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Social environment characteristics are related to self-rated health in four Latin America countries: Evidence from the SALURBAL Project

Camila Teixeira Vaz [a,b,*], Débora Moraes Coelho [b,c], Uriel Moreira Silva [b,c], Amanda Cristina de Souza Andrade [b,d], Francisca González López [e], Olga Lucía Sarmiento Dueñas [f], Amélia Augusta de Lima Friche [b,c], Ana Victoria Diez-Roux [g], Waleska Teixeira Caiaffa [b,c]

[a] *Campus Centro-Oeste Dona Lindu, Federal University of São João del-Rei, Avenida Sebastião Gonçalves Coelho 400, Divinópolis, 35501-296, Brazil*
[b] *Belo Horizonte Observatory for Urban Health, Avenida Alfredo Balena 190, Belo Horizonte, 30130-100, Brazil*
[c] *Faculty of Medicine, Federal University of Minas Gerais, Avenida Alfredo Balena 190, Belo Horizonte, 30130-100, Brazil*
[d] *Institute of Public Health, Federal University of Mato Grosso, Avenida Fernando Corrêa 2367, Cuiabá, 78060-900, Brazil*
[e] *Department of Public Health, School of Medicine, Pontifical University Catholic of Chile, Chile*
[f] *Department of Epidemiology, University of Los Andes, Colombia*
[g] *Dornsife School of Public Health, Drexel University, 3215 Market Street, Philadelphia, PA, 19104, USA*

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ABSTRACT

We investigated the associations of social and built environment and demographic features of urban areas with self-rated health among adults living in four Latin American countries. We estimated multilevel models with harmonized data from 69,840 adults, nested in 262 sub-cities and 112 cities, obtained from the *Salud Urbana en América Latina* project. Poor self-rated health was inversely associated with services provision score at the sub-city-level and with social environment index at the city-level. We did not identify associations of built environment and demographic features with self-rated health. Approaches and policies to improve health in Latin American should be urban context-sensitive.

1. Introduction

Latin America has high levels of urbanization and high levels of socioeconomic inequality (Becerra-Posada, 2015; UNDP, 2010). This socioeconomic inequality is manifested in cities, with 19 of the world's 30 most unequal cities located in the region (UN Habitat, 2012). Choices about how cities develop and grow, how they organize transportation and land use, how they manage access to quality housing and other resources, and the social and economic policies they prioritize and implement will have profound consequences for the health of the residents in Latin America (Diez-Roux et al., 2018).

Urban environment characteristics of cities may affect health through a multiplicity of processes including influencing health-related behaviors through features such as walkability, the location of parks and green spaces, and access to and advertising for different types of foods. Other mechanisms may include community stressors such as violence or lack of safety and the availability of social connections and social support mechanisms (Hale et al., 2010; Gomez et al., 2019; Höfelmann et al., 2015; Ou et al., 2018; Rodrigues et al., 2018; Santos et al., 2018; Sharp et al., 2015). Given residential segregation by race and class, urban environment features have profound implications for health equity (Diez-Roux et al., 2018; Vincens et al., 2018a).

Self-rated health is a significant predictor of morbidity and mortality, as well as health care utilization (Filha et al., 2008; Falk et al., 2017; Guimarães et al., 2012; DeSalvo et al., 2005). In addition, it is a valid, reliable, simple, and easily administered question, commonly used to characterize health in population surveys (Filha et al., 2008). Studies have shown that the contextual characteristics of the places where people live play an important role in self-rated health. For example, in developed countries, area deprivation has been linked to higher

* Corresponding author. Campus Centro-Oeste Dona Lindu, Federal University of São João del-Rei, Avenida Sebastião Gonçalves Coelho 400, Divinópolis, 35501-296, Brazil.

E-mail addresses: vaz.camilateixeira@gmail.com (C.T. Vaz), coelhaenf@gmail.com (D.M. Coelho), uriel.moreira.silva@gmail.com (U.M. Silva), csouza.amanda@gmail.com (A.C.S. Andrade), ftgonzal@gmail.com (F.G. López), osarmien@uniandes.edu.co (O.L.S. Dueñas), gutafriche@gmail.com (A.A.L. Friche), avd37@drexel.edu (A.V. Diez-Roux), caiaffa.waleska@gmail.com (W.T. Caiaffa).

