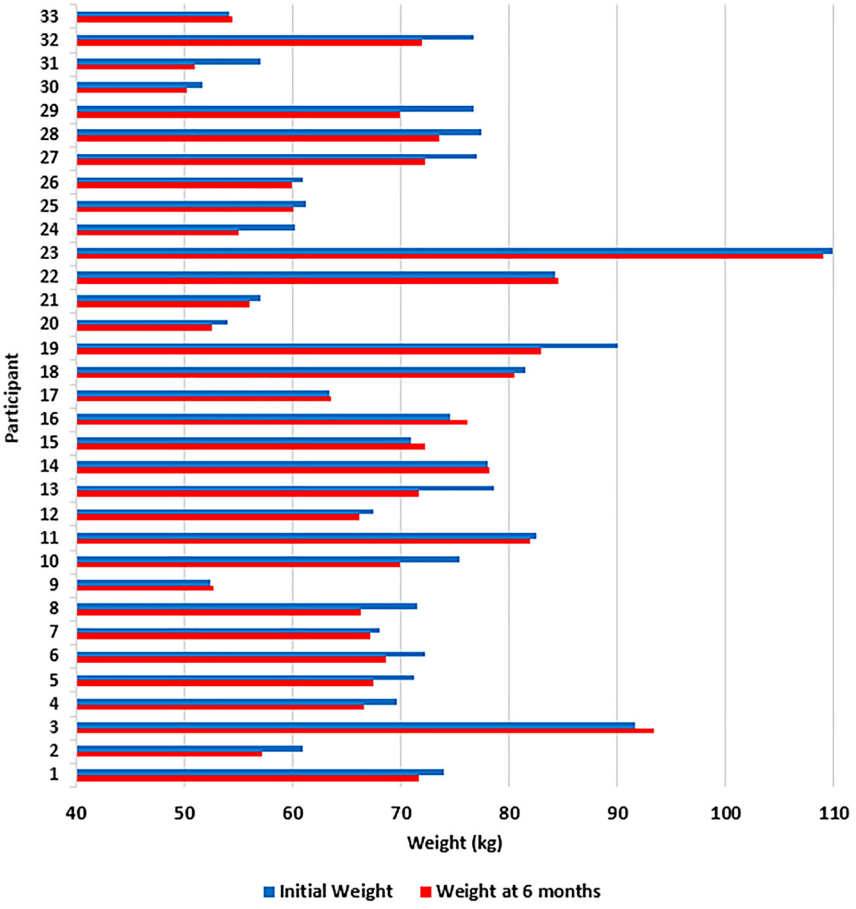

Figure 1: Weight loss (in kg) by patients participating in the DPP over 6 months.

Changes in weight

The mean weight of the DPP participants at the beginning was 71.28 kg (156.81 pounds) (CI, 66.95–75.62 kg), and at the end of the 6 month intervention, it was 67.9 kg (CI, 63.52–72.33 kg), with a mean loss of 3.4 kg per participant (range, 1.5 kg weight gain to 8.3 kg weight loss). Men achieved a mean reduction of 4.07 kg and women a mean reduction of 3.3 kg (Figure 1).

Participants also exhibited a decrease in average BMI over the course of 6 months, with an average initial BMI of 27.6 kg/m^2 and an average BMI at 6 months of 26.9 kg/m^2.

Changes in physical activity

The physical activity goal was defined as achieving at least 150 min per week. At the start of the intervention, 75.8% of participants stated that they performed 0 min of physical activity per week. At 6 months, 78.8% of the patients reached the goal of 150 min of physical activity per week, and all participants exhibited an increase in physical activity over baseline.

