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Perception of neighborhood disorder and blood pressure in adults: a multilevel population-based study

Percepção das desordens de bairro e pressão arterial em adultos: um estudo multinível de base populacional

Percepción sobre desórdenes en barrios y presión arterial en adultos: un estudio multinivel con base poblacional

Carla Zanelatto [1]
Doroteia Aparecida Höfelmann [2]
Maruí Weber Corseuil Giehl [3]
Waleska Nishida [1]
João Luiz Bastos [1]

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Abstract

The aim of this study was to verify whether the perception of neighborhood physical and social disorder is associated with increased systolic (SBP) and diastolic blood pressure (DBP), as well as to examine the influence of the residential census tract's socioeconomic status on this association. This was a cross-sectional study that included a representative sample of 1,720 adults 20 to 59 years of age living in Florianópolis, Santa Catarina State, Brazil. Two blood pressure measurements were taken, and information was collected on the perception of neighborhood disorder. The contextual variable was the mean head-of-household's years of schooling in the selected census tracts. Statistical analysis included multilevel models with the first level represented by individuals and the second by census tracts. Interaction terms were examined between schooling tertiles in the census tract and tertiles of perception of neighborhood disorder on blood pressure. No statistically significant overall associations were identified between neighborhood disorder and SBP or DBP. However, the study showed a mean increase in SBP of 7.88mmHg (95%CI: 1.38; 14.40) in subjects that perceived more neighborhood disorder and lived in census tracts with less schooling, when compared to the reference category. Public policies aimed at lowering or that have an impact on SBP and DBP in the population should also address the characteristics of the context where the population lives, specifically in contexts marked by lower levels of schooling.

Arterial Pressure; Urban Health; Multilevel Analysis

Correspondence
C. Zanelatto
Programa de Pós-graduação em Saúde Coletiva, Centro de Ciências da Saúde, Universidade Federal de Santa Catarina. Rua Delfino Conti s/n, Florianópolis SC 88036-020, Brasil.
carlaz_nutri@hotmail.com

[1] Centro de Ciências da Saúde, Universidade Federal de Santa Catarina, Florianópolis, Brasil.
[2] Departamento de Nutrição, Universidade Federal do Paraná, Curitiba, Brasil.
[3] Departamento de Ciências da Saúde, Universidade Federal de Santa Catarina, Araranguá, Brasil.

Introduction

High blood pressure is one of the most relevant risk factors for morbidity and mortality related to cardiovascular diseases such as acute myocardial infarction, chronic renal failure, and stroke, and there are multiple individual biological, behavioral, and sociodemographic factors (e.g., income and schooling) related to its pathogenesis [1]. Associated nutritional factors include high sodium and alcohol intake and excess body weight [2,3,4]. Recent studies have also shown that altered blood pressure levels may be related to other factors not exclusively at the individual level, such as contextual or environmental characteristics, including their perception about social and physical disorder in the neighborhood [5,6].

The potential mechanisms for the effect of social and physical disorder on health include limited access to resources promoting physical activity and healthy eating, in addition to chronic stress and discouragement of physical activity. Evidence suggests that exposure to social disorder in the neighborhood (vandalism, theft, robberies, muggings, homicides, and kidnappings) can lead to individuals' perception that the environment poses a constant threat, triggering physiological responses linked to increased blood pressure. These responses include modification of the sympathetic nervous system and increased production of hormones like cortisol [7,8]. Thus, exposure to sources of stress along with fewer opportunities and resources for treatment can result in rising blood pressure.

Previous studies have shown an association between lack of safety in neighborhoods and high blood pressure. Malambo et al. [5] conducted a cross-sectional study of 671 South African adults over 35 years of age and found that those who perceived their neighborhood as exposed to crime showed higher odds of hypertension (OR = 1.44; 95%CI: 1.03; 2.02). A study by Kaiser et al. [9] with 3,382 adults 45-84 years of age in six different locations in the United States and covering ten years (2000-2011) found that those who developed hypertension lived in areas that were less favorable to physical activity and with lower presence of healthy foods. In particular, after adjusting for sociodemographic variables, a healthy food environment (fostering the adoption of adequate eating habits and physical activity) was inversely associated with the development of systemic arterial hypertension (HR = 0.95; 95%CI: 0.89; 1.00). A possible explanation for this finding is that the presence of alternative routes, bike lanes, and parks, as well as healthy food outlets in the neighborhoods allow physical activity and the consumption of healthy foods, with a reduction in hypertension.

