

Social inequalities between neighborhoods and cardiovascular disease: a multilevel analysis in a Latin American city

Desigualdades sociais entre vizinhanças e doenças cardiovasculares: análise multinível em uma cidade latino-americana

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Abstract *Studies analyzing relations between cardiovascular diseases (CVDs) and environmental aspects in Latin American cities are relatively recent and limited, since most of them are conducted in high-income countries, analyzing mortality outcomes, and comprising large areas. This research focuses on adults with diabetes and/or hypertension under clinical follow-up who live in deprived areas. At the individual level we evaluated sociodemographic and cardiovascular risk factors from patient's records, and at the neighborhood level, socioeconomic conditions from census data. A multilevel analysis was carried out to study CVD. More women than men were under clinical follow-up, but men had higher frequency, higher odds, and shorter time to CVD diagnosis. Multilevel analysis showed that residing in neighborhoods with worst socioeconomic conditions leads to higher odds of CVDs, even after controlling for individual variables: OR (CI95%) of CVD in quartile 2 (Q2) 3.9 (1.2-12.1); Q3 4.0 (1.3-12.3); Q4 2.3 (0.7-8.0) (vs. highest socioeconomic level quartile). Among individuals living in unequal contexts, we found differences in CVD, which makes visible inequalities within inequalities. Differences between women and men should be considered through a gender perspective.*

Key words Cardiovascular diseases, Inequalities, Multilevel analysis, Urban health, Diabetes

Resumo *Os estudos que analisam as relações entre doenças cardiovasculares (DCVs) e aspectos ambientais em cidades latino-americanas são relativamente recentes e limitados. A maioria é realizada em países de alta renda analisando a mortalidade em grandes áreas. Esta investigação foca a população de adultos em acompanhamento clínico por diabetes e/ou hipertensão residentes em áreas carentes. No nível individual foram avaliados fatores sociodemográficos e de risco cardiovascular a partir dos prontuários médicos; e a partir de dados censitários, as condições socioeconômicas no nível da vizinhança. Mais mulheres do que homens estavam sob acompanhamento clínico, mas os homens apresentaram maior frequência, maior chance e menor tempo para diagnóstico de DCV. A análise multinível mostrou que residir em bairros com piores condições socioeconômicas leva a maiores chances de DCV, mesmo após o controle de variáveis individuais. As OR (IC95%) de DCV foram: Q2 OR 3,9 (1,2-12,1); Q3 OR 4,0 (1,3-12,3); Q4 OR 2,3 (0,7-8,0) (referência: quartil de maior nível socioeconômico). Entre os indivíduos que vivem em contextos desiguais, encontramos diferenças nas DCV, mostrando desigualdades dentro das desigualdades. Diferenças entre homens e mulheres devem ser abordadas com uma perspectiva de gênero.*

Palavras-chave Doenças cardiovasculares, Desigualdades, Análise multinível, Saúde urbana, Diabetes

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Introduction

Disease and mortality burden of noncommunicable diseases, represented by cardiovascular diseases (CVDs), diabetes, cancer, chronic respiratory diseases, are increasing worldwide. In 2016, they represented 71% of world's deaths, such that three out of four of these deaths occurred in low and middle-income countries, where the most premature deaths occurred¹.

The literature based on general population points out that social and material deprivation are directly related to disease occurrence and inversely related to health status^{2,3}. Different reviews show relations between socioeconomic conditions and CVDs in the general population^{3,4}, and also with diabetes^{5,6} and hypertension⁷. In recent years, several studies have shown that the effects of social inequities on health increased^{8,9}. Particularly, there are many studies analyzing the occurrence of CVDs and their relationships to living in deprived neighborhoods or having low socioeconomic status^{10,11}.

Disparities in CVDs occurrence between women and men were also described focusing in two different aspects: sex differences due to the biological factors, and gender differences related to factors such as socioeconomic status, healthcare access, and levels of urbanization¹².

Even though there is a great interest in studying social inequalities effects on CVDs in high-income countries, this literature is scarce in Latin America, a region with income inequalities and a strong residential segregation within urban areas^{13,14}. In addition, in Latin America, the region health information systems mainly provide data and allow studies at country or regional level, yielding averaged information which masks differences and homogenize results^{15,16}.

To evaluate the relationships between chronic diseases and social inequalities, multilevel studies might be considered as an analytical approach. These models can potentially analyze factors from distinct hierarchical levels, such as from macro-economic to individual level. The general concept is that individuals interact with the social contexts to which they belong, meaning that individuals are influenced by social groups¹⁷. Multilevel models integrate individuals in social groups, allowing the analysis of the combined effects of individual and group variables¹⁸ while taking into account the data dependence structure due to the clustered design.

