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Social vulnerability associated with the self-reported diagnosis of type II diabetes: a multilevel analysis

Vulnerabilidade social se associa com o diagnóstico autorreferido de diabetes tipo II: uma análise multinível

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ABSTRACT: ***Objective:*** To analyze the contextual factors associated with type II diabetes mellitus in Belo Horizonte City. ***Methods:*** Cross-sectional study with 5,779 adults living in Belo Horizonte City, participating in the Risk and Protection Factors Surveillance System for Chronic Diseases through Telephone Survey (Vigitel), in 2008, 2009, and 2010. Multilevel regression models were used to test the association between contextual indicators of physical and social environments, and self-reported diagnosis of diabetes, adjusted for individual sociodemographic and lifestyle factors. Descriptive analyzes and multilevel logistic regression models were used, considering a 5% significance level. ***Results:*** The prevalence of diabetes was 6.2% (95%CI 5.54 – 6.92), and 3.1% of the variability of chance of presenting diabetes were explained by contextual characteristics. Living in areas with high density of private places for physical activity and high income was associated with a lower chance of having diabetes. The areas with high level of social vulnerability were strongly associated with the chance of presenting diabetes, adjusted for individual characteristics. ***Conclusion:*** Characteristics of physical and social environments were associated with the chance of diabetes occurrence. Urban centers with opportunities to adopt healthy behaviors can help to reduce the occurrence of diabetes and its complications.

Keywords: Diabetes mellitus. Social vulnerability. Multilevel analysis. Chronic disease.

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RESUMO: ***Objetivo:*** Analisar os fatores contextuais associados ao diabetes mellitus tipo II em Belo Horizonte (MG). ***Métodos:*** Estudo transversal com 5.779 adultos residentes em Belo Horizonte, participantes do Sistema de Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico, nos anos de 2008, 2009 e 2010. Foram utilizados modelos de regressão multinível para testar a associação entre indicadores contextuais do ambiente físico e social e diagnóstico autorreferido de diabetes, ajustados por fatores individuais sociodemográficos e de estilo de vida. Utilizaram-se análises descritivas e modelos de regressão logística multinível, considerando um nível de significância de 5%. ***Resultados:*** A prevalência de diabetes foi de 6,2% (IC95% 5,54–6,92), e 3,1% da variabilidade da chance de diabetes nas áreas de abrangência estudadas foi explicada por características contextuais. Residir em áreas com alta densidade de locais privados para prática de atividade física e com alta renda associou-se a menor chance de ter diabetes. As áreas com alto índice de vulnerabilidade social foram fortemente associadas ao diabetes, independentemente de características individuais. ***Conclusão:*** A ocorrência de diabetes está associada com as características do ambiente físico e social. Centros urbanos com oportunidades para adoção de comportamentos saudáveis podem ajudar a reduzir a ocorrência de diabetes e as suas complicações.

Palavras-chave: Diabetes mellitus. Vulnerabilidade social. Análise multinível. Doença crônica.

INTRODUCTION

Diabetes mellitus (DM) is a chronic non-communicable disease (NCD), considered an intervention priority by the World Health Organization (WHO) and the Action Plan for the Global Strategy for the Prevention and Control of NCD, 2011-2022.[1] DM causes an increase in the years of life lost due to premature death, adjusted for disability, and a reduction in quality of life, considered a significant health problem.[2]

The prevalence of type II diabetes mellitus (DM II) increased by 62% in the last decade. In 2019, roughly half a billion people (9.3% of adults between 20 and 79 years old) lived with diabetes worldwide, but half of these people do not know they have the disease.[3] The projection for 2040 is a prevalence of 10.4%, which represents nine billion people in the world.[4]

In Brazil, DM II accounted for almost 5% of the disease burden in 2008, with a rate of years of life lost adjusted for disability of 9.2 per thousand inhabitants.[5] According to a telephone survey in Brazilian capitals, the prevalence of DM went from 5.5% in 2006 to 7.4% in 2019. In 2019, its prevalence among women was higher (7.8%) in relation to men (7.1%), as well as higher in people aged 65 and over (23.0%).[6]

