



Current State of Diabetes Mellitus Prevalence, Awareness, Treatment, and Control in Latin America: Challenges and Innovative Solutions to Improve Health Outcomes Across the Continent

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Abstract

Purpose of Review Latin America is the scenario of great inequalities where about 32 million human beings live with diabetes. Through this review, we aimed at describing the current state of the prevalence, awareness, treatment, and control of diabetes mellitus and completion of selected guidelines of care across Latin America and identify opportunities to advance research that promotes better health outcomes.

Recent Findings The prevalence of diabetes mellitus has been consistently increasing across the region, with some variation: higher prevalence in Mexico, Haiti, and Puerto Rico and lower in Colombia, Ecuador, Dominican Republic, Peru, and Uruguay. Prevalence assessment methods vary, and potentially underestimating the real number of persons with diabetes. Diabetes unawareness varies widely, with up to 50% of persons with diabetes who do not know they may have the disease. Glycemic, blood pressure, and LDL-C control and completion of guidelines to prevent microvascular complications are not consistently assessed across studies, and the achievement of control goals is suboptimal. On the other hand, multiple interventions, point-of-care/rapid assessment tools, and alternative models of health care delivery have been proposed and tested throughout Latin America.

Summary The prevalence of diabetes mellitus continues to rise across Latin America, and the number of those with the disease may be underestimated. However, some local governments are embedding more comprehensive diabetes assessments in their local national surveys. Clinicians and public health advocates in the region have proposed and initiated various multi-level interventions to address this enormous challenge in the region.

Keywords Latin America · Diabetes prevalence · Diabetes treatment · Control · Diabetes complications · Interventions · Health care

Introduction

Within the last couple of decades, non-communicable diseases (NCDs) have gained worldwide attention, especially in

low- and middle-income countries (LMIC), where they have been increasingly recognized and prevalent [1, 2]. Among the NCDs, diabetes mellitus has become a global health challenge [1, 3, 4]. Type 2 diabetes mellitus—the most common form of diabetes—due to its rather silent disruption may be a current uninvited companion to over 465 million persons worldwide. In 2019, it was estimated that the number of persons with diabetes in Latin America (LatAm) was 31.6 million [5, 6] and is predicted that by 2030, the number will increase to 40.2 million, and to 49.1 million by 2045 [6].

Because of its multi-organ and multi-system impact, diabetes has been associated with both acute and long-term complications that affect not only health care needs and costs but also wellbeing and productivity [7, 8]. Within the last decade, it has also been recognized as one of the leading causes of death in some LatAm countries [9–15] and an important risk factor

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for cardiovascular diseases (CVD), which is the leading cause of death in LatAm [14, 16].

Far from being a monolithic group, the LatAm population is highly heterogeneous, with various populations reflecting diverse genetic ancestry, ethnicity, culture of origin, sociopolitical contexts, environmental exposures, and beliefs and practices [17, 18]. Levels of inequality in LatAm remain among the highest in the world [19–22]. All these factors—coupled with biological susceptibility, income, education, access health care, cultural influences on nutrition, health, self-image, and self-care—influence the development of diabetes in LatAm.

We conducted a review of the most current publications on the state of prevalence, awareness, treatment, and control of diabetes mellitus across LatAm. By laying out a detailed accounting of what is known, we aim to identify population, clinical, and health care needs, and opportunities for future research studies and potential interventions.

Literature Search and Review

We conducted the search using the PubMed electronic database as the primary scientific literature source. LatAm was defined as the countries in the Western hemisphere which were previously colonized by Spain, Portugal, or France. A combination of keywords was used to define the scope of the searches: diabetes prevalence, awareness, treatment, control, guidelines of care, adherence, retinopathy, nephropathy, neuropathy, foot care, fundoscopic exam, and urine albumin, and searched under LatAm and by each individual country. Hispanics/Latinos living in the USA were not included in the search.

We limited the search to publications since 2000 to reflect the most recent research on the prevalence of diabetes across LatAm countries, assessments of awareness, treatment, and control of diabetes (glycemic control), blood pressure and low-density lipoprotein cholesterol (LDL-C), and adherence to guidelines for care recommended by the American Diabetes Association (ADA) [23–25] and the Latin American Diabetes Association (ALAD) [26], and specifically hemoglobin A1c (HbA1c) measurement, fundoscopic exam, foot exam, and urine albumin excretion test. We included literature written in English, Spanish, French, and Portuguese.

In addition to PubMed, when available, we manually searched each country's Ministry of Health and the Pan American Health Organization (PAHO) websites and accessed published and downloadable national health surveys performed during the selected timeframe. Since most available studies did not distinguish between type 1 and type 2 diabetes mellitus, our review is centered on diabetes mellitus (diabetes, henceforth) in general. Because their specific

mechanisms of disease and clinical implications, gestational diabetes mellitus, and type 1 diabetes merit separate reviews.

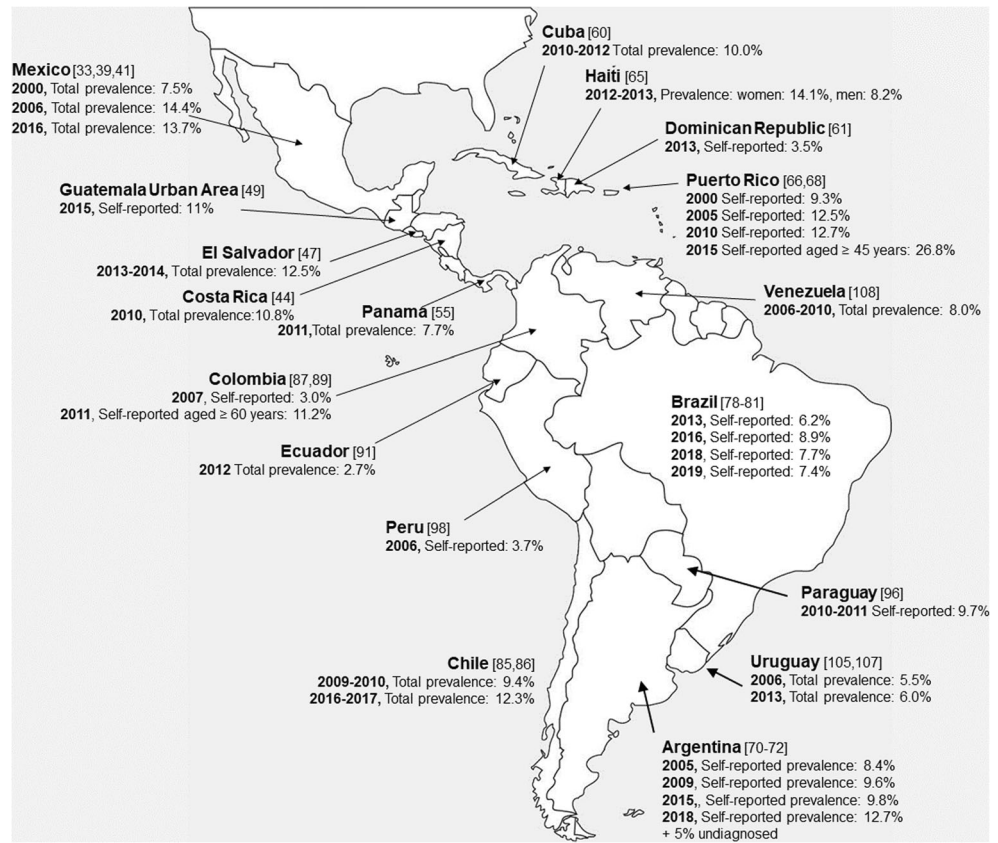
Prevalence of Diabetes Mellitus in Latin America

The earliest contemporary reports on the prevalence of diabetes mellitus among adults throughout LatAm date from the 1950s and 1960s [27–29], when most countries were beginning to experience epidemiologic transitions [30, 31]. In 2001, Barceló reported an incidence of type 1 diabetes in LatAm in the range 0.1 cases/100,000 in Venezuela to 17.4 cases/100,000 in Puerto Rico [32]. However, the authors highlighted a handful of reports on the prevalence of type 2 diabetes and underlined the near absence of surveillance for the disease throughout the LatAm region [32].

From 2005 to 2020, the prevalence of diabetes mellitus across LatAm has been assessed within individual countries and through multinational studies [33–114] and ranged between 3 and 36.3% (Fig. 1, Table 1). In our review, some national surveys assessed the prevalence of diabetes via population representative samples [33, 36, 38, 40, 42–44, 47, 49, 55, 60, 61, 65, 66, 68, 72, 85–87, 89, 91, 96, 98, 105, 107] and used similar population sampling methods (e.g., multi-stage, clustered, probabilistic sampling), whereas other studies focused on specific geographic regions or communities [34, 35, 37, 45, 46, 48–54, 56–58, 63, 67, 73–75, 77, 82–84, 92–95, 102, 110–112], recruited participants from clinical settings [51, 59, 62, 69, 95], or focused on specific age groups [37, 42, 56–58, 75, 109, 112]. Also, the age range of the population surveyed—and consequently, age-adjustment estimates—varied among surveys.

Most of the studies (especially national surveys) reported the overall prevalence of diabetes without differentiating between type 1 and type 2 diabetes mellitus and many estimated the prevalence of the disease based on self-report (being aware of having diabetes and/or taking antihyperglycemic medications) only. Some national surveys and independent studies estimated the prevalence based on the sum of self-report and identifying individuals without history of diabetes but hyperglycemia within the diabetes range [26, 115]. The latter group was considered to have “suspected,” “undiagnosed,” or “unknown” diabetes. Hyperglycemia within the diabetes range was assessed by measuring fasting blood or plasma glucose (FBG or FPG) only, FBG/FPG and 2-h oral glucose tolerance test (OGTT), FBG/FPG and hemoglobin A1c (HbA1c), HbA1c only, or the combination of FBG/FPG, OGTT, and HbA1c, or glucose levels in urine. Some studies measured capillary blood glucose (CBG), while most studies measured venous blood or plasma glucose. While multiple studies used the ADA/ALAD-recommended glucose/HbA1c cut points for

Fig. 1 Prevalence of diabetes mellitus in Latin America Based on national surveys from 2000 to 2020. Prevalence data was extracted from national surveys, when available. Prevalence was estimated either by self-report of diabetes exclusively or in combination with glycemic tests. References next to each country's name in [brackets]



the diagnosis of diabetes [26, 115], some studies used different thresholds (e.g., fasting glucose ≥ 100 mg/dL (per CBG), random blood glucose ≥ 140 mg/dL, or random blood glucose ≥ 200 mg/dL).

Although the differences in the methodology described above limit the ability to perform cross-sectional or trend comparisons among countries, we note several commonalities. During 2005–2020, some countries reported an increase in the prevalence of diabetes [33, 36, 38–40, 66, 70–72, 79, 85, 86], consistent with previously published reviews [5, 15, 32, 116–123]. Compared with the rest of the region, and as previously reported [5, 15, 32, 124, 125], diabetes prevalence varies across the region, with higher prevalence in Mexico (13.7%), Haiti (14.1% in women and 8.2% in men), and Puerto Rico (12.5–12.7% in the population aged $18 \geq$ years and 26.8% in the population aged ≥ 45 years), and lower in Colombia (3.0% in the population aged $18 \geq$ years, but 11.2% in age group ≥ 60 years), Dominican Republic (3.5%), Ecuador (2.7%), Peru (3.7%), and Uruguay (5.5–6.0%) (Fig. 1, Table 1). Multiple studies reported a greater prevalence of diabetes among women [36, 38, 40, 42, 44, 47, 49–52, 57, 60, 62, 63, 65, 70, 72, 75, 78, 79, 83–86, 90, 95, 96, 110, 113], and with increasing age, especially over age 60 years [33, 36, 44, 47, 50, 55, 69–72, 78, 80, 81, 86, 91, 93, 110]. Some studies reported an inverse relationship between diabetes and

socioeconomic status (SES) [33, 79, 103] or educational attainment [33, 44, 62, 63, 70, 72, 73, 75, 76, 78, 79, 86, 101]. Other studies reported a direct relationship between having health insurance and self-reported diabetes [42, 70, 97, 100], implying that persons who have health insurance—proxy of access to health care services—would be aware of their health issues and report them accordingly. This interaction also poses questions about not only the access to health care but also the timeliness and quality of the care, and health literacy (or the lack of) that persons in the lowest SES—and at the highest risk of diabetes—would experience. Some studies reported a lower prevalence of diabetes among indigenous populations [35, 48, 74], with one study proposing that exposure to urbanicity was associated with an increased prevalence of diabetes among some indigenous communities [83]. Indeed, rural to urban migration (or living in rural compared with urban areas) has been associated with increased prevalence or risk of developing diabetes in Peru [126, 127], and multiple countries reported a lower diabetes prevalence in rural compared with urban settings [33, 39, 47, 60, 65, 89–91, 99, 103].

