https://doi.org/10.1590/1678-9865202235e220046

ORIGINAL

Prevalence of prediabetes in adults and its association with sociodemographic, nutritional, metabolic and mental disorders factors: Home Health Survey, *Piauí*, Brazil.

Prevalência de pré-diabetes em adultos e sua associação com fatores sociodemográficos, nutricionais, metabólicos e transtornos mentais: Inquérito de Saúde Domiciliar, Piauí, Brasil.

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ABSTRACT

Objective

To estimate prevalence of prediabetes and to investigate its associated factors in adults living in *Teresina, Piauí*, Brazil

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Support: Interinstitutional Doctorate in Nutrition and Public Health from the University of *São Paulo* (USP) and the Federal University of *Piauí* (UFPI) (Protocol: DINTER 2533/2015).

Article elaborated from thesis by CHR LIMA, entitled "*Status inadequado de 25(OH)D, pré-diabetes e fatores de risco associados em adolescentes, adultos e idosos de uma capital do nordeste brasileiro: ISAD-PI*". Universidade Federal do Piauí; 2022.

How to cite this article

Lima CHR, Da Paz SMRS, Lavôr LCC, Frota KMG, Paiva AA. Prevalence of prediabetes in adults and its association with sociodemographic, nutritional, metabolic and mental disorders factors: Home Health Survey, *Piauí*, Brazil. Rev Nutr. 2022;35:e220046. https://doi.org/10.1590/1678-9865202235e220046

Methods

Cross-sectional, home-based study, with both genders adults in *Teresina*, *Piauí*. The prevalence of prediabetes was estimated using the fasting glucose test, and was classified according to the American Diabetes Association standards (≥100mg/dL; <126mg/dL). The associations between prediabetes and the variables: sociodemographic, anthropometric, food consumption, blood pressure levels, triglycerides and common mental disorders were tested. In addition, a variable was created to verify the association of the simultaneous presence of risk factors in the same individual. Data were reviewed using Pearson's chi-square test and Poisson regression for crude and adjusted prevalence ratios, considering a significance level of 5%.

Results

A total of 224 adults participated in the study, of which 154 (68.7%) were female, aged between 20 and 39 years (53.1%). An 8.04% prevalence of prediabetes was observed. A statistically significant association (p<0.05) was found between lower education (0 to 8 years of study; 17.3%) and increased triglycerides levels (≥150mg/dL; 13.7%). Higher gross prevalence (PR: 2.53; CI 95%: 1.05-6.05) prediabetes ratios were observed with 5 or more simultaneous risk factors when compared to individuals who had up to 4 simultaneous risk factors.

Conclusion

Low schooling, hypertriglyceridemia and the presence of five or more simultaneous risk factors were associated with prediabetes; however, these risk factors are subject to intervention. Therefore, this study points to the need for changes in lifestyle habits as a strategy for glycemic control and diabetes prevention.

Keywords: Adult. Prediabetic state. Risk factors.

RESUMO

Objetivo

Estimar a prevalência de pré-diabetes e investigar os fatores associados em adultos residentes em Teresina, Piauí, Brasil.

Métodos

Estudo transversal de base domiciliar com adultos de ambos os sexos em Teresina, Piauí. A prevalência de pré-diabetes foi estimada pelo teste de glicemia em jejum, e classificado de acordo com a Associação Americana de Diabetes (≥100mg/dL; <126mg/dL). Foram testadas as associações entre pré-diabetes e as variáveis: sociodemográficas, antropométricas, consumo alimentar, níveis pressóricos, triglicerídeos e transtornos mentais comuns. Além disso, foi criada uma variável para verificar a associação da presença simultânea dos fatores de risco no mesmo indivíduo. Os dados foram analisados com o teste do qui-quadrado de Pearson e regressão de Poisson para razões de prevalência bruta e ajustada, considerando nível de significância de 5%.

Resultados

Participaram do estudo 224 adultos, sendo 154 (68,7%) do sexo feminino, entre 20 e 39 anos (53,1%). Verificou-se prevalência de pré-diabetes de 8,04%, com associação significativa (p<0,05) com a menor escolaridade (17,3%), e triglicerídeos elevados (13,7%). Observou-se maior razão de prevalência bruta (RP: 2,53; IC 95%: 1,05-6,05) de pré-diabetes nos indivíduos com 5 ou mais fatores de risco simultâneos quando comparados àqueles com até 4 fatores simultâneos.

Conclusão

A baixa escolaridade, a hipertrigliceridemia e a presença de cinco ou mais fatores de risco simultâneos apresentaram-se associados ao pré-diabetes. Entretanto, os fatores de risco encontrados são passíveis de intervenção. Este estudo aponta a necessidade de mudanças de hábitos de vida comportamentais como estratégia para o controle da glicemia e prevenção do diabetes.

Palavras-chave: *Adulto. Estado pré-diabético. Fatores de risco.*

INTRODUCTION

The condition in which fasting blood glucose levels are above those considered normal for a healthy individual is called hyperglycemia, a condition used as a diagnostic criterion for prediabetes and Diabetes *Mellitus* (DM), when those glucose levels are above 99 mg/dl and 125mg/dl, respectively [1-4].