To study inequalities related to CVD in an urban city in a middle-income country from Latin

America, we propose to simultaneously investigate the effects of individual and neighborhood level characteristics on CVD. We studied adults with diabetes and/or hypertension under clinical follow-up, searching for gender differences (through biological sex variable), and living conditions dissimilarities using multilevel models.

Methods

Study area

This study was conducted in Bariloche, a city located in the Argentinean North Patagonia, with a population of 113 112 according to 2010 census data¹⁹. Its local economy is concentrated in tourism activities, with part of its population living in privileged socioeconomic and environmental conditions, and a large group in highly vulnerable conditions²⁰. Public healthcare system is under the Province responsibility, locally established by the Bariloche Zone Hospital, and by 15 healthcare centers, of which 13 are scattered around different city zones and two in nearby towns. In Argentina, population who attend public healthcare system are those living under deprived living conditions, since it is prioritized to those who do not have health-insurance. Despite that, individuals with health-insurance can be attended in public healthcare system.

Design and population

A cross-sectional study with multilevel analysis was carried out. The studied population were adults (18 years or more) with diabetes and/or hypertension diagnosis under clinical follow-up in public healthcare centers from Bariloche. Data collection was done between 2014 and 2015, including patient's variables (individual level) and neighborhoods variables (aggregated/clustered level). For the patient's variables, data sources were medical records and hospital discharges. Medical records were collected from all patients with type 2 diabetes mellitus (hereinafter diabetes) and primary hypertension (hereinafter hypertension) attended in public healthcare centers in Bariloche. We excluded medical records for the patients with less than three appointments and for those with last primary care appointment before 2009.

To improve registry quality, a deterministic record linkage was done between the databases from healthcare centers and from all hospi-

tal discharges between 2005 and 2015. Hospital discharges were from the hospitalizations of the aforementioned patients in the local hospital. The information from the hospital discharges complement data on the patient's health problems, diagnosis specificity, and omitted hospitalizations in medical records from healthcare centers.

To obtain neighborhoods level characteristics (aggregated/clustered level), block groups, which are census-defined areas with 200 to 400 households, built for census purposes¹⁹ were used as proxies for neighborhoods. Bariloche city has 160 block groups and 65 neighborhoods, thus some neighborhoods are formed by more than one block group. When neighborhoods included more than one block group, individuals were allocated to that block group that presented the most similar characteristics (belonging to the same quartile) according to two census variables: education and unmet basic needs. Block group codes were used to link individuals to their neighborhood's characteristics (level 1 nested to level 2 units), through their address from the medical records.

Variables

The response variable is cardiovascular disease (CVD) diagnosis measured at the individual level (level 1) and defined as complications which have a vascular relationship with diabetes and/or hypertension: *Cerebrovascular disease* (10 ICD codes: I61, I63, I64), *Coronary heart disease* (10 ICD codes: I21, I22, I25). Other studies have studied both diseases as a combined outcome^{21,22}.

Other individual level variables included: (i) socio-demographic characteristics, such as age (less than 55 years, between 56 and 64 years, 65 or more years), *sex* (women/men), *immigrant status* (born in other country: yes, no), (ii) socio-economic characteristics, including *health insurance* (yes, no), *work* (employee, services, domestic work, pensioner or retired), *education* (illiterate, primary incomplete, primary complete, secondary incomplete or more); (iii) cardiovascular risk factors, including *BMI* (body mass index = body/weight²), *bodyweight change* (between beginning of the follow-up and last registered weight: Lost [+2 kg], maintained [within \pm 2 kg], or increased [+2 kg]), *diabetes* (yes, no), *hypertension* (yes, no); *smoking* (no, current, former), *alcoholism* (no, actual or previous alcohol problems). We categorized age using three categories, which incorporates concepts related to the definition of

premature CVD and differences between women and men. However, it is important to acknowledge that different cut points have been used in literature, particularly involving ages before 55 years-old and before 65 years-old^{23,24},

The aggregated level (*neighborhoods*) socio-economic characterization was done according to the proportion of households with *unmet basic needs*. This indicator measures the percentage of population with at least one of the following indicators: households with critical overcrowding, inconvenient housing units (tenancy piece, precarious households or other type), housing with inadequate services, households with school-age children not attending school, and households with high economic dependence (which have four or more individuals per working member, and the household head has low educational level)¹⁹.

