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**ORIGINAL ARTICLE /** *ARTIGO ORIGINAL*

# Prevalence of diabetes mellitus as determined by glycated hemoglobin in the Brazilian adult population, National Health Survey

## *Prevalência de diabetes mellitus determinada pela hemoglobina glicada na população adulta brasileira, Pesquisa Nacional de Saúde*

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**ABSTRACT:** ***Objective:*** To analyze the prevalence of diabetes mellitus (DM) according to different diagnostic criteria, in the Brazilian adult population, according to laboratory results from the Brazilian National Health Survey. ***Methods:*** Analysis of laboratory data from the National Health Survey, collected between 2014 and 2015. The prevalence of diabetes was calculated according to different diagnostic criteria. The prevalence of diabetes was calculated according to the criterion of glycosylated hemoglobin ≥ 6.5% or using medication, using Poisson regression and calculating crude and adjusted PR and 95%CI. ***Results:*** The prevalence of diabetes according to different criteria varies from 6.6 to 9.4%. Intermediate or pre-diabetes hyperglycemia ranged from 6.8 to 16.9%. Considering laboratory criteria or medication use, the prevalence of DM was 8.4 (95%CI 7.65-9.11). The adjusted PR for gender, age, educational level and region was lower for males (PR 0.75; 95%CI 0.63 – 0.89), increased with age: 30 to 34 years (PR 2.32; 95% CI 1.33 – 4.07), 40 to 59 years PR 8.1; 95%CI 4.86 – 13.46), 60 years old or older (PR 12.6; 95%CI 7.1 – 21.0), and higher educational levels was protective (PR 0.8; 95%CI 0.6 – 0.9). There was a higher PR in the Central West Region (PR 1.3; 95%CI 1.04 – 1.7), in overweight people (PR 1.8; 95%CI 1.4 – 2.1), and in obese people (PR 3.3; 95%CI 2.6 – 4.1). ***Conclusion:*** The prevalence of diabetes was higher in females, people over 30 years of age, in populations with low educational levels, and people who were overweight and obese. The study advances in determining the diabetes situation in the country through laboratory criteria.

***Keywords:*** Diabetes mellitus. Prediabetic state. Glycated hemoglobin A. Clinical laboratory techniques. Noncommunicable diseases. Obesity.

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*in memoriam.

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**RESUMO:** ***Objetivo:*** Analisar as prevalências de diabetes *mellitus* segundo diferentes critérios diagnósticos, na população adulta brasileira, segundo os resultados laboratoriais da Pesquisa Nacional de Saúde. ***Métodos:*** Análise dos dados laboratoriais da Pesquisa Nacional de Saúde, coletados entre os anos de 2014 e 2015. Foram calculadas as prevalências de diabetes conforme diferentes critérios diagnósticos. Foram calculadas as prevalências de diabetes segundo o critério de hemoglobina glicosilada ≥ 6,5% ou em uso de medicamentos, empregando regressão de Poisson para o cálculo da razão de prevalência (RP) bruta e ajustada e intervalo de confiança de 95% (IC95%). ***Resultados:*** A prevalência de diabetes segundo diferentes critérios pode variar 6,6 a 9,4%; e a hiperglicemia intermediária, ou pré-diabetes, de 6,8 a 16,9%. Usando-se o critério laboratorial ou uso de medicamentos, a prevalência de diabetes foi de 8,4%. A RP ajustada para sexo, idade, escolaridade e região foi menor no sexo masculino (RP = 0,75; IC95% 0,63 – 0,89); aumentou com a idade: 30 a 34 anos (RP = 2,32; IC95% 1,33 – 4,07), 40 a 59 anos (RP = 8,1; IC95% 4,86 – 13,46), 60 anos ou mais (RP = 12,6; IC95% 7,1 – 21,0); e a escolaridade elevada foi protetora (RP = 0,8; IC95% 0,6 – 0,9). Maior RP foi encontrada na Região Centro-Oeste (RP = 1,3; IC95% 1,04 – 1,7) e naqueles com sobrepeso (RP = 1,8; IC95% 1,4 – 2,1) e obesidade (RP = 3,3; IC95% 2,6 – 4,1). ***Conclusão:*** A prevalência de diabetes foi maior no sexo feminino, naqueles com idade maior que 30 anos, em população com baixa escolaridade, com excesso de peso e obesidade. Os critérios laboratoriais são mais fidedignos para o conhecimento da situação real do diabetes no país.