The prevalence of pre-diabetes has increased worldwide, including in Brazil. A cross-sectional study carried out in this country with laboratory data from the *Pesquisa Nacional de Saúde* (PNS, National Health Survey), using different diagnostic criteria, showed a prevalence of 7.5% to 18.5% of adults with prediabetes [5]. In *Teresina*, capital of the State of *Piauí*, a retrospective survey carried out in 2020 observed an increase in cases of adult individuals with prediabetes who progressed to type II DM, with a prevalence of 10.3% and 21.1% of the population in the years 2003 and 2012, respectively [6].

It is important to highlight some factors that may contribute to the increase in the prevalence of adult prediabetes, including: advanced age, inadequate eating habits, physical inactivity, high blood pressure, presence of dyslipidemia and overweight and/or obesity [7,6].

Such factors are considered an increased risk of pre-diabetes and can be identified through population health surveys, which are tools increasingly used because they allow the collection of a wide range of information and consolidation in a database, in order to identify aggravating factors to the population health and their associated factors [8,9].

Due to the high prevalence of diabetes in the Brazilian population, it is imperative to be aware of the factors associated with prediabetes in the population of *Teresina*, in order to contribute to the planning of more specific actions for the prevention and screening of diabetes and its comorbidities. Therefore, this study investigated the sociodemographic, nutritional and metabolic factors of prediabetes.

In addition, this study reviewed the association of prediabetes with emotional factors, through the investigation of Common Mental Disorders (CMD). In the literature, there are few studies that evaluated this relationship, and it is necessary to carry out research with this purpose in different population segments, in view of the increasing occurrence of mental disorders in the general population, a problem that has been aggravated as a result of the current health crisis [10,11].

Therefore, the aim of this study was to estimate the prevalence of prediabetes and to investigate its associated factors in the adult population in *Teresina, Piauí*, Brazil.

METHODS

This is a cross-sectional study, using data from the *Inquérito de Saúde Domiciliar no Piauí* (ISAD-PI, Home Health Survey in *Piauí*). The study protocol was approved by the Research Ethics Committee of the Federal University of *Piauí* under protocol nº 2,552,426. In this study, only data from adult individuals living in the urban area of *Teresina* were used.

The sample size was calculated based on complex probability sampling, by clusters, in two stages: census sector and household. In the first stage, the Primary Sampling Units (PSU) were generated, so that all districts of the urban area would be represented in the sample, totaling 30 PSU. The second stage involved the systematic sampling of households within each selected PSU [12].

The survey was completed with 497 households visited, 1,285 people interviewed and blood samples taken from 421 individuals, of which 242 were adults. The response rate was 61.2%, and the non-response rate was 38.2%, due to refusal or absence of the resident after three visit attempts [12].

A total of 224 participants were included in the sample. Individuals who reported a diagnosis of DM and with fasting glucose levels consistent with diabetes condition (≥126mg/dl) were excluded. Those who had any deficiencies or disabilities that made data collection difficult were also excluded.

Data were collected by a properly trained multidisciplinary team using the Epicollect 5® (Imperial College, London) software in mobile devices, during the period September 2018 to February 2020. The procedures for data collection and analysis are described below.

Sociodemographic data (age, gender, self-reported skin color, education in years of study and marital status) were obtained through the answers to structured questionnaires, adapted from instruments used in other studies [13,14].

Anthropometric data were obtained through duplicate measurements. Weight was measured in kilograms (kg) on a SECA® portable digital electronic scale with a capacity of 150kg and 100g accuracy. Height was measured using a stadiometer fixed on the floor, with a 0.1 cm accuracy [15,16].

The body mass index was calculated using the formula: weight (kg)/height(m)^2 and the classification of nutritional status for adult individuals was performed according to the World Health Organization standards: underweight/eutrophic (≤24.9kg/m²), overweight (25-29.9kg/m²) and obesity (≥30kg/m²) [16].

Waist circumference was measured using an inelastic measuring tape, with 0.1 cm accuracy, with the individual standing in an upright position. Measurements equal to or greater than 94cm for men and equal or greater than 80cm for women were considered high [16].

Blood pressure was measured using an aneroid sphygmomanometer, duly calibrated, using cuffs measuring 25 to 34cm. The measurement was taken after the subject resting for three to five minutes, in both arms at a time, with the individuals seated, with legs uncrossed, feet on the floor, leaning against the seat back, relaxed, with the arms supported at heart level, and with the hand palms facing up. At least two measurements were taken within one minute, as recommended by the VII Brazilian Guidelines on Arterial Hypertension [17].

For data analysis, the average of the two blood pressure measurements was used. Systolic blood pressure >120mmHg and diastolic blood pressure >80mmHg were considered as high [17].

Blood samples were collected after 8 hours fasting and taken to the laboratory of the *Núcleo de Pesquisas em Plantas Medicinais* (Center for Research in Medicinal Plants), of the Graduate Program in Pharmacology at the Federal University of *Piauí*.