The complete dataset and codebook are available in the following link: <https://data.scielo.org/dataset.xhtml?persistentId=doi:10.48331/scielo-data.SYBBUJ>.

Statistical analysis

Univariate and bivariate descriptive analyses were performed through frequency distributions for the variables. We computed the length (in years) between the diagnosis of CVD and the diagnosis of diabetes or hypertension (whichever had been diagnosed first). We used second-order Rao-Scot chi-square statistic to test the association between categorical variables due to the clustered structure of data, which leads to the violation of the assumption of independent observations.

Two indices were calculated to quantify the socioeconomic gradient in relative and absolute terms related to CVD. For absolute inequality we computed the slope index of inequality (SII), which represents the absolute difference in the predicted values of a health indicator (CVD in our case) between the values of the socioeconomic indicator rank (Unmet Basic Needs), considering its entire distribution. For relative inequality, we computed the relative index of inequality (RII), using the same curve-fitting procedure as for the SII, but instead of calculating the difference between the fitted values, the RII is the ratio between the two^{25,26}. These indices were calculated both in the overall studied population, and separately for women and men.

Finally, multilevel logistic regression models were fitted. Both crude and adjusted OR (odds

ratio) estimates (and corresponding 95% confidence intervals) are presented through different models: (i) ORs without adjustments (crude estimates) (model 1); (ii) ORs controlling for socio-demographic variables (model 2); (iii) ORs controlling for cardiovascular risk factors (model 3), and (iv) ORs controlling for all variables (model 4). Intraclass correlation coefficient (ICC) was calculated for each model²⁷. Due to the high proportion of missing data for the socioeconomic individual level variables, a separate analysis was performed for the subset of individuals with complete data, following the same steps as used for the previous analyses. We conducted analysis with STATA version 15.0 and performed georeference with QGIS version 3.8.

Ethics

This research has been approved by the Ethical Commission from Hospital Zonal Bariloche and by the Ethic Research Commission from Lanus National University. Confidentiality of persons has been protected according to the Protection of Personal Data Law, No. 25,326, processing of Sensitive Data and the Statistical Secrecy Law, No. 17.622.

Results

A total of 820 individuals were studied in 36 neighborhoods, with an average of 22.8 individuals (SD = 17.8) per neighborhood. 43.5% (357) of the individuals were admitted in the local hospital; half of them with only one admission, the rest were admitted twice or more times; 13.0% (107) of the admissions were related to the CVDs studied here. For the patients with at least one hospitalization between 2005 and 2015, the average number of admissions was two, with an average length of stay of seven days.

Table 1 shows the distribution of the variables. Note that 71.1% (583) of the patients were women, with overall mean age of 61.1 years-old. Note that men were slightly older than women (62.3 vs 60.7 years-old). Nearly half of the population, 45.4% (372), were born in other countries, most of them in Chile. Women mainly worked in their homes (53.9%), followed by those who engaged domestic labor and other types of employment. On other hand, men were mainly engaged in construction and other informal jobs. A larger proportion of men, in relation to women, reported being retired or pensioned (10.1% vs

5.3%). Alcoholism (actual or previous) was also higher among men than women (32.1% vs 2.7%, respectively). Similar pattern was observed with smoking (current or former): 39.7% and 26.2%, respectively, among men and women. BMI mean was 32.6 kg/m², with a highest BMI observed in women compared to men (33.5 vs 30.3 kg/m²).

The mean age of the patients at the time of the diagnosis of diabetes and hypertension was 51.5 and 51.8 years-old, respectively. Among these patients, 8.8% (72) were diagnosed with CVD. On average, the diagnosis of CVD was made 6.8 years after the diagnosis of diabetes or hypertension. Longest intervals were observed in women in relation to men: 8.0 vs 5.5 years.

Frequency of CVD diagnosis was higher among older individuals, men, current or former smokers, and those who lived in neighborhoods with higher proportion of Unmet Basic Needs (Table 2). No association was found between body mass index and CVD (results not shown), but a positive association was found with body weight increase throughout the clinical follow-up in the healthcare center.

We quantified socio-economic inequalities in both absolute (SII) and relative (RII) terms. Overall, we found 3.3% difference in CVD between levels of Unmet Basic Needs in absolute terms (SII); separate analysis for men and women showed 9.7% and 0.7% differences respectively. Overall, relative differences (RII) were 47% higher in the poorest quartile compared to the richest, 89% higher among men, and 12% among women.