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prevalence of poor self-rated health even after adjustment for individual-level characteristics (Poortinga et al., 2008; Omariba, 2010; Verhaeghe and Tampubolon, 2012; Becares et al., 2012; Wen et al., 2006). In addition, built or physical environment features such as poor diversity of land use (Gidlow et al., 2010), poor access to amenities, poor neighborhood quality, perceived physical disorder, and dissatisfaction with local services (Poortinga et al., 2008; Becares et al., 2012; Wen et al., 2006) were also found to be associated with poor self-rated health.

Despite the growing urbanization of low- and middle-income countries, the relation of urban environmental features to self-rated health across urban areas in these countries, including Latin America, has been infrequently examined. Some studies have used multilevel analysis to simultaneously investigate area and individual-level factors (Vincens et al., 2018b; Santos et al., 2018; Cremonese et al., 2010; Caicedo-Velásquez and Restrepo-Méndez, 2020; Höfelmann et al., 2015; Lucumí et al., 2013), but the results have not always been consistent. The area definitions examined have varied widely from large geographic areas such as states (Vincens et al., 2018b) to smaller neighborhoods (Vincens et al., 2018b; Santos et al., 2018; Höfelmann et al., 2015; Cremonese et al., 2010; Caicedo-Velásquez and Restrepo-Méndez, 2020; Lucumí et al., 2013). Variables examined have included contextual measures of socioeconomic status (Höfelmann et al., 2015; Santos et al., 2018; Cremonese et al., 2010), measures of income inequality (Vincens et al., 2018b; Caicedo-Velásquez and Restrepo-Méndez, 2020), measures of population density (Cremonese et al., 2010; Caicedo-Velásquez and Restrepo-Méndez, 2020), access to services and infrastructure (Vincens et al., 2018b; Santos et al., 2018; Cremonese et al., 2010; Caicedo-Velásquez and Restrepo-Méndez, 2020) and perceptions of neighborhood problems (Höfelmann et al., 2015; Cremonese et al., 2010; Caicedo-Velásquez and Restrepo-Méndez, 2020; Lucumí et al., 2013).

A recent systematic review concluded that existing studies of neighborhoods and health in the Latin American region frequently have small sample sizes and are often based on only one city, region or country. Heterogeneity across studies does not allow for the identification of patterns that could generalize to the largest urban settings of Latin America (Gomez et al., 2019). While the literature has been exploring the connection between social environment traits and self-rated health, research remains scarce on the relationship between built environment features and self-rated health in the region. In our first paper, using individual data from four Latin American cities, we observed that poor self-rated health was associated with a perceived physical/built-deprived environment (Vaz et al., 2020). Studies, of which we are aware, have yet to examine the relationship between objective measurements of built environment characteristics, at city and sub-city levels, and self-rated health. Therefore, the examination of associations of standardized urban area measurements with health status across a large heterogenous sample of cities, allowing within and between countries comparisons, in Latin America may be especially informative and this study aimed to address these gaps.

We hypothesized that people living in socially deprived environments, people living in fragmented environments, and those living in cities with higher levels of unequal urbanization are more likely to report poor health. Thus, we used harmonized data from health surveys from four Latin America countries (Argentina, Brazil, Chile, and Colombia), linked to social and built environment data, as well as demographic characteristics, for 112 cities to investigate how features of urban areas are related to self-rated health in adults. Understanding these associations is relevant for public health policies and urban policies aimed at improving health, health equity and quality of life in the region (Becerra-Posada, 2015; Caicedo-Velásquez and Restrepo-Méndez, 2020).

2. Methods

2.1. Study design and population

This cross-sectional study used data from *Salud Urbana en América Latina* (SALURBAL), Urban Health in Latin America Project, an international collaboration that studies how urban environments and urban policies impact the health of city residents throughout Latin America (Diez-Roux et al., 2018).