Fasting blood glucose and Triglycerides (TG) were collected in individuals who had fasted for at least 8 hours, and were analyzed using the colorimetric-enzymatic method, using Labtest® reagent kits (*Vista Alegre, Minas Gerais*, Brazil). After analyzing the biological material, pre-diabetes was defined in individuals who had blood glucose levels between 100 and 125mg/dL, following the American Diabetes Association (ADA) criteria [1].

The TG concentrations were considered increased when the values obtained were greater than or equal to 150mg/dL, according to the recommendations of the Brazilian Guideline for Dyslipidemia and Prevention of Atherosclerosis [18].

Data on vegetables and fruits consumption were collected using the Food Frequency Questionnaire adapted from Fisberg *et al.* [13], containing the weekly and daily food frequency of each food group.

Vegetables and legumes consumption was assessed as a whole, while fruits were assessed separately. Low consumption of legumes and vegetables and low consumption of fruits in individuals who did not consume these foods at least three times a day, for at least 5 days a week [19].

To obtain the data regarding the CMD, the Self-Reporting Questionnaire was used; this was an instrument composed of 20 "yes" or "no" questions, of which 4 are related to physical symptoms (somatoform), and 16 to psycho-emotional symptoms [20].

For classification purpose, eight or more positive responses were considered indicative of CMD. This instrument evaluated the presence of symptoms in the last 30 days prior to the interview [21].

In our study, a variable was constructed to verify whether the simultaneous presence of different risk factors in the same individual was associated with pre-diabetes, as shown in the study of Iser *et al.* [5].

To that effect, we started with 7 risk factors already known from the literature: overweight or obesity, increased triglycerides, high blood pressure, increased waist circumference, low consumption of vegetables, low consumption of fruits, and presence of CMD [5,11].

Table 1 describes the relative and absolute values according to the number of risk factors present in the study population. Thus, the factors were grouped into the following categories: 0 – presence of up to 4 risk factors and 1 – presence of 5 or more risk factors.

Table 1 – Description of relative and absolute values according to the number of risk factors present in the study population, Home Health Survey in *Piauí* (n=224). *Teresina* (PI), Brazil, 2018-2020.

Number of risk factors*	n	%
Total	224	100
0	6	2.7
1	22	9.8
2	37	16.5
3	49	21.9
4	65	29.0
5	24	10.7
6	15	6.7
7	6	2.7

Note: ISAD 2018-2020. *Altered Body Mass Index, increased waist circumference, increased triglycerides levels, low consumption of vegetables, low consumption of fruits, increased blood pressure, presence of common mental disorders.

Statistical analyses were performed with the aid of the Data Analysis and Statistical Software (version 14), using the survey considering a complex sampling. Pearson's chi-square test was used to verify the association between categorical variables and prevalence estimates.

Crude and adjusted prevalence ratios with 95%CI were obtained using the Poisson regression method, using the variables gender and age for adjustment. Values with $p<0.05$ were considered significant.

RESULTS

Out of the 224 adults included in the study, 154 (68.7%) were female, aged between 20 and 39 years (53.1%). As for sociodemographic characteristics, the majority had more than 8 years of schooling (66.5%); they self-reported as brown or other skin color (70.5%) and marital status "with a partner" (56.2%). Regarding nutritional characteristics, the population studied was highly overweight (35.7%) and obese (26.8%); they exhibited low fruits (61.2%), vegetables and greens (87.5%) consumption, as detailed in Table 2.

The prevalence of prediabetes found in this study was 8.04% (n=18) for adults aged 20 to 59 years old. There was a significant association with a higher prevalence of pre-diabetes in individuals with up to 8 years of schooling (17.3%) compared to individuals with greater education (3.3%). Regarding metabolic factors, there was a greater incidence of prediabetes in individuals with high TG (13.7%) compared to individuals with adequate levels of TG (3.3%). There was no statistically significant association considering age, gender and other study variables, as described in Table 2.

Table 2 – Association of study population characteristics with prediabetes, Home Health Survey in *Piauí* (n=224). *Teresina* (PI), Brazil, 2018-2020.

Variables	Total		Prediabetes				*p*-value*
			Yes		No		
	n	%	n	%	n	%	
Total	224	100	18	8.04	206	91.96	
Gender							0.214
Male	70	31.3	8	11.4	62	88.6	
Female	154	68.7	10	6.5	144	93.5	
Age group							0.058
20-39	119	53.1	4	3.4	105	96.6	
40-59	105	46.9	14	13.3	91	86.7	
Years of study							0.004
>8	149	66.5	5	3.3	144	96.7	
0 a 8	75	33.5	13	17.3	62	82.7	
Race/skin color							0.100
White	27	12.1	5	18.5	22	81.5	
Black	39	17.4	1	2.6	38	97.4	
Brown /Other	158	70.5	12	7.6	121	92.4	
Marital status							0.277
With partner	126	56.2	12	9.5	114	90.5	
Without partner	98	43.8	6	6.1	92	93.9	
Body Mass Index (kg/m^2)							0.105
Thinness/eutrophy	84	37.5	4	4.8	80	95.2	
Overweight	80	35.7	6	7.5	74	92.5	
Obesity	60	26.8	8	13.3	52	86.7	
Waist circumference (cm)							0.735
Normal	147	65.6	11	7.5	136	92.5	
High	77	34.4	7	9.1	70	90.9	
Triglycerides (mg/dL)							0.006
Normal	122	54.5	4	3.3	118	96.7	
Increased	102	45.5	14	13.7	88	86.3	
Blood pressure levels (mm/Hg)							0.864
Normal	153	68.6	12	7.8	141	92.2	
Increased	70	31.4	6	8.6	64	91.4	
Consumption of vegetables							0.375
Regular	28	12.5	1	3.6	27	94.8	
Low	196	87.5	17	8.7	179	91.6	
Consumption of fruits							0.566
Regular	87	38.8	8	9.2	79	85.7	
Low	137	61.2	10	7.3	127	90.9	
Common Mental Disorders							0.595
Without	162	72.3	12	7.4	150	92.6	
With	62	27.7	6	9.7	56	90.3	

