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ARTICLE

Active urban mobility in adults with hearing loss and their perception of the environment: a multicenter study

Mobilidade urbana ativa de adultos com perda auditiva e a percepção sobre o ambiente: um estudo multicêntrico

Movilidad urbana activa de adultos con pérdida auditiva y percepción sobre el ambiente: un estudio multicéntrico

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Abstract

This study aimed to estimate the association between hearing loss and active urban mobility (walking and/or bicycling), according to perception of the environment in adults in three Brazilian capital cities. This was a cross-sectional study of 2,350 adults (18-59 years) residing in Brasília (Federal District), Florianópolis (Santa Catarina), and Porto Alegre (Rio Grande do Sul), assessed by the multicenter study Healthy Urban Mobility *(MUS) in 2017 and 2018. The outcome variable was active urban mobility (≥ 10 minutes/week), and the principal exposure was self-reported hearing loss. The analyses were stratified by the variable "perception of the environment" – perception of places for walking and bicycling (negative; positive). Logistic regression was used to estimate crude and adjusted odds ratios (OR) with 95% confidence intervals (95%CI). Prevalence rates for self-reported hearing loss and active urban mobility were 17% (95%CI: 15.4; 18.4) and 55.4% (95%CI: 53.4; 57.4), respectively. Adults with hearing loss and that perceived the environment negatively for walking and bicycling showed 34% lower odds of active urban mobility ≥ 10 minutes/week (OR = 0.66; 95%CI: 0.45; 0.97). In conclusion, there was an association between hearing loss and active urban mobility in adults in the three capital cities, according to negative perception of the environment. Persons with hearing loss that perceived the neighborhood negatively tend to circulate less by active means.*

Hearing Loss; Right to Freedom of Movement; Urban Area; Environment Design; Built Environment

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Introduction

According to the World Health Organization (WHO), in the year 2010 more than a billion people were living with some form of disability or incapacity, corresponding to approximately 15% of the world population [1]. In Brazil, that same year, according to data from the Brazilian Institute of Geography and Statistics (IBGE), 23.9% of the population reported at least one of the disabilities listed in the census (visual, hearing, motor, mental, or intellectual). Among the sensory disabilities listed in the census, hearing disability led in absolute numbers, affecting 2.2 million Brazilians [2].

Hearing disability is multifactorial and manifests to different degrees [3]. A deaf individual is defined as one with a hearing loss characterized by absence of auditory responses, namely non-functional hearing. Language acquisition by deaf individuals can be limited, and Brazilian Sign Language (LIBRAS, acronym in Portuguese) is one of the main strategies for their linguistic development. The adult population thus includes deaf individuals with no functional residual hearing and individuals with acquired hearing loss who still have some residual hearing.

Acquired hearing loss in the adult population can be related to continuous exposure to high sound pressure levels (SPL), characterizing noise-induced hearing loss (NIHL) [4]. This type of hearing loss can compromise the individual's social participation and integration due to changes in their life structure caused by communication difficulties imposed by the impairment, with affective and professional harms, thereby increasing their risk of cognitive decline, falls, depression, social withdrawal, and low self-esteem [5,6].

Few authors have analyzed hearing impairment in relation to active urban mobility in adults or discussed the issues related to the urban environment [7,8]. Active urban mobility is defined as circulating in the city by walking and/or bicycling. These modes of travel are considered beneficial to health, since they allow the individual to practice physical activity [9,10], besides reducing the air pollution from motor vehicle traffic.

A review study showed that impediments to movement involving physical obstacles and lack of sensory signage are some of the barriers faced in urban environments by people with disabilities [11]. When encountering these barriers along their way, individuals with sensory loss can end up withdrawing into their homes, limiting their independence and mobility and considerably curtailing their outings for daily activities [12].

In Brazil, there was a recent publication with important studies on the topic. In 2017, authors launched the first book on accessibility and urban mobility from the deaf person's perspective [7], and in 2018 there was a book on accessibility and urban mobility from the perspective of equity and social inclusion [8]. Both books debate issues in the interfaces between urban mobility, social inclusion, and barriers in the built environment, giving voice to persons with disability (including hearing disability) in the face of these challenges.

Epidemiological studies have been developed in other countries, but with different target populations from those in the current study. Mikkola et al. [13] assessed an elderly cohort in Finland and found an association between hearing impairment, failure to participate in leisure-time activities, and reduction in the time spent out of the house in the last seven days, independently of mode of transportation used. Still, most of the studies on the built environment as a moderator of the relationship between disability (physical, sensory, or cognitive) and lower levels of active mobility have been conducted in older populations, which shows the need for studies focusing on young adults, because young people with disabilities have different experiences with the built environment [14].