Understanding the way context affects blood pressure is relevant for the development of public policies to prevent hypertension. The existing initiatives have particularly targeted the individual characteristics involved in this process, which is necessary but insufficient to deal with the problem. For example, in 2001 the Brazilian Ministry of Health [10] proposed the Plan for the Reorganization of Health Care for Hypertension and Diabetes, supplying states and municipalities with a computerized system called HiperDia. The proposal, aimed at guaranteeing diagnosis and the patient's linkage to basic health units, essentially addresses education, lifestyle changes, and medication as strategies to treat the disorder.

In 2008 the Ministry of Health proposed guidelines and recommendations for comprehensive care for noncommunicable diseases (NCDs) [11], including the first official mention in Brazil that behavioral risk factors are potentiated by environmental factors. However, there was no explanation of what these factors were, and neither were interventions proposed to address the effects of residential context on hypertension. This emphasizes the need for studies highlighting the role of context on blood pressure in order to develop measures to deal with this health problem.

Beyond government policies and measures to deal with hypertension, the scientific literature is still incipient on the relationship between neighborhood disorder and hypertension [5,9,12]. A major limitation is that most studies consulted in the literature were conducted in high-income countries, and the results may differ from those in middle and low-income countries due to the diverse contextual characteristics. In particular, there may be interference in people's perception of neighborhood issues in light of ethnic composition, culture, and socioeconomic conditions, thus requiring the study of different communities [13]. One should also assume that the infrastructure for physical exercise, safety, social support, and protection from pollution in high-income countries differs from that of middle-income countries like Brazil, which also displays striking social inequalities [14].

Low schooling level in the neighborhood, a marker of low socioeconomic status, is an important factor that can independently increase the size of negative effect on health through physical and

social disorder, in addition to other neighborhood and individual economic factors. This is because residents of neighborhoods in areas characterized by lower schooling in the census tract are generally more exposed to stressors like crime and worse physical and social infrastructure [15,16].

On the other hand, higher average schooling level in the census tract may reflect the residents' knowledge of the importance of investing in resources to improve the neighborhood's recreation, safety, and infrastructure, in addition to favoring the residents' collective mobilization for common benefits. Such collective movements may thus have a positive impact on residents' health [17].

Studies in different contexts and with comparable methods are useful and necessary because they allow monitoring and identifying relevant differences and similarities between cities and/or countries, besides informing the future effectiveness of specific interventions in the neighborhoods. The results of such research can also contribute to the identification of the population at risk of developing hypertension. The current study thus proposes to verify whether the perception of physical and social disorder in the neighborhood is associated with increased systolic (SBP) and diastolic blood pressure (DBP), as well as to examine the influence of the census tract's socioeconomic status on this association in a city in the South of Brazil.

Methods

This was a cross-sectional population-based study nested in a longitudinal survey entitled the EpiFloripa Adult Study, whose baseline was conducted from September 2009 to June 2010. The study included a representative sample of adults 20 to 59 years of age living in the urban area of Florianópolis, capital of Santa Catarina State, Brazil. The city has a population of 485,000 according to projections by the Brazilian Institute of Geography and Statistics (IBGE) for 2017 (Panorama de Florianópolis, 2017. https://cidades.ibge.gov.br/brasil/sc/florianopolis/panorama, accessed on Mar/2018).

The sample for EpiFloripa was determined according to the following parameters: unknown prevalence of the outcome (50%), 95% confidence interval (95%CI), sampling error of 3.5 percentage points, design effect of 2.0 (due to the cluster sampling), plus 10% for possible losses and/or refusals. An additional 15% was added to the final sample size to allow controlling confounding factors in multivariate analyses, resulting in a sampling size of 2,016 adults [18]. Sixty of the city's 420 urban census tracts were selected, organized according to the deciles of the head-of-family's income (ranging from BRL 192.80 to BRL 13,209.50) [19]. A systematic sample was selected with six census tracts in each income decile. All the selected census tracts were visited by the fieldwork team, having previously numbered the residential blocks. To decrease the coefficient of variation in the number of households between the census tracts, the tracts were merged and divided again. This process resulted in 63 census tracts with 16,755 eligible households. Eighteen households were selected systematically in each tract, totaling 1,134 households and an average of 32 adults selected in each census tract.

Eligibility and exclusion criteria, losses, and refusals

All adults 20 to 59 years of age living in the selected households in each tract were considered eligible. Individuals were excluded if they presented physical or cognitive disabilities that prevented answering the questionnaire. Pregnant women and women who had given birth in the six months prior to the study did not have their blood pressure measured. Individuals that declined to participate in the interview were defined as refusals. Individuals not located in the selected households after four visits, with at least one on the weekend and one in the evening, were defined as losses.