The project has compiled and harmonized data on health as well as social and built environments from all cities of 100,000 residents or more in 2010, in 11 countries (n=371) (Quistberg et al., 2019). In this study we used data from Argentina, Brazil, Chile and Colombia, countries for which survey data on self-rated health was available and had good quality. In SALURBAL, "city" is defined as a single administrative unit (e.g., *municipio*) or combination of adjacent administrative units (e.g., several *municipios*) that are part of the urban extent as determined from satellite imagery (Quistberg et al., 2019). Each "city" is defined based on its component administrative units (*municipios*, *comunas* or similar depending on the country) and each component administrative unit is referred to as a "sub-city" unit. In some cases, a city may include only one sub-city unit, in which case the definitions coincide. More details are available elsewhere (Quistberg et al., 2019).

The outcome variable, self-rated health, was obtained from the harmonized health survey data of adults aged 18 or older for the four countries included in our study. These countries were included considering the availability and quality of data. Of 97,126 survey respondents 72,184 observations were eligible, but we excluded 2,344 because no information on self-rated health was available (1,264 questions was not asked and 1,080 had a missing answer to the question). The final sample for this study consisted of 69,840 participants. Surveys were designed for chronic disease surveillance using random probabilistic household sampling. Survey details are provided in supplementary material (Table S1).

2.2. Outcome

Self-rated health was assessed in the four countries using a 5-point Likert scale. While the question asked was similar across the four countries, "In general, would you say your health is …" the response options differed. The response options in Argentina and Chile were "excellent", "very good", "good", "fair", and "poor". In Brazil and Colombia, the response options were "very good", "good", "fair", "poor", and "very poor". Therefore, a dichotomized self-rated health variable was created, categorized as 1 = poor health (fair/poor/very poor) and 0 = good health (excellent/very good/good) to allow for comparison between countries.

2.3. Exposures

The main exposures were social and built environment indicators and demographic variables, defined at either the sub-city or city level. We chose within SALURBAL data the indicators that were most aligned with our theoretical framework for self-rated health. We therefore hypothesized whether specific effects would be better captured with more/less distal/proximal indicators. In addition, to be consistent with other studies developed by the SALURBAL project team, the variables chosen were measured at the same level as those researches (Castillo-Riquelme et al., 2022; Avila-Palencia et al., 2022; Braverman-Bronstein et al., 2022). See supplementary material for exposures details (Table S2).

The social environment indicators were obtained from national censuses in each country after harmonization (Quistberg et al., 2019). Given that they may vary within cities and sub-cities they were diversely defined either at city or at the sub-city level.

At the sub-city level, three domains (living conditions, services provision, and educational attainment) were identified using a principal component analysis (Ortigoza et al., 2021). They corresponded to conceptually distinct aspects of the social environment, and all may be related to self-rated health through various mechanisms including behaviors, stressors, and environmental exposures. For each of the domains, the scores were defined as the average of the z-scores of the indicators in that domain. Higher score values imply better social environment conditions (Ortigoza et al., 2021). The living conditions score is composed of three variables: (1) the percentage of households with piped water inside the dwelling; (2) the percentage of households with overcrowding conditions (defined as more than 3 people per room, excluding kitchen and bathroom); and (3) the percentage of population aged 15–17 attending school. For the construction of the score, the overcrowding indicator was multiplied by −1 to be in the same direction as the other indicators. The services provision score refers to services provided to dwellings. This score included two variables: (1) percentage of households with access to water source from a municipal public or private water network; and (2) percentage of households with sewage system connected to a municipal public or private sewage network. The population educational attainment score refers to educational achievement in the overall population. This score included two variables: (1) percentage of population age 25 or older that completed high school level education or above; and (2) percentage of population age 25 or older that completed university level education or above (Ortigoza et al., 2021).

At the city level, another social environment index was included, using the following variables from national censuses: (a) proportion of households with piped water access inside the dwelling; (b) proportion of households connected to a public sewage network; (c) proportion of households with more than 3 people per room (reversed); and (d) proportion of the population aged 25 or older who completed primary education or above. The index was defined as the average of the z-scores, with a higher score indicating a better social environment (Bilal et al., 2021).