Understanding the factors associated to DM II is important to guide intervention policies.[7,8] Several studies have shown that sociodemographic, clinical, and unhealthy behavior characteristics are considered risk factors for this outcome.[9,10] However, risk factors at the individual level are not enough to understand the differences in both the prevalence and incidence of DM II in populations.[11]

Recent research suggests additional factors associated with DM II, including the physical and contextual characteristics of where individuals live.[12] Characteristics such as poverty level,[13] lower supply of green areas,[14,15] and greater offer of fast food chains have been associated with a higher prevalence of diabetes;[16] whereas residential environments with more options for physical activity were associated with a lower incidence of DM II.[17] A lower prevalence of diabetes was also observed in geographic places of higher income and education.[18]

Ecological approaches to study factors associated with diabetes have the advantage offered by analysis at the community level being able to better describe economic and social contexts in which individuals live and experience health-related situations.[19] In addition, these studies can also measure the relative importance of each factor by identifying the residual effects of contextual factors.[20]

Studies are still scarce, especially in developing countries. Exploring the topic in greater depth in locations that present differences in the historical process of urban centers formation and recent changes in physical and social environments, such as Brazil, is essential. Considering that, the present study assesses relations between different characteristics of both the built and social environments, using georeferenced information and data from a monitoring system for risk and protection factors for NCD, with a representative sample. The objective of the present study was to assess the contextual factors associated with DM II in Belo Horizonte City (Minas Gerais State).

METHODS

This is a cross-sectional study with data from adults living in Belo Horizonte City, capital of Minas Gerais State, Brazil. They were interviewed by the Risk and Protection Factors Surveillance System for Chronic Diseases through Telephone Survey (Vigitel), in 2008, 2009, and 2010. The complete and specific methodology of this system is available in previous publications.[21]

In 2008, 2009, and 2010, a total of 6,034 interviews were conducted by Vigitel in Belo Horizonte City. Of these interviews, 47 women were excluded (43 who were pregnant at the time of interview and four who did not know if they were pregnant), as well as people who did not inform their Brazilian Zip Code (CEP) data (175 had a blank CEP, one informed a zip code of another city, and 32 could not have their zip codes located). Thus, final sample was composed of 5,779 individuals.

The dependent variable was the self-reported diagnosis of DM II. Individuals who answered positively to the following question were considered diabetic: "Has any doctor ever told you that you have diabetes?"

For the purposes of this study, the area inside coverage area of the basic health unit *(area de abrangência da unidade basica de saude,* AAUBS) was assumed as a contextual unit, which is considered a geographical division delimited by policies of the Brazilian Unified Health System (SUS). To identify the participant's AAUBS, their ZIP codes located inside AAUBS.

To assess the characteristics of the AAUBS context, database with information on the physical and social environment of these areas was developed. This database was geocoded from the full addresses of places, made available by several commercial and government sources, and linked to Vigitel database.

As to independent variables, they were related to both the individual and the physical and social environments of AAUBS.

Individual variables were:

- Age group, whose age in years was categorized into: 18–24; 25–34; 35–44; 45–54; 55–64; 65 or over;
- Sex, categorized into: male and female;
- Education level, categorized into: study years (0–8 years; 9–11 years; 12 or more);
- Civil status: with partner or without partner (single, widowed, separated, and divorced);
- Ethnicity/skin color, categorized into: white, black, *pardo*, and others (Asian/indigenous);
- Perception of poor health: yes/no;
- Leisure physical activity (practice of at least 150 minutes/week of moderate intensity physical activity or at least 75 minutes/week of vigorous intensity physical activity), categorized into: yes and no;
- Smoking – smoking habits, regardless of the cigarettes number, frequency, and duration – categorized into: yes and no;
- Abusive alcohol consumption – consumption of five or more doses (man), or four or more doses (woman) of alcoholic drinks on a single occasion, at least once in the last 30 days – categorized into: yes and no;
- Consumption of fruits, vegetables, and greens – consumption in five or more times a day on five or more days a week, categorized into: yes and no;
- Consumption of sweetened soda – consumption sweetened soda on five or more days a week – categorized into: yes and no;
- Body Mass Index (BMI) – weight in kilograms divided by the square of height in meters – presented continuously.