This context highlights the importance of epidemiological studies on the relations between hearing loss in adults and active urban mobility. There is also a need for collaboration between different areas of knowledge (speech therapy, medicine, architecture and urban planning, psychology, engineering, physical education) for them to jointly improve and/or create effective public policies with changes in the environmental context at the center of the discussions. It is equally important to acknowledge active urban mobility as an activity that can provide numerous health benefits for persons with disability, especially in their quality of life. Such effective practice can be used as a strategy for inclusion of persons with disability in society [7].

Given the above, this study aimed to estimate the association between hearing loss and active urban mobility (walking and/or bicycling), according to the perception of the environment in adults in three Brazilian capital cities.

Methods

Study design and site

This was a cross-sectional study with data from a household survey of adults from the multicenter study *Healthy Urban Mobility* (MUS, acronym in Portuguese) (https://www.hum-mus.org). The main objective of the larger MUS project is to understand the impact of daily mobility/immobility on the health and wellbeing of different social groups. The larger study was conducted in three Brazilian cities: Brasília (Federal District), Florianópolis (Santa Catarina State), and Porto Alegre (Rio Grande do Sul State); and in a city in south of the United Kingdom: Oxford. These cities were chosen due to their different spatial and demographic characteristics and the challenges they face in the promotion of healthy and active urban mobility. The current article only used data from the Brazilian cities Florianópolis, Porto Alegre, and Brasília.

Porto Alegre is the state capital of Rio Grande do Sul, with an estimated population in 2017 of 1,484,941 and a municipal human development index (HDI-M) of 0.805. Florianópolis is the state capital Santa Catarina, with an estimated population of 485,838 and HDI-M of 0.847. Brasília is the national capital of Brazil, with a population of 3,039,444 and HDI-M of 0.824 (IBGE. https://cidades.ibge.gov.br/, accessed on Oct/2018).

Three study areas were selected in each city. In Florianópolis, areas were selected from the neighborhoods of Costeira do Pirajubaé, Saco Grande, and Jardim Atlântico; in Porto Alegre, the neighborhoods Cruzeiro, Menino Deus, and Tronco; and in Brasília, Varjão, Vila Planalto and SQN 409/410. The areas were chosen according to the following inclusion criteria: (a) distance less than 10km from the city center; (b) homogenous socioeconomic status; (c) type of urban fabric, either planned or informal, according to the roadway grid pattern. Thus, data collection took place in three areas of the city: two with household income up to the fifth quintile distribution, one of which informal and the other planned, and a third area with income up to the fourth income quintile.

Sampling procedures and data collection

In Brazil, the data were collected from May 2017 to June 2018. As for the household sample calculation, in Florianópolis and Porto Alegre, after identification of all addresses recorded in each study area in the government agencies (IBGE, National Registry of Addresses for Statistical Purposes, Geoportal), level of confidence was set at 95% and with ± 5% confidence interval, adopting as the universe all the households located in the polygons corresponding to the respective areas. Random sampling used the non-spatial method "*subset*", in the ArcGIS 10.2.2 geoprocessing software (http://www.esri.com/software/arcgis/index.html). This technique, widely used in programming languages, statistical packages, and calculation spreadsheets, divides the data (all the addresses on the list) into two subgroups: the first contains L addresses, and the second contains N - L, where L is 500 and N is the total number of addresses in the universe. This division is done by generating random values based on a uniform distribution (values from 0 to 1). If the value generated is less than L/N, it is allocated to the first subset, otherwise to the second. We also calculated the study's power via the OpenEpi site (https://www.openepi.com), obtaining a power of 100% for the study.

Sampling in Brasília was performed by simple random sample based on a general address list, selecting 500 households, using the IBM SPSS software (https://www.ibm.com). However, in one of the neighborhoods we opted to use the snowball technique, due to situations of violence and insecurity encountered by the interviewers upon visiting the previously selected addresses.

The snowball technique is a form of non-probabilistic sample that uses referral chains, drawing on documents and/or key informants called "seeds" in order to identify persons with the necessary

profile for the study within the general population. This happens because an initially planned probabilistic sample is impossible or impracticable, so that the seeds help the researchers initiate their contacts and explore the group to be studied. Next, the persons indicated by the seeds are asked to name new contacts with the desired characteristics, based on their own personal networks, and so on, such that the sample grows with each interview, in keeping with the researchers' interests [15].