Discussion

This pilot study of the NDPP program yielded results that support its feasibility when applied to an Ecuadorian population, and the results are similar to what has been seen in the United States. The participants in this program had a mean loss of 3.6% of their original weight in the first 6 months and substantially changed their physical activity regimen. The program was well attended. In fact, holding this program at a worksite and providing a portion-controlled lunch were factors that may have increased participation. This may provide valuable lessons for future DPP programs both in Ecuador and in the United States. The practical implications of showing portion size in a real-life example is important because many people underestimate what they eat. Further, programs at worksites often include people that the participants already know and provide an opportunity for camaraderie and ongoing support as they are “in it together.”

Although the weight loss in this pilot study did not achieve the 7% weight loss goal in the DPP program, most people were able to lose some weight. Studies have shown that even small amounts of weight reduction are important.

With weight loss, the risk of diabetes is reduced [34], and this weight loss will also reduce risk factors for other diseases [16, 35]. This may provide more global cardiometabolic benefits for the participants.

In addition, this program showed exceptional participation and retention, with a minimum of 94% of participants attending each meeting and 100% retention over the 6 month period. This is much higher than the participation and retention seen in the programs in the United States. The authors believe that the worksite implementation and the inclusion of lunch were key aspects of this success. This supports that a workplace intervention can be highly effective in engaging participants and is a possible aspect of this program to implement and study in the future.

T2DM has become a serious health concern in Ecuador. Early diagnosis and prevention need to be addressed to prevent an escalation of the burden of morbidity and mortality of T2DM. Diabetes was listed as a health priority of the Ecuadorian Ministry of Health 10-Year Health Plan (2015–2025) [36]. Poor nutrition, obesity, and lack of physical activity are listed as primary concerns in the 10-Year Health Plan. Because the NDPP addresses these issues directly, it could serve as a potential intervention for the population at risk. Part of the 10-Year Health Plan is to engage 40% of the population in healthy lifestyle coaching programs at municipal health centers [36]. Key to this success will be the timely and accurate identification of those at greatest risk.

A recent review found that the translation of diabetes prevention and treatment programs is challenging [37, 38]. Key elements for success included the focus on sustainability that ensured sustainability of the site, diffusion in the wider community, and consistent replication of the intervention in the wider community [39]. This research team will utilize these principles as this program grows. A recent study showed that predictors of success in DPP at 6 months included regular attendance, self-weighing, and self-monitoring behaviors (logging) [39]. This study supports the important role of regular attendance and the importance of choosing a site that makes it easy for participants to attend, such as the workplace.

There is growing evidence that these programs provide long-term diabetes prevention and cost effectiveness [20–22, 40–43]. This provides further evidence that these programs should be widely implemented.

This study has a number of limitations. First, it has a small sample size and was completed in a single city and at a single site. We were able to show that this program was feasible, but our ability to generalize it to 1 year and other settings is limited. This study was conducted among employees of PUCE in Quito, Ecuador. As such, the level of education attained by participants is higher than those of the general population and could reflect sociocultural beliefs and practices of an urban population with easy access to healthy food alternatives. The authors are unable to confirm that the same findings would be evidenced in other areas of the country or in other countries. Further, this study employed only the first half of the NDPP, which is a yearlong program. Therefore, these results reflect the first 6 months of the intensive core program. The results may or may not have held up if the program continued for another 6 months. Many DPP programs in the United States strive for 5% weight loss in the first 6 months, with maintenance or slight additional weight loss in the second 6 months of the program. The tool utilized to measure HbA1c at the clinical lab was an ISO-certified clinical laboratory, but we were unable to determine whether this specific assay met NGSP certification. Nevertheless, a recent study of HbA1c assay testing found that most tests fell well within the acceptable 5% correlation of variance (CV) and that most since 2018 were less than 3% CV [44]. Despite these limitations, the authors demonstrated that these results are useful and compelling to explore options to address prediabetes in Latin America.

