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Noise annoyance, sociodemographic and health patterns, and neighborhood perceptions in a Brazilian metropolis: BH Health Study

Percepção do ruído como incômodo, características sociodemográficas, de saúde e percepção da vizinhança em uma metrópole brasileira: Estudo Saúde em Beagá

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ABSTRACT: ***Objective:*** The present study aims to analyze the association of noise annoyance with individual and sociodemographic factors and self-perception of the neighborhood in an urban center. ***Methods:*** Data were collected through a population-based cross-sectional study held in two of the nine health districts in the city of Belo Horizonte, Minas Gerais, Brazil, from 2008 to 2009. The study included 3,934 individuals of both genders, aged 18 years and older. The response variable was the self-perception of noise, investigated by the question: "In your neighborhood, does the noise bother you?" The explanatory variables were grouped into the following domains: sociodemographic, social determinants, self-rated health, and self-reported diseases. ***Results:*** The prevalence of noise annoyance was 47% for women and 39.8% for men. For both genders, noise annoyance was independently associated with bad traffic and the presence of loud music, discussions, and late-night parties. ***Conclusion:*** Gender differences were identified in the association of noise annoyance with sociodemographic characteristics and self-reported morbidity. Traffic and social customs were the main sources of noise in the regions under study.

Keywords: Urban health. Noise. Residence characteristics. Auditory perception.

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RESUMO: ***Objetivo:*** Analisar a associação entre o incômodo provocado pelo ruído com fatores individuais e sociodemográficos e a autopercepção de vizinhança em um centro urbano. ***Métodos:*** Os dados foram coletados por meio de um estudo transversal de base populacional, desenvolvido em dois dos nove distritos sanitários do município de Belo Horizonte, Minas Gerais, no período de 2008 a 2009. Participaram do estudo 3.934 indivíduos, de ambos os sexos, com 18 anos ou mais. A variável resposta foi a autopercepção do ruído, investigada pela pergunta: "Pensando na sua vizinhança o ruído/barulho incomoda você?". As variáveis explicativas foram agrupadas nos seguintes domínios: sociodemográfico, determinantes sociais, autoavaliação de saúde e autorrelato de doenças. ***Resultados:*** Para as mulheres, a prevalência do incômodo ao ruído foi de 47%, e para os homens, foi de 39,8%. Para ambos os sexos, o incômodo ao ruído foi independentemente associado ao trânsito ruim e presença de música alta, discussões e festas até tarde. ***Conclusões:*** Diferenças entre os sexos foram observadas para associação entre o incômodo ao ruído, características sociodemográficas e morbidade autorreferida. O trânsito e os costumes sociais se configuraram como a principal fonte geradora de ruído nas regiões estudadas.

Palavras-chave: Saúde da população urbana. Ruído. Características de residência. Percepção auditiva.

INTRODUCTION

Urbanization as a global phenomenon led to the restructuring of the nature of cities and, as a consequence, caused unfavorable health and well-being conditions[1]. Among the unfavorable environmental conditions associated with urbanization, noise is an invisible threat to the health of urban dwellers[2]. Noise consists of a combination of sounds coming from different sources such as: traffic of cars, buses, trains, and airplanes; industrial activities; leisure and sports activities, making it difficult to measure the isolated annoyance produced by each source. The soundscape of urban environments encompasses noise-generating and other sources that promote the disturbance of silence and can be observed in lifestyle, leisure, culture, and sports incorporated into people's daily lives[3].

In 2018, the World Health Organization updated its guidelines for Europe and classified health outcomes related to exposure to urban noise as critical and important. Among the critical outcomes, we can mention: cardiovascular diseases, annoyance, sleep disorders, cognitive impairment, hearing loss, and tinnitus. Important outcomes included adverse obstetric outcomes, quality of life, well-being, and mental health, as well as metabolic disorders[3].

Urban noise effects can be estimated objectively by measuring environmental sound pressure levels and subjectively by the annoyance it causes. Noise annoyance is one of the most studied metrics for surveying the impacts of exposure to urban noise[2,4-11]. It is a sensitive indicator of the adverse effects of noise exposure on quality of life and can be considered a marker of health outcomes associated with noise exposure[12].

