Using Brazilian Health Surveys 2013 and 2019 for a nationwide diabetes risk assessment

Marcelo Moreira da Silva Mário Olímpio de Menezes

Abstract

Brazil had, in 2021, almost 15.7 million people with diabetes (type 1 and 2). In this work, using the Pesquisa Nacional de Saúde (PNS) 2013 and 2019, the diabetes risk for the entire population covered by those surveys, with 18 years and older, was assessed applying the American Diabetes Association Risk Test. Only one question from that test, regarding relatives with diabetes, could not be answered from the PNS questionnaires. After applying the test to both PNS 2013 and 2019, 15.9% and 19.0% of the population with 18+ years was found to be at risk of developing diabetes, representing about 23 and 28 million people, respectively. Those with 65+ years were found to be more at risk, increasing from 42.3% in 2013 to 46.0% in 2019. A good result came from those with BMI > 30, whose percentage at risk dropped from 47.9% in 2013 to 42.5% in 2019. Brazilian states with the biggest risk increase were Tocantins, Mato Grosso do Sul, Piauí and Bahia, all with more than 4pp, while ten states had increases bigger than 3pp. The results obtained in this work corroborate recent findings in diabetes prevalence studies and also reinforce the great importance of such nationwide health survey, as it represent an invaluable resource to public health policies.

Keywords: Diabetes Mellitus, Prediabetic State; Health Policy, Planning and Management

Introduction

Diabetes is a major public health concern worldwide. As a silent disease, it's believed that almost half of the world's population doesn't even know whether they have it or not[1]. Due to its quiet nature, a great number of health complications can appear without early treatment, among which are heart diseases, retinopathy, kidney dysfunction, etc[2].

According the International Diabetes Federation – IDF, Brazil had, in 2021, almost 15.7 million people with diabetes, including type 1 and type 2, considering only adults aged 20-79 years, with a growing trend globally[1]. A 2018 survey from Brazilian Health Ministry showed that between 2006 and 2016, the number of Brazilians with diabetes increased by about 61.8%, reaching the stunning value of 8.9% of the entire population, up from 5.5% in the previous survey[2].

Brazil was the 6th country with the highest incidence of diabetes in the world in 2021, for adults aged 20-79 years, according to the IDF Diabetes Atlas. An astonishing estimative for the global economic burden due to diabetes gives a value of USD 966 billion for adults aged 20-79 years. This represents a 316% increase over 15 years. Brazil had an estimate of USD 42.9 billion diabetes-related health expenditure in 2021 for adults aged 20-79 years[1].

Early diagnosis and treatment of diabetes is essential to prevent chronic complications. In an effort to facilitate prediabetes risk assessment in asymptomatic adults, the American Diabetes Association (ADA) produced several guidelines to help physicians screen people who are at high risk of developing it further in their lifetime but do not already meet diabetes criteria based on blood testing results, which use plasma glucose criteria, either the fasting plasma glucose (FPG) or the 2-h plasma glucose (2-h PG) value during a 75-g oral glucose tolerance test (OGTT)[3].

These guidelines were condensed in what is known as the "ADA risk assessment algorithm" which is endorsed by The Brazilian Diabetes Society, that also translated it to Portuguese to ease its application by Brazilian physicians.

Other countries have also produced non-lab screening methodologies for diabetes risk assessment to identify people who might be in danger of developing diabetes but do not yet present positive lab results. We could find such efforts in Canada[4], China[5] and also in Finnish[6]; Buijsse and colleagues did a good study on several of these tools[7].

Reliable information throughout the country is fundamentally important to increase and improve healthcare planning for the population. In an effort to provide such quality data to improve health services in Brazil, the Health Ministry, in collaboration with the Brazilian Statistics and Geography Institute (Instituto Brasileiro de Geografia e Estatística - IBGE), conducted a major national survey called the National Health Survey (PNS) to assess the health status, lifestyle, chronic diseases, medication use, and other points of the Brazilian population.

Two versions of the PNS were conducted: one in 2013 and another in 2019. In the 2013 version, the initially planned sample size was around 80,000 households, and the dataset placed in the public access had 60,202 individuals who agreed to answer the full questionnaire. This represented a probabilistic sample of the Brazilian population over 18 years old, representing about 145 million people. The survey results were published under the name "Pesquisa Nacional de Saúde (PNS) 2013"[8],[9]. In the 2019 version, the initially planned sample size was around 108,000 households, and the final dataset had 90,846 individuals who answered all questions. This represented a probabilistic sample of the Brazilian population over 15 years old, representing about 168 million people. The survey results were published under the name "Pesquisa Nacional de Saúde (PNS) 2019"[10].