The study included adults 18 to 59 years of age and excluded bedridden individuals, pregnant women, and individuals with some limiting mental disability perceived by the interviewer at the time of the interview. For the data collection, properly trained interviewers applied a standardized and pretested questionnaire during face-to-face interviews. The questionnaire was programmed in the Android operational system on a M9 QUAD Multilaser tablet by a specialized technician. Data consistency was verified weekly, and quality control was done by telephone via application of an abridged questionnaire to 10% of the participants, selected randomly. The complete survey consisted of 375 questions, divided into 16 sections of questions. The questions aimed to understand the residents' perception of their neighborhoods and means of transportation, besides their health issues.

Outcome variable

Assessment of the study outcome used the variable "active urban mobility" (walking and/or bicycling), categorized as < 10 minutes/week and ≥ 10 minutes/week, according to previous publications that used this cutoff to investigate active commuting [16,17]. Interviewers asked participants how often they had left home in the previous week for walking or bicycling, and how long they had spent on each trip. The times were transformed into minutes and multiplied by the number of individual outings, thereby obtaining the total commuting time by walking and/or bicycling in minutes during the previous week for each individual, independently of the reasons. This variable is part of the instrument *Impact of Constructing Non-Motorised Networks and Evaluating Changes in Travel* (Iconnect), widely used by British researchers (http://www.iconnect.ac.uk).

Principal exposure variable

The principal exposure variable was self-reported hearing loss (yes; no), asked by the interviewers with the question, "Do you feel you have a hearing loss?". This question was validated by Ferrite et al. [18] for use in adults in population surveys.

Covariables

The following adjustment variables were used: (a) sex (male; female); (b) complete years of schooling (0-8 years; 9-12; 13 or more); (c) race/skin color (white; black; brown; Asian-descendent; indigenous); and (d) age in complete years (18-29; 30-39; 40-49; 50-59).

Effect-modifying variable

The study used the variable "perception of the environment" (positive; negative). We only used questions from the domain on places for walking and cycling from the instrument *Neighborhood Environment Walkability Survey, Abbreviated* (A-NEWS), translated and validated for the Brazilian reality [19]. Authors have observed that the perception of individuals with hearing loss concerning the environment, including the quality of sidewalks and bicycle lanes, can either discourage or encourage active urban mobility [7].

The questions comprising the domain were: Are there sidewalks on most of the streets in your neighborhood?; Are the sidewalks in your neighborhood well maintained (paved, even, and without a lot of cracks)?; Are there parking spaces along the sidewalks in your neighborhood?; Are their bike lanes on most of the streets in your neighborhood?; Are the bike lanes in your neighborhood well maintained (paved, even, and without a lot of cracks)?; Can you walk easily to the bike lane closest to your home?; Are the bike lanes in your neighborhood separated from the streets/avenues by spaces for parking cars?; Are the bike lanes in your neighborhood separated from the streets by unpaved strips?

The questions had the following possible answers: strongly disagree (0), somewhat disagree (1), somewhat agree (2), and strongly agree (3). A score was calculated for this variable, varying from 0 to 24, divided into tertiles: the first tertile was considered the lowest (negative perception), and the second (moderate) and third tertiles (high), were considered the highest (positive perception). The measure of internal consistency in this set of questions was assessed with Cronbach's alpha, obtaining a value of 0.836, considered reliable according to the literature [20].

Data analysis

The analyses were stratified according to the variable "perception of the environment", aimed at identifying differences in the intensity of the association/effect modification between active urban mobility and hearing loss. For description of the sample's categorical variables, the data were presented as absolute and relative frequencies with the respective 95% confidence intervals (95%CI). The chi-square statistical test was used to analyze the association between the principal exposure variable (self-reported hearing loss) and covariables with the outcome (≥ 10 minutes/week).

In both the crude (bivariate) analysis and adjusted analysis, odds ratio (OR) was used as the measure of association, estimated by logistic regression. The principal exposure variable (hearing loss) was adjusted for all the variables (sex, schooling, race/skin color, age), independently of the p-value. The variables were included simultaneously in the adjusted analysis. Data analysis was done with the Stata software, version 14.0 (https://www.stata.com).

Ethical aspects

The MUS research project was approved by the Institutional Review Board of the University of Brasília (UnB) (November 16, 2016), under case review numbers 1.831.179 and CAEE: 58214416.9.1001.0030. All study subjects signed the free and informed consent form.

Results

The study interviewed 2,350 adults in the three cities, with a mean age of 39 years (SD = 12.3). The majority of the sample (67.1%) consisted of women and individuals that self-identified as white (52.3%). Among the participants, 55.4% had commuted at least ten minutes in the previous week by active means of transportation (bicycling and/or walking). There was higher negative perception of the neighborhood in Florianópolis (53%) and a higher positive perception in Porto Alegre (57%) and Brasília (74.2%). As for sensory impairment, presence of hearing loss was reported by 17% of the individuals (Table 1).