Few studies have addressed the self-perception of noise in urban environments in Latin America. However, the size heterogeneity and fast-growing characteristics of Latin American cities make them relevant for investigating how urban environments influence health and

environmental sustainability[13]. Analyzing the outcomes associated with self-perception of urban noise is therefore justified by the need for data to support public policies targeted at its control and the consequent reduction of its effects on health.

The present study aims to analyze the association of noise annoyance with individual and sociodemographic factors and self-perception of the neighborhood in an urban center.

METHODS

This is a population-based cross-sectional study using data from the "BH Health Study" (BHS), developed by the Belo Horizonte Urban Health Observatory (OSUBH) of the Universidade Federal de Minas Gerais (UFMG), from 2008 to 2009, in two of the nine health districts of Belo Horizonte. The BHS is a household-based survey aimed to evaluate aspects of the population's habits and lifestyles, quality of life, and self-rated health. Details of the study design have been reported previously[14].

SAMPLE AND DATA COLLECTION INSTRUMENTS

The study has a probabilistic, three-stage cluster sample design: first, the census tracts were selected, followed by the households and an adult individual (18 years and older) from each household. A total of 149 census tracts were selected. OSUBH researchers elaborated a questionnaire based on national and international epidemiological surveys, thus enabling the comparison with previously published studies. The questionnaire was answered in person, with an approximate duration of 40 minutes, comprising questions grouped into the following modules: home, sociodemographic characteristics, mobility, social determinants, health, habits, and behaviors[14]. The initial sample consisted of 4,048 individuals. Participants who reported hearing impairment, partial deafness, and total deafness or did not respond to the outcome were excluded, resulting in 114 exclusions. Thus, the final sample included 3,934 individuals.

RESPONSE VARIABLE

The response variable was the self-perception of noise, investigated by the question: "*In your neighborhood, does the noise bother you*?" (yes, no, I don't know, no answer).

STRATIFICATION VARIABLE

The World Health Organization recommends analyzing a population's health information according to gender in addition to at least two other social determinants[15]. Also, studies have

shown that noise perception and annoyance differ among men and women[16,17]. Therefore, in the current study, the stratification variable was gender.

EXPLANATORY VARIABLES

Individual-level explanatory variables were grouped into the following domains: sociodemographic, neighborhood perception, self-rated health, self-reported diseases, and sleep quality.

The sociodemographic variables analyzed were: schooling, marital status, and family income.

The neighborhood perception domain included the variables traffic and presence of noise-generating sources. Traffic perception was assessed by asking, *"How do you rate the traffic in your neighborhood?"*. The answers: "very good" and "good" were grouped as "good", and the answers "bad" and "very bad" were grouped as "bad". The presence of noise-generating sources related to habits and behaviors was evaluated by the question:

- *"Are there people or places in your neighborhood where you usually hear loud music and conversations or late-night parties?"*;
- *"Is there gunfire noise in your vicinity?"* (yes, no, I don't know, no answer).

The current health condition was assessed by asking, *"In general, how would you rate your health?"* (very good or good, fair, poor or very poor). The presence of chronic diseases was investigated by the question, *"Has a doctor or other healthcare professional ever said that you have any of the chronic diseases listed below: hypertension, depression, migraine, digestive disorder, mental disease?"* (yes/no). Sleep quality was evaluated by asking, *"In the last 30 days, have you slept poorly?"* (yes, no, I don't know, no answer).

Due to the small number of observations, the "I don't know" and "no answer" options, as well as missing data, were removed from the analysis in all questions.

At the neighborhood level, the explanatory variable was the census tract of residence.

The variables age and time living in the current residence were used with individual adjustment variables in the univariate and multivariate analyses.

STATISTICAL ANALYSIS

After a descriptive analysis, a univariate analysis adjusted for age and time living in the current residence was performed. Variables associated with self-perceived noise at a 20% level were candidates for the multivariate analysis, in the next step. The following categories were regarded as references according to the respective elected variables: 0 to 4 years of schooling; single marital status; family income lower than 2 minimum wages; good traffic; no loud music or late-night parties; no gunfire sound; good sleep quality; no work; very good

or good self-rated health; no report of migraine, hypertension, mental disorders, digestive disorders, diabetes, and heart disease.