This big curated data prompted several researchers to explore its potential, producing high-quality research and helping public health policymakers make better decisions about Brazil's public health. Fiocruz (Fundação Oswaldo Cruz), a Brazilian Health Ministry company, lists some of these publications on its website `https://www.pns.icict.fiocruz.br/volumes-ibge/`.

Most of the papers listed by Fiocruz and others found in several journals dealt, in some way, with the prevalence of diabetes, using public data from PNS or not.

One very recent study from Reis et al[11] analyzed the evolution of diabetes mellitus using PNS 2013 and 2019. Some of the findings of the study are: a relative increase of 24% in crude prevalence from 2013 to 2019, with a higher increase in men than in women, even though women's prevalence remained higher in the 2019 survey (8.4%) versus men's prevalence of 6.9%. In absolute numbers, the number of cases of diabetes was 12.3 million in 2019 against 9.0 million in 2013, a 36.4% increase. Some drivers of this rise include an increase in population size (9.9%) and aging (1.8%). In their conclusion, the authors acknowledge that Brazil is experiencing the same worldwide trend of an increase in the prevalence of diabetes in all of its regions, leading to a huge burden on the health system.

More recently, some authors have started to use non-lab or semi-lab algorithms to assess diabetes risk, using questionnaires and algorithms designed for this task. For instance, Iser and colleagues[12] applied two distinct criteria to evaluate the prevalence of prediabetes and intermediate hyperglycemia, using the American Diabetes Association (ADA) diagnostic criteria and the World Health Organization (WHO). They used clinical data from the PNS 2013, which corresponds to a fraction of the sample we used in this work. These clinical data were collected from a sub-sample, and for their study, 7,548 participants were considered after removing those whose HbA1c level was compatible with diabetes (310 people - HbA1c 6.5%) and 398 people because they had missing information. They found, using both criteria, that between 7.5 (WHO criteria) and 18.5% (ADA criteria) of Brazilian adults presented prediabetes and hyperglycemia.

Another study that used a non-lab method for risk assessment[13] applied the Finnish Diabetes Risk Score (FINDRISC)[6] to two distinct sub-populations of Manaus city, in the Brazil's Amazon state. In their study, Azevedo and colleagues assessed diabetes risk factors through the questionnaire and also with clinical data and further demographic and socio-economic data collected from the population sample under study. Their results indicated that out of the 120 participants (62% women), 43% presented an increased risk for diabetes. They also found statistically significant associations between diabetes risk and increased abdominal circumference, sedentary lifestyle, low daily fruit intake, daily fried foods and salty or fatty meats, and hereditary factors.

Seizing the PNS data, we were able to see an opportunity to apply the ADA algorithm to a really big population sample, and thus producing a large overview of the diabetes risk over Brazil's entire population, detailed by several important facets, such as age, race/skin color, body mass index, education, hypertension status, and also by Brazil's states and regions.

Materials and Methods

PNS is a probabilistic, stratified complex survey. Both versions were designed by IBGE according a master sample built to cover the entire Brazilian territory. This sample was properly divided to supply other surveys needs. Both versions are composed of three-stage strategy: first, the primary sampling units were selected from that master sample. Then, a set of households was chosen and from each household an individual aged 18 or older for the 2013 version and aged 15 years or older for the 2019 version was randomly sampled from all household dwellers[14],[15]. Three questionnaires were used, one regarding the household, one regarding all dwellers and one regarding he single individual answering the survey. This last questionnaire included a module on the participant's medical data.

The PNS data was analyzed using the R software[16] along with the "survey" library[17] and other R packages for data manipulation and graphics. The PNS files were downloaded from the Fiocruz website, and initial data preparation was done following their instructions. All scripts used in this work are available on the Github repository, where all decisions regarding variable recoding and aggregation are also explained. After the initial data preparation, the **survey** object was constructed for each PNS data applying the correct weighting factors, and a subset of all variables was selected to be processed by the risk assessment algorithm. In the PNS 2013 raw data, we found that 800 observations had missing values for person's weight. For PNS 2019 raw data, 892 observations were found with missing values for person's weight and height. Some other variables also have missing values, but they were not used for our work.