Table 2 shows that active urban mobility ≥ 10 minutes/week, without effect from perception of the neighborhood (for all the participants) was more common among younger individuals (61.6%) and blacks (62.1%). Among those with a negative perception of the environment, individuals with hearing loss presented lower prevalence of active urban mobility in the previous week (≥ 10 minutes/week) (41.1%), when compared to those not reporting hearing loss (51.7%; p = 0.020). Meanwhile, among those with a positive perception of the environment, there was a higher proportion of persons with hearing loss that had walked or pedaled at least 10 minutes in the previous week (61.2%), although without statistical significance (Table 2).

Table 3 shows the crude analysis of the association between active urban mobility, hearing loss, and the other study variables. Among individuals with a negative perception of the environment, those with hearing loss showed an OR of 0.65 (95%CI: 0.45; 0.95), demonstrating that these individuals have 35% lower odds of engaging in active urban mobility (≥ 10 minutes/week) when compared to participants without hearing loss.

Table 4 presents the adjusted analysis of the principal exposure variable according to the other study variables. The adjusted analysis maintained the association between hearing loss and the outcome (≥ 10 minutes/week) in the presence of negative perception of the environment (OR = 0.66, 95%CI: 0.45; 0.97). This highlights that persons with hearing loss in these three Brazilian cities that

Table 1

Description of the sample according to sociodemographic characteristics, hearing loss, perception of the environment, active urban mobility, and city. *Urban Mobility Study*, Florianópolis (Santa Catarina State), Brasília (Federal District), and Porto Alegre (Rio Grande do Sul State), Brazil, 2017.

Variable	Florianópolis (n = 651)		Brasília (n = 937)		Porto Alegre (n = 762)	
	n (%)	95%CI	n (%)	95%CI	n (%)	95%CI
Sex (n = 2,350)						
Male	189 (29.0)	25.6; 32.6	326 (34.8)	31.8; 37.9	259 (34.0)	30.7; 37.4
Female	462 (71.0)	67.3; 74.3	611 (65.2)	62.0; 68.1	503 (66.0)	62.5; 69.2
Years of schooling (n = 2,168)						
0-8	229 (35.4)	31.6; 39.0	139 (18.0)	15.4; 20.8	250 (33.5)	30.2; 37.0
9-12	256 (39.4)	35.7; 43.2	266 (34.4)	31.0; 37.7	265 (35.6)	32.2; 39.0
13 or more	164 (25.2)	22.0; 28.7	369 (47.6)	44.1; 51.2	230 (30.9)	27.6; 34.2
Race/Skin color (n = 2,322)						
White	503 (77.3)	73.8; 39.0	265 (29.0)	26.1; 32.0	445 (58.8)	55.2; 6.2
Black	52 (8.0)	61.0; 10.3	179 (19.6)	17.1; 22.2	157 (20.7)	17.9; 23.7
Nrown/Asian-descendant/Indigenous	96 (14.7)	12.2; 17.6	470 (51.4)	48.1; 54.6	155 (20.5)	17.7; 23.5
Age in years (n = 2,350)						
18-29	105 (61.1)	13.4; 19.1	323 (34.5)	31.4; 37.5	214 (28.1)	24.9; 31.3
30-39	124 (19.2)	16.2; 22.2	226 (24.1)	21.4; 26.9	182 (23.9)	20.9; 27.0
40-49	180 (27.6)	23.3; 31.2	209 (22.3)	19.7; 25.0	160 (21.0)	18.2; 24.0
50-59	242 (37.1)	33.5; 40.9	179 (19.1)	16.7; 21.7	206 (27.0)	23.9; 30.3
Hearing loss (n = 2,336)						
No	544 (83.6)	80.5; 86.2	774 (83.6)	81.0; 85.8	623 (82.1)	79.1; 84.6
Yes	107 (16.4)	13.7; 19.4	152 (16.4)	14.1; 18.9	136 (17.9)	15.3; 20.8
Perception of the environment (n = 2,225) *						
Negative	309 (53.0)	48.8; 56.9	234 (25.8)	23.0; 28.7	315 (43.0)	39.3; 46.5
Positive	275 (47.0)	43.0; 51.1	673 (74.2)	71.2; 76.9	419 (57.0)	53.4; 60.6
Active urban mobility (n = 2,327) **						
< 10 minutes/week	393 (60.7)	56.9; 64.4	367 (39.8)	36.6; 43.0	277 (36.5)	33.1; 40.0
≥ 10 minutes/week	254 (39.3)	35.5; 43.0	555 (60.2)	56.9; 63.3	481 (63.5)	59.9; 66.8

95%CI: 95% confidence interval.