Conclusions

The United States–based NDPP was feasible in Ecuadorian individuals with prediabetes in Quito, Ecuador. The program was well received by the coaches, institution, and participants. The program demonstrated relevancy in another country and culture, and while weight loss was a bit less than desired by the CDC program goals, both the attendance and the increase in physical activity was seemingly more than what was seen in U.S.-based programs. This provides additional opportunities to learn across programs. Future areas for intervention and study include program activities that address the participants' environment and support networks. The authors believe that slight modifications of the program to be more culturally specific, including modifications to the language of health and illnesses specific to the culture as well as further refinement of the program examples and demonstrations, will increase the likelihood for success and improve outcomes in this program.

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Competing interests: Dr Shubrook serves as a consultant to Bayer and NovoNordisk, served as a consultant to Lilly Diabetes and Sanofi when the study was conducted, runs a CDC recognized diabetes prevention program, and trains DPP coaches. The other authors report no competing interests.

Informed consent: All participants provided written informed consent prior to enrollment.

Ethical approval: This study was approved by the Institutional Review Boards of the Pontifical Catholic University of Ecuador (115-CEI2015), Ohio University (14E359), and Touro University California (M-1715).

References

1. International Diabetes Federation ATLAS. IDF diabetes; 2019. Available from: https://www.diabetesatlas.org/en/sections/demographic-and-geographic-outline.html [Accessed 14 Dec 2020].
2. Cayon A. PAHO WHO | diabetes. Pan American health organization/World Health Organization. Available from: http://www.paho.org/hq/index.php?option=com_content&view=article&id=6715&Itemid= 39446&lang=fr [Accessed 14 Dec 2020].
3. Instituto Nacional de Estadística y Censos (INEC). Nacimientos y Defunciones – 2018. Available from: https://www.ecuadorencifras.gob.ec/documentos/web-inec/Poblacion_y_Demografia/Nacimientos_Defunciones/2018/Principales_resultados_nac_y_def_2018.pdf [Published August 2019. Accessed 14 Dec 2020].
4. Ecuador. Institute for health metrics and evaluation. Available from: http://www.healthdata.org/ecuador [Accessed 14 Dec 2020].
5. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the global burden of disease Study 2017. Lancet 2019;393:1958–72.
6. Duarte MC, Peñaherrera CA, Moreno-Zambrano D, Santibáñez R, Tamariz L, Palacio A. Prevalence of metabolic syndrome and prediabetes in an urban population of Guayaquil, Ecuador. Diabetes Metab Syndr 2016;10(2 Suppl 1):S119–22.
7. Sempértegui F, Estrella B, Tucker KL, Hamer DH, Narvaez X, Sempértegui M, et al. Metabolic syndrome in the elderly living in marginal peri-urban communities in Quito, Ecuador. Publ Health Nutr 2010;14:758–67.
8. Viteri Holguín MP, Castro Burbano J. Prevalence of metabolic syndrome among the staff of Universidad Internacional del Ecuador, headquarters, period 2014–2015. Nutr Hosp 2015;32:2684–91.
9. Freire W, Ramirez M, Belmont P, Mendieta M-J, Silva-Jaramillo M K, Romero N, et al. RESUMEN EJECUTIVO. TOMO I. Encuesta Nacional de Salud y Nutrición. ENSANUT-ECU 2011-2013. Quito: Ministerio de Salud Pública del Ecuador / Instituto Nacional de Estadística y Censos; 2013:109 p.
10. Escobedo J, Buitrón LV, Velasco MF, Ramírez J C, Hernández R, Macchia A, et al. High prevalence of diabetes and impaired fasting glucose in urban Latin America: the CARMELA Study. Diabet Med 2009;26:864–71.
11. Linetzky B, Curtis B, Frechtel G, Montenegro R Jr., Escalante Pulido M, Stempa O, et al. Challenges associated with insulin therapy progression among patients with type 2 diabetes: Latin American MOSAIc study baseline data. Diabetol Metab Syndrome 2016;8:41.
12. Stewart GL, Tambascia M, Guzmán JR, Etchegoyen F, Carrión JO, Artemenko S. Control of type 2 diabetes mellitus among general practitioners in private practice in nine countries of Latin America. Rev Panam Salud Públic 2007;22. https://doi.org/10.1590/s1020-49892007000600002.
13. American diabetes association standards of care in diabetes 2021. Chapter 2 -diagnosis. Available from: https://care.diabetesjournals.org/content/44/Supplement_1/S15 [Accessed 14 Dec 2020].
14. Diabetes Prevention Program (DPP) Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 2002;25:2165–71.
15. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. Diabetes prevention program research group*· N Engl J Med 2002;346:393–403.
16. Perreault L, Temprosa M, Mather KJ, Horton Ed, Kitabchi A, Larkin M, et al. Regression from prediabetes to normal glucose regulation is associated with reduction in cardiovascular risk: results from the diabetes prevention program outcomes study. Diabetes Care 2014;37:2622–31.
17. Herman WH, Edelstein SL, Ratner RE, Montez MG, Ackermann RT, Orchard TJ, et al. Effectiveness and cost-effectiveness of diabetes prevention among adherent participants. Am J Manag Care 2013;19:194–202.
18. Mokdad AH, Ford ES, Bowman BA, Dietz W, Vinicor F, Bales V, et al. Prevalence of obesity, diabetes, and obesity- related health risk factors, 2001. J Am Med Assoc 2003;289. https://doi.org/10.1001/jama.289.1.76.
19. Schellenberg ES, Dryden DM, Vandermeer B, Ha C, Korownyk C. Lifestyle interventions for patients with and at risk for type 2 diabetes: a systematic review and meta-analysis. Ann Intern Med 2013;159:543–51.