PNS questionnaires have some questions about diabetes and glycemia:

- Regarding diabetes diagnostics:
  - positive, negative, ignored or not applicable;
  - if women, was the diagnostics only in pregnancy: Yes, No, Ignored, Not applicable (men).
- Regarding glycemia's last test:
  - Less than 6 months; between 6 months and less than 1 year; between 1 year and less than 2 years; between 2 years and less than 3 years; 3 years or more; Never did; Ignored; Not applicable.

In our work, we used only the question about diabetes diagnostics, which was grouped in one variable **diabetes** considering the following levels: 1="Yes", 2="Pregnancy only", 3="No", 4="Never tested (for Missing or Ignored)". This variable was used to answer the ADA algorithm question 3 and also to subset the data, that is, we applied the algorithm excluding people which already had a positive diabetes diagnostic, that is, value 1="Yes".

PNS questionnaires also have questions about physical activity, specifically:

- Regarding physical activity practice, just "Yes" or "No".
- Regarding the number of days a week the person have physical activity: from 0 to 7 days, and also "Ignored" for missing data.

When cross-tabulating these questions, the number of missing data (Ignored) in the question about number of days a week the person have physical activity was exactly the same value as the answer "No" in the question regarding if had or not physical activity; so, the Ignored level was reassigned to 0 to be in agreement with the answer "No" in the related question about the physical activity practice. Joining these information, in our work we created a new variable **prat_ativ** and assigned the following levels according to the number of days a week the person have physical activity: 1="3 or more days" and 0="less than 3 days"; this option is still conservative considering that WHO

(World Health Organization)[18] and CDC (Centers for Disease Control - USA)[19] both recommend between 150 and 300 minutes of physical activity per week to a person be considered physically active, which roughly correspond to 5 days with 30 minutes per day. This variable was used to answer the ADA algorithm question number 6.

Ethical Aspects

Both PNS surveys were approved by the National Commision of Ethics in Research (Comissão Nacional de Ética em Pesquisa – CONEP), of the National Health Council (Conselho Nacional de Saúde – CNS); PNS 2013 received its approval on June 2013 and PNS 2019 on August 2019. All participants signed the Free and Informed Consent Form before the interview, guaranteeing data confidentiality, and also, all participants could resign freely at any time of the study. For this work, as we use only PNS data, no Ethical Committee approval was necessary.

American Diabetes Association Algorithm

The algorithm proposed by ADA[3] is based on assigning points to several characteristics of the patient. The resulting sum, if equal or higher than 5, indicates a higher risk of diabetes type 2. The higher the sum, the higher the risk. This algorithm is applied by physicians through a list of questions and also with a lookup table for height and weight, where the patient's obesity is assessed, as shown in Table 1.

Table 1: ADA Algorithm questions and lookup table

<table>
<tr><th>Algorithm questions</th><th>Height(m)</th><th></th><th>Weight (kg)</th><th></th></tr>
<tr><td rowspan="19">1. What's your age?
▪ <40 years: 0 point
▪ 40–49 years: 1 point
▪ 50–59 years: 2 points
▪ Above 60 years: 3 points