***Palavras-chave:*** Diabetes mellitus. Estado pré-diabético. Hemoglobina A glicada. Técnicas de laboratório clínico. Doenças crônicas não transmissíveis. Obesidade.

## INTRODUCTION

Diabetes mellitus (DM) is characterized by a heterogeneous group of metabolic disorders resulting from hyperglycemia caused by defects in insulin action, insulin secretion, or both[1]. It is one of four chronic non-communicable diseases (NCDs) identified as a priority for intervention by the World Health Organization (WHO) and the Strategic Action Plan for Tackling NCDs, 2011-2022[2].

The world population with DM is estimated at 387 million people, and of these, about 80% live in low- and middle-income countries, with a growing proportion of people with DM in younger age groups[3]. Mortality from DM was estimated at 1.5 million in 2012[3]. According to the National Health Survey (*Pesquisa Nacional de Saúde* - PNS) in 2013, the prevalence of self-reported DM for the Brazilian population 18 years of age and over was 6.2%, with 7% in women and 5.4% in men[4].

DM can affect quality of life, with an estimated 89 million disability-adjusted life years (DALYS) lost worldwide[5]. Among the complications of DM are macrovascular (ischemic heart disease, stroke and peripheral arterial disease) and microvascular (retinopathy, nephropathy and neuropathy) diseases[6]. Because of its numerous comorbidities, complications, and disabilities, DM affects the social and professional lives of affected individuals and entails direct and indirect costs to patients, health systems, and society[7].

Glycated hemoglobin (HbA1c)[8] was proposed for the diagnosis of DM in 2009. It is a fraction of the hemoglobin (Hb) produced in the presence of hyperglycemia and, thus, the higher the rates of free blood glucose, the higher the proportion of HbA1c[9]. The HbA1c test has the advantage of estimating the average blood glucose concentration from the past 60 to 90 days, unlike the fasting glucose or glucose tolerance test, which only takes measurements at specific times[9].

Population studies based on self-report of diabetes have been conducted in the United States[10], Brazil[11,12] and in many other countries. They are used because of their ease, low cost and fast collection[9]. However, self-reporting may result in reduced estimates due to portions of previously undiagnosed cases. As such, laboratory tests are recommended[9]. With this in mind, HbA1c is especially efficient as it does not require fasting or glucose challenge testing[9].

As a result, between 2014 and 2015, the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE) and the Ministry of Health added HbA1c as part of the PNS' laboratory component in order to capture more reliable estimates of the Brazilian population's health and disease situation. Thus, the aim of this study was to analyze the prevalence of DM according to different diagnostic criteria in the Brazilian adult population, according to laboratory results from the PNS.

## METHODS

The present study was a descriptive, epidemiological survey, and used data from PNS laboratory exams from 2014 to 2015. The PNS is a nationwide household-based, cross-sectional survey that uses three-stage probabilistic samples. The primary sampling units were the census tracts or set of tracts. The secondary units were households, and the tertiary units were the adult residents, aged 18 years or older present in the household. Details on the sampling and weighting processes are provided in the PNS publications on the results[13,14].