Finally, multilevel multiple logistic regression analysis was performed, as follows[18-20]:

- analysis of variance with random effects for level 1 and level 2;
- model fit with level 1 variables (individual variables);
- adjustment of the complete model by adding the level 2 variable (census tract);
- comparison of models by the maximum likelihood method.

The magnitude of the associations was estimated by odds ratios (OR) and their respective 95% confidence intervals, and the significance level was set at 5%.

The median odds ratio (MOR) was calculated to express the neighborhood-level variability (census tract). Its estimation allows determining whether the probability of the individual reporting the event is related to contextual phenomena[19].

All analyses were performed with the Stata software, version 12, using the Generalized Linear Latent and Mixed Models (GLLAMM) and the Survey (svy) commands, considering the sample design.

BHS was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (protocol no. ETIC 253/06) and the Research Ethics Committee of the Municipal Health Department (opinion no. 073.2008). All participants signed the Informed Consent Form.

RESULTS

A total of 3,934 adults of both genders participated in this study, of whom 59.2% were women (mean age 44.8 years; standard deviation — SD = 16.7), and 40.8% were men (mean age 43.2 years; SD = 17.0). The prevalence of noise annoyance was 47% for women and 39.8% for men.

Among men, 22.7% had 0 to 4 years of schooling, 21.9% had 5 to 8 years, 36.7% had 9 to 11 years, and 18.7% had 12 or more years. Regarding marital status, 31.8% were single, 59.9% were married, in a domestic partnership, or in a free union, 5.5% were separated or divorced, and 2.8% were widowed. As to family income, 19.4% earned less than 2 minimum wages, 47.9% earned 2 to 5 minimum wages, 19.2% earned 5 to 10 minimum wages, and 13.5% earned 10 minimum wages or more. With respect to work, 4% did not work, 72.6% worked, and 23.4% worked in the past but not anymore. Regarding the health vulnerability index (HVI), 18.8% lived in low-risk census tracts, 38.3% lived in moderate-risk census tracts, and 42.9% lived in high- or very high-risk census tracts. Concerning traffic, 71.1% considered traffic as good and 28.9% as bad. Presence of loud music, discussions, and late-night parties in the neighborhood was reported by 42.2% and was not reported by 57.8%. Gunfire sound was reported by 57% and was not reported by 43%. When asked about sleep, 27.1% of men declared poor sleep quality and 72.9% good sleep quality. Self-rated health was considered very good or good by 69.9% of male participants, migraine was reported

by 7%, high blood pressure by 27.6%, depression by 8.1%, mental disorder by 2.3%, digestive disorder by 9.3%, diabetes by 7%, and heart disease by 5.9% (Table 1).

Among women, 28% had 0 to 4 years of schooling, 21.1% had 5 to 8 years, 34.2% had 9 to 11 years, and 16.7% had 12 or more years. Regarding marital status, 29% were single, 48.6% were married, in a domestic partnership, or in a free union, 10.2% were separated or divorced, and 12.2% were widowed. As to family income, 31.5% earned less than 2 minimum wages, 44.3% earned 2 to 5 minimum wages, 14.4% earned 5 to 10 minimum wages, and 9.8% earned 10 minimum wages or more. With respect to work, 13.7% did not work, 53.2% worked, and 33.1% worked in the past but not anymore. Regarding the health vulnerability index (HVI), 19.8% lived in low-risk census tracts, 38.4% lived in moderate-risk census tracts, and 41.8% lived in high- or very high-risk census tracts. Concerning traffic, 67% considered traffic as good and 33% as bad. Presence of loud music, discussions, and late-night parties in the neighborhood was reported by 43% and was not reported by 57%. Gunfire sound was reported by 59.8% and was not reported by 40.2%. When asked about sleep, 41.8% of women declared poor sleep quality and 58.2% good sleep quality. Self-rated health was considered very good or good by 63.8% of female participants, migraine was reported by 22.7%, high blood pressure by 32.1%, depression by 22.7%, mental disorder by 4.2%, digestive disorder by 15.9%, diabetes by 8.4%, and heart disease by 7.1% (Table 1).