The built environment variables investigated were: intersection density and population density at sub-city level, landscape isolation and fragmentation of urban development at city level. Intersection density measures the number of intersections per square kilometer of area within the street network. Population density was defined as the population per square kilometer in all the urban patches inside the geographic boundary. Landscape isolation is defined as the mean distance (in meters) to the nearest urban patch within the geographic boundary, weighted by the area (in squared meters) of each patch. Fragmentation was measured using urban patch density (defined as the number of urban patches divided by the total area of the geographic unit) (He et al., 2020; Tian et al., 2020; Zhang et al., 2017). Higher patch density reflects a higher fragmentation of the urban development. People living in environments with higher intersection density and high population density at the sub-city level, as well as higher landscape isolation and higher fragmentation at the city level, are more likely to report poor health. These built environment characteristics may be related to self-rated health through mechanisms involving access to services and jobs, including access to health services, since they can represent geographic barriers, especially for city residents living in peripheral areas of large urban centers (Carrasco-Escobar et al., 2020).

We included total population and population growth, as demographic variables, both at city level. Total population is defined as the city population in the year of the corresponding census for each country (2010 for Argentina and Brazil, 2007 for Chile and Colombia), computed using intercensal projections. Population growth was computed as the relative difference in the city population between the year of the census and the 5 years prior (e.g. [population in 2015 – population in 2010]/ population in 2010, for each city in Argentina and Brazil). Considering that Latin America has high levels of disorganized urbanization, resulting in patterns of residential segregation and inequality, we hypothesized that people living in cities with higher total population and higher population growth are more likely to report poor health.

2.4. Covariates

Individual-level covariates that may be confounders of our main associations of interest included: age (in years), sex (male and female) and education (less than complete primary; complete primary; complete high school; and complete university or higher), and were obtained from each country's health survey. The percentage of urban area (defined as the total built-up urban area divided by the total area of the geographic unit in meters and multiplied by 100) was also included as a covariate to account for cities that may spread across areas that include largely unpopulated sections of land and facilitate interpretation of the fragmentation measure.

2.5. Statistical analysis

Descriptive analyses were performed using frequency distributions, means and standard deviations (SD). Kruskal-Wallis or chi-square tests were used to compare variables across countries and by status of self-rated health. Multilevel logistic regressions were used to estimate the association between individual poor self-rated health and the explanatory variables, including random effects for sub-city and city, and a fixed effect for each country (Larsen et al., 2000). To account for unobserved factors that may cause variation in self-rated health across different countries, the model included fixed effects at the country level.

Initially, we fitted a null model to assess the variability of self-rated health at different levels. We then fit four models, each adjusted for individual sex, age and education: Model A included each exposure separately; Model B included all of the social environment exposures jointly; Model C included built environment and demographic exposures jointly; and Model D included all of the exposures jointly. Every explanatory variable was transformed into a Z-score to facilitate interpretation. Median Odds Ratios (MOR) were computed for each model by taking the exponential of 0.95 multiplied by the standard deviation of each random intercept (city and sub-city level). We also computed Variance Inflation Factors (VIF) for model D to assess potential collinearity issues.

Analyses were conducted using the glmmTMB package and VIFs were computed using the performance package, both within the R software environment. The SALURBAL study protocol was approved by the Drexel University Institutional Review Board with ID #1612005035.

3. Results

The 69,840 individuals included in this study were distributed in 262 sub-cities nested in 112 cities. The median of participants per sub-city was 78, ranging from 5 to 3,196 and the median of participants per city was 506, ranging from 19 to 3,925 (Table 1).

The overall proportion of poor self-rated health was 27.4% (95%CI = 27.1–27.7). Chile had the highest proportion of poor self-rated health (41.6%) among its residents, followed by Brazil (29.9%), Colombia (28.5%) and Argentina (21.6%). The mean age of the study population was 42.8 years (SD = 16.6), the majority of participants (57.7%) were female, and 38.5% had completed a high school degree. Although some differences were observed, the distribution of participants by sex and education did not differ substantially across countries. Colombia has a lower mean age because the survey in this country did not enroll individuals older than 70 years (Table 1).