* Perception of the neighborhood environment concerning ease in walking and bicycling;

** Mobility in minutes in the previous 7 days by walking and/or bicycling.

perceive the neighborhood negatively in terms of infrastructure for walking and bicycling tend to circulate less by active means of transportation.

Table 5 shows the adjusted analysis stratified by the three cities in the study. In negative perception of the environment for walking and bicycling, participants with hearing loss were less likely to engage in active urban mobility ≥ 10 minutes/week, when compared to individuals without hearing loss (28% lower odds in Brasília, 35% in Porto Alegre, and 45% in Florianópolis), although these differences were not statistically significant.

Discussion

Prevalence of self-reported hearing loss in this study was 17.0%. Participants from the three Brazilian cities with hearing loss and negative perception of the environment presented an OR of 0.66, i.e., these individuals had 34% lower odds of engaging in active urban mobility (≥ 10minutes/week) when compared to individuals without hearing loss. These data reinforce the importance of the urban environment as a moderator of active mobility in cities, especially among the current study's target public.

Table 2

Prevalence of active urban mobility according to the sample's characteristics and stratified by perception of the environment concerning ease in walking and bicycling. *Urban Mobility Study*, Florianópolis (Santa Catarina State), Brasília (Federal District), and Porto Alegre (Rio Grande do Sul State), Brazil, 2017.

Variable	Negative perception of the environment			Positive percetion of the environment			All		
	≥ 10 minutes/week			≥ 10 minutes/week			≥ 10 minutes/week		
	%	95%CI	p-value *	%	95%CI	p-value *	%	95%CI	p-value *
Sex			0.062			0.551			0.959
Male	45.0	39.0; 51.1		60.8	56.3; 65.0		55.5	51.9; 59.0	
Female	51.9	47.9; 55.9		59.1	55.8; 62.3		55.4	52.9; 57.8	
Years of schooling			0.167			0.208			0.385
0-8	53.4	47.3; 59.3		56.4	50.7; 62.0		54.4	50.4; 58.3	
9-12	46.8	41.4; 52.2		58.5	53.7; 63.2		53.1	49.6; 56.6	
13 or more	45.7	39.3; 52.3		62.5	58.1; 66.6		56.6	53.0; 60.1	
Race/Skin color			< 0.001			0.506			0.004
White	42.5	38.1; 47.1		60.0	56.2; 63.6		52.6	49.7; 55.4	
Black	65.9	57.7; 73.3		61.7	55.0; 68.0		62.1	57.1; 66.8	
Brown/Asian-descendant/ Indigenous	53.8	47.3; 60.1		57.4	52.6; 61.9		55.8	52.1; 59.4	
Age (years)			0.008			0.032			< 0.001
18-29	56.6	49.7; 63.1		65.0	60.1; 69.6		61.6	57.7; 65.3	
30-39	54.7	47.9; 61.3		61.0	55.2; 66.4		57.7	53.4; 61.9	
40-49	43.7	36.6; 51.0		54.8	49.4; 60.2		50.5	46.3; 54.7	
50-59	44.2	38.0; 50.5		57.3	51.9; 62.6		51.4	47.5; 55.3	
Hearing loss			0.020			0.623			0.347
No	51.7	48.0; 55.4		59.4	56.5; 6.2		55.9	53.6; 58.1	
Yes	41.1	33.3; 49.3		61.2	54.4; 67.5		52.3	48.3; 58.2	

95%CI: 95% confidence interval.

* Pearson's chi-square test.

Few studies in Brazil have investigated the prevalence of hearing loss in the population, and the existing studies have used different methods, thus hindering comparison of the current study's findings with those from previous research [3,21]. However, the 17% prevalence of hearing loss in adults in this study is similar to the data from 2011 in the *U.S. National Health Interview Survey* (NHIS) [22], with 16% prevalence of hearing disorders in 231,376 individuals 19 years and older. Meanwhile, a population-based study by Cruz et al. [3] in four cities in the state of São Paulo in individuals over 12 years of age found a lower prevalence of self-reported hearing loss (5.2%). Importantly, the current study investigated the prevalence of hearing loss in adults, and hearing loss may end to increase with population aging [21].

Urban mobility of individuals without disability has already been the focus of research, given the numerous difficulties in cities, especially resulting from the prioritization of individual motor vehicle transportation to the detriment of pedestrians and cyclists. Still, active urban mobility and the capacity of persons with disability to come and go is just as important as the mobility of individuals without disabilities. In addition, proper mobility is essential to the identity, life experiences, and opportunities of persons with disabilities [23].