In the univariate analysis for men, significant associations ($p \leq 0.20$) were found between noise annoyance and the following variables: schooling, marital status, bad traffic, presence of loud music, discussions, and late-night parties, gunfire sound, poor sleep, and self-reported digestive disorders. For women, significant associations ($p \leq 0.20$) were identified between the perception of noise annoyance and the following variables: schooling, marital status, bad traffic, presence of loud music, discussions, and late-night parties, gunfire sound, poor sleep, fair self-rated health, and self-reported migraine, depression, mental disorder, and digestive disorder (Table 2).

The final multivariate analysis model for men indicated that noise annoyance was independently associated with being married, in a domestic partnership, or in a free union; being a widower; perceiving traffic as bad; and living in a neighborhood with loud music, discussions, and late-night parties or gunfire sounds. According to the analysis performed, the likelihood of perceiving noise as annoyance increased by 73% (OR = 1.73; 95%CI 1.13 – 2.67) among men who were married, in a domestic partnership, or in a free union and by 287% (OR = 2.87; 95%CI 1.06 – 7.81) among widowers when compared to single men. The likelihood of perceiving noise as annoyance was 71% higher (OR = 1.71; 95%CI 1.22 – 2.38) among those who considered traffic as bad compared to those who considered it as good. The presence of loud music, discussions, and late-night parties increased the chance of perceiving noise as annoyance by 364% (OR = 3.64; 95%CI 2.55 – 5.21). The perception of noise as annoyance was 81% higher (OR = 1.81; 95%CI 1.26 – 2.60) in the presence of gunfire sounds when compared to their absence (Table 2).

The final multivariate analysis model for women indicated that noise annoyance was independently associated with being separated or divorced; perceiving traffic as bad; living in a

Table 1. Descriptive analysis of self-reported health conditions (n = 3,934).

Variable	n	%	Men		Women	
			n	%	n	%
Self-rated health						
Very good and good	2,609	66.3	1,124	69.9	1,485	63.8
Fair	1,077	27.4	407	25.4	670	28.8
Poor or very poor	248	6.3	76	4.7	172	7.4
Migraine						
No	3,292	83.7	1,493	93.0	1,799	77.3
Yes	642	16.3	113	7.0	529	22.7
High blood pressure						
No	2,744	69.7	1,164	72.4	1,580	67.9
Yes	1,190	30.3	442	27.6	748	32.1
Depression						
No	3,276	83.3	1,475	91.9	1,801	77.3
Yes	658	16.7	130	8.1	528	22.7
Mental disorder						
No	3,799	96.6	1,568	97.7	2,231	95.8
Yes	135	3.4	37	2.3	98	4.2
Digestive disorder						
No	3,414	86.8	1,456	90.7	1,958	84.1
Yes	520	13.2	149	9.3	371	15.9
Diabetes, hyperglycemia						
No	3,627	92.2	1,493	93.0	2,134	91.6
Yes	307	7.8	112	7.0	195	8.4
Heart disease						
No	3,676	93.4	1,513	94.1	2,161	92.9
Yes	258	6.6	94	5.9	166	7.1

neighborhood with loud music, discussions, and late-night parties or gunfire sounds; declaring poor sleep; and self-reporting digestive disorders. According to the analysis performed, the likelihood of perceiving noise as annoyance was 55% lower (OR = 0.55; 95%CI 0.31 – 0.98) among women who were separated or divorced when compared to single women. The likelihood of perceiving noise as annoyance was 73% higher (OR = 1.73; 95%CI 1.28 – 2.34)

Table 2. Univariate and multilevel multivariate analysis of the association between noise annoyance and sociodemographic characteristics, social and health determinants, adjusted for age and time living in the current residence (n = 3,934)[#].