Living conditions scores were on average highest in Chile (mean = 1.9, SD = 0.7) and lowest in Colombia (mean = 0.1, SD = 1.3). Services provision scores were also highest in Chile (mean = 1.8, SD = 0.5) but lowest in Brazil (mean = 0.1, SD = 1.8), whereas educational attainment scores were lowest in Chile (mean = −0.5, SD = 1.0) and highest in Brazil (mean = 1.2, SD = 0.8). The social environment index's values were on average highest in Chile (mean = 0.9, SD = 0.2) and lowest in Brazil (mean = −0.03, SD = 0.5) (Table 1).

Mean intersection density (inter./km^2) was lowest in Argentina

Table 1
Individual level, sub-city and city characteristics in the sample, by country.

VARIABLES	TOTAL	Argentina	Brazil	Chile	Colombia	p-value[c]
Sample characteristics						
Number of participants	69,840	21,451	27,017	2,719	18,653	–
Number of cities	112	33	27	19	33	–
Participants per city						
Median (1stQ-3rdQ)	506 (209–818)	511 (417–693)	854 (746-1,113)	85 (34–175)	422 (203–653)	–
Min-Max	19-3,925	24-3,925	520-2,568	19–799	65-3,491	–
Number of sub-cities	262	108	27	70	57	–
Participants per sub-city						
Median (1stQ-3rdQ)	78 (30–396)	86 (50–340)	854 (746-1,113)	21 (14–48)	202 (67–421)	–
Min-Max	5-3,196	7–893	520-2,568	5–241	15-3,196	–
Individual characteristics						
Poor self-rated health (%)	27.4	21.6	29.9	41.6	28.5	<0.001
Adjusted poor self-rated health[a]	27.4	21.9	29.9	37.4	25.1	–
Age m(SD)	42.8 (16.6)	44.7 (18.0)	43.1 (16.6)	46.8 (17.7)	39.3 (14.1)	<0.001
Sex (%)						<0.001
Female	57.7	56.2	59.0	59.8	57.4	
Education (%)[b]						<0.001
Less than primary school	16.2	9.3	21.4	10.8	17.3	
Primary school	30.5	36.9	22.0	34.8	34.7	
High school	38.5	37.0	38.6	45.9	39.2	
Uni. degree or higher	14.8	16.8	18.0	8.5	8.8	
Social environment characteristics (individuals within sub-cities within cities)						
Living conditions m(SD)	1.4 (1.3)	1.7 (0.9)	1.9 (0.9)	1.9 (0.7)	0.1 (1.3)	<0.001
Services provision m(SD)	0.5 (1.5)	0.4 (1.3)	0.1 (1.8)	1.8 (0.5)	0.9 (1.3)	<0.001
Pop. educ. attainment m(SD)	0.4 (1.1)	−0.3 (0.9)	1.2 (0.8)	−0.5 (1.0)	0.1 (0.8)	<0.001
Social Env. Index m(SD)	0.22 (0.5)	0.34 (0.3)	−0.03 (0.5)	0.93 (0.2)	0.32 (0.7)	<0.001
Built environment and demographic characteristics (individuals within sub-cities within cities)						
Intersection density m(SD)	27.22 (30.5)	19.21 (28.4)	37.56 (31.1)	38.55 (56.3)	19.80 (19.6)	<0.001
Population density m(SD)	8,714 (5,162)	5,115 (3,034)	8,041 (3,596)	7,234 (3,024)	14,044 (4,985)	<0.001
Isolation m(SD)	84.28 (37.7)	88.95 (32.7)	71.45 (11.1)	93.79 (39.6)	96.13 (57.2)	<0.001
Fragmentation m(SD)	0.46 (0.3)	0.34 (0.3)	0.61 (0.4)	0.29 (0.2)	0.40 (0.2)	<0.001
Total population (x10^6) m(SD)	3.33 (5.0)	3.16 (5.5)	4.29 (5.7)	2.00 (2.6)	2.32 (2.9)	<0.001
Population growth m(SD)	6.19 (3.1)	6.18 (2.1)	6.52 (3.4)	6.77 (2.9)	5.65 (3.5)	<0.001

[c] p-values refer to Kruskal-Wallis tests (for continuous variables) and chi-square tests (for categorical variables).
[a] Proportions of self-rated health adjusted by individual age, sex, and education.
[b] 1 observation missing.