2. Are you a man or a woman?
▪ Male: 1 point
▪ Female: 0 point

3. If woman, have been diagnosed with gestational diabetes?
▪ Yes: 1 point
▪ No: 0 point

4. Any relative (mother, father, sister or brother) with diabetes?
▪ Yes: 1 point
▪ No: 0 point

5. High blood pressure diagnosis?
▪ Yes: 1 point
▪ No: 0 point

6. Physically active?
▪ Yes: 0 point
▪ No: 1 point

7. What is your weight status?</td><td>1.47</td><td>54-64</td><td>65-86</td><td>87+</td></tr>
<tr><td>1.50</td><td>56-67</td><td>67-89</td><td>90+</td></tr>
<tr><td>1.52</td><td>58-69</td><td>69-92</td><td>93+</td></tr>
<tr><td>1.55</td><td>60-71</td><td>72-95</td><td>96+</td></tr>
<tr><td>1.57</td><td>62-74</td><td>74-98</td><td>99+</td></tr>
<tr><td>1.60</td><td>64-76</td><td>77-102</td><td>102+</td></tr>
<tr><td>1.63</td><td>66-78</td><td>79-105</td><td>105+</td></tr>
<tr><td>1.65</td><td>68-81</td><td>82-108</td><td>109+</td></tr>
<tr><td>1.68</td><td>70-84</td><td>84-112</td><td>112+</td></tr>
<tr><td>1.70</td><td>72-86</td><td>87-115</td><td>116+</td></tr>
<tr><td>1.73</td><td>74-89</td><td>89-118</td><td>119+</td></tr>
<tr><td>1.75</td><td>77-92</td><td>92-122</td><td>122+</td></tr>
<tr><td>1.78</td><td>79-94</td><td>95-126</td><td>126+</td></tr>
<tr><td>1.80</td><td>81-97</td><td>98-129</td><td>130+</td></tr>
<tr><td>1.83</td><td>83-100</td><td>100-133</td><td>133+</td></tr>
<tr><td>1.85</td><td>86-103</td><td>103-137</td><td>137+</td></tr>
<tr><td>1.88</td><td>88-105</td><td>106-141</td><td>141+</td></tr>
<tr><td>1.91</td><td>91-108</td><td>109-144</td><td>144+</td></tr>
<tr><td>1.93</td><td>93-111</td><td>112-148</td><td>149+</td></tr>
<tr><td>Points based on height and weight (0 if smaller or lighter)</td><td>--</td><td>1 point</td><td>2 points</td><td>3 points</td></tr>
</table>

From these questions, only the number 4, about relatives (mother, father, sister or brother) with diabetes, could not be answered with PNS data. Even with this absence, the algorithm was applied to the available data, making it possible to assess the risk of diabetes for about 136 million adult Brazilians for PNS 2013 and for about 147 million for PNS 2019, corresponding to those with the following diabetes status: "Pregnancy only," "No," and "Never tested" from Table 2. To accomplish this, the ADA algorithm questions were translated into several steps in the R programming language for computing the points associated with each particular characteristic. The sum was then assigned to a new variable to allow further analysis and segmentation.

Results and Discussion

Table 2 shows the prevalence of diabetes among the whole population of 18+ years and also by gender for 2013 and 2019 data. These results are in agreement with Malta and colleagues[20] and also with Reis and colleagues[11], except for some minor differences that could be due to the PNS release date. We are using the release from late 2020, which was recalibrated by IBGE regarding population projection, to allow comparisons with the new 2019 PNS. Additionally, we are utilizing the Fiocruz' release of this latest version of the PNS.

Table 2: Prevalence of Diabetes: Total, Men and Women

	2013			2019		
	N	(%)	95%CI	N	(%)	95%CI
Geral						
Yes	9,058,746	6.2	5.9-6.5	12,293,140	7.7	7.4-8
Pregnancy	389,034	0.3	0.2-0.3	511,699	0.3	0.3-0.4
No	119,266,280	81.9	81.4-82.5	136,425,285	85.7	85.3-86.1
Never Tested	16,858,151	11.6	11.1-12.1	9,941,187	6.2	6-6.5
Women						
Yes	5,416,067	7.0	6.6-7.5	7,141,173	8.4	8-8.8
Pregnancy	389,034	0.5	0.4-0.6	511,699	0.6	0.5-0.7
No	65,205,842	84.7	84-85.3	73,851,302	87.3	86.8-87.8
Never Tested	5,992,741	7.8	7.3-8.3	3,114,439	3.7	3.4-4
Men						
Yes	3,642,679	5.3	4.8-5.8	5,151,966	6.9	6.5-7.3
No	54,060,438	78.8	77.9-79.8	62,573,983	83.9	83.3-84.6
Never Tested	10,865,410	15.8	15-16.7	6,826,749	9.2	8.6-9.7

After applying the algorithm to PNS 2013 and 2019 data, the missing data for weight and height in data resulted also in missing data in the risk assessment results, shown on Table 3. This happened because the algorithm needs the weight and height of the individuals to calculate the risk.

Table 3: Distribution of Missing Data for Risk by diabetes diagnostics

Diab. Diagnostics	2013	2019
Yes	13,960	19,558
Pregnancy	51,468	41,299
No	1,304,934	1,478,086
Never Tested	105,049	72,492

Table 4 shows the results of ADA risk assessment algorithm applied to both 2013 and 2019 PNS data for those with diabetes status of "Pregnancy only", "No" and "Never Tested"; these are the "at risk people". In all discussion below, the population at risk was calculated considering only those with diabetes status of "Pregnancy only", "No" and "Never Tested", representing 135,052,014 people in 2013 and 145,286,294 people in 2019 – numbers from Table 2, excluding missing data from Table 3.