Variable	Univariate				Multivariate			
	Men		Women		Men		Women	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Years of schooling								
0–4	1.00	- -	1.00	- -				
5–8	1.08	0.70 – 1.68	1.27	0.89 – 1.82*				
9–11	1.42	0.95 – 2.13*	1.41	0.97 – 2.05**				
12 or more	1.83	1.04 – 3.23**	1.24	0.78 – 1.99				
Marital status								
Single	1.00	- -	1.00	- -	1.00	- -	1.00	- -
Married, domestic partnership, free union	1.77	1.19 – 2.64**	0.90	0.68 – 1.20	1.73	1.13 – 2.67**	1	0.72 – 1.4
Separated or divorced	1.85	0.89 – 3.86*	0.52	0.31 – 0.89**	1.88	0.86 – 4.11	0.55	0.31 – 0.98**
Widowed	3.21	1.19 – 8.69**	0.70	0.42 – 1.18*	2.87	1.06 – 7.81**	0.79	0.46 – 1.37
Traffic								
Good	1.00	- -	1.00	- -	1.00	- -	1.00	- -
Bad	1.96	1.45 – 2.67***	1.96	1.46 – 2.62***	1.71	1.22 – 2.38**	1.73	1.28 – 2.34***
Loud music, late-night parties								
No	1.00	- -	1.00	- -	1.00	- -	1.00	- -
Yes	4.21	3.00 – 5.93***	3.45	2.73 – 4.36***	3.64	2.55 – 5.21***	3.11	2.38 – 4.06***
Gunfire								
No	1.00	- -	1.00	- -	1	- -	1	- -
Yes	2.16	1.49 – 3.12***	1.77	1.33 – 2.36***	1.81	1.26 – 2.6**	1.45	1.06 – 1.98**

Continue...

Table 2. Continuation.

Variable	Univariate						Multivariate					
	Men			Women			Men			Women		
	OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI	
Poor sleep quality												
No	1.00	-	-	1.00	-	-	-	-	-	1.00	-	-
Yes	1.86	1.28 – 2.71**		1.79	1.41 – 2.27***		-	-	-	1.66	1.31 – 2.11***	
Self-rated health												
Very good and good				1.00	-	-						
Fair				1.44	1.14 – 1.82**							
Poor or very poor				1.22	0.79 – 1.88							
Migraine												
No				1.00	-	-						
Yes				1.35	1.06 – 1.71**							
Depression												
No				1.00	-	-						
Yes				1.37	1.03 – 1.82**							
Mental disorder												
No				1.00	-	-						
Yes				1.90	1.17 – 3.08**							
Digestive disorder												
No	1.00	-	-	1.00	-	-	-	-	-	1.00	-	-
Yes	1.38	0.87 – 2.20***		1.68	1.21 – 2.32**		-	-	-	1.52	1.1 – 2.11**	

[#]Reference categories: 0 to 4 years of schooling, single marital status, good traffic, no loud music, discussions, or late-night parties, no gunfire, good sleep quality, very good and good self-rated health, and no report of migraine, depression, mental disorder, or digestive disorder; 95%CI: 95% confidence interval; *p < 0.20; **p < 0.05; ***p < 0.001.

among those who considered traffic as bad compared to those who considered it as good. In the presence of loud music, discussions, and late-night parties, the chance of perceiving noise as annoyance increased by 311% (OR = 3.11; 95%CI 2.38 – 4.06). Also, noise annoyance was 45% higher (OR = 1.45; 95%CI 1.06 – 1.98) in the presence of gunfire sounds; 66% (OR = 1.66; 95%CI 1.31 – 2.11) greater when the sleep quality was poor; and 52% higher (OR = 1.52; 95%CI 1.10 – 2.11) when the participant self-reported digestive diseases (Table 2).

MOR was 1.89 (0.45) for males and 1.71 (0.32) for females, indicating that the neighborhood contributed to the variance in noise perception.

DISCUSSION

The present study analyzed individual characteristics and environmental perceptions related to annoyance produced by noise, revealing that the variables bad traffic and presence of loud music, discussions, and late-night parties are independently associated with self-perceived noise annoyance.

The prevalence of noise annoyance was higher among women than in men. This association was also detected in a study of the Finnish population, whose results showed a positive relationship between being a woman and having greater knowledge about the risks of urban noise, greater concern about environmental risks to their health and that of their family, and with a positive attitude towards environmental preservation[5]. In an investigation comparing noise annoyance among residents of vulnerable areas in Switzerland and South Africa, women were more sensitive and reported annoyance more often than men in both countries. For African women, noise annoyance decreased with the increase in schooling, whereas for Swiss women, noise annoyance increased with the increase in schooling[16]. Our study found no association between schooling and noise annoyance in women.

A study conducted in the city of Porto (Portugal) evaluated the perception of soundscapes and noise annoyance in different environments, such as leisure spaces, home, and workplace, revealing that noise annoyance was reported more often in the workplace and at home[11].