In the PNS sample, 81,254 households were selected, of which 69,994 were occupied households. The survey was conducted in 64,348 households and 60,202 adult individuals, selected in each household with equal probability, were interviewed. Given that 25% of the census tracts were selected for laboratory testing and assuming a non-response rate of 20%, the expected number of individuals with laboratory data was 12,000 individuals, approximately[13,14]. To facilitate the logistics of biological material collection, census tracts were selected based on a probability that was inversely proportional to the difficulty of collection. The selection of the subsample was made with a probability proportional to the inverse distance from the municipality where the primary sampling unit was located and the nearest municipality with 80,000 inhabitants or more, in all of the federal units[14]. Several factors decreased the number of individuals indicated for the laboratory tests, such as the hired laboratory having difficulty locating the address, and the selected resident refusing to perform the biological material collection. Thus, the sample consisted of 8,952 people. Post-stratification weights were estimated

according to gender, age, educational level, race/color and geographical macro-region, based on data from residents selected for individual interviews in the initial phase of the PNS.

The PNS was approved by the National Research Ethics Commission (*Comissão Nacional de Ética em Pesquisa* - CONEP) of the National Health Council (*Conselho Nacional de Saúde* - CNS), of the Ministry of Health. Participation in the research was voluntary and information was guaranteed to remain confidential. The research participants signed an Informed Consent Form and authorized the collection of laboratory tests.

HbA1c was collected in a tube with ethylenediamine tetra-acetic acid (EDTA) and dosed by high pressure liquid chromatography (HPLC) in a laboratory certified by the National Glycohemoglobin Standardization Program. Peripheral blood collection was performed at any time of the day. No fasting was required.

The WHO[9] and the American Diabetes Association (ADA)[15] recommend a value of HbA1c ≥ 6.5% for the diagnosis of DM. There are still divergences as to the cutoffs adopted for intermediate hyperglycemia: according to the ADA, the criterion is HbA1c between 5.7 and 6.4%[15], according to the International Expert Committee (IEC),[8] even though the evidence is still not solid, higher values of 6 to 6.4% indicate a higher risk[9]. The study also included other cutoff points that refer to the categorization of glycemic control levels in DM[15] (ie. 6.5 to 6.9%; 7 to 7.4%; 7.5 to 7.9; 8 to 8.9%; and ≥ 9%). These monitoring points are justified by the following criteria: 6.5 to 6.9% (<7% is the control level recommended as "reasonable" by the ADA)[15], 7 to 7.4% and 7.5 to 7.9% (<8% is ADA's less strict control alternative)[15], 8 to 8.9%, and ≥ 9 (≥ 9% uniformly recognized as indicating the need for better control)[16].

For the analyzes, a comparison of different diagnostic criteria of DM was initially considered: just laboratory (HbA1c ≥ 6.5%); laboratory or reported medication use (insulin or oral hypoglycemic); laboratory or self-reported having a medical diagnosis of DM; and just self-reported having a medical diagnosis of DM. Subsequently, the prevalence of DM was calculated according to the criteria of having a laboratory diagnosis or being on medication for DM, in the strata of the following sociodemographic characteristics: gender, age, education level, race/color, region and body mass index (BMI). Being <25 kg/m$^2$ was considered to be eutrophic or low weight, being between 25 and 29.9 kg/m$^2$ was considered to be overweight and ≥ 30 kg/m$^2$ was considered to be obese.

Analyzes were performed with Data Analysis and Statistical Software (Stata), version 14. The command survey was used to incorporate the post-stratification weights. The bivariate analysis and prevalence calculations were performed with a 95% confidence interval (95% CI). Prevalence ratios (PR) were calculated using the Poisson regression method with robust crude and adjusted variance for age, gender, education level and region.

## RESULTS

A total of 8,952 exams were collected. Four hundred and eleven were not included in the analysis due to collection problems such as insufficient material, hemolysis, sample loss and others. Thus, there remained a total of 8,541 exams for HbA1c analysis.

According to the categories for HbA1c analysis, the presence of DM according to the HbA1c criterion ≥ 6.5% was detected in 6.6% of the adults. It was distributed as follows: 1.9% with HbA1c between 6.5 and 6, 9%; 1.1% with HbA1c between 7 and 7.4%; 0.8% with HbA1c between 7.5 and 7.9%; 1.0% with HbA1c between 8 and 8.9%; and 1.8% with HbA1c ≥ 9%. Fully 76.5% of the total population had normo-range HbA1c. 16.9% had intermediate hyperglycemia according to the ADA criterion (HbA1c 5.7 to 6.4%)[15] and 6.8% according to the IEC criterion (HbA1c 6 to 6.4%)[8] (Table 1).