The number of epidemiological studies published since 2005 indicates greater public health awareness about diabetes mellitus across LatAm. Multiple countries have performed at least one national survey on chronic non-communicable diseases in which self-reported diabetes mellitus and/or elevated

Table 1 Prevalence of diabetes mellitus across Latin America based on reports published from 2005 to 2020

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Mexico Oláiz-Fernandez, 2007 [33]	1999–2000	Mexico	National Health Survey - Encuesta Nacional de Salud 2000 (ENSA 2000)	<i>N</i> = 45,294 (52% women) Age ≥ 20 years	Self-report and capillary fasting glucose levels ≥ 126 mg/dL or random ≥ 200 mg/dL	Total prevalence: 7.5%, of which 77.3% was self-reported Men: 7.2% (5.5% self-reported) Women: 7.8% (6.2% self-reported) Increased with age urban: 8.1%; rural: 6.5% Inverse relationship to educational attainment and income Geographic differences > in the North and lower in the South
Meaney, 2007 [34]	2001–2002	Mexico (Factores de Riesgo en México –FRIMEX)	Volunteer sample recruited via mobile clinics near public places in Monterrey, Tijuana, Guadalajara, Mexico City, Puebla, and León	<i>N</i> = 140,017 (58% women) Age ≥ 18 years	Fasting blood glucose ≥ 126 mg/dL or random ≥ 200 mg/dL Self-report and medication intake	Total prevalence of diabetes was 10.5%.. Prevalence by sex and self-reported diabetes was not reported.
Stoddard, 2011 [35]	2002	Mexico (Mexican Family Life Survey)	Secondary analysis Stratified multi-stage sampling	<i>N</i> = 19,577 (53% women) Age ≥ 20 years	Self-report	Prevalence of diabetes among indigenous participants was 6%, and among non-indigenous participants was 9%. Indigenous participants were 3 times more physically active and reported half of the prevalence of smoking than non-indigenous participants but lived in settings with more fragile infrastructure.
Secretaría de Salud de México, Instituto Nacional de Salud Pública (INSP), 2006 [36]	2006	Mexico (National Health and Nutrition Survey - ENSANUT 2006)	Probabilistic, poly-stage, stratified and clustered sampling.	<i>N</i> = 1476 households (planned) (52.1% women) Age: all	Self-report and blood tests	Prevalence (self-report): 7.0% Laboratory test results not available men: 6.5%, women: 7.3% Increased with age No information on urban-rural differences
Kumar, 2016 [37]	2012	Mexico (Mexican Health and Aging Study)	Sub-analysis Cross-sectional data from the 2012 cohort. Participants recruited in four Mexican states with different urban/rural concentration, U.S.-Mexico migration patterns and diabetes prevalence	<i>N</i> = 2012 (sex breakdown not reported) Age ≥ 50 years	Self-report and HbA1c ≥ 6.5%	Prevalence of self-reported diabetes: 21.4% S Undiagnosed diabetes: 18%. Participants living in a high US migration state had decreased odds of prediabetes and undiagnosed diabetes.
Secretaría de Salud de México, Instituto Nacional de Salud Pública (INSP), 2012 [38]	2012	Mexico [Encuesta Nacional de Salud y Nutrición (ENSANUT 2012)]	National Health and Nutrition Survey Stratified probabilistic sampling	<i>N</i> = 46,303 (52.7% women) age ≥ 20 years	Self-report and blood tests	Prevalence (self-report): 9.2% (blood test results not available) Men: 8.6% Women: 9.7% Increased with age Urban

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Bello-Chavolla, 2016 [39]	1993–2012	Mexico	Review of four cycles of the National Health and Nutrition Survey “ENSANUT”	NA	Self-report and detected during the examination	Increasing total prevalence: 1993: 6.7%, 2000: 7.5%, 2006: 14.4%; incomplete data for 2012 In 2006: 7.1% self-reported, and 7.3% newly diagnosed In 2006, higher prevalence in urban areas (15.5%) compared with rural areas (10.3%) Self-reported: 9.4% (blood tests not available) greater in women than in men. Regional variation.
Secretaría de Salud de México, Instituto Nacional de Salud Pública (INSP), 2016 [40]	2016	Mexico [Encuesta Nacional de Salud y Nutrición de Medio Camino (ENSANUT-MC 2016)]	National Health and Nutrition Survey Stratified probabilistic sampling	N = 29,795 (51.1% women) all ages	Self-report and blood tests	
Basto-Abreu, 2020 [41]	2016	Mexico (ENSANUT-MC 2016)	Secondary data analysis of 3700 participants with diabetes	N = 3700 (52.6% women)	Self-report and/or fasting blood glucose ≥ 126 mg/dL and HbA1c $\geq 6.5\%$	Total prevalence = 13.7% Self-reported: 9.5%, undiagnosed: 4.1%
Central America						
Brenes-Camacho, 2007 [42]	2004–2006	Costa Rica [Costa Rica: Estudio de Longevidad y Envejecimiento Saludable (CRELES)]	Nationally representative sample	N = 3000 (sex breakdown not reported) Age ≥ 60 years	Self-report, intake of antihyperglycemic medications and/or fasting blood glucose ≥ 126 mg/dL and HbA1c $\geq 6.5\%$	Total prevalence = 23.4% (women = 27.5%; men = 18.8%) Self-reported = 21%, Undiagnosed = 2.4% among those with diabetes: 95.7% participants had health insurance 61.2% were women 54% lived in the metropolitan capital city area
Wong-McClure, 2015 [44]	2010	Costa Rica (Costa Rican National Cardiovascular Risk Factors Surveillance System)	Probabilistic sampling	N = 3653 (men = 1023; women = 2630) Age ≥ 20 years	Previously diagnosed = self-report, use of insulin, or hypoglycemic oral treatment in past 2 weeks. Unknown diabetes = no self-report with fasting blood glucose > 125 mg/dL Self-report or fasting blood glucose ≥ 126 mg/dL	Total prevalence 10.8% (women = 11.9%; men = 9.5%) Self-reported = 9.5% Undiagnosed = 1.3% prevalence increased with age. Over 75% participants had less than high school education.
Orantes, 2011 [45]	2009	El Salvador (Nefrolempa Study)	Assessment of risk factors for chronic kidney disease (CKD) Communities represented in this study are mostly poor and primarily work in agriculture.	N = 775 (men = 343; women = 432) Age ≥ 18 years	Self-report or fasting blood glucose ≥ 126 mg/dL	Total prevalence = 10.3%
Orantes Navarro, 2015 [46]	2009–2011	El Salvador (Study related to the Nefrolempa Study)	Assessment of risk of CKD in women from low-income three agricultural communities National Survey	N = 1412 all women Aged ≥ 18 years	Self-report and fasting plasma glucose ≥ 126 mg/dL	Total prevalence = 9.3%
	2013–2014	El Salvador (Encuesta Nacional de			Self-report and fasting plasma	Overall: 12.5% Men: 10.6%, women: 12.5%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Ministerio de Salud de El Salvador, 2015 [47]		Enfermedades Crónicas No Transmisibles y Factores de Riesgo en la Población Adulta de El Salvador.	Two-stage probabilistic sampling (STEPS)	<i>N</i> = 4817 (56.4% women) Age ≥ 20 years	glucose ≥ 126 mg/dL	Prevalence increased with age and was higher in the metropolitan area (San Salvador).
Chen, 2017 [48]	2012–2013	Guatemala (Non-Communicable Disease Surveillance Study in Santiago de Atitlán)	Indigenous populations Simple random sampling	<i>N</i> = 350 (72.3% women) Age not specified	Self-report and fasting blood glucose	Prevalence = 3% (1.3% previously known, 1.7% previously unknown) Despite high rates of poverty, hypertension, and dyslipidemia, there was a low rate of diabetes compared to other regions of the country.
Ministerio de Salud Pública y Asistencia Social de Guatemala, 2018 [49]	2015	Guatemala (Encuesta Nacional de Prevalencia de Enfermedades No Transmisibles y sus Factores De Riesgo Dominio I: Urbano Metropolitana)	National Survey – Metropolitan Area only Random, stratified sampling (STEPS)	<i>N</i> = 2036 (77.4% women) Age ≥ 18 years	Self-report; fasting CBG ≥ 110 mg/dL	Self-reported prevalence = 11.3% Women: 9.5% diagnosed within last 12 years (total 12.5%) Men: 7% diagnosed within last 12 years (9.9% total)
Bream, 2018 [50]	2018	Guatemala	Geographic-randomized Focus on indigenous populations in the rural highland region of Atitlán.	<i>N</i> = 400 (69.1% women) Age ≥ 18 years	FBG > 7.0 mmol/L (≥ 126 mg/dL) HbA1c > 6.5%	Total: 13.81% (women = 14.56%; men = 12.20%) Prevalence increased with age, but not BMI (kg/m ²).
Montalván Sánchez, 2020 [51]	2016–2017	Honduras	CVD burden in Copán First study on CV Risk Factors in Western Honduras Random volunteer-based, cross sectional descriptive study Attending both private and public medical institutions in the Department of Copán	<i>N</i> = 384 (62% women) Age: 45–75 years	Self-report and taking meds; fasting blood glucose > 125 mg/dL	Self-reported diabetes: women = 22.1% and men = 19% (overall 21%) 6.7% with abnormal blood glucose without a previous diagnosis of diabetes.
Laux, 2012 [52]	2007–2009	Nicaragua	Study on the prevalence of diabetes and hypertension in one urban and five rural communities in Nicaragua Five communities in the northwest (Leon and Chinandega) and one community in central Nicaragua (Matagalpa)	<i>N</i> = 1355 (56.5% women) Age: 20–60 years	Self-report or glucosuria ≥ 100 mg/dL, uncontrolled diabetes solely diagnosed as glucosuria > 100 mg/dL	Total prevalence = 3.0% (40/1355); 33 (82.5% women). Prevalence in persons with normal blood pressure = 1.6% Prevalence in persons with hypertension = 7.7%
Lebov, 2015 [53]	2010–2011	Nicaragua (Leon Health and Demographic Surveillance System)	Randomly selected 50 of 208 pre-defined geographical clusters	<i>N</i> = 3000 (57.6% women) Age: 18–70 years	Self-report and?	Total prevalence = 7.2%; 5% of the total (69.4% of those with diabetes) reported previous history of diabetes. Most of the participants lived in poverty. Overall prevalence, based on self-report = 7%
Ferguson, 2020 [54]	2012–2014	Nicaragua				