Environmental variables were:

- Population density: population of the AAUBS coverage area/total area (km^2);
- Density of public places for physical activity: number of parks, squares and public lanes, and gyms in the city within the AAUBS coverage area/total area (km^2);
- Density of private places for physical activity: number of spaces for practicing sports, dance, gyms and sports social clubs in the AAUBS coverage area/total area (km^2);
- Homicide rate: (number of homicides in the AAUBS coverage area/population) × 10,000;
- Residential density: number of households in the coverage area/coverage area (km^2);
- AAUBS average family income: total income of people aged 10 or over, from AAUBS, divided by 10,000;
- Density of establishments with mainly healthy food for sale;
- Number of butchers, fish markets, fresh products, dairy products and cold cuts, and supply in the AAUBS coverage area/total area (km^2);
- Density of establishments with predominant sale of unhealthy food: number of establishments that sell sweets, candies, chocolates and similar products, snack bars, bars, street vendors, department stores and mini-markets in the AAUBS coverage area/total area (km^2);

- Density of establishments that sell both types of food: number of hypermarkets, supermarkets, restaurants and bakeries in the AAUBS coverage area/total area (km^2);
- AAUBS health vulnerability index.

For data analysis, multilevel logistic regression was used, considering the individual as unit at level 1 and the AAUBS as unit level 2. Modeling was carried out in three stages: the first included only the random intercept, in order to detect the existence of a contextual effect; the second included the individual variables; and the third included variables at the contextual level. The entry of individual and environmental variables in the multilevel model was organized considering $p < 0.20$ in the bivariate analyzes.

The variance partition coefficient (VPC) was quantified to examine the ratio of total variance attributed to the contextual level. The percentage of reduction in variance was calculated between the null model and each subsequent model, to assess the proportion of variance explained by the variables included in the model. The adjust of models was assessed with the Akaike Information Criterion, AIC), in which the best model had the lowest AIC.[22,23]

All analyzes were performed using the Stata 14.0 statistical package, and the weightings attributed to each individual were considered: the inverse of the telephone number lines in the respondent's home and the number of adults living in the respondent's home.[21] For the final model analysis, 5% significance level was considered.

The Vigitel implementation project was approved by the Ethics Committee of the Brazilian Ministry of Health. The present study was developed respecting Resolution No. 466/2012 of the National Health Council and is part of a project entitled "Inequalities in small geographical areas of NCD indicators, violence, and their risk factors", approved by the Research Ethics Committee of Universidade Federal de Minas Gerais.

RESULTS

Of the 5,779 individuals studied, 53.9% were female, 40.5% had zero to eight years of study, 54.1% were *pardo*/black, and 53.9% lived without a partner. The average age of participants was 42.2 years (SD = 16.32) (Table 1).

The prevalence of diabetes was 6.2% (95%CI 5.54–6.92). Among individual variables, increased age, presence of a partner, increased BMI, and poor self-perception of health were associated with a greater chance of presenting diabetes. On the other hand, higher levels of education, smoking habit, alcohol abuse, and soda consumption were associated with a lower chance of having DM II (Table 2). As to environmental variables, living in areas with a high family income and high density of private places for physical activity were factors associated with a lower chance of presenting diabetes (Table 2).

Table 3 presents the multilevel logistical models for diabetes. The variance of the null model ($\sigma 2u0 = 0.10$; $p < 0.05$) indicates that there is significant variability in the occurrence of diabetes in the AAUBS. The VPC of the null model was 0.031 (95%CI 0.012–0.074), that is, 3.1% of the total variance in the AAUBS.