Hearing is the main sense that furnishes information on events in one's surroundings. Hearing is a form of social and emotional bonding and provides important warning signs for individuals' physical safety. From the perspective of the person with hearing disability, in a previous study, persons with hearing loss reported that their sensory-abled organs could simplify their movements, offering

Table 3

Crude analysis of the association between active urban mobility, hearing loss, and other variables in the sample, stratified by perception of the environment concerning ease in walking and bicycling. *Urban Mobility Study*, Florianópolis (Santa Catarina State), Brasília (Federal District), and Porto Alegre (Rio Grande do Sul State), Brazil, 2017.

Variable	Negative perception of the environment ≥ 10 minutes/week		Positive percetion of the environment ≥ 10 minutes/week		All ≥ 10 minutes/week	
	Crude OR (95%CI)	p-value	Crude OR (95%CI)	p-value	Crude OR (95%CI)	p-value
Sex		0.062		0.551		0.959
Male	1.00		1.00		1.00	
Female	1.32 (0.98; 1.77)		0.93 (0.74; 1.17)		0.99 (0.83; 1.18)	
Years of schooling		0.085		0.081		0.77
0-8	1.00		1.00		1.00	
9-12	0.76 (0.55; 1.06)		1.08 (0.80; 1.46)		0.95 (0.76; 1.17)	
13 or more	0.73 (0.51; 1.05)		1.28 (0.95; 1.71)		1.09 (0.88; 1.35)	
Race/Skin color		0.001		0.415		0.092
White	1.00		1.00		1.00	
Black	2.61 (1.77; 3.86)		1.07 (0.78; 1.47)		1.47 (1.16; 1.87)	
Brown/Asian-descendant/Indigenous	1.57 (1.14; 2.15)		0.89 (0.70; 1.14)		1.13 (0.94; 1.37)	
Age (years)		0.002		0.011		< 0.001
18-29	1.00		1.00		1.00	
30-39	0.92 (0.63; 1.35)		0.84 (0.61; 1.15)		0.85 (0.67; 1.07)	
40-49	0.59 (0.39; 0.88)		0.65 (0.48; 0.88)		0.63 (0.50; 0.80)	
50-59	0.60 (0.41; 0.88)		0.72 (0.53; 0.97)		0.66 (0.52; 0.82)	
Hearing loss		0.020		0.623		0.347
No	1.00		1.00		1.00	
Yes	0.65 (0.45; 0.93)		1.07 (0.79; 1.45)		0.90 (0.72; 1.11)	

95%CI: 95% confidence interval; OR: odds ratio.

Table 4

Adjusted analysis of the association between active urban mobility, hearing loss, and other variables in the sample, stratified by perception of the environment concerning ease in walking and bicycling. *Urban Mobility Study*, Florianópolis (Santa Catarina State), Brasília (Federal District), and Porto Alegre (Rio Grande do Sul State), Brazil, 2017.

Variable	Negative perception of the environment ≥ 10 minutes/week		Positive percetion of the environment ≥ 10 minutes/week		All ≥ 10 minutes/week	
	Adjusted OR * (95%CI)	p-value	Adjusted OR * (95%CI)	p-value	Adjusted OR * (95%CI)	p-value
Hearing loss		0.039		0.387		0.699
No	1.00		1.00		1.00	
Yes	0.66 (0.45; 0.97)		1.15 (0.83; 1.60)		0.95 (0.75; 1.20)	

95%CI: 95% confidence interval; OR: odds ratio.

* Adjusted by sex, schooling, race/skin color, and age.

Table 5

Adjusted analysis of the association between active urban mobility and hearing loss, stratified by city and perception of the environment concerning ease in walking and bicycling. *Urban Mobility Study*, Florianópolis (Santa Catarina State), Brasília (Federal District), and Porto Alegre (Rio Grande do Sul State), Brazil, 2017.

City/Variable	Negative perception of the environment		Positive percetion of the environment		All	
	≥ 10 minutes/week		≥ 10 minutes/week		≥ 10 minutes/week	
	Adjusted OR * (95%CI)	p-value	Adjusted OR * (95%CI)	p-value	Adjusted OR * (95%CI)	p-value
Brasília						
Hearing loss		0.412		0.794		0.770
No	1.00		1.00		1.00	
Yes	0.72 (0.33; 1.56)		0.93 (0.56; 1.54)		0.94 (0.62; 1.41)	
Porto Alegre						
Hearing loss		0.160		0.532		0.947
No	1.00		1.00		1.00	
Yes	0.65 (0.36; 1.18)		1.21 (0.66; 2.22)		0.98 (0.66; 1.47)	
Florianópolis		0.093				
Hearing loss				0.516		0.309
No	1.00		1.00		1.00	
Yes	0.55 (0.27; 1.10)		1.25 (0.62; 2.52)		0.79 (0.51; 1.23)	

95%CI: 95% confidence interval; OR: odds ratio.