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
McDonald Posso, 2013 [55]	2010–2011	Panama [Primera Encuesta de Factores de Riesgo de Enfermedad Cardiovascular (PREFREC)]	Study of CVRF in Southwestern Nicaragua Department of Rivas agricultural communities	N = 1227 (533 households) (56.3% women) Age range 17.4–101.8 years	Venous blood samples obtained, but unclear if blood glucose measurements used for assessment	7.3% self-reported having diabetes and 2.2% were not aware of having diabetes; hence the estimated prevalence was 9.5%. The age-adjusted rate for the 2012 Panamanian population was 7.7%. Non-adjusted prevalence: 10.3% in men and 9.1% in women.
Caribbean						
Da Silva Coqueiro, 2010 [56]	1999–2000	Cuba	Subsample of participants from Cuba in the National Survey of Health, Wellbeing, and Aging - Encuesta Nacional de Salud, Bienestar, y Envejecimiento (SABE) study	N = 1905 (62.8% women) Age ≥ 60 years	Self-report	Total prevalence based on self-report = 14.8% Diabetes was not associated with overweight.
De Jesus Llibre, 2011 [57]	Two phases: 2003–2006 and 2007–2010	Cuba (10/66 Study recruited in Havana City and Matanzas)	Sub-sample analysis First-stage sampling five municipalities in Havana City Province and the city of Matanzas	N = 2944 (64.7% women) Age ≥ 65 years	Self-report (history and medications) and fasting glucose ≥ 7.0 mmol/L	Overall prevalence = 24.8% Prevalence in women = 27.5% Prevalence in men = 19.4%
Herrera-Valdés, 2008 [58]	2004–2006	Cuba [Community-Based Epidemiological Study of Chronic Kidney Disease, Cardiovascular Disease, Diabetes Mellitus and Hypertension (ISYS)]	“Isle of Youth Study” Focus on prevalence of obesity and its association with other conditions	N = 14,322 (sex breakdown not reported) Age ≤ 60 years	Self-report and laboratory tests	Prevalence of diabetes in individuals aged ≤ 20 years: 1.3–9.5% for obese and 1.1% for non-obese Prevalence of diabetes in individuals aged ≥ 20 years: overall 4.7% in non-obese and 11.3% in obese persons.
Armas Rojas, 2008 [59]	2006	Cuba	CV risk among older women in the Havana area Cross-sectional, catchment area served by the Mártires del Corynthia Polyclinic in Havana Single-stage clustering	N = 3396 women Age ≥ 60 years	Self-report and on treatment	Prevalence ranged from 5.5 to 21%, by age group Overall = 21.8%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Bonet-Gorbea, 2014 [60]	2010–2011	Cuba (III Encuesta Nacional de Factores de Riesgo y Actividades Preventivas de Enfermedades No Transmisibles. Cuba 2010–2011)	Family doctor and nurse offices selected randomly National Health Survey Clustered, multi-stage, stratified	<i>N</i> = 7928 persons, from 4150 households (50.3% women) Age ≥ 15 years	Self-report and fasting blood glucose (≥ 7.0 mmol/L)	Total prevalence: 10.0% (6.1% self-reported) Women: 12.9%, Men: 7.2% Urban: 11.1%, rural: 6.8%; Self-reported: 7.1% urban, and 3.0% rural Undiagnosed: 4.2% (4.3% urban, 3.9% rural) Prevalence based on skin color: “negra” (12.3%), “blanco” (10.2%) and “mulato” (8.6%) Prevalence: 3.5% (4% women and 3% men self-reported diagnosis of diabetes)
Ministerio de Salud Pública de la República Dominicana, 2014 [61] Carrère, 2017 [62]	2013 2014	Dominican Republic (Encuesta Demográfica y de Salud - República Dominicana 2013) Guadeloupe	National Health Survey Nationally representative, probabilistic, clustered, stratified and two-stage. Cross-sectional multicenter study Persons undergoing a periodic health examination on invitation from the general social security fund of Guadeloupe (CGSS). Population-based survey Two-stage cluster method; representative sample of Port-au-Prince, and six surrounding cities	<i>N</i> = 39,564 (19,878 women) Age: women 15–49 years Age: men 15–59 years <i>N</i> = 2252 (56.5% women) Age: 18–74 years	Self-report Self-report of antihyperglycemic treatment use, fasting blood glucose ≥ 7 mmol/L HbA1c ≥ 6.5% Casual Blood Glucose 80 mg/dL (4.4 mmol/L) Fasting blood glucose ≥ 126 mg/dL (7 mmol/L), and 2-h post glucose load (OGTT) ≥ 200 mg/dL (11.1 mmol/dL)	Total prevalence: women 8.2%, men 5% Previously diagnosed: 6.7% in women, 3.3% in men. Higher prevalence among those with lower education. Age-standardized prevalence was 4.8% in men and 8.9% in women (77.3% men and 69.2% women known diabetes) Odds of diabetes were greater with age, abdominal obesity, hypertension, lower educational attainment, and higher income.
Jean-Baptiste, 2006 [63]	2002–2003	Haiti (Prevalence of Diabetes and Hypertension in Haiti-PREDIAH)	Single-enter, prospective study in Deschappelles; assessment of prevalence of CKD and associated risk factors Random sampling, two-stage, stratified	<i>N</i> = 1620 (331 men, 782 women) Age ≥ 20 years	Binary data – physician answered yes/no	Prevalence diabetes = 36.3% The authors explain that the high prevalence of diabetes may be due to selection bias.
Burkhalter, 2014 [64]	2012–2013	Haiti	Single-enter, prospective study in Deschappelles; assessment of prevalence of CKD and associated risk factors Random sampling, two-stage, stratified	<i>N</i> = 608 patients with full medical datasets (64.5% women) Age ≥ 18 years <i>N</i> = 14,371 women aged 15–49; 9795 men aged 15–64, 1142 women 50–64, and 2091 men 35–64	Binary data – physician answered yes/no	Prevalence diabetes = 36.3% The authors explain that the high prevalence of diabetes may be due to selection bias.
Ministère de la Santé Publique et de la Population, 2018 [65]	2016–2017	Haiti (Enquête Mortalité, Morbidité et Utilisation des Services (EMMUS-VI))	Random sampling, two-stage, stratified	aged 15–49; 9795 men aged 15–64, 1142 women 50–64, and 2091 men 35–64	Hemoglobin A1c > 6.5%	In the 35–64 age group, the prevalence of diabetes based on HbA1c > 6.5% was: 14.1% in women and 8.2% in men. Previously informed of having “hyperglycemia”: 3% of women and 2% of men. Prevalence Urban (Women 17%, men 12%) Prevalence Rural (Women 11%, men 7%) Prevalence increased with “bien-être économique du ménage”.

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Geiss, 2012 [66]	1995–2010	Puerto Rico [Behavioral Risk Factors Surveillance Systems (BRFSS)]	Sub-analysis based on four cycles Random-digit-dialed telephone surveys of noninstitutionalized US civilian adults aged ≥18 years	N = Not reported Age ≥ 18 years	Self-reported only	Due to the high prevalence of iron-deficiency anemia, HbA1c may have been elevated. Prevalence (age-adjusted for adults aged ≥18 years) 1995: 11.7%, 2000: 9.3%, 2005: 12.5%, and 2010: 12.7%
Pérez, 2015 [67]	2005–2007	Puerto Rico	Household survey in San Juan metropolitan area	N = 857 (65.7% women) Age: 21–79 years	Self-report and/or FPG ≥ 126 mg/dL and HbA1c ≥ 6.5%	Age-standardized: total 25.5% (11.4% undiagnosed) 89% had health insurance; 67.2% with annual income < \$20 K They compared prevalence using FPG alone or combination of FPG and HbA1c to detect undiagnosed diabetes. FPG + HbA1c yielded a higher percentage than either one alone. Aged-adjusted prevalence in adults aged ≥ 45 years was 26.8%
Pickens, 2019 [68]	2015	Puerto Rico (2015 BRFSS)	As described above	N = 3642 (sex breakdown not reported) Age ≥ 45 years N = 2603 surgical patients (56% women) Age: all	Self-report only	Aged-adjusted prevalence in adults aged ≥ 45 years was 26.8%
Cruz, 2016 [69]	2014	Puerto Rico	Analysis of surgical cases from various hospitals in the San Juan metropolitan area	N = 2603 surgical patients (56% women) Age: all	Medical records	Prevalence = 21% but increased to 40% in patients aged ≥ 65 years. Statistically significant greater percent of complications and mortality for patients with diabetes.
South America						
Ministerio de Salud de Argentina, 2011 [70]	2009	Argentina (2nda Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles)	Second National Survey on Risk Factors for Non-Communicable Diseases- 4-stage, probabilistic, clustered sampling of 24 jurisdictions	N = 34,732 (No sex breakdown) Age ≥ 18 years	Self-report only	Self-report of diabetes and/or elevated blood glucose = 9.6% (an increase from 8.4% in 2005). Prevalence of diabetes in women = 10.2%, and in men = 8.9%. Prevalence of diabetes increased with age and with lower educational attainment. Prevalence of diabetes increased with age.
Ministerio de Salud de Argentina, 2015 [71]	2013	Argentina (3ra Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles)	Third National Survey on Risk Factors for Non-Communicable Diseases 4-stage, probabilistic, clustered sampling	N = 32,365 (52.6% women) Age ≥ 18 years	Self-report only	Prevalence of diabetes increased with age and with lower educational attainment. Prevalence of diabetes increased with age.
Ministerio de Salud de Argentina, 2019 [72]	2018	Argentina (4ta Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles)	Fourth National Survey on Risk Factors for Non-Communicable Diseases 4-stage, probabilistic, clustered sampling	Three steps sampling and exam: Step 2: 16,577 and for Step 3: 5331 (No sex breakdown) Age ≥ 18 years N = 2948 adults (1036 men; 1497 women) Age ≥ 20 years	Self-report and fasting blood glucose (CBG ≥ 110 mg/dL)	Prevalence: 12.7% based on self-report (women: 13.7%, men: 11.6%) In addition, 5% who did not report having diabetes had CBG ≥ 110 mg/dL. Diabetes prevalence increased with age, and with lower educational attainment. Total prevalence = 7.2%
Barceló, 2001 [73]	1998	Bolivia	Population-based survey of households in four urban	N = 2948 adults (1036 men; 1497 women) Age ≥ 20 years	Fasting blood glucose ≥ 126 mg/dL and OGTT	Diabetes prevalence increased with age, and with lower educational attainment. Total prevalence = 7.2%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Kaplan, 2017 [74]	2014–2015	Bolivia	areas: La Paz, El Alto, Santa Cruz, Cochabamba Assessment of CAD in the Tsimane population of Bolivia (Maniqui River)	<i>N</i> = 705 (sex breakdown not specified) Age ≥ 40 years <i>N</i> = 842 (406 men; 436 women)	Fasting blood glucose > 6.9 mmol/L	Greater prevalence among those with more limited education. Greater prevalence among Aymara-speaking participants. Prevalence was almost zero. Other CV assessments revealed low to negligible presence of CAC, and other CV risk factors.
Busch Mendés, 2011 [75]	2003	Brazil	São Paulo Probabilistic sampling, two-stage	Age ≥ 60 years <i>N</i> = 15,102 (6685 men, 8217 women) Age: 35–74 years	Self-report	Prevalence: 26.31% (15.54% in men, 18.89% in women) Inverse relationship with educational attainment
Schmidt, 2014 [76]	2008–2010	Brazil [Estudo Longitudinal da Saúde do Adulto (ELSA-Brasil)]	Prospective cohort study of active or retired civil servants	<i>N</i> = 15,102 (6685 men, 8217 women) Age: 35–74 years	Self-report Fasting plasma glucose ≥ 126 mg/dL, 2 h-OGTT ≥ 200 mg/dL or HbA1c ≥ 6.5%	Prevalence (by self-report or medication use): 19.7% Percent undiagnosed: 50.4% of the total Higher prevalence of diabetes among those with less than primary education, Asian, black, and indigenous participants.
Dal Fabbro, 2014 [77]	2008–2012	Brazil	Descriptive study on health of Xavante Indians from Mato Grosso	<i>N</i> = 948 (463 men; 485 women) Age ≥ 20 years	Capillary sample, although venous samples were obtained for other biomarkers; HbA1c	Total age-adjusted: 28.3% (18.4% in men, 40.6% in women)
Ministério do Planejamento, Orçamento e Gestão, 2014 [78]	2013	Brazil (Pesquisa Nacional de Saúde -PNS 2013)	Brazilian National Health Survey Random, clustered, three-stage sampling	<i>N</i> = 62,986 households (no sex breakdown) Age ≥ 18 years	Self-report; HbA1c was tested, but results not presented in this report	Prevalence based on self-report = 6.2% (7.0% in women, 5.4% in men) Prevalence increased with age and with lower educational attainment.
de Oliveira, 2018 [79]	2006–2016	Brazil [Surveillance Systems of Risk and Protection Factors for Chronic Diseases by Telephone Survey (Vigitel)]	Secondary analysis National Telephone Survey Quantitative review	<i>N</i> = 572,437 adults (sum of all years (no sex breakdown)) Age ≥ 18 years	Self-report	Prevalence (2016): 8.9% Increased from 5.5% in 2006 Higher prevalence among women, with lower income, and with lower education.
Ministério da Saúde do Brasil, 2019 [80]	2018	Brazil Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico (VIGITEL BRASIL 2018)	National Telephone Survey Capital cities of each of the 26 states and the Federal District, land lines Random, stratified	<i>N</i> = 52,395 19,039 men, 33,356 women Age ≥ 18 years	Self-report only	Prevalence self-reported: 7.7% (8.1% in women, 7.1% in men) Diabetes prevalence Increased with age.
Ministério da Saúde do Brasil, 2020 [81]	2019	Brazil Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico (VIGITEL BRASIL 2019)	National Telephone Survey	<i>N</i> = 52,443 18,354 men, 34,089 women Age ≥ 18 years	Self-report only	Prevalence self-reported: 7.4% (7.8% in women, 7.1% in men). Diabetes prevalence Increased with age.
Santos, 2001 [82]	1997	Chile		<i>N</i> = 196 (78 men, 118 women)		Prevalence of 1.3% in men and 1.7% in women