Data collection and pilot study

The data were collected by 35 interviewers/examiners who had undergone a training and standardization process before conducting the fieldwork. Prior to the data collection, a pilot study was conducted with 100 adult individuals residing in two census tracts selected intentionally and that were not included in the cohort's baseline.

Outcome

The study's outcome variables were SBP and DBP, obtained with two blood pressure measurements taken during the visit. Resting time prior to the blood pressure measurements was at least 30 minutes, and the interval between the two measurements was approximately 15 minutes. The SBP and DBP values (in mmHg) were obtained with an electronic pulse sphygmomanometer with digital readout (Techline, São Paulo, Brazil), previously calibrated by the Brazilian National Institute of Metrology, Standardization, and Industrial Quality (INMETRO). During the blood pressure measurements, each participant remained sitting with their feet on the floor, arm resting on a table and level with the heart, palm turned upward [20]. The statistical analysis explored the outcome as continuous, with the mean of the two measurements as the reference [1,21].

Principal exposure

The perception of problems with neighborhood disorder was investigated using the answers to a 16-item list adapted from Ellaway et al. [22]. The complete process of cross-cultural adaptation to Portuguese and the construction of scales for perception of neighborhood disorder are described in detail in Höfelmann et al. [23]. The variables were grouped in two dimensions: (1) social disorder (vandalism, theft, robbery, mugging, homicide, kidnapping, illegal drug use, hazardous walking in the area after dark, bad reputation, and problems with the police) and (2) physical disorder (presence of garbage, irregular sidewalks, speeding, and urban transportation) [24]. The set of items was operationalized in three different ways: (a) the overall sum of the physical and social disorder items; (b) sum of the physical disorder items; and (c) sum of the social disorder items. Multilevel models (three levels) were used to develop the scales, leading to bayesian estimates, used to transform individuals' perceptions of the neighborhoods into group-level variables [22,25]. Level 1 referred to individual items, level 2 to persons grouped inside neighborhoods, and level 3 the neighborhoods. For the analyses, the perception scales were divided into tertiles: lower tertile (fewer problems in the neighborhood); intermediate and upper tertiles (more problems in the neighborhood) [23].

Covariables

The individual-level covariables included gender, age (20-29; 30-39; 40-49; 50-59 years), schooling (≤ 4 years, 5-8 years, 9-11 years, and ≥ 12 years), total monthly household income (divided into tertiles: first tertile – BRL 0.00-BRL 2,000.00; second tertile – BRL 2,050.00-BRL 4,000.00; third tertile – BRL 4,018.00-BRL 100,000.00) – and use of antihypertensive medication in the 30 days prior to the data collection (yes or no). All the covariables were collected during the interviews. Gender was observed and noted by the interviewer, and age was calculated from date of birth, while total monthly household income was recorded during application of the questionnaire.

Contextual variable

The contextual variable was mean head-of-household's years of schooling in each of the census tracts [19]. This variable was divided into tertiles. Data were collected from the 2000 *Brazilian Population Census* (IBGE. http://www.ibge.gov.br) for each of the 63 census tracts.

Statistical analyses

Stata statistical package version 13.1 (https://www.stata.com) was used for the analyses. Initially, a descriptive statistic of the sample was performed according to individual and contextual characteristics. The variables were included stepwise in groups, in a sequence of multilevel linear regression models, with the first level consisting of individuals and the second level consisting of census tracts. These models were adjusted to test the association between the perception of neighborhood disorder and SBP and DBP, jointly with the selected covariables, including the contextual variable (mean head-of-family's schooling). The analyses were corrected for design effect and sampling plan for the estimates

of prevalence rates, and the multilevel models considered the complex sampling design (weights and clusters) in the calculation of the standard errors, confidence intervals, and probability values.

From the empty model with the intercept, the variables were included in the analysis in blocks, with three models for each outcome in total. Model 1 was adjusted for the demographic variables (gender, age), while in model 2 the adjustment was by family income and schooling, in addition to gender and age. Finally, model 3 included a health status variable (use of antihypertensive medication), along with the variables listed in model 2. All the models included the principal exposure (perception of physical and social disorder in the neighborhood) in the analysis.

The Akaike (AIC) and Bayesian information criteria (BIC) were used to assess the models' fit, and intraclass correlation (ICC) of the multilevel linear regression was calculated for each model as follows: variance of level 2/(variance of level 2 + variance of level 1). This measure provides an estimate of the total variance in blood pressure attributed to the census tract's level and explained by each model. The fixed effects with their 95%CI as well as the random effects were also calculated and presented for each model. All the study's associations were examined in the context of multilevel regression models, and specifically the modifying effect of the census tract's schooling on the principal target association was tested by inserting interaction terms in the analysis. In particular, the p-values of the interaction tests were adjusted by the Bonferroni algorithm, considering $p < 0.001$ as statistically significant interaction.