Table 4: Breakdown of Population with Diabetes Risk according to ADA Algorithm

	2013			2019		
	N	(%)	95%CI	N	(%)	95%CI
AtRisk						
Total	23,211,321	15.9	15.5-16.4	27,916,466	19.0	18.6-19.4
Age(years)						
18-24	37,150	0.2	0-0.3	23,315	0.1	0-0.1
25-34	115,567	0.5	0.3-0.7	128,943	0.5	0.2-0.7
35-44	845,510	3.6	3-4.3	1,022,166	3.7	3.1-4.2
45-54	4,345,818	18.7	17.2-20.3	4,542,324	16.3	15.1-17.4
55-64	8,046,127	34.7	32.7-36.6	9,368,255	33.6	32.1-35
65+	9,821,149	42.3	40.5-44.1	12,831,463	46.0	44.7-47.2
RaceSkinColor						
White	12,319,338	53.1	50.7-55.4	13,225,407	47.4	45.7-49
Black	2,178,308	9.4	8.4-10.4	3,203,772	11.5	10.6-12.3
Mixed-race	8,455,912	36.4	34.5-38.3	11,015,761	39.5	38-40.9
Asian	189,724	0.8	0.5-1.1	315,910	1.1	0.8-1.5
Indigenous	67,843	0.3	0.1-0.4	154,910	0.6	0.4-0.7
Ignored	196	0.0	0-0	706	0.0	0-0
Education						

IncElem	14,451,833	62.3	59.6-64.9	15,955,263	57.2	55.5-58.8
CompElem	2,385,066	10.3	9.2-11.3	3,267,909	11.7	10.6-12.8
CompHiSc	4,013,020	17.3	15.7-18.8	5,467,842	19.6	18.4-20.7
CompHigher	2,361,403	10.2	8.8-11.6	3,225,452	11.6	10.6-12.5
Body mass index(kg/mš)						
Low/Normal (<25)	2,899,520	12.5	11.3-13.7	4,405,314	15.8	14.8-16.7
Overweight (25-29.9)	9,204,150	39.7	37.7-41.6	11,655,109	41.7	40.4-43.1
Obesity (>30)	11,107,651	47.9	45.5-50.2	11,856,044	42.5	40.6-44.3
Hypertension						
Yes	15,726,457	67.8	65.1-70.4	20,197,173	72.3	70.4-74.3
No	7,484,863	32.2	30.5-34	7,719,293	27.7	26.5-28.9

As can be seen in Table 4 the number of people at risk of developing diabetes has increased from about 23 million in 2013 to approximately 28 million in 2019, representing 15.9% and 19.0% of the population, respectively. This means an increase of 3.1 percentage points. This same population grew from about 135 million in 2013 to approximately 145 million people in 2019.

The proportional increase in the number of people at risk for diabetes of about 3.1 percentage points is almost the double of the increase observed for diabetes prevalence, as shown in Table 2, which went from 6.2% in 2013 to 7.7% in 2019.

Both results corroborate the global trend observed for diabetes – a steady increase in prevalence, while the world population increasingly adheres to unhealthy habits. Population aging can also help to understand the increase in prevalence and also the increase of at risk people. In 2013, 42.3% of the 65+ people were at risk; in 2019, this figure went to 46.0% of the 65+ people, an increase of 3.7 percentage points, again, more than the double of the overall increase in diabetes prevalence from 2013 to 2019.

Figure 1 presents the ranking of Brazilian states according to the diabetes risk assessment, showing the changes from 2013 to 2019. Overall, there was a 3 percentage points increase for the whole range, so that the minimal value increased from 9.9% to 12.7% and the maximum from 21.5% to 24.2%. All states, but one and the Federal District, presented increases in the risk values, and some states experienced major increases of about 5 percentage points in diabetes risk. There were 10 states with increases above or equal 3 percentage points, indicated with an "*" near their names. The Federal District presented a decrease in risk value of 0.2 percentage point and Rio Grande do Norte state had a decrease of 1.4 percentage points.