Table 3 shows results of CVD from unadjusted and adjusted multilevel logistic models. In the unadjusted model (model 1), neighborhood's socioeconomic score was significantly associated with CVD. The relation appeared to be graded from quartile 1 to quartile 3 and drops in quartile 4 (quartile 2 OR = 3.87; 95%CI = 1.24;12.05; quartile 3 OR = 3.95; 95%CI = 1.26;12.35; quartile 4 OR = 2.27; 95%CI = 0.65;7.95), with an inverse J-shaped pattern. After adjustment for individual sociodemographic variables (model 2), cardiovascular risk factors (model 3), and both sets of variables (model 4), this pattern is maintained. Looking at the individual level variables adjusted by the neighborhood level, we found higher odds among men than women, (around three times higher), among older individuals, and among those who increased their weight along the clinical follow-up. Smoking was not statistically significant; while alcoholism presented a protective effect, with statistical significance in model 4 (OR 0.21; 95%CI = 0.08-0.59).

Table 1. Characteristics of individuals and neighborhoods by sex. Bariloche, Argentina. 2015.

Characteristics	Total (n = 820)		Women (n = 583)		Men (n = 237)		p-value ^b
	n	(%)	n	(%)	n	(%)	
Individual							
Age							
≤ 55 years	220	(26.8)	167	(28.6)	53	(22.3)	0.183
56-64 years	302	(36.8)	209	(35.8)	93	(39.2)	
≥ 65 years	298	(36.3)	207	(35.5)	91	(38.4)	
Mean (SD)	61.1	(11.7)	60.7	(11.8)	62.3	(11.4)	
Immigrant							
Yes	372	(45.4)	256	(43.9)	116	(48.9)	0.097
No	445	(54.2)	327	(56.1)	118	(49.8)	
Missing data	3	(0.4)	-		3	(1.3)	
Health insurance							
Yes	257	(31.3)	191	(32.8)	66	(27.8)	0.165
No	563	(68.7)	392	(67.2)	171	(72.1)	
Education							
Secondary incomplete or more	109	(13.3)	77	(13.2)	32	(13.5)	0.131
Primary complete	165	(20.1)	115	(19.7)	50	(21.1)	
Primary incomplete	163	(19.9)	118	(20.3)	45	(19.0)	
Illiterate	80	(9.8)	67	(11.5)	13	(5.5)	
Missing data	303	(36.9)	206	(35.3)	97	(40.9)	
Diabetes and hypertension							
Only diabetes	108	(13.2)	72	(12.3)	36	(15.2)	0.514
Only hypertension	473	(57.7)	333	(57.1)	140	(59.1)	
Both	239	(29.1)	178	(30.5)	61	(25.7)	
Alcoholism							
No	728	(88.7)	567	(97.3)	161	(67.9)	< 0.001
Actual	72	(8.8)	13	(2.2)	59	(24.9)	
Previous	20	(2.5)	3	(0.5)	17	(7.2)	
Smoking							
No	573	(69.9)	430	(73.8)	143	(60.3)	0.082
Current	158	(19.3)	100	(17.1)	58	(24.5)	
Former	89	(10.8)	53	(9.1)	36	(15.2)	
Weight							
Normal	91	(11.1)	58	(9.9)	33	(13.9)	0.002
Overweight	222	(27.1)	142	(24.4)	80	(33.8)	
Class I obesity	252	(30.7)	175	(30.0)	77	(32.5)	
Class II obesity	132	(16.1)	105	(18.0)	27	(11.4)	
Class III obesity	114	(13.9)	98	(16.8)	16	(6.8)	
Missing data	9	(1.1)	5	(0.9)	4	(1.7)	
Initial BMI. Mean (SD)	32.6	(6.9)	33.5	(7.2)	30.3	(5.3)	
Bodyweight change							
Lost	355	(43.3)	271	(46.5)	84	(35.5)	0.108
Maintained	192	(23.4)	126	(21.6)	66	(27.8)	
Increased	264	(32.2)	181	(31.0)	83	(35.0)	
Missing data	9	(1.1)	5	(0.9)	4	(1.7)	
Cardiovascular disease							
	72	(8.8)		35	(6.0)	(15.6)	
Neighbourhoods							
Unmet basic needs ^a							
Quartile 1 (0-11,5)	133	(16.2)	101	(17.3)	32	(13.5)	< 0.001
Quartile 2 (12,1-17,2)	233	(28.4)	161	(27.6)	72	(30.4)	
Quartile 3 (17,3-24,7)	240	(29.3)	166	(28.5)	74	(31.2)	
Quartile 4 (27,1-56,5)	214	(26.1)	155	(26.6)	59	(24.9)	

BMI = body mass index; SD = standard deviation. ^a Values between parentheses represent percentage of households with at least one unmet basic need. ^b p-value from second-order Rao-Scot chi-square statistic.