When including the individual variables (Table 3) (model 2), increasing age, poor self-perceived health, and increasing BMI were significantly associated with a greater chance of having diabetes. In contrast, having higher education and consuming soda were significantly associated with a lower chance of diabetes (Table 3) (model 2).

With the inclusion of contextual variables, three different multivariate models were generated (Table 3) (models 3 to 5), since the contextual variables are highly correlated. After adjusting for individual characteristics, living in AAUBS with a high density of private places for physical activity and high income was significantly associated with a lower chance

Table 1. Characteristics of the study participants. Belo Horizonte City, Minas Gerais State. 2008–2010.

Characteristics	% (95%CI)
Sex	
Male	46.1 (44.5 – 47.6)
Female	53.9 (52.4 – 55.4)
Age group (years)*	**42.2 (± 16.32)**
18–24	14.6 (13.5 – 15.7)
25–34	24.6 (23.2 – 26.1)
35–44	20.0 (18.8 – 21.2)
45–54	17.4 (16.3 – 18.6)
55–64	11.9 (11.0 – 12.8)
> 65	11.5 (10.7 – 12.4)
Education (study years)*	**9.9 (± 5.02)**
0 to 8	40.5 (39.0 – 42.1)
9 to 11	35.2 (33.8 – 36.6)
12 or more	24.3 (23.1 – 25.5)
Civil status	
With partner	46.1 (44.5 – 47.6)
Without partner	53.9 (52.3 – 55.4)
Ethnicity/Skin color	
White	37.6 (36.2 – 39.1)
Black	7.9 (7.0 – 8.8)
Pardo	54.1 (52.5 – 55.6)
Others (Asian/Indigenous)	0.4 (0.2 – 0.6)

95%CI: 95% confidence interval; *mean and standard deviation.

Table 2. Unadjusted analysis of potential factors associated with the occurrence of diabetes. Belo Horizonte City, Minas Gerais State. 2008–2010.

Variables	OR (95%CI)
Individuals	
Age (years)	**1.06 (1.05 – 1.07)**
Female (Ref. male)	1.08 (0.89 – 1.32)
Education (Ref. 0 to 8 study years)	
9 to 11	**0.41 (0.32 – 0.54)**
12 or more	**0.26 (0.18 – 0.38)**
Skin color (Ref. White)	
Black	1.16 (0.76 – 1.78)
Black and *pardo*	1.23 (0.93 – 1.63)
Others (Asian and Indigenous)	2.29 (0.45 – 11.54)
Civil status (Ref. without partner)	**1.70 (1.34 – 2.16)**
Leisure-time physical activity (Ref. no)	0.89 (0.64 – 1.24)
Smoker (Ref. no)	**0.62 (0.40 – 0.96)**
Alcohol abuse (Ref. no)	**0.47 (0.32 – 0.70)**
BMI (kg/m^2)	**1.09 (1.07 – 1.12)**
Perception of poor health: (Ref no.)	**4.56 (3.27 – 6.35)**
Soda consumption (Ref. no)	**0.33 (0.21 – 0.51)**
Regular consumption of fruits and vegetables	1.29 (0.99 – 1.68)
Environmental	
Social environment	
Homicide rate (per 10,000 inhabitants)	1.03 (0.99 – 1.06)
Family income (BRL)	**0.99 (0.99 – 0.99)**
Health Vulnerability Index (HVI)	3.60 (0.92 – 13.99)
Physical environment	
Density of private places for PA practice (number/km^2)	**0.98 (0.96 – 0.99)**
Density of public places for PA practice (number/km^2)	0.99 (0.81 – 1.21)
Density of establishments that sell mainly healthy food;	1.00 (0.99 – 1.01)
Density of establishments that sell unhealthy food (number/km^2)	0.99 (0.99 – 1.00)
Density of establishments that sell both types of food (number/km^2)	0.99 (0.99 – 1.00)
Population density (inhabitants/km^2)	0.99 (0.99 – 1.00)
Population density (inhabitants/km^2)	0.99 (0.99 – 1.00)

OR: odds ratio; 95%CI: confidence interval; Ref.: reference; BMI: Body mass index; PA: physical activity.