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Carrasco, 2004 [83]	NR	Chile	Aymara in Northern Chile living in rural areas in the highlands Mapuche and Aymara living in four urban communities of Santiago and northern Chile; volunteers	Age ≥ 20 years Mapuche (42 men, 105 women) Aymara (42 men, 118 women) Age ≥ 20 years	Fasting blood glucose and 2 h- post glucose load (OGTT) Fasting blood glucose and 2-h post glucose load (OGTT)	Assessed two indigenous groups, Aymara and Mapuche Prevalence among Aymara: 6.9% (2.4% in men, 8.5% in women) Prevalence among Mapuche: 8.2% (14.3% in men, 5.7% in women)
Cuevas, 2008 [84]	1993–2001	Chile	Cross-sectional epidemiology study Only from urban sector La Florida in Santiago, Mid socioeconomic level	N = 964 (336 men, 628 women) Age ≥ 18 years	Fasting plasma glucose ≥ 126 mg/dL and/or self-reported diagnosis	Total prevalence in 2001: 10.1% (10.7% women., 8.9% men) The total prevalence of diabetes in 1993 was 3.8%.
Ministerio de Salud de Chile, 2010 [85]	2009–2010	Chile (Encuesta Nacional de Salud, ENS Chile 2009–2010)	Random sampling of households (multi-stage and stratified), representative of the national, regional, and urban/rural zones, cross-sectional analysis	N = 5, 416 (59% women) Age ≥ 15 years	Self-report and FPG ≥ 126 mg/dL and HbA1c	Total prevalence = 9.4% (8.4% in men, 10.4% in women) based on self-report and FPG. Diabetes prevalence increased with age and with lower educational attainment. Greatest prevalence in women of the lowest educational level
Ministerio de Salud de Chile, 2017 [86]	2016–2017	Chile (Encuesta Nacional de Salud, ENS Chile 2016–2017)	National random sampling of households (multi-stage and stratified), representative of the national, regional, and urban/rural zones, cross-sectional analysis	N = 6233 (62.9% women) Age ≥ 15 years	Self-report and FPG ≥ 126 mg/dL	Total prevalence = 12.3% (10.6% in men, 14.0% in women) Diabetes prevalence increased with age (30.6% in persons aged ≥ 65 years) and with lower educational attainment (24.8% with < 8 years of education)
Rodríguez, 2009 [87]	2007	Colombia [Encuesta Nacional de Salud (ENS)]	National Health Survey Probabilistic, national representative including 41,543 households	N = 164,474 persons (52.5% women) Subsample of those in the 18–69-year age group had additional interviews and exams (glycemia) women) Age: 35–70 years	Self-report	Prevalence = 3.0% based on self-report, per Executive Summary
Camacho, 2020 [88]	2005–2009	Colombia [Prospective Urban Rural Epidemiology (PURE) Study]	Sub analysis of data from Colombia	N = 7485 (64.1% women) Age: 35–70 years	Self-report	Prevalence: 5.7% (6.0% in women, 5.1% in men) Greater prevalence with lower education
Profamilia, 2011 [89]	2010	Colombia [Encuesta Nacional de Demografía y Salud (ENDS 2010)]	National Health Survey Nationally-representative, in urban and rural settings, probabilistic, clustered, stratified and poly-staged.	N = 17,574 No sex breakdown Age > 60 years	Self-report	Prevalence only reported for adults aged ≥ 60 years Self-reported prevalence: 11.2% (12.2% urban, 8.3% rural; 12.8% in women and 9.0% in men)
Orces, 2018 [90]	2010	Ecuador [National Survey of Health, Wellbeing, and	Secondary data analysis Probability sampling in	N = 2298 (1041 men, 1257 women)	Self-report or FPG ≥ 126 mg/dL	Prevalence = 16.7%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Ministerio de Salud Pública de Ecuador [91]	2012	Aging - Encuesta Nacional de Salud, Bienestar, y Envejecimiento (SABE)] Ecuador [Encuesta de Salud y Nutrición del Ecuador (ENSANUT-ECU 2012)]	Andes Mountains and coastal regions, multi-stage sampling National Health and Nutrition Survey Probabilistic, stratified, three-stage, and cluster sampling	Age ≥ 60 years N = 15,916 (49% women) Age: 10–59 years	Self-report and FPG ≥ 126 mg/dL	Higher among women, blacks, urban coastal, and obese individuals. Higher in urban coastal areas. Overall prevalence = 2.7% Diabetes prevalence increased with age. No sex differences. Higher prevalence among Afro-Ecuadorian: 3.1% Higher prevalence in urban (3.2%) compared to rural (1.6%) areas. Prevalence was higher in persons from coastal than mountain regions.
Tufton, 2015 [92]	2012	Ecuador	Santa Cruz Island, Galápagos Santa Cruz is the main island Diabetes screening program at the main local clinic	N = 141 (59.6% women) Age ≥ 18 years	Medical history and fasting blood glucose > 126 mg/dL	Prevalence based on self-report: 16.3% Undiagnosed: 11.3% who had fasting blood glucose > 126 mg/dL
Alexander, 2017 [93]	2014	Ecuador	Isabela, Galápagos Secondary data analysis	N = 534 (67% women) Age ≥ 21 years	Fasting blood glucose, postprandial glucose	Prevalence in persons aged ≥ 50 years: 24% Prevalence in persons aged < 50 years: 8%
Bonilla-Sierra, 2020 [94]	2019	Ecuador	Loja, Ecuador 10th most populous town Patients attending health care centers of the Health Ministry of Ecuador or living in the geriatric center	N = 283 (130 women) Age ≥ 60 years	Self-report	Total prevalence = 28.27%
Chaves, 2015 [95]	2006–2013	Paraguay [Asunción, Modificación de Factores de Riesgo Cardiovascular – (AsuRiesgo)]	Urban area of Asunción In-hospital and outpatient clinic patients, in waiting rooms invited to participate. Single-center, prospective study	N = 18,287 (67.5% women) Ages ≥ 18 years	Self-report and fasting blood glucose	Overall Prevalence: 13.3% (14% in women, 11.8% in men)
Ministerio de Salud Pública y Bienestar Social de Paraguay, 2012 [96]	2010–2011	Paraguay (Primera Encuesta Nacional de Factores de Riesgo de Enfermedades No Transmisibles en Población General)	First National Health Survey Probabilistic, three-stage sampling	N = 2538 (49.4% women) Ages: 15–74 years	Self-report	Overall: 9.7% (women 11.1%, men 7.9%) Increased with age
Segura-Vega, 2006 [97]	2004	Peru (TORNASOL I)	Cross-sectional, random sampling in 26 cities across the whole country	N = 14,826 (50.5% women) Age ≥ 18 years	Self-report	Overall = 3.3% self-reported, with no lab assessment performed. Higher prevalence in men. Lower prevalence in the highlands. Prevalence increased with SES and having health insurance.
Ministerio de Salud de Perú, 2006 [98]	2005	Peru [Encuesta Nacional de Indicadores Nutricionales, Bioquímicos,	National Survey Stratified and clustered sampling	N = 4206 (50.1% women) Age ≥ 20 years	Blood glucose ≥ 100 mg/dL with self-report, random	Previous diagnosis: 3.7% Unaware: 2.8%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Miranda, 2011 [99]	2007–2008	Socioeconómicos y Culturales Relacionados con las Enfermedades Crónicas Degenerativas (ENINBSC-ECNT 2005) Peru (PERU MIGRANT)	Cross-sectional survey of three population-based groups: rural, rural-urban migrants, and urban	N = 1706 (52.8% women) Age > 30 years	≥ 200 mg/dL with no previous history, or taking diabetes medications	Higher prevalence in men and with increasing age. Higher diabetes prevalence in metropolitan area Lima (6%) and lowest in the Sierra Urbana (0.9%)
Segura-Vega, 2013 [100]	2010–2011	Peru (TORNASOL II)	Single-stage random sampling Comparison with first wave Similar sampling and 26 cities	N = 14, 675 (50.8% women) Age ≥ 18 years N = 1677 (sex breakdown not reported) Age ≥ 25 years	Fasting glucose, HbA1c	A gradient was reported for age-standardized prevalence of diabetes: 0.8% rural, 2.8% rural-to-urban migrants, and 6.3% urban.
Seclen, 2015 [101]	2010–2012	Peru (PERUDIAB)	Random cluster sampling of urban and suburban areas	Age ≥ 18 years N = 1677 (sex breakdown not reported) Age ≥ 25 years	Self-report	Diabetes prevalence: 4.4% Prevalence increased with socioeconomic status and having health insurance.
Bernabé-Ortiz, 2016 [102]	2010–2011	Peru (CRONICAS)	Single-stage random sampling	N = 3135 (48.5% men) Age ≥ 35 years	Self-report and fasting plasma glucose ≥ 126 mg/dL History of pharmacological treatment	7.0% (National), 8.4% in Lima (7.01% in men, 7.04% in women) Diabetes prevalence was higher in coastal (8%) than in highlands (4%), and significantly higher among those without formal education.
Krishnadhath, 2016 [103]	2013	Suriname (Suriname Health Study)	Stratified multistage cluster sample of households	N = 3393 (48.5% men) Age: 15–65 years	Fasting blood glucose ≥ 7.0 mmol/L or self-reported diabetes medication use	Baseline prevalence was 7.1%; 121 new cases in mean 2.4 years. Prevalence: 13.0%
Minderhoud, 2015 [104]	2013–2014	Suriname [The Rapid Assessment of Avoidable Blindness (RAAB)]	Random clusters Survey; sub-analysis	N = 2806 689 had diabetes (274 men, 415 women) Age ≥ 50 years N = 2008 (1324 women) Age: 25–64 years	Previously diagnosed, receiving treatment, random blood glucose of ≥ 200 mg/dL	Highest prevalence for Hindustanis (23.3%). Higher prevalence for lower income. Lower prevalence in rural areas. Prevalence: 24.6% Highest prevalence for Hindustanis and urban dwellers
Ministerio de Salud Pública de Uruguay, 2007 [105]	2006	Uruguay (Primera Encuesta Nacional de Factores de Riesgo de Enfermedades Crónicas No Transmisibles - ENFRECNT)	National Health Survey Multi-stage Cluster stratification Representative sampling of urban areas	N = 74,420 patients (51% women) Age ≥ 15 years	Self-report; fasting blood glucose ≥ 110 mg/dL	Total prevalence: 5.5% Men = 6.2%, Women = 4.7% No sex differences
Fort, 2012 [106]	2008–2011	Uruguay	CVRF assessment of national health insurance card applicants Cross-sectional, electronic records	N = 74,420 patients (51% women) Age ≥ 15 years	Self-report and/or fasting blood glucose > 125 mg/dL	Prevalence in men: 2.4–20.2% (6.8%) Prevalence in women: 1.5–14.3% (6.1%)
Ministerio de Salud Pública de Uruguay, 2014 [107]	2013	Uruguay (Segunda Encuesta Nacional de Factores de Riesgo de Enfermedades	National Health Survey Representative sampling of urban areas Cluster stratification	N = 3204 (1539 women) Age: 15–64 years	Self-report and taking meds; fasting blood glucose ≥ 126 mg/dL	Total prevalence: 6.0% (25–64, men 7.4%, women 7.8%; 55–64 = 16.8%) Undiagnosed: 50.2% Non-diagnosed and non-treated 66.3% men, 30.7%

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Nieto-Martínez, 2018 [108]	2006–2010	No Transmissibles – ENFREN Venezuela [Venezuela Metabolic Syndrome, Obesity and Lifestyle Study (VEMSOLS)]	Multi-stage stratified random sampling Andes, Western and Capital District	<i>N</i> = 1334 (men = 419, women = 915) Age ≥ 20 years	Self-report and blood samples (plasma glucose)	women, overall 48.9% Age-adjusted prevalence = 8.0% Higher among men
Multinational studies						
Menéndez, 2005 [109]	2000–2001	Argentina, Cuba, Mexico, Uruguay, Chile and Brazil [National Survey of Health, Wellbeing, and Aging- Encuesta Nacional de Salud, Bienestar, y Envejecimiento (SABE)]	Sub-analysis Multi-stage probabilistic sampling in capital cities	<i>N</i> = 10,891 (58.9–65.7% women across sites) Age ≥ 60 years	Self-report	Buenos Aires: 12.5%, São Paulo: 17.7%, Santiago: 13.3%, Mexico City: 21.9%, and Montevideo: 13.0%
Escobedo, 2009 [110]	2003–2005	Venezuela, Colombia, Argentina, Peru, Mexico, Ecuador, and Chile [Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA)]	Cross-sectional, population-based, observational study. Equiprobabilistic sampling of households; only urban sites	<i>N</i> = 11,550 (38.58–49.53% men across sites) Age: 25–64 years	Fasting blood glucose ≥ 7.0 mmol/L or self-reported diagnosis	Prevalence of DM was 7% (range 4–9%) Weight adjusted: (Barquisimeto: 6.0%, Bogotá: 8.1%, Lima: 4.4%, Mexico City: 8.9%, Quito: 5.9%, Santiago: 7.2%) Generally higher in women, increasing prevalence with age.
Barceló, 2012 [111]	2003–2006	Belize, Costa Rica El Salvador Guatemala Honduras Nicaragua [Central America Diabetes Initiative (CAMDI)]	Cross-sectional survey of six Central American Populations Probabilistic sampling; it included the entire population of Belize and samples from urban areas in the other countries.	<i>N</i> = 10,822 (50.2% women) 7234 underwent anthropometry measurement and laboratory tests	Self-report, fasting blood glucose ≥ 126 mg/dL, 2-h OGTT ≥ 200 mg/dL	Belize: 12.9% (men: 8.3%, women: 17.6%) Costa Rica: 8.8% (men: 9.6%, women: 8.0%) El Salvador: 7.6% (men: 8.7%, women: 6.8%) Guatemala: 7.3% (men: 7.8%, women: 6.8%) Honduras: 5.4% (men: 5.5%, women: 5.4%) Nicaragua: 9.8% (men: 9.1%, women: 10.5%) Total prevalence across all sites: 8.5% 40% were undiagnosed.
Salas, 2016 [112]	2003–2009	Cuba Dominican Republic Puerto Rico Venezuela Peru Mexico (10/66 Dementia Research Group)	Sub-analysis Population-based studies in 13 catchment areas in six Latin American countries: urban areas in Cuba, Dominican Republic, Puerto Rico and Venezuela, and urban and rural areas in Peru and Mexico	<i>N</i> = 17, 945 including sites in India, China and Nigeria Age ≥ 65 years	Self-report and fasting blood glucose > 7 mmol/L BP and TG and TC were also assessed	Self-report: Cuba: 18.3% (women > men) Dominican Republic: 14.0% (women > men) Peru Urban: 8.7% (men > women) Peru Rural: 10.3% (women > men) Venezuela: 16.2% (no difference) Mexico Urban: 24.9% (no difference) Mexico Rural: 19.2% (women > men) Puerto Rico: 32.2% (men > women) Undiagnosed: Cuba: 5.7% (men > women) Dominican Republic: 3.3% (women > men) Peru Urban: 3.3% (men > women) Venezuela: 4.9% (men > women) Mexico Urban: 2.5% (no difference) Mexico Rural: 4.8% (men > women) Puerto Rico: 11.6% (men > women)