Source: Authors, based on patient's records and National Census.

Table 2. Frequency of cardiovascular disease according to individual and neighborhood characteristics. Bariloche, Argentina, 2015 (n = 820).

Characteristics	Cardiovascular disease (n = 72, 8.8%)		
	n	(%)	P-value ^b
Age			
≤ 55 years	8	(3.6)	
56-64 years	26	(8.6)	
≥ 65 years	38	(12.7)	0.008
Sex			
Women	35	(6.0)	
Men	37	(15.6)	< 0.001
Alcoholism			
No	66	(9.1)	
Actual o previous	6	(6.5)	0.493
Smoking			
No	45	(7.9)	
Current or former	27	(10.9)	0.223
Health insurance			
Yes	27	(10.5)	
No	45	(7.99)	0.222
Diabetes/hypertension			
Only hypertension	42	(8.9)	
Only diabetes	2	(1.9)	
Both	28	(11.7)	0.007
Bodyweight change			
Lost	19	(5.3)	
Maintained	19	(9.9)	
Increased	33	(12.5)	0.019
Unmet basic needs ^a			
Quartile 1	4	(3.0)	
Quartile 2	25	(10.7)	
Quartile 3	26	(10.8)	
Quartile 4	17	(7.9)	0.053

^aNeighborhoods distribution (in quartiles): households with one unmet basic need. ^bp-value from second-order Rao-Scot chi-square statistic.

Source: Authors, based on patient's records and National Census.

Table 4 shows a separate analysis on the subset of individuals with complete data for level of education due to its high missingness (36.9%). The final model (model 5 in the Table 4), with results adjusted by sociodemographic, cardiovascular risk factors, and neighborhood level, showed that as individuals had worse educational level they presented higher odds of CVD, even though not statistically significant (quartile 2 OR

= 1.14; 95%CI = 0.43;3.02; quartile 3 OR = 1.81; 95%CI = 0.70;4.67; quartile 4 OR = 2.09; 95%CI = 0.94;4.66). Neighborhood level presented similar J-shaped pattern as the results described previously.

Table 5 shows estimates for the effects of the variables for two specific diseases: hypertension, and diabetes (as defined by model 4 in Table 3). All variables were significantly associated to the diagnosis of hypertension, except smoking, with estimates in the similar direction as those described for model 3 in Table 3. Despite the chance of being diagnosed as diabetic increases three times the unmet basic needs worsens, this association was no longer statistically significant. Note, however, that the ICC increased, such that neighborhood explains 18.0% of the variability.

Discussion

Different models were explored to describe the association of individual and aggregated level characteristics with CVD. The results showed that there are differences in CVDs when we simultaneously evaluate individual and contextual characteristics. Some relevant aspects merit further discussion: differences between women and men, relationship between cardiovascular risk factors and CVD, and the relations between urban environments and health problems.

Differences between women and men should be discussed in relation to differential healthcare access. The studied population was constituted by all adults who had access to the healthcare services and were under clinical follow-up in public healthcare centers. Most of them were women, fact that can be linked to differential access to healthcare-system between women and men, to the role that the women have in family-care, and to the prioritization of maternal and childhood healthcare in the local policies. In contrast, men had higher frequency in CVDs diagnosis, presenting higher odds of CVD, a shorter interval between the diagnosis of diabetes and/or hypertension and the diagnosis of CVD, and higher impact of inequalities.

The women access to healthcare seems to be related to their social role, such that their first access is usually related to the contraception planning, followed by the pregnancy care, and later they continue using the healthcare system due to their role in the childcare (as well as in the grandchildren medical care). In contrast, men mostly access medical healthcare to resolve acute

Table 3. ORs (and 95% CIs) of cardiovascular disease associated with individual and neighborhood's characteristics. Bariloche, Argentina, 2015.