Ethical aspects

All the participants received and signed a free and informed consent form explaining the study's objectives and potential risks. The study was approved by the Ethics Research Council of Federal University of Santa Catarina (UFSC), under protocol 351/08 of December 15, 2008.

Results

The final sample consisted of 1,720 adults, which represented 85.3% of the initially calculated sample (2,016 adults). The majority of participants were women (55.3%) and had 12 years of schooling or more (44.2%). Mean age was 38.0 years (SD = 11.6). Table 1 describes the entire sample. Mean SBP and DBP were 133.0mmHg (SD = 19.7) and 85.0mmHg (SD = 14.1), respectively (information not shown in the table).

Table 2 shows the overall effect of each principal independent variable on blood pressure. In relation to SBP, compared to the null model, the intraclass correlation decreased by 1.5%, both for the overall scale and for physical and social disorder, while there was a 2.2% increase in intraclass correlation for DBP when the effect of physical disorder was analyzed. In the upper tertile of social disorder, SBP and DBP were 0.53mmHg (95%CI: -3.18; 2.09) and 0.25mmHg (95%CI: -1.57; 2.07) higher than in the lower tertile, respectively, although neither difference reached statistical significance ($p < 0.05$).

As for the effect of physical disorder, SBP levels in the intermediate and upper tertiles were, respectively, 1.76mmHg (95%CI: 0.58; 4.11) and 1.26mmHg (95%CI: -1.00; 3.53) higher than in the lower tertile in model 3, although these results were not statistically significant. The intraclass correlation was 8.5 for model 1 (adjusted for gender and age), and there was a reduction of 15.3% when use of antihypertensive medication was included in model 3 (Table 3). There was also an increase in DBP among participants from the intermediate and upper tertiles of disorder, as well as a 9.8% reduction in intraclass correlation when medication was included in model 3 (Table 4).

In relation to the overall and social disorder scales, there were no statistically significant findings in the multilevel linear regression models (Tables 3 and 4). Still, after application of the multiple comparisons command with Bonferroni adjustment, persons from the upper tertile in the overall disorder scale and those living in census tracts with lower average schooling showed mean SBP that was 7.88mmHg higher (95%CI: 1.38; 14.40, $p = 0.004$) than persons that perceived intermediate levels of overall disorder and lived in neighborhoods with higher average schooling in the census tract. This result suggests possible interaction between average schooling in the census tract and perception of social disorder in the neighborhood.

The models were also tested for the outcome classified as high versus low blood pressure according to the current guidelines of the Brazilian Society of Cardiology [21], which define hypertension as SBP ≥ 140mmHg and/or DBP ≥ 90mmHg. The models were also explored with the new classification of hypertension proposed by Whelton et al. [26], as follows: stage 1 hypertension (SBP: 130-139mmHg or DBP: 80-89mmHg) and stage 2 hypertension (SBP: ≥ 140mmHg or ≥ 90mm Hg). No contextual effect or significant result was observed for any of the strategies for operationalization of the outcome.

Discussion

No statistically significant associations were identified in the study sample between neighborhood disorder and SBP or DBP, even after including the use of antihypertensive medication in the analysis. A possible explanation is the quality of the collected data. Blood pressure was measured by trained examiners with calibrated equipment, but the use of antihypertensive medication was self-reported by the participants. Studies indicate that this self-report measure should be used with caution, since it may underestimate the use of medication [27,28].

Such underestimation may have occurred in the present study, in which few participants reported using medication for hypertension (only 5.8%). Antihypertensive medication aims to help maintain SBP and DBP pressure within adequate levels to preserve the individual's health. In the current study, some participants may have reported not using antihypertensive drugs when they actually were on such medication and would have presented normal blood pressure, thus attenuating the estimated of effect of neighborhood disorder on blood pressure.

Table 1

Descriptive characteristics of the study participants. Florianópolis, Santa Catarina State, Brazil, 2009/2010.