Table 1 (continued)

Author (reference)	Study period	Place (study name, if available)	Type of study	Sample characteristics	Glycemic criteria	Diabetes prevalence and other key findings
Rubinstein, 2015 [113]	2010–2011	Argentina, Chile and Uruguay [Centro de Excelencia en Salud Cardiovascular para el Cono Sur I (CESCAS I)]	4 small- to mid-size cities 4-stage stratified sampling	N = 7524 men and women Age: 35–74 years	Fasting blood glucose \geq 110 mg/dL or taking medications for diabetes	Prevalence diabetes women 14%, men 9.4% (Marcos Paz 11.9%; Bariloche 8.4%, Temuco 14.3%; Barrios Blancos 14.2%)
Macineko, 2019 [114]	2013–2014	Brazil, Colombia El Salvador, Jamaica, Mexico, and Panama (Inter-American Development Bank's International Primary Care Survey)	Sub-analysis National sample adults, noninstitutionalized selected nationwide list of households and interviewed by phone (including mobile phones and landlines); 1500 interviews per country	N = NR (sex breakdown not reported) Age \geq 18 years	Self-report	19% had diabetes only. In addition to diabetes, six additional chronic conditions were assessed. 30.7% had one additional condition, 25.6% had 2 additional conditions, and 24.8% had 3 or more.

glycemia has been included (Table 1). Some surveys have also included at least one laboratory test (i.e., fasting or random blood glucose measurement or HbA1c), which could identify individuals at risk of developing diabetes or those who may have it and are not aware of it. Because hyperglycemia may be mediated by at least two mechanisms of disease—increased hepatic glucose output manifested as fasting hyperglycemia and uncoupled postprandial insulin secretion manifested as postprandial hyperglycemia [115, 128]—a single blood test or measurement may not identify all or most of individuals affected by the disease [115]. Therefore, the actual prevalence of diabetes may still be underestimated in many countries, as highlighted in previous reviews [5, 15, 124].

The etiologies of diabetes mellitus are complex. Thus, the increasing prevalence of diabetes experienced across LatAm may reflect the convergence or interaction of multiple factors [18, 125, 129]. For instance, the increasing prevalence of overweight and obesity documented across LatAm has paralleled the increasing prevalence of diabetes in the region [84, 125, 130, 131]. In addition to increased adiposity, type 2 diabetes mellitus and insulin resistance have also been linked to malnutrition (at different life stages) in some LMICs [130, 132–134]. Stress associated with chronic poverty, intergenerational poverty, natural disasters, and other adverse events [1, 129, 132, 135] has been linked to chronic systemic inflammation and epigenetic changes, potential common denominators of multiple NCDs [136, 137]. Many LatAm major cities may be epicenters where a fragile built environment and infrastructure and changes in lifestyle and nutrition intersect increasing the cumulative risk of developing diabetes in low-income communities [30, 126, 127, 129, 135, 138, 139]. Increased life expectancy has been associated with increased diabetes prevalence [4, 16, 30, 125, 140], whereas higher educational attainment, increased access to health care, and higher health literacy level are associated with increased awareness of the disease [117]. These are all factors to consider upon designing comprehensive diabetes prevention and treatment strategies across LatAm countries.

In addition, the growing prevalence of diabetes mellitus across LatAm and the complexity of the disease suggest opportunities to create or strengthen collaborations towards its prevention and early detection [141–144]. For example, multinational and multidisciplinary research–public health–health care policy–clinical care partnerships which already exist in formal or informal platforms may be well-positioned to evaluate the impact of nutrition, health insurance, housing, and other public policies [79, 141, 143, 145–154] on health outcomes and assess their potential translation into preventive strategies at the public health and clinical care levels. At the same time, the eventual implementation of such strategies will be strengthened by

local governments' commitment to prioritize the prevention and treatment of NCDs, in this case, diabetes, as previously voiced by experts and advocates in the region [79, 141, 155–158].

Diabetes Awareness, Treatment, and Control

Diabetes Awareness

Although fewer than studies focused on prevalence, a considerable number of reports centered on diabetes awareness, treatment, and control across LatAm were published between 2005 and 2020 (Table 2) [33, 37, 40, 41, 43, 44, 49, 51, 60–63, 65, 72, 73, 87, 98, 101, 103, 104, 111, 112, 159–189]. A few of the studies evaluated diabetes awareness, treatment, and control altogether [85, 185, 189]. Most studies did not use the term “diabetes awareness,” but equated it (or more appropriately, diabetes unawareness) to “suspected,” “undiagnosed,” “unknown,” or “new” diabetes or “elevated glycemia.”

“Undiagnosed” diabetes—a proxy for lack of diabetes awareness—ranged widely from 10.3 to 50% across studies and countries (Table 2). The prevalence of undiagnosed diabetes was higher in Guatemala (48.8%), Uruguay (48.7%), Puerto Rico (37.7–50%), Honduras (31.9–53.7% range), Mexico (29.9–50% range), and Nicaragua (43.3%) and lower in Colombia (Bogota) (23.5%), the southernmost countries of South America (20.2%), and Costa Rica (10.3–28.4%). Irazola et al. [189] described that diabetes awareness slightly increased with educational attainment. However, associations between undiagnosed diabetes with age, sex, educational attainment, SES, or geographic location were not published by most studies.

The observed range of undiagnosed diabetes suggests that the actual prevalence of diabetes across LatAm could exceed previous estimates [6, 124] and that a potentially significant proportion of persons with diabetes for whom both macro- and microvascular complications may be present but not assessed and treated. Therefore, current estimates of the prevalence of diabetes across continents may not fully account for the necessary resources to provide adequate health care for Latin Americans with diabetes [7, 8, 190, 191]. Considering the workforce and resources needed to screen the millions of persons across the region who are at risk of diabetes or have the disease and are not aware, experts have proposed diabetes predictive models requiring specific easily obtained clinical data points that could be readily used in primary care settings [192–194]. Also, the Finnish Diabetes Risk Score (FINDRISC) has been proposed, tested, or modified to screen and identify individuals at high risk of developing diabetes in Latin America [195–199]. Point-of-care tests for HbA1c and urine microalbumin have also been proposed as alternatives to

identify persons with “undiagnosed diabetes” and/or those at risk of chronic kidney disease (CKD) in low-resource and remote settings in LatAm [200–203]. The standardization, reliability, and repeatability of some of these tests, as well as the clinical and public health benefit derived from their integration into the health care systems, may need to be determined [204]. However, these and other emerging diagnostic technologies [205, 206] are promising alternatives that could be incorporated to assess the prevalence of diabetes and implement timely interventions.

Treatment and Control of Diabetes, Blood Pressure, and LDL-C

The percent of persons with diabetes following any treatment for diabetes ranged from 52.6 to 99% across studies (Table 2). Prescription and/or use of antihyperglycemic medications was mostly assessed via interviews, although a few studies evaluated medical records. Most individuals reported taking oral antihyperglycemic medications either as monotherapy or as a combination of oral medications, while a smaller percent reported using insulin alone or in combination with oral medications. Five (5%) to 12.9% only followed diet/exercise prescription [161, 163, 167, 176, 179, 186], and 3.2 to 10.1% were not taking any medications [41, 104, 168, 169, 175]. Receiving or adhering to pharmacological treatment was positively associated with having health insurance [71], and receiving medical care in private rather than public health care settings [71, 187]. At least one study observed better pharmacologic treatment adherence with female sex [185].

Achievement of ADA/ALAD-recommended glycemic goals [23, 207] was assessed by multiple studies. The percentage of persons attaining HbA1c < 7% ranged from 3.5 to 54%. However, some studies defined glycemic control based on fasting or random blood glucose thresholds and reported attainment of glycemic control in the 31.4 to 61.4% range. Attainment of glycemic control was associated with higher socioeconomic status (SES) [160], having health insurance [160], and better access and services [208]. Not attaining glycemic control was associated with longer duration of diabetes [163, 187, 209], taking insulin (alone or in combination with oral antihyperglycemic medications) [176], forgetfulness (e.g., taking multiple medication for more than one condition) [185], complex therapeutic regimes [209], inadequate access to health care services [22], and availability or health insurance coverage of medications [187], among other factors.

In addition to glycemic control, a smaller number of studies examined the attainment of ADA/ALAD-recommended blood pressure and LDL-C—blood pressure < 130/80 mmHg and LDL-C < 100 mg/dL—for patients with diabetes [24, 207]. The percentage achieving blood pressure goals ranged from 25 to 67%, and the percent achieving LDL-C goals ranged from 12 to 52.6%

Table 2 Diabetes awareness, treatment, and control across Latin America based on reports published from 2005 to 2020

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Mexico								
Olaiz, 2007 [33]	2000	Mexico	ENSA 2000 – (study described in Table 1.)	77.3	NR	NR	NR	NR
Secretaría de Salud de México, Instituto Nacional de Salud Pública (INSP), 2016 [40]	2006–2016	Mexico	ENSANUT 2016 MC (study described in Table 1) The report has information on 2006, 2012, and 2016 cycles.	Only self-reported available: In 2006: 7.2 In 2012: 9.2 In 2016: 9.4	Only <i>insulin</i> : 2006: 6.8 2012: 6.5 2016: 11.1 Only <i>oral meds</i> 2006: 84.8 2012: 72.4 2016: 67.9 <i>Both</i> 2006: 2.5 2012: 6.6 2016: 8.8 <i>None</i> 2006: 5.9 2012: 14.5 2016: 12.2	NR	NR	NR
López-López, 2012 [159]	2001–2008	Mexico	Sub-analysis 2000 and 2006 ENSANUT data for the state of Hidalgo and comparison with local diabetes program, <i>n</i> = 2856 (73.1% women)	All participants had diabetes	NR	35.6	99.6	15.5
Kumar, 2016 [37]	2012	Mexico	Based on the Mexican Health and Aging Study (Study described in Table 1.)	Self-reported: 21.4%	NR	NR	NR	NR
Flores-Hernández, 2015 [160]	2006, 2012	Mexico	Cross-sectional analysis based on ENSANUT 2006 and 2012 data from participants who self-reported diabetes <i>N</i> = 2965 in 2006 and <i>N</i> = 4483 in 2012; Age ≥ 20 years	All participants had self-reported diabetes	NR	HbA1c < 7% In 2006: 3.5 In 2012: 25.6	NR	NR
Fanghanel Salmon, 2011 [161]		Mexico	Secondary analysis using data for Mexico from the International Diabetes Management Practices Study)	All participants had diabetes	Oral meds: 66.0 Insulin only: 11.0 <i>Both</i> : 18.0 Diet only: 5.0	HbA1c < 7%: 31.1	25.2	29.7