Note: ISAD 2018-2020. *Chi-square test.

In Table 3, the prevalence and prevalence ratios of pre-diabetes and risk factors are reported. There was a positive and significant association between the outcome and years of schooling. In fact individuals with up to 8 years of schooling had a pre-diabetes prevalence ratio 5.17 times higher compared to adults with more than 8 years education. Even after analysis adjustment, the prevalence ratio remained significant (p=0.038).

Regarding race/skin color, significant associations with the prevalence of pre-diabetes were observed, indicating a lower pre-diabetes prevalence ratio (PR: 0.13; 95%CI: 0.25-0.76) in self-declared black individuals compared to self-declared white individuals, both in crude and adjusted analysis.

Table 3 – Prevalence and Prevalence Ratio of prediabetes and risk factors, Home Health Survey in *Piauí* (n=224). *Teresina* (PI), Brazil, 2018-2020.

Variables	Prev. (%)	$_{gross}$PR	CI (95%)	*p*-value	$_{adjust.}$PR	CI (95%)	*p*-value
Total	8.04						
Years of study							
>8	3.3	1	-	-	1	-	-
0 to 8	17.3	5.17	(1.53-17.33)	0.010	4.25	(1.09-16.55)	0.038
Race/color							
White	18.5	1	-	-	1	-	-
Black	2.7	0.13	(0.25-0.76)	0.025	0.11	(0.02-0.73)	0.024
Brown/Other	7.6	0.41	(0.13-1.28)	0.121	0.37	(0.12-1.10)	0.074
Marital status							
With partner	9.5	1	-	-	1	-	-
Without partner	6.1	0.64	(0.28-1.46)	0.281	0.85	(0.36-1.97)	0.693
Body Mass Index (kg/m^2)							
Thinness/eutrophy	4.8	1	-	-	1	-	-
Overweight	7.5	1.58	(0.53-4.71)	0.403	1.55	(0.52-4.67)	0.421
Obesity	13.3	2.8	(0.93-8.41)	0.065	2.37	(0.91-6.18)	0.076
Waist circumference (cm)							
Normal	7.5	1	-	-	1	-	-
High	9.1	1.21	(0.38-3.93)	0.736	1.09	(0.39-3.04)	0.864
Triglycerides (mg/dL)							
Normal	3.3	1	-	-	1	-	-
Increased	13.7	4.19	(1.41-12.45)	0.012	4.45	(1.58-12.54)	0.006
Blood pressure levels (mmHg)							
Normal	7.8	1	-	-	1	-	-
Increased	8.6	1.09	(0.38-3.15)	0.865	1.30	(0.42-4.02)	0.636
Consumption of vegetables							
Regular	3.6	1	-		1	-	-
Low	8.7	2.42	(0.29-20.55)	0.401	2.19	(0.24-19.77)	0.470
Consumption of fruits							
Regular	9.2	1	-	-	1	-	-
Low	7.3	0.79	(0.35-1.80)	0.568	0.76	(0.35-1.72)	0.507
Common Mental Disorder							
Without	7.4	1	-	-	1	-	-
With	9.7	1.30	(0.47-3.62)	0.595	1.43	(0.42-4.91)	0.550

Note: ISAD 2018-2020. Prev: Prevalence, $_{gross}$PR: Gross Prevalence Ratio. $_{adjust.}$PR: PR adjusted by bivariate analysis (gender and age).

Among the morbidities investigated, individuals with hypertriglyceridemia showed a positive and significant association with a crude pre-diabetes prevalence ratio that was 4.19 times higher (95%CI: 1.41-12.45), when compared to individuals with normal TG levels, the outcome remained significant even after adjusting for age and gender.

Regarding the other investigated morbidities, no significant associations were found with increased blood pressure levels and with the nutritional status of overweight or obesity. Likewise, in cases of large waist circumference, low consumption of fruits and vegetables and presence of CMD.

Table 4 presents data regarding the prevalence and the crude and adjusted prevalence ratio of individuals with prediabetes with the number of simultaneous risk factors. There was a positive and significant association, in a crude analysis, with a higher prevalence ratio of pre-diabetes in individuals who had 5 or more simultaneous risk factors (PR: 2.53; 95%CI: 1.05-6.05), compared with individuals with up to 4 risk factors. However, after adjustment, this association did not remain significant.

 https://doi.org/10.1590/1678-9865202235e220046

Table 4 – Prevalence and prevalence ratio of prediabetes by number of risk factors, Home Health Survey in *Piauí* (n=224). *Teresina* (PI), Brazil, 2018-2020.