Variables	n	%	95%CI
Gender			
Male	734	44.7	42.5; 46.9
Female	909	55.3	53.1; 57.4
Age (years)			
20-29	524	31.9	27.9; 36.1
30-39	378	23.0	20.4; 25.8
40-49	422	25.7	22.7; 28.9
50-59	319	19.4	17.2; 21.9
Schooling (years)			
0-4	148	9.0	6.8; 11.7
5-8	228	13.9	11.3; 17.0
9-11	541	32.9	28.5; 37.6
≥ 12	726	44.2	37.3; 51.3
Family income			
First tertile (BRL 0-2,000)	623	37.9	31.8; 44.5
Second tertile (BRL 2,050-4,000)	498	30.3	26.9; 34.0
Third tertile (BRL 4,018-100,000)	522	31.8	25.8; 38.4
Use of medication for hypertension			
No	1,548	94.2	92.8; 95.3
Yes	95	5.8	4.6; 7.2
Total	1,643		

95%CI: 95% confidence interval.

Table 2

Overall effect of neighborhood disorder on systolic (SBP) and diastolic blood pressure (DBP). Florianópolis, Santa Catarina State, Brazil, 2009/2010 (N = 1,643).

	SBP Coefficient (95%CI)	DBP Coefficient (95%CI)
Null model		
AIC	415,925.0	385,062.9
BIC	415,941.2	385,079.1
Intercept	133.0 (131.5; 134.6)	85.0 (84.0; 86.0)
ICC (%)	6.8	4.6
Variance level-1	24.1	8.3
Variance level-2	363.2	191.4
Overall disorder scale		
Lower tertile	Reference	Reference
Intermediate tertile	-0.35 (-3.03; 2.32)	-0.16 (-1.95; 1.92)
Upper tertile	-0.75 (-3.57; 2.06)	-0.13 (-2.00; 1.74)
AIC	415,919.0	385,066.3
BIC	415,946.0	385,093.3
Intercept	133.4 (131.2; 135.6)	85.0 (83.5; 86.6)
ICC (%)	6.9	4.6
Variance level-1	24.3	8.3
Variance level-2	363.5	191.4
Physical disorder		
Lower tertile	Reference	Reference
Intermediate tertile	0.69 (-1.95; 3.34)	-0.10 (-2.13; 1.93)
Upper tertile	-0.37 (-2.96; 2.21)	-0.23 (-1.97; 1.52)
AIC	415,905.1	385,065.3
BIC	415,932.2	385,092.3
Intercept	132.9 (131.0; 134.8)	85.1 (83.6; 86.6)
ICC (%)	6.9	4.7
Variance level-1	24.2	8.3
Variance level-2	363.4	191.4
Social disorder		
Lower tertile	Reference	Reference
Intermediate tertile	-0.39 (-2.59; 1.80)	-0.84 (-2.53; 0.85)
Upper tertile	0.54 (-3.18; 2.09)	0.25 (-1.57; 2.07)
AIC	415,923.3	385,015.1
BIC	415,950.4	385,042.2
Intercept	133.3 (131.4; 135.3)	85.2 (83.7; 86.7)
ICC (%)	6.9	4.6
Variance level-1	24.2	8.2
Variance level-2	363.6	191.2

95%CI: 95% confidence interval; AIC: Akaike information criterion; BIC: Bayesian information criterion; ICC: intraclass correlation.

In high-income countries, findings from previous studies showed an association between lack of safety and worse infrastructure in neighborhoods and high blood pressure. A study in the Netherlands with 1,322 participants (Turkish, Dutch, and Moroccan individuals) 18 to 65 years of age found that after adjusting for age, gender, schooling, and body mass index among Turkish individuals, high neighborhood crime rates and annoyance from motor vehicle traffic were associated with higher

Table 3

Multilevel linear regression models for association between perception of neighborhood disorder and systolic blood pressure (SBP), adjusted for covariables. Florianópolis, Santa Catarina State, Brazil, 2009/2010 (N = 1,643).