Among the 6.6% of the population that was identified by the DM laboratory criterion (HbA1c ≥ 6.5%), the following met the ADA control criteria[15]: 28.8% of the population had values within the rigid control (HbA1c <7%); an additional 28.8% of the population was also within the most flexible level of glycemic control (HbA1c <8%); and 42.4% had HbA1c ≥ 8% (Table 1).

Using different criteria, the prevalence of DM varied from: 6.6% by laboratory criteria; 8.4% by laboratory criteria or medication use; 9.4% for laboratory criteria or self-reporting a previous medical diagnosis of DM; and 7.5% for the medical diagnosis criterion of self-reported DM. Across all of the criteria, the prevalence was highest among women and in individuals over the age of 30, reaching between 14.2 (for laboratory) and 22.6% (for laboratory or self-reported) of those over 60 years of age (Table 2).

Within the criterion of laboratory (HbA1c ≥ 6.5%) or reporting medication use (insulin or oral hypoglycemic), the prevalence of DM was 9.7% in women (95% CI 8.65 - 10.74) and 6.9% in men (95% CI 5.90 - 7.91); higher in those 30 years of age and older, and it reached 20.6% (95% CI 18.22 - 22.96) in those over 60 years of age; and in the Southeast and Midwest population. A total of 8.5% (95% CI 7.3 - 9.8) of overweight people and 16.9% (95% CI 14.7 - 19.0) of obese people had DM (Table 3).

Table 4 shows the crude and adjusted prevalence ratios (PRad) according to age, gender, education level, race/color, region, and BMI. Men had lower PR (PRad = 0.75; 95%

Table 1. Glycated hemoglobin categories according to sociodemographic characteristics (n = 8,541). Brazil, National Health Survey (PNS), 2014–2015.

| Categories HbA1c % | Sample | Male % | Female % | Total % |
|---|---|---|---|---|
| < 5.7 | 6.848 | 78.5 | 74.7 | 76.5 |
| 5.7 to 5.9 | 896 | 9.4 | 10.7 | 10.1 |
| 6 to 6.4 | 566 | 6.5 | 7.1 | 6.8 |
| 6.5 to 6.9 | 175 | 1.3 | 2.4 | 1.9 |
| 7 to 7.4 | 88 | 0.8 | 1.3 | 1.1 |
| 7.5 to 7.9 | 57 | 0.9 | 0.8 | 0.8 |
| 8 to 8.9 | 87 | 1.1 | 1.0 | 1.0 |
| ≥ 9 | 188 | 1.5 | 2.0 | 1.8 |

CI 0.63-0.89). The prevalence increased with age: 30 to 44 years old (PRad = 2.32; 95% CI 1.33 - 4.07), 45 to 59 years old (PRad = 8.1; 95% CI 4.8 - 13.5), 60 years old and older (PRad = 12.7; 95% CI 7.61 - 21.0). The highest educational level was protective (PRad = 0.79; 95% CI 0.64 - 0.97) and prevalence was higher in the Midwest (PRad = 1.34; 95% CI 1.04 - 1.72). The following remained positively associated with DM after the adjustment: being overweight (PRad = 1.78; 95% CI 1.4 - 2.26) and being obese (PRad = 3.3; 95% CI 2.6 - 4.14) were also associated with the presence of diabetes (Table 4).