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Hernández-Romieu, 2011 [162]	2005	Mexico	Total world-wide $N = 17,232$ $N = 2620$ from Mexico Probabilistic sampling $N = 937$ of self-reported diabetes (65.85% women, and mean age = 56) HbA1c was measured. The study was performed in urban and rural zones of seven Mexican states Secondary analysis using data for Mexico from the International Diabetes Management Practices Study) $N = 2642$ from Mexico (91% patients with type 1 and 89% patients with type 2 diabetes living in urban areas)	All participants had diabetes	85.0	HbA1c < 7%: 30.0 HbA1c > 9.5%: 50.0	NR	NR
Lavalle-González [163]	2012–2007	Mexico	Family Medicine Clinics under the Instituto Mexicano del Seguro Social in the Mexico City's metropolitan area Secondary data analysis of a database of 1170 patients with type 2 diabetes with disease diagnosed within 3 years $N = 638$ (women 68.2%, mean age = 51.8 years)	All patients had diabetes	Type 2 Oral only: 63.0 Insulin only: 10.9 Both: 22.3 Diet and exercise: 3.8	HbA1c < 7% Type 1: 20.9 Type 2: 36.8	NR	4.0
Wachter, 2016 [164]	2000–2003 and 2006–2009	Mexico City	Encuesta Nacional de Salud y Nutrición de Medio Camino (ENSANUT-MC 2016) (Study described in Table 1.)	All participants had diabetes	In 2003: 59.2 In 2006: 71.9	HbA1c < 7% In 2003: 38.9 In 2006: 21.4	In 2003: 78.2 In 2006: 46.9	In 2003: 51.9 In 2006: 12.2
Basto-Abreu, 2020 [41]	2016	Mexico	Encuesta Nacional de Salud y Nutrición de Medio Camino (ENSANUT-MC 2016) (Study described in Table 1.)	Total prevalence: 13.8 (4.1 undiagnosed) 70.1 aware	10.1 were not taking medications	HbA1c < 7%: 31.8 HbA1c 7–8%: 16.4	NR	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Central America								
Gough, 2009 [165]	2006	Belize	CAMDI – Belize (Study described in Table 1)	Total prevalence: 13.1 (5.4 undiagnosed) 58.8 aware	69.1 on prescribed treatment: 95.9 taking medications	NR	NR	LDL-C ≤ 130 mg/dL; 12.0
Dekker, 2017 [166]	2014–2015	Belize	Toledo, Belize Hillside Health Care International Clinic Diverse population, poorest district in Belize Mixed methods: medical chart review and health care provider and patient interviews Ages ≥ 18 years N = 178 charts	Not applicable - medical chart reviews of patients with diabetes	All patients on pharmacological treatment: 9% on insulin	Glycemic control “good only for 26%”	50.0	NR
Ministerio de Salud Pública de Costa Rica, 2009 [167]	2004	Costa Rica	CAMDI – San Jose, Costa Rica	Total prevalence: 7.9 (1.9 undiagnosed) 75.9 aware	Oral meds: 57.2 Insulin: 24.8 Diet: 12.9	29.2 uncontrolled	NR	NR
Brenes-Camacho, 2007 [42]	2004–2006	Costa Rica	Costa Rica: Estudio de Longevidad y Envejecimiento Saludable (CRELES) (Study described in Table 1)	Total prevalence: 23.4 (2.4 undiagnosed) 89.7 aware	Oral meds: 69.4 Insulin: 31.0	HbA1c ≥ 7%: 37.0	SBP ≥ 130 mmHg: 78.0 DBP ≥ 80 mmHg: 66.0	LDL-C ≥ 100 mg/dL; 78.0
Brenes-Camacho, 2008 [43]	2010	San Jose, Costa Rica	Costa Rican National Cardiovascular Risk Factors Surveillance System (study described in Table 1)	Total prevalence: 10.8 (1.3 undiagnosed) 88.0 aware	NR	NR	NR	NR
Organización Panamericana de la Salud [168]	2004	Honduras	CAMDI – Tegucigalpa (study described in Table 1)	Total prevalence 6.4 (3.1 undiagnosed) 50 aware	On meds: 85.5 On no treatment: 3.2 On treatment: 95.7	BG < 130 mg/dL: 37.0	77.4	LDL-C, 130 mg/dL; 65.4
Montalván Sánchez, 2020 [51]	2016–2017	Honduras	Western Honduras (study described in Table 1)	68.1 aware	NR	NR	NR	NR
Orellana-Pontaza, 2007 [169]	2006	Guatemala	CAMDI – Villa Nueva, Guatemala (study described in Table 1)	51.2 aware	Taking meds: 77.7 Oral meds: 58.3 Insulin: 8.2 Both: 2.0 None: 26.1 Taking meds: 56.1 Insulin: 19.0	BG ≥ 130 mg/dL: 61.7	HTN: 26.5	LDL-C < 130 mg/dL: 69.6
Ministerio de Salud Pública y Asistencia Social de Guatemala, 2018 [49]	2015	Guatemala	National Survey – Urban region	NR	NR	NR	NR	NR
	2004	Managua, Nicaragua			Taking meds: 97.1	HTN: 33.5		NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals			Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	LDL-C < 100 mg/dL (%)	
Amador Velazquez, 2010 [170]			CAMDI – Nicaragua (study described in Table 1)	Total prevalence: 9.0 (3.9 undiagnosed, or 43.3 of those with diabetes) 56.7 aware		BG < 130 mg/dL: 43.4	LDL-C < 130 mg/dL: 46.1		
Caribbean Ministerio de Salud Pública de Cuba [60]	2010–2011	Cuba	III Encuesta Nacional de Factores de Riesgo y Actividades Preventivas de Enfermedades No Transmisibles, Cuba 2010–2011	61 aware	On meds: 75.5	NR	NR	NR	
Dethlefs, 2019 [171]	2010–2012	Dominican Republic	Study of the implementation of diabetes and hypertension program in two rural clinics serving 30 communities in the Dominican Republic. The program was implemented 2010–2012, N = 1191	All patients had diabetes	NR	50% of patients had A1c < 9% at baseline	NR	NR	
Ministerio de Salud Pública de la República Dominicana, 2014 [61]	2013	Dominican Republic	National Survey “Encuesta Demográfica y de Salud - República Dominicana 2013” Study described in Table 1.	NR	On oral meds: women: 23.0 men: 51.0 On insulin: women: 12.0 men: 15.0	NR	NR	NR	
Carrère, 2017 [62]	2014	Guadeloupe	Cross-sectional multicenter study- Persons undergoing a periodic health examination on invitation from the general social security fund of Guadeloupe (CGSS).	Aware Women: 84.5 Men: 67.3	Women: 97.7 Men: 97.0	HbA1c < 7% Women: 26.9 Men: 25.9	NR	NR	
Jean-Baptiste, 2006 [63]	2002–2003	Haiti	Population-based survey PREDIAH	Aware Men: 77.3 Women: 69.2	On insulin: 10.0	< 10.0 normal BP	NR	NR	

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)	
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)		< 100 mg/dL (%) LDL-C < 100 mg/dL (%)
Ministère de la Santé Publique et de la Population, 2018 [65]	2016–2017	Haiti	(study described in Table 1) Enquête Morbidité, Morbidité et Utilisation des Services (EMMUS- VI) Random sampling, two-stage, stratified	65.4% of women aged 35–64 years knew they had diabetes	No information on other medications Women: 76.5 prescribed medications, but 54.2 taking them. Men: 71.1 prescribed medications, but 53.9 taking them.	HbA1c > 6.5 Women: 64.5 Men: 62.7	NR	NR	
Pérez, 2012 [172]	2005–2007	Puerto Rico	Three-stage cluster sampling design random selection N = 859 Secondary analysis of a previous epidemiologic study	50 aware	Oral meds only: 64.7 Insulin only: 8.1 Both: 12.3	HbA1c < 7.0%: 28.7	41.2	47.8	6.6
Rodríguez-Vigil, 2014 [173]	2010	Puerto Rico	Descriptive study of patients with diabetes based on a random sampling throughout the five health regions. Age ≥ 18 years, N = 600	All participants had diabetes	Oral meds only: 64.5 Insulin only: 11.7 Both: 19.0	HbA1c < 7.0%: 37.3	34.0	59.9	9.9
South America Ministerio de Salud de Argentina, 2011 [70]	2009	Argentina (2da Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles)	Second National Survey on Risk Factors for Non-Communicable Diseases- 4-stage, probabilistic sampling of 24 jurisdictions	NR	On treatment: 55.2 On "medical treatment: 39.5 No pharmacologic treatment: 16.9 Both: 43.65	NR	NR	NR	NR
Ministerio de Salud de Argentina, 2015 [71]	2013	Argentina (3ra Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles)	Third National Survey on Risk Factors for Non-Communicable Diseases 4-stage probabilistic sampling	NR	On treatment: 61.3 (65.8% on insurance, 44.9% public system) Pharmacologic treatment: 34.1 No pharmacologic treatment: 14.4 Both: 51.5	NR	NR	NR	NR
Ministerio de Salud de Argentina, 2019 [72]	2018	Argentina	Fourth National Survey National Survey of	60.7 aware	On treatment: 52.6 (59.3% men	NR	NR	NR	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals	Attainment of three goals (%)	
						Glycemic (%) Blood pressure < 130/80 mmHg (%) LDL-C < 100 mg/dL (%)		
Argentina (4ta Encuesta Nacional de Factores de Riesgo para Enfermedades No Transmisibles Argentina)			Risk Factors for Non-communicable Diseases 4-stage probabilistic sampling International Diabetes Management Practice Study (IDMPS) - an international, multicenter, prospective, observational study of patients with diabetes Sub-analysis of people with type 2 diabetes from Argentina ($N = 2551$)	All participants had type 2 diabetes.	47.4% women Medications only: 24.8 Diet only: 22.5 Both: 52.7 Oral meds only: 65.0 Insulin only: 13.0 Both: 22.0	31.4% had elevated CBG (≥ 110 mg/dL)		
Gagliardino, 2019 [174]	2006–2012	Argentina			Oral meds only: 25.4 Insulin only: 25.1 Both: 18.3	Oral meds only: 40.4 Insulin only: 34.5 Both: 38.2	Oral meds only: 5.5 Insulin only: 2.7 Both: 1.5	
Santero, 2018 [175]	NR	Argentina	Analysis of the implementation of an mHealth program in public primary clinics in the province of Corrientes. Quasi-experimental study with outcome measurements at baseline, 6 and 12 months $N = 947$ patients with diabetes (92.9% with Type 2)	All participants had diabetes	Oral meds only: 79.4 Insulin only: 5.8 Both: 8.9 No treatment: 5.9	HbA1c $\geq 8\%$: 44.4	BP $\geq 140/90$: 48.2	NR
Barceló, 2001 [73]	1998	Bolivia	Population-based survey of households in four cities (study described in Table 1)	Aware Men: 73.6 Women: 69.8	NR	BP 140–159/90–99 mmHg: 21.4	NR	NR
Gomes, 2006 [176]	2000–2001	Brazil	13 public endocrine clinics in 8 Brazilian cities Review of medical charts of patients with type 2 diabetes $N = 2233$ (60% women),	All patients had diabetes and received health care from the National Brazilian Health Care System	Oral meds (monotherapy): 33.2 Insulin monotherapy or in combination: 55.2 Unknown treatment:	HbA1c < 7%: 46.0 all (women 42.8%, men 50.9%)	SBP (27.6 women, 29.8 men) DBP (19.8, women, 18.6 men)	Women 17.2 Men 25.7