Covariates	Model 1 ^b		Model 2 ^c		Model 3 ^d		Model 4 ^e	
	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)
Age								
≤ 55 years	1.00		1.00				1.00	
56-64 years	2.48	(1.09-5.62)	2.34	(1.02-5.36)			2.51	(1.08-5.84)
≥ 65 years	3.87	(1.75-8.56)	3.57	(1.61-7.92)			3.74	(1.65-8.50)
Sex								
Women	1.00		1.00				1.00	
Men	2.87	(1.59-5.17)	2.74	(1.66-4.52)			3.29	(1.91-5.66)
Smoking								
No	1.00				1.00		1.00	
Actual o previous	1.40	(0.84-2.34)			1.54	(0.90-2.62)	1.65	(0.94-2.88)
Alcoholism								
No	1.00				1.00		1.00	
Actual o previous	0.91	(0.35-2.37)			0.44	(0.17-1.18)	0.21	(0.08-0.59)
Bodyweight change								
Lost	1.00				1.00		1.00	
Maintained	2.08	(0.90-4.82)			1.83	(0.93-3.61)	1.58	(0.78-3.19)
Increased	3.13	(1.50-6.50)			2.43	(1.33-4.45)	2.29	(1.23-4.25)
Unmet basic needs ^a								
Quartile 1	1.00		1.00		1.00		1.00	
Quartile 2	3.87	(1.24-12.05)	3.46	(1.12-10.77)	3.38	(1.05-10.90)	3.25	(0.99-10.66)
Quartile 3	3.95	(1.26-12.35)	3.48	(1.20-10.75)	3.41	(1.05-11.15)	3.43	(1.06-11.11)
Quartile 4	2.27	(0.65-7.95)	2.20	(0.63-7.72)	2.19	(0.60-7.98)	2.17	(0.59-7.95)
ICC		0.040		0.029		0.051		0.048

OR = odds ratio; 95%CI = 95% confidence interval; ICC = interclass correlation coefficient. ^a Neighborhoods distribution (in quartiles): households with one unmet basic need. ^b Model 1 is unadjusted model. ^c Model 2 is adjusted for individual age and sex. ^d Model 3 is adjusted for individual alcoholism, smoking, and bodyweight increase. ^e Model 4 is adjusted for all individual characteristics.

Source: Authors, based on patient's records and National Census.

health problems in order to continue working²⁸. Women, as direct users of healthcare system, carry out most health-services consultations. Since it is socio-subjective, the women's roles enabled them to express and consult for health discomfort; leading them to consult the health services earlier than men²⁹. This leads us to consider the inequalities through a gender perspective, which encompasses distinct stereotyped roles for women and men, differences in healthcare access, in self-care, and in family-care, differentiating their ways of living, getting sick, consulting, receiving treatment, and dying²⁹.

Based on the 2013 National Survey of Risk Factors from Argentina, women presented higher diabetes and hypertension prevalence. Additionally, the percentage of women with glucose screening (82.2 vs 70.2%) or blood pressure screening (86.6 vs 77.8%) were also higher. Sim-

ilar results were observed in the 2018 survey³⁰. In general population, other studies showed that women with diabetes had higher risk than men for coronary disease and stroke³¹⁻³³.

Tobacco use, the practice of physical activity, the searching for medical treatment and the care practices are also different between women and men^{30,34}, which may impact on the course of disease occurrence.

No association was found between bodyweight and CVDs. In our case, the studied population was composed by individuals from deprived neighborhoods with chronic disease problems (such as diabetes and hypertension), for which overweight and obesity are involved in their causal pathway. Therefore, change in bodyweight during the clinical follow-up was analyzed, and we found a positive association between increase in bodyweight and CVDs occur-

Table 4. OR of cardiovascular disease associated with individual and neighborhood's characteristics. Bariloche, Argentina, 2015.