## DISCUSSION

The study found that 6.6% of adults have glycated hemoglobin ≥ 6.5%; and the proportion of intermediate hyperglycemia, or pre-diabetes, was 6.8% when defined by the criteria of the IEC[8] and 16.9% when defined by the criteria of the ADA[15]. The prevalence of DM was higher when simultaneous criteria were adopted, such as the association of laboratory criteria or drug use, or laboratory or self-reported criteria. In all of the criteria, women had a higher prevalence. Prevalence increased with age, reaching about one fifth of the elderly. Using the criterion of altered glycated hemoglobin or medication use, after adjustments for variables such as gender, age, education level and region, PRs were higher for females, the elderly, those with only an elementary level education, those living in the Center-West, and those overweight or obese.

In Brazil, estimates of DM prevalence are generally self-reported. The Telephone Survey Risk Factors and Protection Surveillance System (*Vigilância de Fatores de Risco e Proteção*

Table 2. Prevalence of diabetes diagnosis *mellitus* according to different criteria. Brazil, National Health Survey (PNS), 2014–2015.

| Variables | Laboratory | | Laboratory or medicine use | | Laboratory or self-reported | | Self-reported | |
|---|---|---|---|---|---|---|---|---|
| | % | 95%CI | % | 95%CI | % | 95%CI | % | 95%CI |
| Total | 6.6 | 5.93 – 7.24 | 8.4 | 7.65 – 9.11 | 9.4 | 8.63 – 10.14 | 7.5 | 6.73 – 8.19 |
| Gender | | | | | | | | |
| Female | 5.59 | 4.68 – 6.51 | 6.90 | 5.90 – 7.91 | 7.80 | 6.74 – 8.86 | 6.39 | 5.29 – 7.49 |
| Male | 7.48 | 6.55 – 8.41 | 9.7 | 8.65 – 10.74 | 10.79 | 9.73 – 11.86 | 8.33 | 7.35 – 9.31 |
| Age range (years) | | | | | | | | |
| 18 to 29 | 1.45 | 0.73 – 2.17 | 1.47 | 0.75 – 2.19 | 2.01 | 1.14 – 2.88 | 1.44 | 0.53 – 2.35 |
| 30 to 44 | 3.19 | 2.26 – 4.13 | 3.48 | 2.53 – 4.43 | 4.00 | 3.02 – 4.99 | 2.43 | 1.60 – 3.26 |
| 45 to 59 | 10.46 | 8.88 – 12.04 | 12.60 | 10.88 – 14.32 | 13.96 | 12.21 – 15.70 | 10.81 | 9.13 – 12.49 |
| 60 or older | 14.24 | 12.21 – 16.26 | 20.59 | 18.22 – 22.96 | 22.66 | 20.25 – 25.07 | 18.22 | 15.95 – 20.50 |

95%CI: 95% confidence interval.

Table 3. Prevalence of diabetes *mellitus* (glycated hemoglobin ≥ 6.5% or medication use), according to sociodemographic characteristics and body mass index. Brazil, National Health Survey (PNS), 2014–2015.

| Variables | % | 95%CI |
|---|---|---|
| Total | 8.4 | 7.6 – 9.1 |
| Gender | | |
| Female | 9.7 | 8.6 – 10.7 |
| Male | 6.9 | 5.9 – 7.9 |
| Age range (years) | | |
| 18 to 29 | 1.47 | 0.75 – 2.19 |
| 30 to 44 | 3.48 | 2.53 – 4.43 |
| 45 to 59 | 12.60 | 10.88 – 14.32 |
| 60 or older | 20.59 | 18.22 – 22.96 |
| Education level | | |
| None | 12.35 | 11.03 – 13.66 |
| Elementary school only | 7.41 | 5.62 – 9.20 |
| Completed high school | 5.33 | 4.39 - 6.27 |
| Race/color | | |
| White | 8.42 | 7.28 – 9.55 |
| Dark skinned black | 10.26 | 7.47 – 13.05 |
| Light skinned black | 7.93 | 6.95 – 8.91 |
| Other | 7.70 | 3.35 – 12.06 |
| Region | | |
| North | 6.29 | 5.25 – 7.33 |
| Northeast | 7.64 | 6.71 – 8.57 |
| Southeast | 9.29 | 7.87 – 10.71 |
| South | 7.43 | 5.87 – 8.98 |
| Center West | 9.39 | 7.55 – 11.24 |
| Body mass index | | |
| Underweight/normal | 4.03 | 3.25 – 4.81 |
| Overweight | 8.54 | 7.32 – 9.77 |
| Obese | 16.86 | 14.68 – 19.03 |

95%CI: 95% confidence interval.