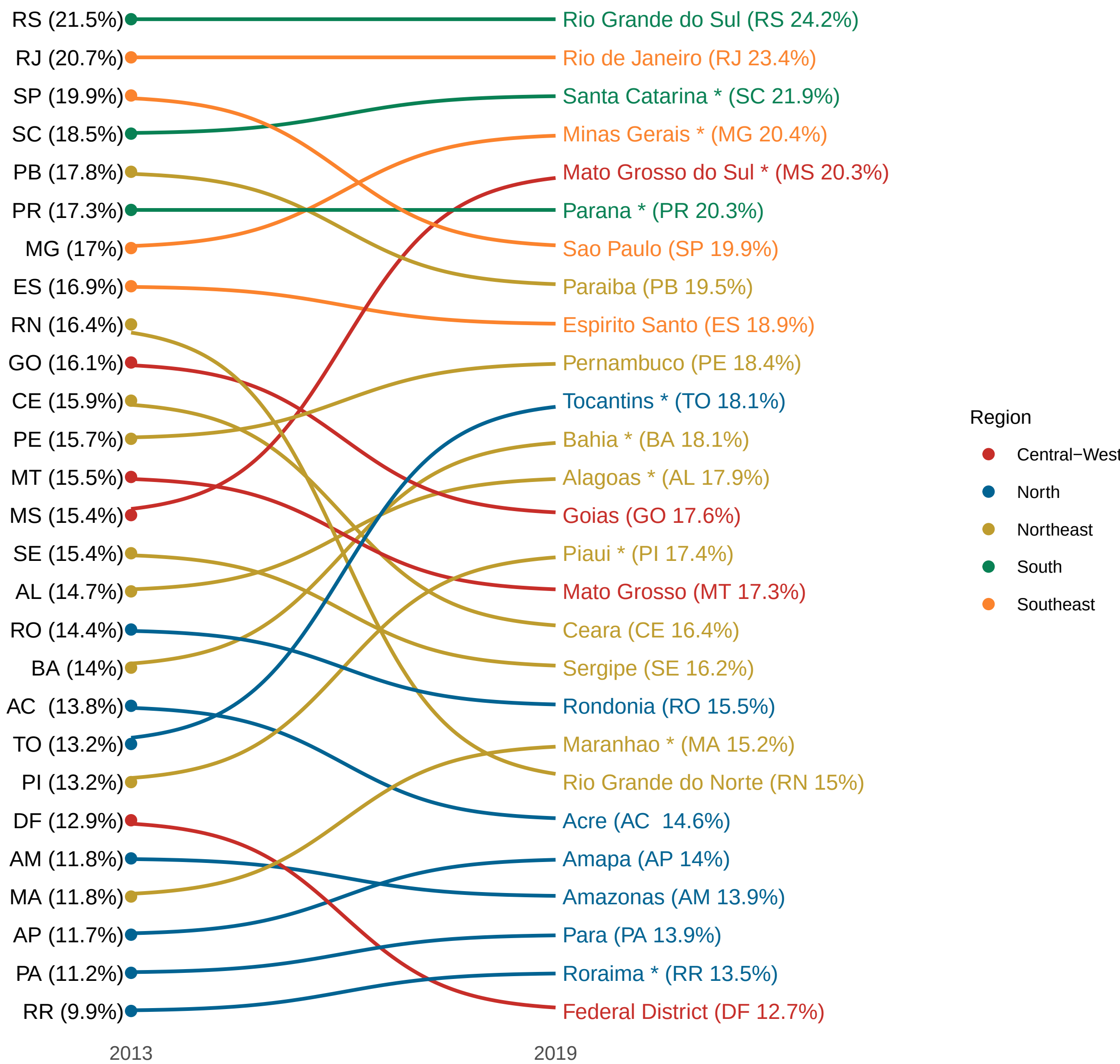

Figure 1: Ranking of Brazilian states for diabetes risk
(* indicates states with 3+pp increase)

Figure 2 shows the evolution of diabetes risk in the five Brazilian regions. The South region presented the biggest increase of 3 percentage points, while the Southeast region had the smallest increase of 1.4 percentage points. As the overall increase in the diabetes risk was about 3 percentage points, the observed result in Brazilian Regions is the population-weighted average of the individual state's increase or decrease. In the Southeast region, for example, São Paulo state, with the biggest population, remained with the same percentual risk of 19.9%, while Rio de Janeiro, Minas Gerais and Espírito Santo all had an increase of about 3 percentage points.