	Model 1 Coefficient (95%CI)	Model 2 Coefficient (95%CI)	Model 3 Coefficient (95%CI)
Overall scale of disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	0.60 (-1.99; 3.19)	0.59 (-2.07; 3.25)	0.51 (-1.94; 2.96)
Upper tertile	0.69 (-1.96; 3.33)	0.77 (-1.85; 3.37)	0.92 (-1.67; 3.52)
AIC	408,630.7	408,072.0	406,231.6
BIC	408,679.3	408,147.7	406,312.6
Intercept	148.5 (145.0; 152.0)	151.2 (146.6; 155.9)	151.1 (146.5; 155.6)
ICC (%)	8.6	7.2	7.3
Variance level-1	25.4	22.0	21.0
Variance level-2	307.0	304.0	293.0
Physical disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	1.55 (-0.84; 3.94)	1.82 (-0.59; 4.24)	1.76 (-0.58; 4.11)
Upper tertile	0.91 (-1.37; 3.19)	1.16 (-1.12; 3.44)	1.26 (-1.00; 3.53)
AIC	408,591.1	408,013.8	406,180.2
BIC	408,639.8	408,089.4	406,261.3
Intercept	147.9 (144.3;151.4)	150.8 (145.9; 155.6)	150.6 (145.8; 155.4)
ICC (%)	8.5	7.0	7.2
Variance level-1	25.2	21.7	20.7
Variance level-2	306.4	303.7	292.2
Social disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	0.37 (-1.71; 2.46)	0.22 (-1.85; 2.29)	0.50 (-1.47; 2.48)
Upper tertile	0.28 (-2.18; 2.75)	0.18 (-2.18; 2.54)	0.49 (-1.96; 2.93)
AIC	408,164.7	407,604.4	405,763.2
BIC	408,213.3	407,680.1	405,844.3
Intercept	148.4 (145.3; 151.4)	151.5 (146.9; 156.2)	151.2 (146.6; 155.8)
ICC (%)	8.7	7.3	7.4
Variance level-1	25.6	22.2	21.2
Variance level-2	307.0	304.3	292.8

95%CI: 95% confidence interval; AIC: Akaike information criterion; BIC: Bayesian information criterion; ICC: intraclass correlation.

Note: Model 1: adjusted for gender, age; Model 2: adjusted for gender, age, family income, schooling; Model 3: adjusted for gender, age, family income, schooling, and use of medication for hypertension.

DBP (β = 2.96; 95%CI: 0.71; 5.20 and β = 2.83; 95%CI: 0.60; 5.06, respectively) [29]. Another study in the United States with 2,612 individuals 45 to 85 years of age found that residents of neighborhoods with better perceived safety were less prone to hypertension (OR = 0.74; 95%CI: 0.63; 0.86) [30]. Studies have also mentioned the potential protective effect of an environment that favors access to proper resources for physical activity. Malambo et al. [5], in a study with 671 adults in South Africa, observed that the likelihood of hypertension was significantly lower in persons that perceived the neighborhood infrastructure as favorable for walking and cycling (OR = 0.65; 95%CI: 0.46; 0.90). Likewise, Li et al. [12] found lower SBP and DBP in residents of neighborhoods with favorable conditions for walking.

Table 4

Multilevel linear regression models for the association between perception of neighborhood disorder and diastolic blood pressure (DBP), adjusted for covariables. Florianópolis, Santa Catarina State, Brazil, 2009/2010 (n=1643).

	Model 1 Coefficient (95%CI)	Model 2 Coefficient (95%CI)	Model 3 Coefficient (95%CI)
Overall scale of disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	0.64 (-1.19; 2.46)	0.61 (-1.31; 2.53)	0.56 (-1.23; 2.35)
Upper tertile	0.62 (-1.06; 2.33)	0,62 (-1.02; 2.27)	0.74 (-0.91; 2.39)
AIC	379,872.5	379,405.9	377,905.9
BIC	379,921.2	379,481.5	377,986.9
Intercept	91.8 (89.2; 94.4)	92.3 (88.8; 95.9)	92.2 (88.7; 95.7)
ICC (%)	6.1	5.2	5.4
Variance level-1	9.9	8.8	8.6
Variance level-2	168.7	167.4	162.1
Physical disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	0.40 (-1.48; 2.27)	0.52 (-1.40; 2.44)	0.48 (-1.42; 2.39)
Upper tertile	0.43 (-1.22 ;2.08)	0.50 (-1.13; 2.14)	0.57 (-1.03; 2.18)
AIC	379,885.2	379,413.3	377,915.9
BIC	379,933.8	379,489.0	377,997.0
Intercept	91.9 (89.2; 94.6)	92.4 (88.5; 96.3)	92.3 (88.5; 96.1)
ICC (%)	6.1	5.3	5.5
Variance level-1	9.9	8.9	8.7
Variance level-2	168.7	167.4	162.1
Social disorder			
Lower tertile	Reference	Reference	Reference
Intermediate tertile	-0.30 (-1.80; 1.19)	-0.44 (-1.94; 1.06)	-0.24 (-1.71; 1.23)
Upper tertile	0.67 (-1.03; 2.37)	0.60 (-1.03; 2.24)	0.81 (-0.86; 2.48)
AIC	379,391.5	378,928.1	377,429.7
BIC	379,440.1	379,003.7	377,510.7
Intercept	92.1 (89.8; 94.5)	92.7 (89.2; 96.2)	92.4 (89.0; 95.9)
ICC (%)	6.0	5.3	5.4
Variance level-1	9.8	8.8	8.6
Variance level-2	168.8	167.4	162.2

95%CI: 95% confidence interval; AIC: Akaike information criterion; BIC: Bayesian information criterion; ICC: intraclass correlation.