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Busch Mendes, 2011 [75]	2003	Brazil	Age ≥ 30 years Study described in Table 1	Awareness was not determined	11.6 Diet only: 11.6 Oral meds: 60.8 Insulin: 15.1	NR	NR	NR
Valverde Mendes, 2010 [177]	2006–2007	Brazil	Health centers located in ten large cities in Brazil Cross-sectional study, nationwide survey Review of medical charts of 20 centers in 10 cities in four Brazilian regions; the largest cities in their regions and most populous. Sample of consecutive patients with diabetes attending each center during a 30-day period. N = 6671 patients with either type 1 or type 2 diabetes. Age ≥ 18 years	All participants had diabetes	NR	Inadequate control: 76 (type 1: 90, type 2: 73)	NR	NR
Moraes, 2020 [178]	2008–2010	Brazil	Secondary analysis based on Estudo Longitudinal da Saude do Adulto (ELSA-Brasil) Prospective cohort study of active or retired civil servants from six public higher education institutions Analysis of sample of participants with previously diagnosed diabetes (N = 1242)	All participants had diabetes	*Low/medium adherence to medications*: 60.2 Oral meds only: 86.5 Insulin only: 5.7 Both: 7.8	HbA1c ≥ 6.5%: 54.2	NR	NR
Viana, 2013 [179]	2006–2011	Brazil	5750 patients with type 2 diabetes from 14 centers in five regions of Brazil, including primary care units and outpatient clinics of	All patients had type 2 diabetes	On treatment: 99.0 Oral meds: 57.0 Insulin only: 13.0 Both: 22.0 Diet 6.0	HbA1c < 7%: 26.0 -Those who performed more SBGM had lower A1c “non-white” had HbA1c	NR	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)	
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)		< 100 mg/dL (%) LDL-C < 100 mg/dL (%)
Baptista, 2015 [180]	2012–2013	Brazil	university hospitals Public outpatient clinic at a university hospital in Curitiba, Parana. Adults ≥ 18 years, and elderly adults ≥60 years with type 1 or type 2 diabetes: 1031 records: 299 type 1 (55.2% women) and 732 type 2 (68% women). All patients received care from the National Brazilian Health Care System and at the same endocrine clinic.	All patients had either type 1 or type 2 diabetes	Type 2 diabetes Oral meds and/or oral meds/insulin: 47.1 Diet alone: 2.1 Type 1 diabetes Insulin/oral meds: 12.1	HbA1c < 7%: 9.5	NR	NR	NR
Ministério da Saúde do Brasil, 2019 [80]	2018	Brazil	VIGITEL BRASIL 2018 study described in Table 1	All self-reported	On meds: 88.7 (89.7 men, 88.0 women)	NR	NR	NR	NR
Ministério da Saúde do Brasil, 2020 [81]	2019	Brazil	VIGITEL BRASIL 2019 study described in Table 1	All self-reported	On meds: 89.3 (90.8 women, 87.4 men)	NR	NR	NR	NR
Ministerio de Salud de Chile, 2010 [85]	2009–2010	Chile	Encuesta Nacional de Salud, ENS Chile 2009–2010 study described in Table 1.	Total aware: 78.49 (women 84.07, men 71.32)	All: 52.05 (women 53.08, men 50.7)	HbA1c < 7%: 34.32 of all with diabetes (women 38.52, men 29.33) (44% of those on pharmacological treatment had HbA1c < 7%)	NR	NR	NR
Ministerio de Salud de Chile, 2017 [86]	2016–2017	Chile	Encuesta Nacional de Salud, ENS Chile 2016–2017 study described in Table 1	NR	NR	58.2	NR	NR	NR
Ministerio de Salud y Protección Social de Colombia [87]	2007	Colombia	National survey “Encuesta Nacional de Salud (ENS) 2007” (study described in Table 1)	NR	50.7	NR	NR	NR	NR
Alba, 2009 [181]	2008	Colombia	Cross-sectional study of a type 2 diabetes patient population attending a clinic associated with a university hospital in Bogotá	All participants had diabetes	On insulin: 54.0	HbA1c < 7%: 49.0	47.0	52.6	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Machado-Alba, 2009 [182]	2006–2007	Colombia	N = 150 Retrospective study, N = 19,704 patients treated by the national social security health system	All patients had type 2 diabetes	45.8	HbA1c < 7%: 42.9	NR	NR
Ministerio de Salud Pública y Bienestar Social de Paraguay, 2012 [96]	2010–2011	Paraguay (Primera Encuesta Nacional de Factores de Riesgo de Enfermedades No Transmisibles en Población General)	Age > 30 years First National Health Survey Probabilistic, three-stage sampling Study described in Table 1.	All self-reported	During the last 2 weeks: On oral meds only: 53.7 On insulin only: 5.3 On insulin or oral meds: 54.8	NR	NR	NR
Ministerio de Salud de Perú, 2006 [98]	2005	Peru	National Survey 2005 (study described in Table 1)	Aware: Close to 50.0	65.4	NR	NR	NR
Seelen, 2015 [101]	2010–2012	Peru	PERUDIAB Study described in Table 1	Aware: 60.0	NR	NR	NR	NR
Minderhoud, 2015 [104]	2013–2014	Republic of Suriname	The Rapid Assessment of Avoidable Blindness (RAAB) survey method (Study described in Table 1.)	Aware: 89.6	Oral meds only: 77.3 Insulin: 15.6 No medical treatment: 6.9	58.5% were considered well-controlled (based on random blood sugar ≥ 200 mg/dL)	NR	NR
Krishnadath, 2016 [103]	2013	Suriname	Secondary data analysis from the Suriname Health Study Stratified multistage cluster sample of households	Aware: 60.0	NR	NR	NR	NR
Fort, 2012 [183]	2008–2011	Uruguay	CVRP assessment of national health insurance card applicants Cross-sectional, electronic records	Awareness: 50.3 (men: 39.3, women: 64.3)	NR	All: 14.4 (men: 6.0, women: 25.2)	NR	NR
Multinational studies Gagliardino, 2001 [184]	1999–	Argentina Brazil Chile Colombia Paraguay Uruguay	Analysis of 13,513 records from the diabetes network QUALIDIAB	All participants had diabetes.	Type 2: Oral meds monotherapy: 42.0 Combination oral meds: 14.0 Insulin only: 14.0	HbA1c < 8.0%: 33.0	BP < 140/90 mmHg: 38.0	NR
Barceló A, 2012 [111]	2003–2006	Belize, Costa Rica El Salvador		Overall Undiagnosed: 40.0	NR	NR	NR	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Salas, 2016 [112]	2003–2009	Guatemala	Central America Diabetes Initiative (CAMDI) (study described in Table 1)	Belize: 41.1				
		Honduras Nicaragua		Honduras: 53.7 Costa Rica: 28.4 Nicaragua: 45.9 Guatemala: 39.7				
Silva, 2010 [185]	2003–2005	Cuba	Sub-analysis of data from the 10/66 Dementia Research Group	Undiagnosed Cuba: 31.1 (men > women) Dominican Rep: 24.3 (women > men) Urban Peru: 41.3 (men > women)	On pharmacological treatment: Cuba: 62.0 Dominican Rep: 70.0 Urban Peru: 60.0	Among those with self-reported diabetes, with FG < 7 mmol/L Cuba: 61.4	NR	NR
		Dominican Republic Puerto Rico Venezuela Peru Mexico	Population-based studies in 13 catchment areas in six Latin American countries (study described in Table 1)	Venezuela: 30.2 (men > women) Urban Mexico: 85.0 (no sex difference) Rural Mexico: 25 (men > women) Puerto Rico: 37.7 (men > women)	Venezuela: 65.0 Urban Mexico: 85.0 Rural Mexico: 90.0 Puerto Rico with the largest proportion of insulin 40.0	Republic: 61.1 Urban Peru: 37.2 Venezuela: 56.9 Urban Mexico: 45.7 Rural Mexico: 40.0 Puerto Rico: 34.6	NR	NR
Commentatore, 2013 [186]	NR	Argentina Colombia Ecuador Mexico Uruguay Venezuela	Sub-analysis from Cardiovascular Risk Factor Multiple Evaluation in Latin America study CARMELA (study described in Table 1)	Awareness: 78.0 Highest in Bogota (87.5) and lowest in Lima (61.7)	Not on treatment: 67.0 Adherence 63% among those on treatment	Based on fasting plasma glucose ≥ 126 mg/dL: 16.0	NR	NR
		Argentina Colombia Peru	Analysis of subsample from the Registry of medical data from patients with diabetes (QUALIDIAB). Six specialized diabetes centers in 3 countries N = 1118	All patients had diabetes	Oral meds only: 56.0 Insulin only: 13.0 Both: 26.0 Diet: 5.0	HbA1c < 7% Oral meds only: 54.0 Insulin only: 32.0 Both: 27.0	44%	NR
López Stewart, 2007 [187]	October 2004	Argentina Brazil Chile Costa Rica Ecuador Guatemala Mexico Peru Venezuela	Country data combined Multicenter, cross-sectional study, epidemiological study N = 3592 patients with type 2 diabetes Interviews with physicians	All patients had diabetes	NR	HbA1c < 7%: 43.2 HbA1c < 6.5%: 30.0 Costa Rica, Argentina, and Chile had the largest % of	NR	NR

Table 2 (continued)

Author (reference)	Study period	Place	Type of Study and participant characteristics	Diabetes awareness (%)	Diabetes treatment (%)	Glycemic, blood pressure, and LDL-C goals		Attainment of three goals (%)
						Glycemic (%)	Blood pressure < 130/80 mmHg (%)	
Duarte, 2019 [188]	February 2006- June 2007	Brazil and Venezuela	Some country data combined Cross-sectional study based on nationwide survey on prevalence of glycemic control, 20 centers in Brazil and 32 in Venezuela Charts from consecutive patients attending the clinic during a 30-day period N = 5692 in Brazil, and N = 3726 in Venezuela Age ≥ 18 years	All patients had diabetes	NR	HbA1c < 7% HbA1c ≥ 7.0%: (74.0 women and 73.0 men) Brazil: men: 72.0 women: 74.0 Venezuela: men: 75.0 women: 75.0 Higher education was associated with lower HbA1c. Private health insurance was associated with lower HbA1c.	NR	NR
Irazola, 2017 [189]	2010-2011	Argentina Chile Uruguay	Centro de Excelencia en Salud Cardiovascular para el Cono Sur I (CESCAS I) (study described in Table 1)	Aware: 79.8 Marcos Paz 64.5, Bariloche 78.9, Temuco 81, Barros Blancos 85.2, Awareness slightly increased with educational attainment Awareness and control higher in women	Treatment at the time of the home interview: 58.8 overall Marcos Paz 77.6 Bariloche 69.3 Temuco 78.9 Barros Blancos 60.9	Control defined as on pharmacologic treatment and FPG < 126 mg/dL L: Controlled, all: 46.2 Marcos Paz 36.9 Bariloche 45.8 Temuco 51.6 Barros Blancos 50.3	NR	NR

(Table 2). The percent achieving optimal glycemic, blood pressure, and LDL-C levels altogether was reported by a handful of studies and up to 9.9% (Table 2).

The findings described above denote critical aspects of the state of diabetes care in Latin America. The achievement of glycemic goals reported by the studies included in our review is similar to previously published studies [164, 179, 180, 187, 210]. This implies seriously chronic and inadequate glycemic control at the population level across the region.

The inclusion of questions on treatment for glycemic control, medical, and self-care in some national surveys increases our understanding of health-seeking behaviors, both patients' and clinicians' adherence to recommended guidelines of care, and challenges related to the utilization of health care services and availability of medications. The smaller number of studies reporting on the attainment of blood pressure and LDL-C goals and the proportion of patients achieving those goals also poses questions about the prevention of macrovascular complications in persons with diabetes in Latin America, considering the raising prevalence of CVD in the region [16, 211]. Of note, most national surveys report prevalence and treatment and/or control of diabetes, hypertension, and blood cholesterol and the prevalence of tobacco use individually. Since diabetes involves multiple organs and deserves a holistic care approach, reporting on the co-existence of other CV risk factors with diabetes would enhance critical understanding of CV risk and health care needs. Also, some surveys collected biospecimens, but the test results were not included in the reports. It is possible that they are analyzed and published later. Yet including test results in the surveys would offer a more comprehensive picture of the status of diabetes prevention and care needs [180, 212, 213] to plan interventions accordingly.

Following Guidelines of Care for the Prevention of Microvascular Disease

Various studies included in our review reported on participants' receiving or following ADA/ALAD-recommended guidelines of care [25] for early detection and prevention of microvascular disease—annual fundoscopic exam, examination for peripheral neuropathy and comprehensive foot examination, annual function/urine albumin excretion testing, and HbA1c tested at least 3 times per years [38–40, 72, 96, 159, 160, 165, 166, 168, 169, 171, 172, 175, 176, 180, 182, 186, 214] (Table 3). Some studies assessed the completion of several guidelines, whereas most studies focused on a few. The completion of the selected ADA guidelines varied, ranging from 14.7 to 97.5% for the foot exam, from 8.6 to 92% for the fundoscopic exam, and from 1.1 to 51.1% for the urine albumin excretion test. Most studies (especially national surveys) inquired about having HbA1c checked within the previous 12 months. The affirmative response ranged from 3.7 to

90.0%. In addition to inquiring about HbA1c testing, some surveys asked whether the participant's blood glucose had been tested (by a health care professional). Having private health insurance was associated with a greater number of affirmative responses to the latter [70, 71, 91].

Despite the smaller number of studies evaluating the completion of the ADA guidelines for foot care and prevention of microvascular disease, and the varied guideline completion rates previously described (Table 3), the prevalence of long-term microvascular complications associated with diabetes has been documented across LatAm. For instance, in the studies included on our review and others published during the same time frame, the rate of foot ulcers ranged from 1.2 to 14.8% [40, 214–216], and non-traumatic lower extremity amputations attributable to diabetes ranges from 1.2 to 7.3% [40, 184, 214, 215, 217–221], and the prevalence of diabetic retinopathy ranged from 11.2 to 48% [40, 184, 214, 222, 223]. CKD has become a major public health concern across Central America [224–226], and the increasing prevalence of diabetes could exacerbate the incidence of CKD—and eventually end-stage renal disease and its associated health complications—in the region [227–229].