(mean = 19.2, SD = 28.4) and highest in Chile (mean = 38.6, SD = 56.3), and mean population density (hab./km^2) was highest in Colombia (mean = 14,043, SD = 4,895) and lowest in Argentina (mean = 5,115, SD = 3,034). On average, isolation of urban patches (m) was highest in Colombia (mean = 96.1, SD = 57.2) and lowest in Brazil (mean = 71.5, SD = 11.1), whereas fragmentation of urban expansion (patches/100ha) was highest in Brazil (mean = 0.6, SD = 0.4) and lowest in Chile (mean = 0.3, SD = 0.2) (Table 1). Mean city population (mm. hab.) was highest in Brazil (mean = 4.3, SD = 5.73) and lowest in Chile (mean = 2.0, SD = 2.6), and mean population growth (%) was highest in Chile (mean = 6.8, SD = 2.9) and lowest in Colombia (mean = 5.7, SD = 3.5) (Table 1).

Individuals who reported poor health were, on average, more likely to be older (mean age of 49.4 for poor *vs.* 40.3 years old for good health), female (65.8% of females reported poor health and 54.7% of them reported good health), and less educated (65.0% of individuals with complete primary education or less reported poor health *vs.* 39.8% of those reported good health), than those who reported good health (Table 2).

Sub-city living conditions and services provision scores and city social environment index were, on average, lower for persons who reported poor health (mean = 1.3 for poor health *vs.* 1.4 for good health, mean = 0.4 for poor health *vs.* 0.6 for good health and mean = 0.1 for poor health *vs.* 0.2 for good health, respectively). Population growth (%) was, also, lower for individuals who reported poor health (mean = 6.1 for poor health *vs.* 6.2 for good health). On the other hand, sub-city population density (hab./km^2) was higher for those who reported poor health (mean = 8,927.3 for poor health *vs.* 8,633.5 for good health). No significant difference was found between the means of sub-city population educational attainment scores and intersection density and city isolation, fragmentation and total population measures for persons who reported poor health and those who did not (Table 2).

Table 2
Individual level, sub-city and city characteristics in the sample, by self-rated health status.

VARIABLES	Self-rated health		p-value[b]
	Good	Poor	
Individual Characteristics			
Age m(SD)	40.3 (15.7)	49.4 (17.2)	<0.001
Sex (%)			<0.001
Female	54.7	65.8	
Education (%)[a]			<0.001
Less than primary school	11.2	29.5	
Primary school	28.6	35.5	
High school	42.5	27.8	
Uni. degree or higher	17.7	7.2	
Social environment characteristics			
Living conditions m(SD)	1.40 (1.3)	1.29 (1.3)	<0.001
Services provision m(SD)	0.55 (1.5)	0.38 (1.6)	<0.001
Pop. educ. attainment m(SD)	0.39 (1.1)	0.36 (1.1)	0.757
Social Env. Index m(SD)	0.24 (0.5)	0.17 (0.6)	<0.001
Built environment and demographic characteristics			
Intersection Density m(SD)	27.10 (30.2)	27.54 (31.2)	0.221
Population Density m(SD)	8,634 (5,220)	8,927 (4,998)	<0.001
Isolation m(SD)	83.83 (35.8)	85.50 (42.3)	0.784
Patch density m(SD)	0.46 (0.3)	0.46 (0.3)	0.092
Total pop. (x10^6) m(SD)	3.35 (5.0)	3.27 (5.0)	0.412
Population growth m(SD)	6.20 (3.0)	6.19 (3.2)	0.003

b p-values refer to Kruskal-Wallis tests (for continuous variables) and chi-square tests (for categorical variables).
[a] 1 observation missing.

In Model A, living conditions, services provision, population educational attainment scores and the social environment index were found to be negatively associated with poor health (OR = 0.86 per SD, 95% CI = 0.81–0.91; OR = 0.88 per SD, 95% CI = 0.84–0.92; OR = 0.91 per SD, 95% CI = 0.88–0.95; OR = 0.84 per SD; 95% CI = 0.79–0.89, respectively). Isolation was found to be positively associated with poor health (OR = 1.06 per SD, 95% CI = 1.01–1.13). Higher population density and higher total population were associated with lower odds of poor SRH (OR = 0.95, although confidence intervals included the null) (Table 3).