Note: model 1: adjusted for gender, age; model 2: adjusted for gender, age, family income, schooling; model 3: adjusted for gender, age, family income, schooling, and use of medication for hypertension.

The lack of association between perception of neighborhood disorder and high blood pressure in the EpiFloripa study can be attributed partly to the fact that Florianópolis is a typical Brazilian city, characterized by the contrast between impoverished areas neighboring on wealthy areas. This may influence individual responses, so that the perception of the neighborhood is similar among respondents, even if they reside in tangibly different locations from the economic, social, and geographic point of view [31]. Another factor that may have contributed to the lack of statistical association is the fact that participants were asked about their "neighborhood" without having received a definition of the term. Thus, less uniformity in interpreting the meaning of the term "neighborhood" may have resulted in a non-differential information bias, which tends to attenuate the study's target associations.

Another relevant point involves the urban characteristics around the households in Florianópolis. According to data from the 2010 *Population Census* (IBGE. http://www.ibge.gov.br), in a total of 141,956 permanent private households, only 2,398 had garbage accumulated on their lots and only 3,281 had open-air sewage, while the great majority had public lighting and paved streets. In other words, low variability in these characteristics may also have contributed to the lack of a statistically significant association between perceived neighborhood disorder and hypertension.

An important finding from the current study was the level of schooling in the census tract, identified as a possible effect modifier in the relationship between perceived neighborhood disorder and blood pressure. Neighborhoods with high levels of crime, unemployment, and violence are generally located in census tracts characterized by less schooling and lower income, which represent a constant source of stress [15,16]. Residents can also be more exposed to environmental stressors such as harmful chemical products and pollution that can have negative health implications [32]. Thus, residents in economically underprivileged neighborhoods tend to have worse health when compared to those living in better-off areas, since the context can make individuals more vulnerable to the perception of neighborhood disorder, while these same residents can encounter relatively fewer environmental, financial, and social resources to help them deal with their health problems.

Meanwhile, individuals living in neighborhoods with higher average educational levels not only have more income but may be more inclined to engage in collective work involving the mobilization of resources to improve neighborhood safety, recreation, education, and health [17]. All these collective efforts generate the perception of a safe, convenient, and friendly environment, which consequently leads to improvement in the residents' physical and mental health. Importantly, the context's schooling represents a measure of socioeconomic status and is more stable than income, which is subject to important fluctuations when recorded in a relatively short time frame [33]. This is true because income depends on the country's economy and can vary substantially across seasons and years. In addition, depending on the situation, seasonal work may be more common than formal employment. The use of "occupation" as a study variable also presents limitations, since persons may be working at temporary jobs without specification of their occupation.

As suggested by some empirical studies, the effects of high levels of schooling in a neighborhood's residents can benefit all the residents, regardless of the harmful effects of income inequality [17,34,35]. Based on the *Hawaii Health Survey* 2007-2008, Zhang et al. [35] found that education at the neighborhood level independently affects self-rated health and partially mediates the association between ethnicity and health outcomes.

Equally important is that adult individuals may spend a major part of their day away from home, so that not only their residential neighborhood but also other neighborhoods where they work or study may impact their health. In other words, individuals in better financial condition may have more resources to seek alternatives in other areas outside the neighborhoods where they live [36].

The limitations that may have influenced the results feature the way the neighborhood disorder scales were built, based on individual responses, which are influenced by the objective reality but also by personal factors and perceptions [23,25]. Although the sample is representative of the city as a whole, it was not representative of each census tract, which may have affected the measured perception of the neighborhood generated in the context of the analyses, possibly influencing the lack of association between perceived neighborhood disorder and high blood pressure. However, we reiterate that the study was conducted with a representative sample of adults and reached 85.3% of the initially calculated sample size, besides adhering to methodological rigor through prior training of the field team and the use of validated data collection instruments. In addition, few studies have been conducted and published in Brazil that have used more robust analytical models such as multilevel models. The use of data from the 2000 *Brazilian Population Census*, collected nine years before this study, was not considered a limitation, since the impact of neighborhood on health outcomes tends to occur in the long term. There is a minimum latency period between the neighborhood's characteristics and their effects on blood pressure, and the latter could not have been detected if the study had used data from the more recent 2010 *Brazilian Population Census* [37].