Table 4. Crude and adjusted prevalence of diabetes mellitus (glycated hemoglobin ≥ 6.5% or medicine use), according to sociodemographic characteristics and body mass index. Brazil, National Health Survey (PNS), 2014–2015.

| Variables | $PR_{crude}$ | 95%CI | $PR_{adjusted}$* | 95%CI |
|---|---|---|---|---|
| Gender | | | | |
| Female | 1.00 | | 1.00 | |
| Male | 0.71 | 0.59 – 0.85 | 0.75 | 0.63 – 0.89 |
| Age range (years) | | | | |
| 18 to 29 | 1.00 | | 1.00 | |
| 30 to 44 | 2.36 | 1.35 – 4.13 | 2.32 | 1.33 – 4.07 |
| 45 to 59 | 8.56 | 5.16 – 14.21 | 8.09 | 4.86 – 13.46 |
| 60 or older | 13.99 | 8.47 – 23.10 | 12.65 | 7.61 – 21.00 |
| Education level | | | | |
| None | 1.00 | | 1.00 | |
| Elementary school only | 0.60 | 0.46 – 0.78 | 1.07 | 0.83 – 1.39 |
| Completed high school | 0.43 | 0.35 – 0.53 | 0.79 | 0.64 – 0.97 |
| Race/color | | | | |
| White | 1.00 | | 1.00 | |
| Dark skinned black | 1.22 | 0.90 – 1.65 | 1.21 | 0.89 – 1.65 |
| Light skinned black | 0.94 | 0.78 – 1.13 | 1.09 | 0.89 – 1.32 |
| Other | 0.92 | 0.51 – 1.64 | 0.91 | 0.49 – 1.72 |
| Region | | | | |
| North | 1.00 | | 1.00 | |
| Northeast | 1.21 | 0.99 – 1.49 | 1.05 | 0.86 – 1.28 |
| Southeast | 1.48 | 1.18 – 1.85 | 1.18 | 0.95 – 1.48 |
| South | 1.18 | 0.90 – 1.54 | 0.96 | 0.74 – 1.25 |
| Center West | 1.49 | 1.16 – 1.93 | 1.34 | 1.04 – 1.72 |
| Body mass index | | | | |
| Underweight/normal | 1.00 | | 1.00 | |
| Overweight | 2.12 | 1.67 – 2.69 | 1.78 | 1.41 – 2.26 |
| Obese | 4.18 | 3.32 – 5.27 | 3.30 | 2.63 – 4.14 |

PR: prevalence ratio; * adjusted for age, gender, education level and region; 95%CI: 95% confidence interval.

*para Doenças Crônicas por Inquérito Telefônico* - Vigitel) estimates that there has been a rise in prevalence in the capital cities of Brazil, increasing from 5.5% in 2006 to 7.6% in 2017[17]. The PNS, using the same criterion, identified a prevalence of 6.2% of the Brazilian population in 2013, which would represent a population contingent of about nine million patients with DM[18].

The study also points to the high proportion of hyperglycemia, affecting about one fifth of the elderly. These data demonstrate the importance of controlling hyperglycemia in order to avoid the vascular and systemic effects of DM[1].

The study identified a predominance of DM among women. The literature highlights aspects such as gestational diabetes and hormonal changes in menopause, increasing abdominal adiposity, as justifications for a greater frequency among women[19,20]. However, in several countries such as Australia[21], England[22] and in Brazil, the Longitudinal Adult Health Study (*Estudo Longitudinal de Saúde do Adulto* - ELSA)[23], using laboratory criteria, detected a higher prevalence of DM among men. Therefore, this topic still needs to be further investigated.