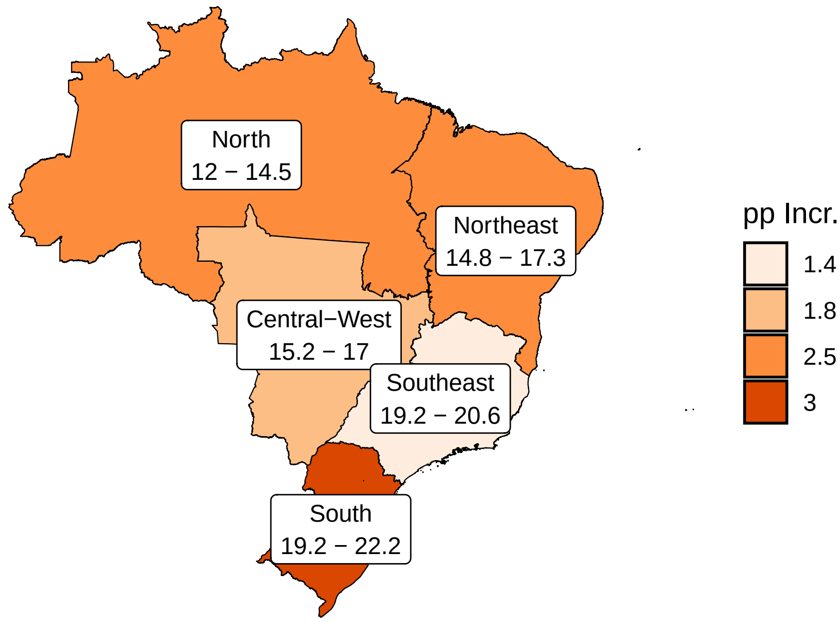

Figure 2: Brazilian Regions' Diabetes Risk according to ADA Algorithm
(Inside the map are Region's Names, with 2013 and 2019 percent risk values)

As a final remark, it's important to highlight the relevance of the "National Health Survey" (PNS) for nationwide health studies. PNS contains many invaluable data on the Brazilian population's health assessment, and this wonderful data treasury has being constantly explored by scientists throughout the country and beyond. We urge the Health Ministry to continue and expand the PNS survey. One suggestion for expansion would be adding a question about the relatives (mother, father, sister or brother) with diabetes, that was the only missing information for the ADA risk assessment algorithm.

Acknowledgements

The ADA algorithm implementation used in this work was adapted from the unpublished undergraduate final project named "Análise dos Fatores Preditivos da Diabetes por Ciência de Dados" (Analysis of Diabetes Predictive Factors by Data Science) developed by Aguirre, D.B., Souza, G.R. and Alves, H.S., at the Mackenzie Presbyterian University, Computing and Informatics College in 2020.

Authors are grateful to Dr. Simone Cristina Soares Brandão for her valuable suggestions for the manuscript.

Author’s contribution

Marcelo Moreira da Silva was responsible for writing and reviewing the manuscript.

Mário Olímpio de Menezes was responsible for the conceptualization, data curation and analysis, methodology and writing the original draft.

Both authors were responsible for reviewing the final version.

Conflict of Interests

Authors declare no conflict of interests.

Research Data availability

All the R scripts used in this paper are available in the public GitHub repository `https://github.com/ipencnensp/diabetesPNSpub`.

PNS data is available at FIOCRUZ website `https://www.pns.icict.fiocruz.br/`; a script is provided to automatically download PNS data to reproduce all analysis.

References

1. International Diabetes Federation (IDF). IDF Diabetes Atlas. 10th ed. Brussels, Belgium: International Diabets Federation; 2021.
2. Oliveira JEP, Cristina FF Maria, Magalhães MJ Renan, Sérgio V, editors. Diretrizes da Sociedade Brasileira de Diabetes 2017-2018. São Paulo, SP: Clanad Editora Científica; 2017.
3. American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2018. Diabetes Care [Internet]. 2018 Jan [cited 2020 Jun 10];41(Supplement 1):S13–27. Available from: https://care.diabetesjournals.org/content/41/Supplement_1/S13
4. Robinson CA, Agarwal G, Nerenberg K. Validating the CANRISK prognostic model for assessing diabetes risk in Canada’s multi-ethnic population. Chronic Diseases and Injuries in Canada. 2011 Dec;32(1):19–31.
5. Li W, Xie B, Qiu S, Huang X, Chen J, Wang X, et al. Non-lab and semi-lab algorithms for screening undiagnosed diabetes: A cross-sectional study. EBioMedicine [Internet]. 2018 Sep [cited 2022 Oct 20];35:307–16. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2352396418302950

6. Lindström J, Tuomilehto J. The Diabetes Risk Score: A practical tool to predict type 2 diabetes risk. Diabetes Care [Internet]. 2003 Mar [cited 2022 Oct 20];26(3):725–31. Available from: https://diabetesjournals.org/care/article/26/3/725/29197/The-Diabetes-Risk-ScoreA-practical-tool-to-predict