Table 3. Multilevel logistic regression models for the presence of diabetes. Belo Horizonte City, Minas Gerais State, 2008–2010.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed effect					
Intercept (β; 95%CI)	-2.74 (-2.87 – 2.62)	-7.13 (-7.84 – -6.41)	-7.11 (-7.83 – -6.39)	-7.09 (-7.80 – -6.37)	-7.80 (-8.74 – -6.86)
Individuals					
Age (years old)		1.05 (1.05 – 1.06)	1.05 (1.05 – 1.06)	1.06 (1.05 – 1.06)	1.06 (1.05 – 1.06)
Education (Ref. 0 to 8 study years)					
9 to 11 study years)		0.92 (0.70 – 1.20)	0.96 (0.74 – 1.26)	0.99 (0.76 – 1.29)	1.00 (0.78 – 1.30)
12 or more study years		0.55 (0.38 – 0.82)	0.61 (0.42 – 0.89)	0.66 (0.46 – 0.96)	0.66 (0.43 – 1.01)
Perception of poor health		2.87 (2.03 – 4.06)	2.86 (2.02 – 4.06)	2.89 (2.04 – 4.09)	2.71 (1.90 – 3.88)
Soda consumption		0.51 (0.32 – 0.82)	0.51 (0.32 – 0.82)	0.52 (0.32 – 0.82)	0.51 (0.32 – 0.82)
BMI		1.08 (1.06 – 1.10)	1.08 (1.06 – 1.10)	1.08 (1.05 – 1.10)	1.08 (1.06 – 1.10)
Environmental					
Density of private places for PA practice (number/km^2)			0.97 (0.94 – 0.99)		
Family income (BRL)				0.99 (0.99 – 0.99)	
Health Vulnerability Index (HVI)					7.98 (1.29 – 49.42)
Random effect (σ^2u0) Coverage area					
Variance (95%CI) – intercept	0.10 (0.040 – 0.263)				
Variance partition coefficient (VPC) (95%CI)	0.031 (0.012 – 0.074)	0.036 (0.015 – 0.086)	0.030 (0.011 – 0.086)	0.021 (0.005 – 0.089)	0.024 (0.007 – 0.081)
AIC	2,667.79	2,262.45	2,261.07	2,255.99	2,253.25

β: beta coefficient; 95%CI: 95% confidence interval; Ref.: reference; BMI: Body mass index; PA: physical activity; AIC: Akaike information criterion; Model 1: null model; Model 2: model with individual variables; Models 3 to 6: models with individual and environmental variables.

of diabetes. On the other hand, individuals living in AAUBS with a high health vulnerability index (HVI) were associated with a higher chance of having diabetes.

After introducing contextual variables, a reduction in the VPC is observed, suggesting that they contribute to explaining the variability in the AAUBS. Table 3 also presents the results of AIC, showing reduced values when adding individual and contextual variables, which means that the inclusion of variables improves the model's adjust.

DISCUSSION

The study uses multilevel regression models to identify characteristics of the physical and social environments and individual variables associated with DM II in Belo Horizonte City. Individual variables associated with DM II were age, education, existence of a partner, overweight, and poor health perception. Additionally, an inverse relation between soda consumption, smoking, and alcohol abuse and DM II was shown, which can be explained by the lack of temporality between exposure and the outcome resulting from the cross-sectional design in this case. Diabetic patients are encouraged to reduce their consumption of sweetened beverages, as well as to adopt healthy behaviors, such as avoiding tobacco and alcohol consumption. These results are consistent with that of national and international literature.[6,24-37] Thus, the importance of age, low education, marital status, and the poor health perception and high BMI is evident in the development of DM II.