20. Perreault L, Pan Q, Mather KJ, Watson KE, Hamman RF, Kahn SE. Effect of regression from prediabetes to normal glucose regulation on long-term reduction in diabetes risk: results from the Diabetes Prevention Program Outcomes Study. Lancet 2012; 379:2243–51.
21. Lindström J, Ilanne-Parikka P, Peltonen M, Aunola S, Eriksson J, Hemiö K, et al. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the finnish diabetes prevention study. Lancet 2006;368:1673–9.
22. The Diabetes Prevention Program Group. Long-term effects of lifestyle intervention or metformin on diabetes development and microvascular complications over 15-year follow-up: the Diabetes Prevention Program Outcomes Study. Lancet Diabetes Endocrinol 2015;3:866–75.
23. Alouki K, Delisle H, Bermúdez-Tamayo C, Johri M. Lifestyle interventions to prevent type 2 diabetes: a systematic review of economic evaluation studies. J Diabetes Res 2016;2016:1–14.
24. Sun Y, You W, Almeida F, Estabrooks P, Davy B. The effectiveness and cost of lifestyle interventions including nutrition education for diabetes prevention: a systematic review and meta-analysis. J Acad Nutr Diet 2017;117. https://doi.org/10.1016/j.jand.2016.11.016.
25. Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: the Da Qing IGT and diabetes study. Diabetes Care 1997;20:537–44.
26. Eriksson J, Lindström J, Valle T, Aunola S, Hämäläinen H, Ilanne-Parikka P, et al. Prevention of Type II diabetes in subjects with impaired glucose tolerance: the diabetes prevention study (DPS) in Finland. Study design and 1-year interim report on the feasibility of the lifestyle intervention programme. Diabetologia 1999;42:793–801.
27. Sagarra R, Costa B, Cabré JJ, Solà-Morales O, Barrio F, el Grupo de Investigación DE-PLAN-CAT/PREDICE. Lifestyle interventions for diabetes mellitus type 2 prevention. Rev Clin Esp 2014;214:59–68.
28. Aguilar M, Bhuket T, Torres S, Liu B, Wong RJ. Prevalence of the metabolic syndrome in the United States, 2003–2012. J Am Med Assoc 2015;313:1973–4.
29. Pérez-Galarza J, Baldeón L, Franco OH, Muka T, Drexhage H, Voortman T, et al. Prevalence of overweight and metabolic syndrome, and associated sociodemographic factors among adult Ecuadorian populations: the ENSANUT-ECU study [Internet]. J Endocrinol Invest 2020;44:63–74.
30. Liu B, Sun Y, Bao W. Creating and supporting a healthy food environment for type 2 diabetes prevention. Lancet Planet Health 2018;2:e423–4.
31. Ammerman AS, Lindquist CH, Lohr KN, Hersey J. The efficacy of behavioral interventions to modify dietary fat and fruit and vegetable intake: a review of the evidence. Prev Med 2002;35: 25–41.