At any rate, public policies are needed that aim to reduce or have an impact on hypertension in the population (in addition to individual characteristics), and that consider and incorporate strategies to address physical and social disorder in neighborhoods, especially in census tracts with lower

average schooling. The challenge is thus to make environmental changes through the creation of more spaces for safe and friendly community living in daily activities, as well as to improve transportation, neighborhood lighting, reinforcement of security in more violence-prone areas, and other factors that expand the possibilities for social interaction. Another important point is to expand access to healthcare in areas still lacking sufficient coverage, aimed at assisting or treating persons that are more exposed to stress.

The current study was thus an important point of departure for the development and implementation of environmental intervention programs, since it allowed the analysis and identification of a population apparently more vulnerable to the effects of perceived physical and social disorder. Longitudinal studies are necessary to confirm the effect of physical and social disorder on blood pressure over time. Analyses are also needed on the role of schooling in the census tract, aimed at elucidating the possible mechanisms involved in this relationship.

Contributors

C. Zanelatto, D. A. Höfelmann, M. W. C. Giehl, W. Nishida and J. L. Bastos contributed in the study conception, data analysis and interpretation, writing and critical revision of the article, and approval of the final version for publication.

Additional informations

ORCID: Carla Zanelatto (0000-0002-6168-9898); Doroteia Aparecida Höfelmann (0000-0003-1046-3319); Maruí Weber Corseuil Giehl (0000-0002-4460-3116); Waleska Nishida (0000-0002-4937-5124); João Luiz Bastos (0000-0002-1816-0745).

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Resumo

O objetivo foi verificar se a percepção das desordens físicas e sociais da vizinhança está associada a uma maior pressão arterial sistólica (PAS) e diastólica (PAD), bem como examinar a influência do nível socioeconômico do setor censitário de residência sobre essa associação. Trata-se de um estudo transversal que incluiu uma amostra representativa de 1.720 adultos de 20 a 59 anos, residentes em Florianópolis, Santa Catarina, Brasil. Foram realizadas duas medidas de pressão arterial e coletadas informações referentes à percepção das desordens no bairro de moradia. A variável contextual utilizada foi a média de anos de escolaridade do chefe da família dos setores censitários investigados. A análise estatística incluiu modelos multiníveis, com o primeiro nível representado pelos indivíduos e o segundo, pelos setores censitários. Termos de interação entre os tercis de escolaridade do setor censitário e os tercis de percepção de desordens de vizinhança sobre a pressão arterial foram examinados. Não foram identificadas associações estatisticamente significativas globais entre desordens de bairro e PAS ou PAD. Entretanto, foi identificada uma média de PAS 7,88mmHg (IC95%: 1,38; 14,40) maior entre os respondentes que percebiam mais desordens de vizinhança e residiam em um setor com menor escolaridade, quando comparados com a categoria de referência. As políticas públicas que visam a reduzir ou que tenham impacto sobre os níveis pressóricos sistólico e diastólico na população também devem considerar as características do contexto em que a população está inserida, especificamente aqueles marcados por menores níveis de escolaridade.

Pressão Arterial; Saúde da População Urbana; Análise Multinível

Resumen

El objetivo de este trabajo fue verificar si la percepción de desórdenes físicos y sociales en el vecindario está asociada a una mayor presión arterial sistólica (PAS) y diastólica (PAD), así como examinar la influencia del nivel socioeconómico del sector censal de residencia sobre esta asociación. Se trata de un estudio transversal, que incluyó una muestra representativa de 1.720 adultos de 20 a 59 años, residentes en Florianópolis, Santa Catarina, Brasil. Se realizaron dos medidas de presión arterial y se recogió información referente a la percepción de desórdenes en el barrio de residencia. La variable contextual utilizada fue la media de años de escolaridad del jefe de familia en los sectores censales investigados. El análisis estadístico incluyó modelos multiniveles, con un primer nivel representado por individuos y, el segundo, por los sectores censales. Se examinaron los términos de interacción entre los terciles de escolaridad del sector censal y los terciles de percepción de desórdenes en el vecindario sobre la presión arterial. No se identificaron asociaciones estadísticamente significativas globales entre los desórdenes en el barrio y la PAS o PAD. No obstante, se identificó una media de PAS de 7,88mmHg (IC95%: 1,38; 14,40) mayor entre quienes respondían que percibían más desórdenes en el vecindario y residían en un sector con menor escolaridad, si se comparan con la categoría de referencia. Las políticas públicas que tienen como fin reducir o tener impacto sobre los niveles de presión sistólico y diastólico en la población, también deben considerar las características del contexto en el que la población está ubicada, específicamente aquellos espacios marcados por sus menores niveles de escolaridad.

Presión Arterial; Salud Urbana; Análisis Multinivel

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