Among both men and women, noise annoyance was independently associated with the perception of bad traffic and the presence of loud music, discussions, and late-night parties in the neighborhood. This association corroborates literature findings, which describe the main sources of noise in the urban environment as traffic, social habits and customs, and leisure activities[5,6,8,10,21-26]. In fact, transportation is the main source of noise in the urban environment. Therefore, improvements should be implemented in this context to reduce not only noise exposure but also pollutant emissions, since they are associated with undesirable health and well-being outcomes[2,3,7,21,22,27]. The use of alternative and public transport has been widely discussed and encouraged as a way to promote health and reduce noise and pollutants, representing a sustainability challenge in modern societies[28].

Annoyance caused by gunfire noise has not been reported in other studies, to the best of our knowledge. This association might have roots in urban violence, which is a reality in most Brazilian municipalities, especially in large cities, such as Belo Horizonte[29].

Defined as a well-being impairment due to exposure to urban noise, annoyance can be a trigger to stress and the genesis of pathophysiological mechanisms, leading to metabolic, cardiovascular[3], psychological, and emotional changes, interfering in the performance of daily activities, and causing tiredness[30,31]. Despite being a subjective reaction, it is understood as an indicator of the psychological response to adverse environmental events, such as air and noise pollution[10,32], and is considered one of the critical outcomes associated with exposure to urban noise[3]. Although not listed by the International Classification of Diseases as a disease, noise annoyance can preclude the attainment of a "state of complete physical, mental, and social well-being", which is the World Health Organization's concept of health, since it can generate discomfort, as found in this study[33].

Among the health manifestations associated with exposure to environmental noise described in the literature, self-reported digestive disorders are connected with annoyance in women. Digestive changes are reported in individuals in stress situations[33]. Even though we found no association in the final model between noise annoyance and self-reported cardiovascular or even metabolic diseases, the univariate analysis showed relationships with self-reported migraine, mental disorders, and depression in women.

Poor sleep quality caused by noise exposure is one of the critical outcomes of noise exposure in urban environments[3]. According to the World Health Organization, 1–1.6 million disability-adjusted life years are lost annually in Western Europe due to environmental noise, of which 903,000 are due to sleep disorders[34]. The current study identified an association between noise annoyance and poor sleep quality among women. This association has also been described in other investigations, which detected that noise annoyance is related to sleep disorders[14,34,35].

The MOR for male participants was 1.89, revealing that noise annoyance increased by 89% in this population if they moved from one census tract to another. For women, MOR was 1.71, demonstrating that noise annoyance increased by 71% if they moved from one census tract to another. These results indicate the importance of investigating which neighborhood characteristics of each of the sampled census tracts are associated with noise perception variability, as well as how individual health determinants may be directly related to the living environment. Although Belo Horizonte was one of the first planned cities in Brazil, its growth was disorganized, and the current urban design reveals important socioeconomic inequalities, with vulnerable areas interspersed with middle- and upper-class neighborhoods[36].

This study has several limitations. The main one is the lack of objective noise measures. On the other hand, since sound maps of the Belo Horizonte metropolitan region are not available, and no significant differences were observed in the last ten years concerning the demographic and epidemiological profile of the population, subjective evaluation of noise annoyance allows a valuable estimate of the potential effects of exposure to urban noise on health.

Another limitation is the lack of information related to the work environment of the participating population. Noise perception is a complex phenomenon that suffers interference

from various factors, such as years of work; stress rate; time spent at home during the day and night; windows in rooms and rooms that face the street; characteristics of day and night noise-generating sources[37], which were not investigated in the present study but should be tested in future investigations on the subject in question.

Despite the limitations described above, the strengths of this research remain, as, in addition to individual factors, we investigated the relationship of noise annoyance with the perceived living environment, socioeconomic status, and time living in the current residence, considering gender differences, using a population sample, and adopting a multilevel approach. As far as we know, no other study has data comparable to those presented herein for a Latin American metropolis, such as the city of Belo Horizonte.

Also, the results highlighted the high prevalence of noise annoyance in one of the largest cities in Brazil. Considered one of the critical outcomes associated with noise exposure[3], annoyance is at the physiological basis of health conditions responsible for the loss of thousands of disability-adjusted life years[33]. These results cannot be neglected; they indicate the need for public policies that can establish sound mapping in Brazil, so the effects of urban noise exposure on health and well-being can be investigated.

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