As for age, the elderly have a higher prevalence, which may be justified by the physiological changes inherent in the aging process[24,25]. DM in the elderly is related to a higher risk of premature death, a greater association with other comorbidities and major geriatric syndromes, as well as impairments regarding functional capacity, autonomy and quality of life[26]. It is important to highlight that DM, as well as the metabolic syndrome, which is associated with cardiovascular diseases in adulthood, is increasing in young populations. The increase in the prevalence of obesity in adolescence in recent years, partly due to inadequate diet and physical inactivity, probably explains the progress of the disease in young populations[27,28].

Being overweight affects more than half of the Brazilian adult population and obesity effects about 17.4%. This is suggestive of a lifestyle pattern made up of fatty foods, sugars and physical inactivity[29]. The study pointed to a strong association between being overweight, being obese and DM. The pathophysiological mechanisms that result in the association between obesity and DM are complex and multifactorial[23]. These include increased circulating free fatty acids, decreased adiponectin, and adipose tissue secretion of cytokines that ultimately exacerbate insulin resistance and lead to the subsequent exhaustion of pancreatic insulin, aggravating the condition[23.24].

Regarding the higher frequency of DM in low-educated populations, this association has already been found in Brazil[30-32] and in other countries[33]. Educational level is an important socioeconomic indicator and implies different risks in the health and disease process, especially due to vulnerable living environments, poor access to health services and the most unfavorable practices with regard to food, physical activity, body care and prevention of diseases[31,33]. Although there are still problems regarding access to health services, the PNS indicated that patients with DM have access to medical care (70%), specialist consultations (83.3%) and medicines (80.2%), and more than half receive them through the Popular Pharmacy Program[18]. Additionally, there are special

protocols for the care of those with DM in the Unified Health System (SUS). They aim to give more attention to people with the disease, by offering comprehensive, long-term care[34]. These data reveal the importance of SUS in reducing health inequities and in providing access to care[18,34].

Among the regions of Brazil, the highest PR was found in the Midwest, similar to self-reported data, which point to more diagnoses of DM in the Midwest, South and Southeast[17,18].

The study also found a high prevalence of pre-diabetes, with a similar behavior of increasing with age, reaching approximately one sixth of the elderly (data not shown). Similarly, studies performed by ELSA-Brasil[23] also identified high frequencies of intermediate hyperglycemia, ranging from 16.1 to 52.6%, depending on the definition used. These data increase the need for attention and monitoring of populations, especially those risk factors such as cardiovascular disease, obesity, physical inactivity, and genetic traits. The therapeutic approach of detected cases, the monitoring and control of blood glucose, as the health education process are fundamental for preventing complications and maintaining patients' quality of life[35].

Different levels of HbA1c have also been identified. The ADA[15] explains that for individuals already diagnosed with DM, HbA1c should be kept below 7%, which would protect against the onset and progression of microvascular complications of DM and neuropathy. Individuals with long-term DM who already have chronic complications (ocular, renal, atherosclerosis, and neuropathy changes) may have less stringent control targets of HbA1c, up to 8%[15]. In the present study, about 60% of those with HbA1c ≥ 6.5% had values below 8%, however, these are preliminary data, as no other comorbidities or the use of medication to define DM control were investigated.

Among other study limitations, the rate of failure to obtain laboratory values was high, especially due to the contracted laboratory's difficulty in locating the addresses. However, post-stratification weights allow us to infer estimates for the general population.

## CONCLUSION

This is the first study to analyze the prevalence of DM using laboratory data from a representative sample of the Brazilian population, which will serve as a baseline for future studies.

The study found up to one-tenth of the population had DM, according to the adopted criterion. The proportion of pre-diabetes can reach up to a sixth of the population. Laboratory testing performed by the PNS contributes to health surveillance and health care in SUS and can support the monitoring of the WHO Strategic Action Plan for Tackling NCDs and the goal of reducing premature mortality from NCDs.

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