Variables*	Prev. (%)	$_{gross}$PR	CI (95%)	*p*-value	$_{adjust.}$PR	CI (95%)	*p*-value
Up to 4 factors	6.15	1	-	-	1	-	-
5 or more factors	15.56	2.53	(1.05-6.05)	0.038	2.33	(0.98-5.55)	0.05

Note: ISAD 2018-2020. *Altered Body Mass Index, increased waist circumference, increased triglycerides level, low consumption of vegetables, low consumption of fruits, increased blood pressure, presence of common mental disorders. Prev: Prevalence, $_{gross}$PR: Gross Prevalence Ratio, $_{adjust.}$PR: PR adjusted by bivariate analysis (gender and age).

DISCUSSION

The prevalence of prediabetes found in the adult population of *Teresina, Piauí*, was 8.04% and was associated with factors such as lower education, increased levels of triglycerides and the presence of five or more simultaneous risk factors.

There are few studies in the literature that estimated the prevalence of pre-diabetes in the population of *Piauí*, this being the first home-based study to be carried out in the state capital. Actually, the studies available have evaluated fasting blood glucose in order to estimate the prevalence of pre-diabetes and diabetes in Brazil and in other countries [22-24].

Regarding the worldwide prevalence of prediabetes, comprehensive data on this metabolic condition are still unavailable [25]. However, in 2019, the International Diabetes Federation (IDF) estimated the global prevalence of impaired glucose tolerance as being 7.5% of the population aged between 18 and 99, of both genders. A total of 72.2% of those individuals lived in low- and middle-income countries. As for regions, North American and Caribbean countries exhibited a higher prevalence of impaired glucose tolerance individuals (13.8%), compared to the European region (5.1%) [26].

On the other hand, the IDF estimates do not include other data regarding the glucose profile, such as: glycated hemoglobin, 2 hours postprandial glucose after ingestion of 75 grams of glucose as well as fasting glucose, which causes an underestimation of the real prevalence of prediabetes in the world population, in relation to other glycemic parameters [26].

Data from the North American survey, entitled National Health and Nutrition Examination Survey carried out between 2015 and 2016, using the International Experts Committee criteria for glycated hemoglobin, and the ADA criteria for fasting blood glucose, showed a prevalence of 4.5% and 43.5%, respectively, of prediabetes in the adult population [25].

In Brazil, the PNS carried out in different regions of the country, and using different diagnostic criteria, showed that the prevalence of prediabetes in the adult population, according to the ADA and the *Sociedade Brasileira de Diabetes* (Brazilian Society of Diabetes) criteria, was 18.5%, and according to the World Health Organization/International Diabetes Federation/International Experts Committee criteria, it was 7.5%. In this study, at least 7.5% of the Brazilian population exhibited high blood glucose levels within the diagnostic criteria for prediabetes [5].

Most of the studies mentioned above showed different prevalences, differing from the present study. This divergence can be explained by the type of population and sample, since they are investigations carried out in populations from different regions with different assessment methods and larger size sample.

The most specific study, which used fasting blood glucose to estimate the prevalence of pre-diabetes, as in our study, was a population-based study carried out in the state of *Santa Catarina*, in which the prevalence of pre-diabetes was 26.4% in older adults [27]. In the aforementioned study, the prevalence

found was higher than that obtained in the present study, a fact that can be explained by the differences in the type of population, since the study evaluated individuals aged 60 years or older.

As for the association with sociodemographic variables, less education was more related to the prevalence and prevalence ratio of pre-diabetes, and this association was also observed in other cross-sectional studies carried out in different regions of Brazil and Ireland with adult populations [5,7,23]. The level of education is pointed out as an important socioeconomic indicator of an individual, and can imply different risks of illness and even mortality [28].

A less educated individual may choose inadequate food, physical inactivity and poor adherence to health services, which can contribute to an increase in blood glucose. Hence, the importance of education is enhanced for knowledgeable decision-making regarding a health situation [29], especially related to pre-diabetes and its implications in the health and disease process.

Regarding race/skin color, in the present study, individuals who self-reported as black had an inverse association with pre-diabetes compared to self-reported white individuals. Thus, this study is discrepant with the findings of other studies in which prediabetes was more prevalent in the self-reported black population [30,29]. It is important to highlight that in our study the race/skin color variable was self-reported this means that the study participants were free to answer this question, and they may have given answers that were not consistent with their reality. In addition, the sample size may be another factor associated with this divergence, since in the studies mentioned the sample population was larger than that of the present investigation, a fact that may be the cause of these different results.

Unlike other populations, Brazilians form a heterogeneous society, as a result of several centuries of miscegenation among European colonizers, African and indigenous people [22]. Just like Brazil, *Piauí* and the city of *Teresina* have large people's differences regarding race/skin color, and therefore the results of the present study may not be representative of the general population.