	Model 1 ^b		Model 2 ^c		Model 3 ^d		Model 4 ^e		Model 5 ^f	
	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)	OR	(95%CI)
Age										
≤ 55 years	1.00		--		1.00		--		1.00	
56-64 years	2.70	(1.07-6.85)			2.28	(0.99-5.22)			2.63	(0.99-6.95)
≥ 65 years	3.94	(1.57-9.90)			3.32	(1.49-7.45)			3.16	(1.16-8.61)
Sex										
Women	1.00		--		1.00		--		1.00	
Men	3.15	(1.77-5.60)			2.87	(1.72-4.78)			3.59	(1.85-7.00)
Education										
Secondary incomplete or more	1.00		1.00		--		--		1.00	
Primary complete	0.92	(0.39-2.15)	0.97	(0.41-2.32)	--		--		1.14	(0.43-3.02)
Primary incomplete	1.54	(0.70-6.41)	1.64	(0.73-3.70)					1.81	(0.70-4.67)
Illiterate	1.41	(0.56-3.58)	1.64	(0.63-4.25)					2.09	(0.94-4.66)
Smoking										
No	1.00		--		--		1.00		1.00	
Actual o previous	1.74	(0.99-3.06)					1.83	(1.00-3.32)	2.03	(1.07-3.85)
Alcoholism										
No	1.00		--		--		1.00		1.00	
Actual o previous	0.88	(0.36-2.16)					0.59	(0.22-1.60)	0.26	(0.09-0.77)
Bodyweight change										
Lost	1.00		--		--		1.00		1.00	
Maintained	2.13	(1.01-4.51)					2.02	(0.94-4.32)	1.84	(0.84-4.05)
Increased	1.80	(0.92-3.50)					1.75	(0.89-3.45)	1.69	(0.83-3.42)
Unmet basic needs ^a										
Quartile 1			1.00		1.00		1.00		1.00	
Quartile 2	2.35	(0.74-7.43)	2.30	(0.73-7.30)	3.46	(1.12-10.77)	2.36	(0.72-7.72)	1.90	(0.55-6.63)
Quartile 3	2.71	(0.86-8.56)	2.70	(0.86-8.50)	3.48	(1.20-10.75)	2.58	(0.78-8.49)	2.21	(0.64-7.71)
Quartile 4	1.49	(0.42-5.24)	1.40	(0.40-4.90)	2.20	(0.63-7.72)	1.44	(0.40-5.26)	1.20	(0.31-4.64)
ICC	0.017		0.011		0.029		0.031		0.043	

OR = odds ratio; 95%CI = 95% confidence interval; ICC = interclass correlation coefficient. ^aNeighborhoods distribution (in quartiles): Households with one unmet basic need. ^bModel 1 is unadjusted model. ^cModel 2 is adjusted for individual education. ^dModel 3 is adjusted for individual age and sex. ^eModel 4 is adjusted for individual alcoholism, smoking, and bodyweight increase. ^fModel 5 is adjusted for all individual characteristics.

Source: Authors, based on patient's records and National Census.

rence. This shows the relevance of bodyweight change during the clinical follow-up.

The frequency of alcohol problems differed between women and men. After accounting for individual and contextual characteristics, alcohol consumption showed a protective effect on CVD. According to previous studies, alcohol consumption has complex effects on CVD, and different patterns were described according to the consumption level: a reduced risk (protective effect) for coronary disease and stroke among current alcohol consumption, but increased risk when consumption was in larger amounts³⁵⁻³⁷. Despite this, we should bear in mind that epidemiological studies differ in consumption threshold, and

how alcohol consumption is measured and categorized³⁸. The protective effect of alcohol consumption regarding CVD does not mean potential harmful effects on other outcomes, such as violence, injuries, cirrhosis, or cancer, which were not included in this study.

We included group level variables, using census data, to study CVDs, allowing us to evaluate simultaneous examination of variables from groups to which individuals belong (such as neighborhoods) and individual level variables. We were not interested in the causal effects of neighborhood composition per se in the disease occurrence, but in its physical and social environment effects, which can be captured by

Table 5. ORs (and 95%CI) of cardiovascular disease associated within individual and neighborhood's characteristics among patients with hypertension, diabetes, and both. Bariloche, Argentina, 2015.

Covariates	Diabetes and/or hypertension ^b		Hypertension ^c		Diabetes ^d	
	OR	(95%CI)	OR	(95%CI)		
Age						
≤ 55 years	1.00		1.00		1.00	
56-64 years	2.51	(1.08-5.84)	2.23	(0.91-5.45)	16.29	(1.94-136.83)
≥ 65 years	3.74	(1.65-8.50)	3.10	(1.30-7.47)	24.58	(2.71-222.3)
Sex						
Women	1.00				1.00	
Men	3.29	(1.91-5.66)	3.20	(1.83-5.58)	3.57	(1.35-9.44)
Alcoholism						
No	1.00		1.00		1.00	
Actual o previous	0.21	(0.08-0.59)	0.24	(0.08-0.66)	0.10	(0.01-0.92)
Smoking						
No	1.00		1.00		1.00	
Actual o previous	1.65	(0.94-2.88)	1.57	(0.89-2.79)	1.28	(0.61-2.72)
Bodyweight change						
Lost	1.00		1.00		1.00	
Maintained	1.58	(0.78-3.19)	1.64	(0.80-3.36)	0.70	(0.22-2.34)
Increased	2.29	(1.23-4.25)	2.40	(1.29-4.51)	1.28	(0.48-3.42)
Unmet basic needs ^a						
Quartile 1	1.00		1.00		1.00	
Quartile 2	3.25	(0.99-10.66)	3.63	(1.15-11.38)	3.31	(0.46-22.65)
Quartile 3	3.43	(1.06-11.11)	3.40	(1.07-10.78)	3.34	(0.45-24.59)
Quartile 4	2.17	(0.59-7.95)	2.29	(0.64-8.13)	3.18	(0.40-24.71)
ICC	0.048		0.023		0.180	