Innovative Solutions: Emerging Research and Alternative Models of Care

The findings described above underline not just the urgent need to prevent diabetes but also to prevent complications among those with established disease, and the potentially underestimated burden on patients, societies, and health care systems across LatAm. In this regard, several innovative models of health care for patients with diabetes have been proposed and tested throughout LatAm. Combining care of diabetes and other chronic conditions would be expected to maximize time and resources and improve health outcome. Although combining diabetes and chronic pulmonary disease care did not demonstrate a difference in outcomes [230], this model could be revisited. Also, interventions at the health care system element of the chronic care model might need to be adapted to the local health care system [231] or synchronized with interventions at other levels. Improvement of health care system structure and processes [232] would assure timely access to patient information and enhance clinician decision-making. Integrating social determinants of health into diabetes care demonstrated objective improvements in patient knowledge and cardiometabolic parameters [233]. Enhancing medical continuing education [234], an intervention combining diabetes prevention and self-management [235], co-creating interventions with community stakeholders and other countries [141, 144] are other examples of alternatives to improve diabetes care throughout the region. Another major regional example of efforts to implement better care for patients with

Table 3 Completion of selected ADA-recommended guidelines of care across Latin America on reports published from 2005 to 2020

Study (reference)	Study period	Place	Study type	A1c checked as recommended (ADA guidelines) (%)	Foot exam at least once a year (%)	Annual fundoscopic Exam (%)	Urinary albumin and renal function test at least once a year (%)
Mexico							
López-López, 2012 [159]	2000 and 2006	Mexico, State of Hidalgo	Based on the 2000 and 2006 National Survey (ENSANUT) data subsamples for the state of Hidalgo. (study described in Table 2.)	35.6	97.5	92.0	1.1
Flores-Hernández, 2015 [160]	2006 and 2012	Mexico (National Survey)	Analysis based on two cycles of ENSANUT (Study described in Table 2.)	2006: 3.7 2012: 7.7	2006: 9.4 2012: 14.7	2006: 12.3 2012: 8.6	2006: 6.6 2012: 12.6
Secretaría de Salud de México, Instituto Nacional de Salud Pública (INSP), 2016 [40]	2016	Mexico	National Health and Nutrition Survey (ENSANUT-MC 2016) (Study described in Table 1.)	15.2 within the last 12 months	20.9 within the last 12 months	13.1 within last 12 months	4.7 within the last 12 months
Central America							
Gough, 2009 [165]	2006	Belize	CAMDI– Belize Study described in Tables 1 and 2.	1.7% reported having it checked	NR	NR	NR
Dekker, 2017 [166]	2014–2015	Belize	Study described in Table 2.	NR	41.0	41.0	39% serum creatinine 28% urinalysis
Orellana-Pontaza, 2007 [169]	2006	Guatemala	CAMDI – Villa Nueva, Guatemala Study described in Tables 1 and 2.	7.6	27.1	30.0	NR
Organización Panamericana de la Salud [168]	2004	Tegucigalpa, Honduras	CADMI – Honduras Study described in Tables 1 and 2.	NR	NR	NR	NR
Caribbean							
Dehtlefs, 2019 [171]	2010–2012	Dominican Republic	Study described in Table 2.	50.0	20.0	NR	NR
Pérez, 2012 [172]	2005–2007	Puerto Rico	136 adults who self-reported DM in Puerto Rico	52.3	43.8	49.2	NR
South America							
Ministerio de Salud de Argentina, 2019 [72]	2018	Argentina	Fourth National Survey- Study described in Table 2.	NR	30.0	40.0	NR
Santero, 2018 [175]	–	Argentina	Quasi-experimental study (Study described in Table 2.)	16.9	69.1	29.0	NR
Gomes, 2006 [176]	2000–2001	Brazil	Study described in Table 2.	84.3	58.2	46.9	38.9
Baptista, 2015 [180]	2012–2013	Brazil	Public outpatient clinic at a university hospital in Curitiba, Paraná. (Study described in Table 2.)	NR	59.9	43.2	NR
Ministerio de Salud de Chile, 2010 [85]	2009–2010	Chile (Encuesta Nacional de Salud, ENS Chile 2009–2010)	Study described in Table 1.	NR	6.7 in the last year	34.8 (7.6 with retinopathy)	NR
Machado-Alba, 2009 [182]	2006–2007	Colombia	Study described in Table 2.	NR	55.5	35.6	57.0
Ministerio de Salud Pública y Bienestar Social de Paraguay, 2012 [96]	2010–2011	Paraguay	Study described in Table 1.	NR	17% had their feet checked within the last year; 78.3% had not ever had their feet examined.	31.5% had an exam within the last 2 years, and 55.8% had not ever had an eye exam	51.1% within the last 2 years, and 36.2% had not ever had a 24-hr urine test done.
Multinational studies							
Commentatore, 2013 [186]	–	Argentina Colombia Peru	Analysis based on QUALIDIAB Registry. Study described in Table 2.	90.0	60.0	62.0	NR

NR, not reported; HbA1c, hemoglobin A1c

diabetes has been led by the Latin American Diabetes Association (ALAD in Spanish) to engage 17 medical associations and wrote a consensus statement on the treatment of type 2 diabetes in LatAm [207].

Kaselitz et al. published a scoping review of policies and interventions for diabetes in LatAm [147], telehealth, mobile clinics, and other non-traditional health care delivery models. In addition, a non-exhaustive list of examples of past or current interventions, policies, and initiatives is provided in Table 4 [184, 186, 234, 236–252]. Interventions in the list include tele-ophthalmology [249, 250, 253, 254], team-based foot self-care education [236], diabetic retinopathy education and screening at a community pharmacy [255], rapid assessment/diagnostic tools to screen for or detect retinopathy, nephropathy, and risk of developing foot ulcers [201, 256–262] and are examples of clinical research and/or implementation activities designed to strengthen the prevention and early detection of diabetes-associated complications and improve health outcomes throughout LatAm.

Many interventions on diabetes care have focused on patients and/or clinicians as the primary recipients or enablers of the interventions. Because of the complex nature of the disease and the multiple factors that mediate treatment effectiveness, interventions involving other levels or elements within the health care organization or system [155, 157, 232, 263–265] or the health care workforce [158, 263, 266] could be considered. Interventions involving other sectors (e.g., housing, infrastructure, national or local policies) could uncover very valuable and needed strategies to enhance treatment effectiveness and potentially reduce health care costs in the long-term. The feasibility and sustainability of such research efforts—and subsequent policies—would need to be demonstrated and supported locally [143].

Additional Observations

Women

Multiple studies in our review reported a higher prevalence of diabetes among women [36, 38, 40, 42, 44, 47, 49–52, 57, 60, 62, 63, 65, 70, 72, 75, 78, 79, 83–86, 90, 95, 96, 110, 113]. While the mediating factors for this sex difference need further study (e.g., history of GDM, which was outside of the scope of this review), the increased prevalence of diabetes among women in some LatAm countries would be expected to have implications for health and health care, and potentially future generations [267–269]. Since diabetes may increase women's risk for CVD, including stroke [270], cognitive decline [271, 272], or some cancers [273, 274], timely and comprehensive preventive care for women of all ages would need to be prioritized.

Older Adults

Due to the epidemiologic transition already experienced by some countries throughout LatAm, the population pyramid is also shifting towards a greater proportion of older adults. Studies included in our review consistently reported an increased prevalence of diabetes with age. Diabetes care challenges specific to this age group include risk of obesity or undernutrition [42, 56], increased risk for disability [57], economic barriers to appropriate access to health care [42], disruption in funding of health insurance [275], disparate completion of diabetes care guidelines based on health insurance coverage [276], inequalities in access to and utilization of health care services [277–279], complex medical care needs and frailty [280], cultural beliefs, mental health, and lack of family or social support [281], among others. Prevention of diabetes and its complications and reliable continuity of care and social support [282] need to be especially tailored for this population across the region.

Indigenous and Other Ethnic Underserved Populations

A few studies in our review reported a low prevalence of diabetes among some indigenous populations in LatAm [55, 74, 82], in parallel to some previous reports [283–286] about other indigenous groups in the region and in contrast with the higher prevalence of diabetes among American Indians in the USA [287] and the First Nations in Canada [288]. However, other studies in our review and in the current literature have documented elevated diabetes prevalence or risk among indigenous and other socioeconomically disadvantaged ethnic groups [48, 50, 73, 76, 77, 83, 90, 91, 166, 289–293]. Some of the diabetes prevalence studies included in our review focused on or mentioned participants from indigenous groups [35, 48, 50, 74, 83] and other underrepresented groups (e.g., Garifuna, Afro-Panamanian, Afro-Peruvian, Afro-Ecuadorian) [55, 76, 90, 91, 166]. However, a few studies have evaluated diabetes care, prevalence, and/or prevention of macro- or microvascular complications, diabetes management interventions, other health care needs and access to health care among indigenous populations [241, 244, 246, 294–302], and none on the other groups (that we could identify through our search). Understanding the protective mechanisms (e.g., biochemical, immune, epigenetic) against diabetes experienced by some indigenous populations would be relevant to millions at high risk of developing diabetes. At the same time, the increased prevalence of the metabolic syndrome and diabetes experienced by some indigenous groups and other ethnic groups may increase their risk not only for CVD and other diabetes long-term complications but also for re-emerging

Table 4 examples of past and ongoing diabetes care interventions initiated in Latin America from 2000 to 2020

Author [reference]	Year of Study	Place	Key findings
Batista, 2010 [236]	2000–2010	São Paulo, Brazil	A multidisciplinary health care team was established aiming at increasing limb salvage
Barceló, 2010 [237]	2002–2004	Mexico	The VIDA project - RCT to test improvement of quality of diabetes care in primary health care centers using the chronic care model and the breakthrough series collaborative methodology. The proportion of patients attending the clinics under the intervention with HbA1c <7% increased from 28% to 39%, and the proportion of patients who achieved 3 or more quality improvement goals increased from 16.6% to 69.7%.
Lerario, 2010 [238]	2009	Brazil	The Brazilian Diabetes Society developed a new algorithm for the treatment of type 2 diabetes
Piette, 2013 [239]	2009–2011	Mexico, Honduras	Interactive Voice Response (IVR) support calls for chronic disease management for Spanish speakers- The investigators report cumulative findings in Honduras, Mexico, and Spanish-speakers in the U.S. Involvement of caregivers enhanced engagement. By self-report, there was improved medication adherence and self-management was similar across sites.
Piette, 2011 [240]	2010	Honduras	Cloud-Computing Model - The investigators tested a mobile phone-based intervention of weekly VoIP calls and IVR with patients with diabetes and automated emails to clinicians and voicemail reports to family caregivers for six weeks. Improved self-care and diabetes management and significant improvement in glycemic control were reported.
Piette, 2016 [241]	2013	Bolivia	Structured caregiver feedback – The investigators assessed whether automated telephone feedback to caregivers (“CarePartners”) increased engagement in mobile-health support among patients with diabetes and hypertension in Bolivia. Significantly greater engagement was observed. Patients who spoke indigenous languages at home were more than 3X as likely to complete the IVR calls.
Piette, 2014 [242]	2013	Bolivia	Mobile health program for chronic disease self-management in Bolivia – Assessment and implementation of IVR for 12 weeks. It was associated with improved medication adherence, self-reported health status, and satisfaction.
Prestes, 2017 [243]	2016–2017	Argentina	DIAPREM – integrated diabetes care program including systemic changes education, registry and disease management
Flood, 2016 [244]	2010	Guatemala	Implementation and outcomes of a comprehensive type 2 diabetes program in rural Guatemala through a non-government organization and involving nurse-directed care
Flood, 2017 [245]	2012	Rural Guatemala	Implementation of a multi-level quality improvement program for ambulatory diabetes care based on input from patients and other stakeholders
Flood, 2017 [246]	2014–2016	Rural Guatemala	Home-based type 2 diabetes self-management – intervention delivered by diabetes educator at home and synchronized with clinic follow-up. Mayan communities
Tapia-Conyer, 2016 [247] Gallardo-Rincón, 2017 [234]	2012 to present	Mexico	CASALUD Model –is a comprehensive primary health care model implemented in Mexico that enables proactive prevention and disease management using innovative technologies and a patient-centered approach. The program was pilot tested in 2009 and implemented nationwide in 2012.

Table 4 (continued)

Author [reference]	Year of Study	Place	Key findings
Salamanca, 2018 [248]	2014–2017	Peru	Implementation of a diabetic retinopathy referral and treatment network via collaboration and co-funding from a non-governmental organization.
Avendaño-Veloso, 2019 [249]	2014–2015	Chile	A non-experimental teleophthalmology program in the public health system to increase the reach of patients at risk of having diabetic retinopathy. The program allowed the evaluation of more than a quarter of the patients with diabetes.
Flores, 2019 [250]	2016	Chile	Implementation of a telemedicine model management network for diabetic retinopathy at a primary care level.
Cani, 2015 [251]	Not mentioned	Brazil	RCT to an intervention individualized pharmacotherapeutic care and diabetes education by a pharmacist. At 6 months the HbA1c improved and quality of life
Gagliardino, 2013 [252] Gagliardino, 2001 [184] Commendatore, 2013 [186]	2007–2009	Argentina Argentina and other countries	PRODIACOR prospective intervention of diabetes education in primary care settings in the city of Corrientes QUALIDIAB Network—Registry of type 2 diabetes patients to measure the quality of care

infectious diseases, like tuberculosis [303–305]. Therefore, disease prevention and health care models that account and reach these populations need to be considered.

Conclusion

Through this review, we have highlighted the most current reports on prevalence, awareness, treatment, control, and adherence to recommended guidelines of care for diabetes mellitus across LatAm published from 2000 to 2020. During that time frame, a considerable number of surveys assessing the prevalence of the disease and an increasing body of reports on the achievement of treatment and care goals were identified. Such reports demonstrate the imperative need to garner a more comprehensive understanding of the extent of diabetes across countries, and both past and ongoing efforts to establish effective and sustainable models of prevention and high-quality care able to reach and serve all peoples across the region.

During the writing of this manuscript, Latin America had been recognized as the new epicenter of the SARS-CoV-2 (COVID-19) pandemic [306]. The effects of the disease in persons with diabetes in the region are beginning to be uncovered [307–309], while some solutions are proposed [310, 311]. The magnitude of the impact of the pandemic on the health and health care needs of persons with diabetes mellitus and other NCDs—let alone on the health care systems infrastructures—in the region are yet to be known. The task ahead is substantial and will require multidisciplinary and

cross-sectoral strategies and collaborations to reduce diabetes burden and improve health outcomes across Latin America.

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Data Availability NA

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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Code Availability NA

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