* Adjusted by sex, schooling, race/skin color, and age.

more visual information clearly and precisely, since difficulty in locomotion can emerge from lack of signage, adding to their difficulty in asking for information from passersby [7].

An experimental study in Italy with 62 adult individuals with disabilities identified the main perceived obstacles to access in urban areas. Nineteen of the participants had hearing disabilities, and the authors concluded that crossing the street is particularly dangerous for individuals with hearing problems, since they have to be careful when trying to reach the sidewalk on the other side and offset their inability to capture the sound of approaching vehicles. The authors concluded that the individuals may perceive the urban environment as hostile and adverse, and that such barriers can limit their desire to meet people and visit places, potentially contributing to their social withdrawal, decreasing their time out of the house and the frequency of their outings, essentially corroborating the current study's findings [24]. Another study, in a different population (767 elderly individuals in Finland) found an association between hearing problems and time spent away from home and failure to engage in leisure-time activities. Persons with hearing loss spent less time outside the home (estimate average: 161 minutes/week) than individuals that reported good hearing (estimated average: 242 minutes/week) [13].

In the current study, persons with hearing loss that perceived the environment negatively showed lower prevalence of active urban mobility ≥ 10 minutes/week. This scenario highlights the issue of accessibility for persons with this sensory disability, and that walking and/or bicycling is impacted by the way the individual perceives the environment, often viewed as non-accessible, uninviting, or unfavorable. Accessible cities are essential for persons with disability to enjoy high-quality urban mobility. Brazil's *Law n. 10,098/2000* [25], regulated by *Decree n. 5,296/2004*, provides for the elimination of barriers in social spaces and within city limits and aims to create alternative techniques that allow communication and signage for persons with sensory disabilities. In addition, NBR 905/2004 of the Brazilian Association of Technical Standards (ABNT) sets the standards for accessibility in urban buildings, furnishings, spaces, and equipment. The parameters set by these standards include all the necessary instrumentalization for any individual to be able to adapt to the environmental conditions in the built space. However, most Brazilian cities fail to comply with these standards [26].

Studies indicate that perception of the built environment is closely tied to the individuals' choice of mode of transportation [27,28], since persons' perceived safety is another characteristic that can either encourage or discourage transportation use. Sallis et al. [29] investigated the use of bicycling by 1,780 American adults. The authors concluded that there were higher odds of bicycling when cyclists reported a feeling of safety in relation to automobile traffic. This situation is further aggravated for hearing-impaired individuals, because, as mentioned, hearing provides important safety-related warning signs. Individuals with hearing disability thus tend to feel insecure when they perceive the environment unfavorably, preferring to use more convenient means of transportation or those assessed subjectively as safer.

Some elements should be considered when interpreting the study's results. The use of self-reported measures can be considered a limitation, especially those related to environmental perception, since they express the individuals' perceptions rather than objective measures. Such measures may even be subject to social desirability. Still, in assessing perception of the environment and hearing loss, validated instruments were used here, widely employed in previous studies and with valid results. Another potential limitation is that the study was performed in adults from the cities of Florianópolis, Porto Alegre and Brasília, and it is not possible to generalize the results to other populations.

The study's contributions were mainly the fact that it involves a theme that has received little attention and is crucially important, contributing to future discussions on accessibility and mobility in Brazil, given that hearing loss is considered a relatively invisible disability. The study's methods are another strength, emphasizing that health surveys constitute an important method for collecting epidemiological data, capable of backing more effective health promotion actions.

For future research, we suggest studies whose analyses include objective measures of the built environment. In addition, the investigation of hearing loss could include not only self-report, but also other feasible measures in household surveys. In March 2019, the WHO launched a hearing loss screening tool via an app, where individuals that fail the screening test receive an alert and are referred for diagnostic tests such as audiometry. According to the app's developers, the tool's sensitivity and specificity exceed 85% [30].

Discussion of active urban mobility for persons with disability is essential for their social inclusion. The built environment can provide adequate and safe conditions for mobility to allow individual autonomy, eliminating architectural barriers. Urban spaces should be accessible to all, offering equitable and inclusive opportunities to users, especially in a society were most people are hearing-abled, representing a participatory planning action in pursuit of active urban mobility.

The study concluded that there was an association between hearing loss and levels of active urban mobility in adults in three Brazilian cities, according to negative perception of the environment. Persons with hearing loss that perceived the neighborhood negatively in terms of infrastructure for walking and pedaling tend to use active means of transportation less. It is necessary to motivate public policymakers and members of civil society in various social policy areas to develop and implement strategies with the environmental context at the center of the discussions. This should allow improving the urban population's health conditions, especially for persons with this sensory disability.