OR = odds ratio; 95%CI = 95% confidence interval; ICC = interclass correlation coefficient. ^a Neighborhoods distribution (in quartiles): households with one unmet basic need. ^b Individuals with diabetes, hypertension, and/or both (n = 820). ^c Individuals without hypertension were excluded (n = 712). ^d Individuals without diabetes were excluded (n = 347).

Source: Authors, based on patient's records and National Census.

these proxy measures. Physical environment includes man-made built environment, street design, public spaces, healthy food access, and public spaces; while social environment includes the social connections, social norms, violence, and safety levels. Both aspects may affect health through constraints or enhancements of different health-related behaviors³⁹.

Other studies with multilevel methodology and analyses by neighborhoods has often shown modest associations compared to those observed for individual-level characteristics³⁹⁻⁴¹. Additionally, differences in results can be explained by the need that the outcome variable has a relatively high prevalence and vary sufficiently across groups⁴²; and/or a larger number of individuals are required when using multilevel logistic model when compared to the traditional linear regression. Both issues are present in this research (low

frequency of the event and small sample size), particularly for the analyses performed for the specific outcomes (hypertension and diabetes). Straining the limitations of small-area studies and large-area studies: small-area studies with modest associations, and large-areas studies where differences are masked.

Finally, the strengths and limitations of this study are highlighted. Medical records constitute a good data source to study chronic health diseases as opposed to its known limitations for studying acute health problems⁴³. Health-disease aspects registered in medical records are diagnosed by standardized methods, which improve its validity, such as body mass index measurement or diagnosis of the CVD included in this study^{44,45}. A limitation of the medical records, however, is the absence of data allowing measurement of inequalities, food consumption, or physical activity

at individual level. Likewise, these aspects are usually measured by self-report in studies in the general population. Another limitation of this study is related to the temporal relationship between exposures and outcome. To take this over we used different strategies: a) considered characteristics that do not change over time (being immigrant or biological sex); b) combined previous and current behaviors in the same category for conducting the analyses, such as current and former smoking, and actual and previous alcoholism⁴⁵; c) evaluated the temporal relationship between time to diagnosis of diabetes/hypertension and CVD; d) use record linkage with hospital discharges.

This work has several strengths. In addition to what has already been mentioned above, the inclusion of contextual level variables (neighborhood) to study health problems allows for an insight into how individual characteristics are related to group characteristics, and in turn, how health problems are related to socioeconomic heterogeneity in urban spaces, in cities with rapid urban growth, and without adequate urban planning. This interrelated process represents a major challenge for policy-makers³⁹.

In Argentina, and more broadly in Latin America, studies using multilevel methodology and exploring simultaneous analysis of individual and contextual characteristics in small areas are relatively recent and scarce¹³. The population selection process was also an important aspect

of our research: different sources of patients' records were used to improve the quality of data, and all individuals under clinical follow-up in the healthcare centers were included. Study participants represented people living in neighborhoods with heterogeneous conditions of deprivation. However, we were not able to detect contrasts among people living in neighborhoods with advantageous conditions and those living in more disadvantaged neighborhoods, as the former were not included in the study. Thus, the real gap between these populations remains hidden.

Despite this, we have been able to show differences within groups living in neighborhoods with disadvantageous conditions. In this sense, our results highlight an inequality within inequality pattern. Specifically, inequalities in disease occurrence between individuals living in disadvantageous neighborhoods, as well as inequalities regarding access to health, are linked to the contexts where individuals belong.

Finally, this study offers insights about differences within groups that live in unequal contexts. Inequalities follow the individuals throughout their lives and shape other inequalities. These inequalities become embodied and are expressed through individual and biological aspects (such as age, blood glucose, or blood pressure values), which, in its turn, are manifestations of the unequal contexts the individuals have experienced throughout their lives.

Collaborations

MS Perner and M Alazraqui conceived the initial idea and performed the methodological design. MS Perner did the data collection, the analysis, and the first version of this article, supervised by M Alazraqui. L Amorim gave statistical advice, and contributed to the analysis of the results. All authors worked on the revision and final edition of the manuscript.

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