The present study identified that there are differences in the chances of DM II occurring in the AAUBS studied. These differences can be explained, in part, by characteristics of the physical and social environments. Among contextual variables, the number of private places for physical activity and high family income were associated with a lower chance of diabetes. Areas of greater social vulnerability were strongly associated with a greater chance of DM II. Thus, environment's characteristics can impact on the occurrence of this disease, regardless of individual attributes. Living in areas with a high density of private places for physical activity was found to decrease the chance of having diabetes. Previous studies have found that the greater the availability of resources for physical activity, the greater the practice of this activity.[24-26] The practice of physical activity can help in the prevention of chronic diseases, such as diabetes, with the stabilization of glycemic metabolism, weight control, and lower insulin resistance.[27] Thus, the existence of places for physical activity close to home can facilitate the practice of these activities.

Associations between the occurrence of diabetes and geographic areas with few opportunities for physical activity have been reported in other studies.[14,28] The association of physical activity with only private places may be related to the fact that these places offer more security and better structures when compared to public places, which are, for the most part, outdoors. In Brazil, insecurity and crime are increasing due to rapid urbanization. The greater the violence or insecurity, the fewer the options for places and the lesser the practice of physical activity is observed.[24,29,30] Therefore, unsafe locations are associated with socioeconomic deprivation.

Another important result of the present study was that the social context assessed with the HVI and family income was associated with the occurrence of DM II. Therefore, living in areas with greater social vulnerability and low income can potentially increase the chance of DM II. An explanation for these results is related to the effect of socioeconomic deprivation in lifestyles. Studies show that, especially in low and middle income countries, and to a lesser extent in developed countries, neighborhoods with less social vulnerability have a higher density of places that sell healthy food, and these places have greater variety and quality of this type of food.[31,32] On the other hand, more socioeconomically vulnerable neighborhoods have fewer places that sell healthy food, with less variety.[31] Besides that, healthier eating patterns are associated with higher socioeconomic positions and healthier behaviors.[33] Socioeconomic variables showed greater magnitude, highlighting the importance of contextual factors and social determinants in the prediction of NCD.[34] Similarly, studies have shown that areas with greater socioeconomic deprivation have fewer options for places to practice physical activity.[24,29,30]

There are some limitations to highlight in the present study. The first is the impossibility of establishing cause and effect relations. The diagnosis of self-reported diabetes may overestimate or underestimate outcome's prevalence. On the other hand, direct measurements, obtained with laboratory tests, are difficult to be carried out in large populations, in addition to being costly. In addition, a validity and reproducibility study of data was carried out comparing measures obtained through self-reports, with measures indicating good results and data reliability.[38] Another limitation is that contextual data come from commercial and government sources, and may be subject to inaccuracies. However, results are consistent with most of the literature, demonstrating the internal validity of the results found herein.

Strength points of the present study are its pioneering aspect in Brazil. It also uses the multilevel analytical methodology. Multilevel analysis incorporates objective characteristics of environments (physical and social) in the analysis and, thus, verifies the importance of each one of them for diabetes. Moreover, the use of information from a large Brazilian urban center stands out, based on a database derived from an important national system for monitoring the risk and protection factors for NCD. Therefore, the study can expand the discussion on aspects of health promotion and prevention from a more comprehensive perspective.

Research showed that a greater chance of occurrence of DM II was associated with the characteristics of the physical and social environments of AAUBS, such as: lower density of private places for practicing physical activity, lower family income, and higher index of social vulnerability, regardless of individual characteristics. Thus, health strategies to reduce DM II can be beneficial and more effective if they consider both the context in which the individual lives and individual characteristics. Better-organized urban centers with ample opportunities for adopting healthy behaviors can help to reduce social inequities, as well as the progression and complications of preventable chronic diseases, such as DM II, in urban communities.

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