Regarding the metabolic markers of dyslipidemia, in the present study, the association of prevalence and prevalence ratio of pre-diabetes was observed in individuals with high triglycerides levels. Another study that also sought to assess and explain this association was a study carried out in a semi-urban Brazilian population, in which a statistically significant relationship between pre-diabetes and hypertriglyceridemia was observed [22]. This association can be explained by pathophysiological factors linked to insulin resistance, such as: altered glycemia, visceral adiposity and high inflammatory markers [31,32].

When blood glucose levels raise, insulin produced by the pancreatic beta cells increases, which can lead to insulin resistance and make it difficult to eliminate glucose. The metabolic consequences of this resistance can also raise the levels of blood triglycerides and other blood lipids, which is worrisome as it significantly increases the risk of cardiovascular disease [32].

Commonly, pre-diabetes is also associated with other risk factors, such as: systemic arterial hypertension, increased waist circumference, dyslipidemia, obesity, advanced age and a low-fiber diet with low consumption of fruits and vegetables [33-35]. In this study, these factors were analyzed separately and simultaneously. Although the majority did not present a significant association when analyzed separately, with the occurrence of five or more factors simultaneously, this association was significant. There are few studies that evaluate the simultaneous presence of different risk factors on prediabetes; what we found in the literature are studies that show the occurrence of simultaneous risk factors associated with cardiovascular diseases and non-communicable chronic diseases [36,37].

The most specific study that addresses simultaneous risk factors in pre-diabetes and that corroborated the findings of our investigation was carried out with data from the PNS [5]. In this study, the presence of five or more risk factors for prediabetes in the same individual increased the prevalence ratio by up to four times compared with individuals who exhibited only one risk factor.

Thus, the simultaneous occurrence of prediabetes risk factors can increase the risk of the individual developing this metabolic condition and subsequent type II DM [37]. Studies show the association of several risk factors with prediabetes, especially in individuals with obesity and exposed to behavioral and metabolic risk factors [38,33]. Among the behavioral factors, consumption of foods rich in saturated fats and refined carbohydrates can significantly contribute to raising blood glucose [39,40]. In contrast, in relation to the metabolites, insulin resistance, oxidative stress and pro-thrombotic and pro-inflammatory changes are linked to a reduced glucose tolerance and hyperglycemia, which can lead to the emergence of type II DM [41].

In addition, other factors are associated with hyperglycemia, such as high blood pressure and increased waist circumference. Although in this study we did not observe such association, research carried out in Brazil and in the world found a significant association between pre-diabetes and those metabolic risk factors [29,41,42]. This divergence between studies can be explained by the sample size, since in our study the sample size was smaller compared to that of other studies, a fact that may have interfered with the statistical significance of the results.

In addition to the factors mentioned, the present study also evaluated the association of prediabetes with the presence of CMD in the population studied, and found no statistically significant association between these variables. However, there are studies that revealed an association between mental illness and the occurrence of diabetes, with a higher risk of type II DM in individuals with depressive disorders [43,44].

Therefore, this study had as a limitation the type of investigation, since it was a cross-sectional investigation, which did not allow investigating the association of temporality with most of the variables studied. However, it identified several variables through validated questionnaires applied by trained interviewers. In addition, this study was carried out with high methodological rigor and obtained a good response rate from the investigation participants.

CONCLUSION

Prediabetes is a metabolic state that must be taken into account, and is associated with sociodemographic and metabolic factors such as less education, increased triglycerides and the presence of five or more risk factors simultaneously.

It is noteworthy that the associated factors identified in the present study are subject to intervention, emphasizing the importance of public policies aimed at promoting health of *Teresina* adult population with measures aimed at changes in life habits that culminate in glycemic control and prevention of diabetes *Mellitus* and its comorbidities.

ACKNOWLEDGMENTS

We are grateful to our colleagues and co-authors who participated in the preparation of this manuscript through critical reading and precious contributions that allowed improving this article quality.

CONTRIBUTORS

CHR LIMA contributed to the production, study, data analysis and preparation of the manuscript. SMRS DA PAZ contributed in data interpretation. LCC LAVÔR contributed to the review of data analysis. KMG FROTA contributed to the approval of the final version of the manuscript. AA PAIVA contributed to the review and approval of the final version of the manuscript.