32. Diabetes prevention program curriculum 2012 participant curriculum (Spanish). Available from: https://www.cdc.gov/diabetes/prevention/resources/curriculum.html [Accessed 2 Jul 2021].
33. CDC diabetes risk test. Available from: https://www.cdc.gov/diabetes/prevention/pdf/Prediabetes-Risk-Test-Final.pdf [Accessed 2 Jul 2021].
34. Hamman RF, Wing RR, Edelstein SL, Lachin J, Bray G, Delahanty L, et al. Effect of weight loss with lifestyle intervention on risk of diabetes. Diabetes Care 2006;29:2102–7.
35. Swain JF, Mccarron PB, Hamilton EF, Sacks FM, Appel LJ. Characteristics of the diet patterns tested in the optimal macronutrient intake trial to prevent heart disease (OmniHeart): options for a heart-healthy diet. J Am Diet Assoc 2008;108:257–65.
36. Roldós MI, Hopenhayn C, Sacoto F, Bustamante K. Developing local health policy: profiling needs and opportunities in the Municipality of Quito, Ecuador. J Publ Health Pol 2017;38:221–33.
37. Oldenburg B, Absetz P, Dunbar JA, Reddy P, O'Neil A. The spread and uptake of diabetes prevention programs around the world: a case study from Finland and Australia. Transl Behav Med 2011;1: 270–82.
38. Garst J, L'Heveder R, Siminero LM, Motala A, Gabbay RA, Chaney D, et al. Sustaining diabetes prevention and care interventions: a multiple case study of translational research projects. Diabetes Res Clin Pract 2017;130:67–76.
39. Eaglehouse YL, Venditti EM, Kramer MK. Factors related to lifestyle goal achievement in a diabetes prevention program dissemination study. Transl Behav Med 2017;7:873–80.
40. Rockette-Wagner B, Storti KL, Dabelea D, Edelstein S, Florez H, Franks P, et al, Diabetes Prevention Program Research Group. Activity and sedentary time 10 years after a successful lifestyle intervention: The diabetes prevention program. Am J Prev Med 2017;52:292–9.
41. Qiao Q, Pang Z, Gao W, Wang S, Dong Y, Zhang l, et al. A large-scale diabetes prevention program in real-life settings in Qingdao of China (2006–2012). Primary Care Diabetes 2010;4: 99–103.
42. Bray A, Chatellier A, Duncan C, Greenway FL, Levy E, Ryan DH, et al, Diabetes Prevention Program Research Group. 10-year follow-up of diabetes incidence and weight loss in the diabetes prevention program outcomes study. Lancet 2009;374:1677–86.
43. Gong Q, Zhang P, Wang J, Ma J, An Y, Chen Y, et al, Da Qing diabetes prevention study group. Morbidity and mortality after lifestyle intervention for people with impaired glucose tolerance: 30-year results of the Da Qing diabetes prevention outcome study. Lancet Diabetes Endocrinol 2019;7:452–61.
44. Little RR, Rohlfing C, Sacks DB. The national glycohemoglobin standardization program: over 20 years of improving hemoglobin A1c measurement. Clin Chem 2019;65: 839–48.