Contributors

D. Hillesheim contributed substantially to the study's conception and design, data analysis and interpretation, writing and critical revision of the final article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. K. M. Paiva contributed substantially to the study's conception and design, data interpretation, writing and revision of the final article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. C. R. Rech contributed substantially to the study's conception and design, writing and critical revision of the final article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. J. C. B. Vargas contributed substantially to the study's design, standardization, writing and critical revision of the article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. I. L. Neto contributed substantially to the study's standardization, data analysis, writing and critical revision of the article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. H. Günther contributed substantially to the data analysis, writing and critical revision of the article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work. E. d'Orsi contributed substantially to the study's conception, orientation, and design, data analysis and interpretation, writing and critical revision of the final article, and approval of the final version for publication, besides assuming responsibility for all aspects of the work.

Additional informations

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Resumo

O objetivo deste estudo foi estimar a associação entre perda auditiva e mobilidade urbana ativa (a pé e/ou de bicicleta), segundo a percepção sobre o ambiente em adultos de três capitais brasileiras. Trata-se de um estudo transversal com 2.350 adultos (18-59 anos) residentes das cidades de Brasília (Distrito Federal), Florianópolis (Santa Catarina) e Porto Alegre (Rio Grande do Sul), avaliados pelo estudo multicêntrico Mobilidade Urbana Saudável *(MUS), em 2017 e 2018. A variável de desfecho foi a mobilidade urbana ativa (≥ 10 minutos/semana), e a exposição principal foi a perda auditiva autorreferida. As análises foram estratificadas pela variável percepção do ambiente – percepção dos lugares para caminhar e andar de bicicleta (negativa; positiva). Utilizou-se a análise de regressão logística, estimando-se as* odds ratio *(OR) brutas e ajustadas, com intervalos de 95% de confiança (IC95%). A prevalência de perda auditiva autorreferida e de mobilidade urbana ativa foi de 17% (IC95%: 15,4; 18,4) e 55,4% (IC95%: 53,4; 57,4), respectivamente. Adultos com perda auditiva e que percebiam o ambiente de forma negativa para caminhar e andar de bicicleta possuíam 34% menos chance de realizar mobilidade urbana ativa ≥ 10 minutos/semana (OR = 0,66; IC95%: 0,45; 0,97). Conclui-se que houve associação entre perda auditiva e mobilidade urbana ativa dos adultos das três capitais brasileiras, segundo a percepção negativa sobre o ambiente. Pessoas com perda auditiva que percebem negativamente o bairro tendem a se deslocar menos por meios de transportes ativos.*

Perda Auditiva; Liberdade de Circulação; Área Urbana; Planejamento Ambiental; Ambiente Construído

Resumen

El objetivo de este estudio fue estimar la asociación entre la pérdida auditiva y la movilidad urbana activa (a pie y/o en bicicleta), según la percepción sobre el ambiente en adultos de tres capitales brasileñas. Se trata de un estudio transversal con 2.350 adultos (18-59 años), residentes en las ciudades de Brasília (Distrito Federal), Florianópolis (Santa Catarina) y Porto Alegre (Rio Grande do Sul), evaluados por el estudio multicéntrico Movilidad Urbana Saludable *(MUS), en 2017 y 2018. La variable de resultado fue la movilidad urbana activa (≥ 10 minutos/semana) y la exposición principal fue la pérdida auditiva autoinformada. Los análisis fueron estratificados por la variable percepción del ambiente -percepción de los lugares para caminar y montar en bicicleta (negativa; positiva). Se utilizó el análisis de regresión logística, estimando las* odds ratio *(OR) brutas y ajustadas, con intervalos de 95% de confianza (IC95%). La prevalencia de pérdida auditiva autoinformada y de movilidad urbana activa fue de un 17% (IC95%: 15,4; 18,4) y 55,4% (IC95%: 53,4; 57,4), respectivamente. Adultos con pérdida auditiva y que percibían el ambiente de forma negativa para caminar y montar en bicicleta poseían un 34% menos de oportunidad de realizar movilidad urbana activa ≥ 10 minutos/semana (OR = 0,66; IC95%: 0,45; 0,97). Se concluye que hubo asociación entre la pérdida auditiva y la movilidad urbana activa de los adultos de las tres capitales brasileñas, según la percepción negativa sobre el ambiente. Las personas con pérdida auditiva que perciben negativamente el barrio tienden a desplazarse menos a través de medios de transportes activos.*

Pérdida Auditiva; Derecho a la Libre Circulación; Área Urbana; Planificación Ambiental; Entorno Construido

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