REFERENCES

1. American Diabetes Association. Standards of medical care in diabetes. Diabetes Care. 2019;42(1):S1193.
2. Vas PRJ, Alberti KG, Edmonds ME. Prediabetes: moving away from a glucocentric definition. Lancet Diabetes Endocrinol. 2017;5(11):8489. https://doi.org/10.1016/S22138587(17)302346
3. Beulens J, Rutters F, Rydén L, Schnell O, Mellbin L, Hart HE, *et al.* Risk and management of prediabetes. Eur J Prev Cardiol. 2019;26(2):4754. https://doi.org/10.1177/2047487319880041
4. American Diabetes Association. Prevention or delay of type 2 diabetes: standards of medical care in diabetes 2020. Diabetes Care. 2020;43(1):S326. https://doi.org/10.2337/dc20S003
5. 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. Cien Saude Colet. 2021;26(2):531540. https://doi.org/10.1590/141381232021262.34852020
6 Arrais KR, Castro AGS, Alves MMS, Vieira IRL, Coelho BRB, Monteiro AKC, *et al.* Perfil sociodemográfico e clínico de indivíduos com Diabetes Mellitus em Teresina, Piauí. J Nurs Health. 2020;10(3):e20103009. https://doi.org/10.15210/jonah.v10i3.19019
7. Mendes Lúcio MC, Reis JS, Moreira AD, Horta Murta TG, Rosário PW. Factors associated to type 2 diabetes among employees of a public hospital in Belo Horizonte, Brazil. Rev Bras Med Trab. 2020;17(3):292-9. https://doi.org/10.5327/Z1679443520190395
8 Szwarcwald CL, Malta DC, Pereira CA, Vieira MLFP, Conde WL, Souza Junior PRB, *et al.* Pesquisa Nacional de Saúde no Brasil: concepção e metodologia de aplicação. Cien Saude Colet. 2014;19(2):33342. https://doi.org/10.1590/141381232014192.14072012
9. Lavôr LCDC, Sousa RRD, Rodrigues LARL, Rodrigues ODS, Paiva ADA, Frota KDMG. Prevalence of arterial hypertension and associated factors: a population-based study. Rev Assoc Med Bras. 2020;66(5):630636. https://doi.org/10.1590/18069282.66.5.630
10. COVID-19 Mental Disorders Collaborators. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. Lancet. 2021;398(10312):1700-12. https://doi.org/10.1016/S0140-6736(21)02143-7
11. Geraets AFJ, Köhler S, Muzambi R, Schalkwijk CG, Oenema A, Eussen SJPM, *et al.* The association of hyperglycaemia and insulin resistance with incident depressive symptoms over 4 years of follow-up: the Maastricht Study. Diabetologia. 2020;63(11):2315-28. https://doi.org/10.1007/s00125-020-05247-9
12. Rodrigues LARL, Silva DMC, Oliveira EAR, Lavôr LCC, Sousa RR, Carvalho RBN, *et al.* Plano de observação e aspectos metodológicos: inquérito de saúde domiciliar no Piauí. Rev Saude Publica. 2021;55:118. https://doi.org/10.11606/s1518-8787.2021055003441
13. Fisberg RM, Marchioni DML. Manual de Avaliação do Consumo Alimentar em estudos populacionais: a experiência do inquérito de saúde em São Paulo (ISA). São Paulo: Faculdade de Saúde Púbica da Universidade de São Paulo; 2012.
14. Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional de Saúde, 2013: acesso e utilização dos serviços de saúde, acidentes e violências: Brasil, grandes regiões e unidades da federação/IBGE, Coordenação de Trabalho e Rendimento. Rio de Janeiro: Instituto; 2015.
15. Ministério da Saúde (Brasil). Norma Técnica do Sistema de Vigilância alimentar e nutricional SISVAN: orientações para a coleta e análise de dados antropométricos em serviços de saúde. Brasília: Ministério; 2011.
16. World Health Organization. Waist Circumference and Waist–Hip Ratio: Report of a WHO Expert Consultation. Geneve: Organization; 2008.
17. Malachias MVB, Souza WKSB, Plavnik FL, Rodrigues CIS, Brandão AA, Neves MFT, *et al.* 7ª Diretriz Brasileira de Hipertensão Arterial: capítulo 2 diagnóstico e classificação. Arq Bras Cardiol. 2016;107:0713.
18. Faludi, AA. Atualização da diretriz brasileira de dislipidemias e prevenção da aterosclerose–2017. Arq Bras Cardiol. 2017;109:1-76.
19. World Health Organization. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation Geneve: Organization; 2003.
20. Beusenberg M, Orley J. A user's guide to the Self Reporting Questionnaire (SRQ). Geneve: World Heal Organ; 1994.

21. Gonçalves DM, Stein AT, Kapczinski F. Avaliação de desempenho do Self-Reporting Questionnaire como instrumento de rastreamento psiquiátrico: um estudo comparativo com o Structured Clinical Interview for DSM-IV-TR. Cad Saude Publica. 2008;24:380-90. https://doi.org/10.1590/S0102-311X2008000200017

22. Moreira NCV, Montenegro RM, Meyer HE, Bhowmik B, Mdala I, Siddiquee T, *et al.* Glycated Hemoglobin in the Diagnosis of Diabetes Mellitus in a Semi Urban Brazilian Population. Int J Environ Res Public Health. 2019;16(19):3598. https://doi.org/10.3390/ijerph16193598

23. Junker K, Buckley CM, Millar SR, Flynn S, Harrington JM, Kearney PM, *et al.* The prevalence and correlates ofpre-diabetes in middle- to older-aged Irish adults using three diagnostic methods. Plos One. 2021;16(6):e0253537. http://doi.org/10.1371/journal.pone.0253537

24. Andes LJ, Cheng YJ, Rolka DB, Gregg EW, Imperatore G. Prevalence of prediabetes among adolescents and young adults in the United States, 2005-2016. JAMA Pediatr. 2020;174(2):e194498. http://doi.org/10.1001/jamapediatrics.2019.4498

25. Echouffo-Tcheugui JB, Selvin E. Prediabetes and what it means: the epidemiological evidence. Annu Rev Public Health. 2021;1(42):59-77. http://doi.org/10.1146/annurevpublhealth-090419-102644

26. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, *et al.* IDF Diabetes Atlas Committee. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107843. https://doi.org/10.1016/j.diabres.2019.107843

27. Espanhol FZ, Cássia, RSM, Silvano GP, Manoel AL, Silveira LR, Schuelter-Trevisol F, *et al.* Prevalência de pré-diabetes em idosos: um estudo de base populacional. Scientia Medica. 2016;26(4):25246. http://dx.doi.org/10.15448/1980-6108.2016.4.25246

28. Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. Int J Epidemiol. 2011;40(3):804-18. https://doi.org /10.1093/ije/dyr029

29. Moraes HABD, Mengue SS, Molina MDCB, Cade NV. Fatores associados ao controle glicêmico em amostra de indivíduos com diabetes mellitus do Estudo Longitudinal de Saúde do Adulto, Brasil, 2008 a 2010. Epidemiol Serv Saude. 2020;29(3):2020. https://doi.org/10.5123/S1679-49742020000300017

30. Herman WH, Cohen RM. Racial and ethnic differences in the relationship between HbA1c and blood glucose: implications for the diagnosis of diabetes. J Clin Endocrinol Metab. 2012;97(4):1067-72. https://doi.org/10.1210/jc.2011-1894

31. Wu C, Yu P, Sun R. Adipose tissue and age dependent insulin resistance: new insights into WAT browning (Review). Int J Mol Med. 2021;47(5):71. https://doi.org/10.3892/ijmm.2021.4904

32. Freeman AM, Pennings N. Insulin Resistance. 2021 Jul 10. In: StatPearls [Internet]. Treasure Island: StatPearls Publishing; 2022.

33. Rossaneis MA, Andrade SMD, Gvozd R, Pissinati PDSC, Haddad MDCL. Fatores associados ao controle glicêmico de pessoas com diabetes mellitus. Cienc Saude Colet. 2019;24(3):9971005. https://doi.org/10.1590/1413812320182 43.02022017

34. Rajpal A, Rahimi L, Ismail Beigi F. Factors leading to high morbidity and mortality of COVID19 in patients with type 2 diabetes. J Diabetes. 2020;12(12):895908. https://doi.org/10.1111/17530407

35. Vlachos D, Malisova S, Lindberg FA, Karaniki G. Glycemic Index (GI) or Glycemic Load (GL) and dietary interventions for optimizing postprandial hyperglycemia in patients with T2 diabetes: a review. Nutrients. 2020;12(6):1561. https://doi.org/10.3390/nu12061561

36. Paulitsch RG, Dumith SC, Susin, LRO. Simultaneidade de fatores de risco comportamentais para doença cardiovascular em estudantes universitários. Rev Bras Epidemiol. 2017;20(4):624-35. https://doi.org/10.1590/1980-5497201700040006

37. Hirschmann R, Bortolotto CC, Martins-Silva T, Machado AKF, Xavier MO, Fernandes MP, *et al.* Simultaneidade de fatores de risco para doenças crônicas não transmissíveis em população rural de um município no sul do Brasil. Rev Bras Epidemiol. 2020;23:1-15. https://doi.org/10.1590/1980-549720200066

38. Malta DC, Duncan BB, Schmidt MI, Machado ÍE, Silva AGD, Bernal RTI, *et al.* Prevalência de diabetes mellitus determinada pela hemoglobina glicada na população adulta brasileira, Pesquisa Nacional de Saúde. Rev Bras Epidemiol. 2019;22(2):e190006. https://doi.org/10.1590/1980549720190006.supl.2

39. La Sala L, Pontiroli AE. Prevention of diabetes and cardiovascular disease in obesity. Int J Mol Sci. 2020;21(21):e8178. https://doi.org/10.3390/ijms21218178

40. La Sala L, Prattichizzo F, Ceriello A. The link between diabetes and atherosclerosis. Eur J Prev Cardiol. 2019;26:e1524. https://doi.org/10.1177/2047487319878373

41. Flores YN, Toth S, Crespi CM, Ramírez Palacios P, McCarthy WJ, Briseño Pérez A, *et al.* Risk of developing prediabetes or diabetes over time in a cohort of Mexican health workers. Plos One. 2020;15(3):e0229403. https://doi.org/10.1371/journal.pone.0229403

42. Lord J, Roberson S, Odoi A. Investigation of geographic disparities of prediabetes and diabetes in Florida. BMC Public Health. 2020;20(1):1226. https://doi.org/10.1186/s12889020093112

43. Sartorius N. Depression and diabetes. Dialogues Clin Neurosci. 2018;20(1):47-52. https://doi.org/10.31887/DCNS.2018.20.1/nsartorius

44. van Dijk SEM, Pols AD, Adriaanse MC, van Marwijk HWJ, van Tulder MW, Bosmans JE. Cost-effectiveness of a stepped care program to prevent depression among primary care patients with diabetes mellitus type 2 and/or coronary heart disease and subthreshold depression in comparison with usual care. BMC Psychiatry. 13;21(1):e402. https://doi.org/10.1186/s12888-021-03367-z

Received: March 3, 2022
Final version: August 31, 2022
Approved: September 28, 2022