7. Buijsse B, Simmons RK, Griffin SJ, Schulze MB. Risk Assessment Tools for Identifying Individuals at Risk of Developing Type 2 Diabetes. Epidemiologic Reviews [Internet]. 2011 Jul [cited 2022 Oct 20];33(1):46–62. Available from: https://academic.oup.com/epirev/article-lookup/doi/10.1093/epirev/mxq019

8. Szwarcwald CL, Malta DC, Pereira CA, Vieira MLFP, Conde WL, Souza Júnior PRB de, et al. Pesquisa Nacional de Saúde no Brasil: Concepção e metodologia de aplicação. Ciência & Saúde Coletiva [Internet]. 2014 Feb [cited 2020 Jun 8];19(2):333–42. Available from: http://www.scielo.br/scielo.php?script=sci_abstract&pid=S1413-81232014000200333&lng=pt&nrm=iso&tlng=pt

9. Instituto Brasileiro de Geografia e Estatística - IBGE. Pesquisa Nacional de Saúde 2013: Percepção do estado de saúde, estilos de vida e doenças crônicas : Brasil, grandes regiões e unidades da federação [Internet]. Rio de Janeiro: IBGE; 2014. Available from: https://biblioteca.ibge.gov.br/pt/biblioteca-catalogo?view=detalhes&id=291110

10. IBGE, Coordenação de Trabalho e Rendimento, editor. Pesquisa Nacional de Saúde 2019: Percepção do estado de saúde, estilos de vida, doenças crônicas e saúde bucal: Brasil, Grandes Regiões e Unidades da Federação [Internet]. Rio de Janeiro, RJ: Instituto Brasileiro de Geografia e Estatística - IBGE; 2020 [cited 2022 Apr 27]. Available from: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101764

11. Reis RCP dos, Duncan BB, Malta DC, Iser BPM, Schmidt MI. Evolution of diabetes in Brazil: Prevalence data from the 2013 and 2019 *Brazilian National Health Survey*. Cadernos de Saúde Pública [Internet]. 2022 May [cited 2022 Jul 27];38. Available from: http://www.scielo.br/j/csp/a/4YWtmtvQkgFm3mmQ4f7kxDr/

12. Iser BPM, Pinheiro PC, Malta DC, Duncan BB, Schmidt MI. Prevalência de pré-diabetes e hiperglicemia intermediária em adultos e fatores associados, Pesquisa Nacional de Saúde. Ciência & Saúde Coletiva [Internet]. 2021 Feb [cited 2021 Jun 10];26:531–40. Available from: https://www.scielosp.org/article/csc/2021.v26n2/531-540/pt/

13. De Azevedo AP, Fernandes EB, Metteles BP, De Souza PBA, Simplício CP, Almeida BA, et al. Rastreamento dos riscos para desenvolvimento de diabetes mellitus tipo 2 em duas populações distintas. Revista Eletrônica Acervo Enfermagem [Internet]. 2021 Feb [cited 2022 Oct 20];9:e5014. Available from: https://acervomais.com.br/index.php/enfermagem/article/view/5014

14. Instituto Brasileiro de Geografia e Estatística, editor. Pesquisa nacional de saúde, 2013: ciclos de vida: Brasil e grandes regiões. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística - IBGE; 2015.

15. IBGE, Coordenação de Trabalho e Rendimento, editor. Pesquisa Nacional de Saúde 2019: Informações sobre domicílios, acesso e utilização dos serviços de saúde - Brasil, Grandes Regiões e Unidades da Federação. Rio de Janeiro, RJ: Instituto Brasileiro de Geografia e Estatística - IBGE; 2020.
16. R Core Team. R: A language and environment for statistical computing [Internet]. Vienna, Austria: R Foundation for Statistical Computing; 2022. Available from: https://www.R-project.org/
17. Lumley T. Complex surveys: A guide to analysis using R. Hoboken, N.J.: Wiley; 2013.
18. Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion. Move More; Sit Less. Centers for Disease Control and Prevention. https://www.cdc.gov/physicalactivity/basics/adults/index.htm; 2023.
19. World Health Organization. Physical activity. https://www.who.int/news-room/fact-sheets/detail/physical-activity;
20. Malta DC, Bernal RTI, Iser BPM, Szwarcwald CL, Duncan BB, Schmidt MI. Fatores associados ao diabetes autorreferido segundo a Pesquisa Nacional de Saúde, 2013. Revista de Saúde Pública [Internet]. 2017 Jun [cited 2021 Jun 10];51:12s. Available from: https://www.scielosp.org/article/rsp/2017.v51suppl1/12s/pt/