In Model B, which includes the social environment exposures jointly, services provision and the social environment index remained negatively associated with poor health (OR = 0.94 per SD, 95% CI = 0.88–0.99 and OR = 0.89 per SD, 95% CI = 0.82–0.98, respectively), although association was slightly attenuated. However, the association of living conditions and population educational attainment with poor health disappeared (Table 3). In Model C, which includes the built environment and demographic exposures jointly, the point estimates for population density and isolation remained unchanged, with higher population density being associated with lower odds of poor health and higher isolation being associated with higher odds of poor health (OR = 0.95 and 1.06, respectively) (Table 3).

In Model D, which included all variable together, the services provision score and the social environment index remained negatively associated with poor health (OR = 0.93 per SD, 95% CI = 0.87–0.99 and OR = 0.90 per SD, 95% CI = 0.82–0.99, respectively), with point estimates being very similar to those observed in Model B. However, associations of population density and isolation with poor health were reduced. Higher isolation and higher fragmentation were both weakly associated with higher odds of poor health, but confidence intervals were wide. The MOR ranged from 1.14 (sub-city level) and 1.25 (city level) in Model D to 1.15 (sub-city level) and 1.32 (city level) in the null model (Table 3). The VIF were below 5 for all exposures and covariates except for the country fixed effect (VIF = 7.42), living conditions score (VIF = 5.35) and percentage of urbanization (VIF = 5.26), which indicates that collinearity issues in this model are unlikely (this is corroborated by the relatively small confidence intervals for the estimated associations) (Fig. S1).

4. Discussion

We investigated whether social and built environment and demographic features were associated with self-rated health among adults living in Argentina, Brazil, Chile, and Colombia. Our analysis showed that people living in sub-city units with better services provision (such as a higher percentage of households with access to water source from a municipal public or private water network and a higher percentage of households with a sewage system) and in cities with better social environment index (such as higher percentage of households with access to piped water inside the dwelling, a higher percentage of households with a sewage system, a higher percentage of the population aged 25 or older with completed primary education or above, and a less percentage of households with overcrowded rooms) were less likely to report poor health, even after controlling for individual and other environmental characteristics.

One prior study conducted in Brazil investigated the association between essential services and self-rated health (Vincens, Emmelin & Stafström, 2018b). Similar results were reported related to better basic infrastructure, at the neighborhood level, such as households with access to water, sewage, and other essential services, with good self-rated health (Vincens, Emmelin & Stafström, 2018b). Studies conducted in high-income countries have primarily concentrated on particular pollutants, such as air-borne hazards or soil contamination, in specific scenarios. For instance, the spread of treated sewage sludge or residing near a wastewater treatment plant has been studied (Lowman et al., 2013; Stellacci et al., 2010). This makes it challenging to compare our study with previous research.

Water and sewage are important health markers worldwide. Although they are not perfect markers, they are considered an important proxy for essential services in the urban area, which can ensure health and well-being, explaining why they remained in the final model. Both are influenced by unequal urbanization, marked in Latin American countries (Pasternak, 2016; WHO, 2015), and are strongly linked to the social determinants of health (Prüss-Üstün and Neira, 2016). Less developed regions, with less education and/or income, for example, may have less coverage of these services (Trolla, 2014). It is known that the area's socioeconomic characteristics can affect chronic disease occurrence (Chaix et al., 2010). In addition, the deficiency in the supply of water and sewage in the place of residence is also related to the greater susceptibility of individuals to diseases associated with inadequate sanitation (Teixeira et al., 2014; Ventura and Lopes, 2017). The increased incidence of these diseases, in turn, can significantly influence the health conditions in populations (Ferreira et al., 2016).

In addition, our findings are consistent with two other studies, also conducted in Brazil, which found that higher numbers of individuals per household (Santos et al., 2018) and lower education (Cremonese et al., 2010), both at neighborhood level, were significantly associated with

Table 3
Odds ratios of poor self-rated health associated with social and built environment and demographic characteristics. All models are adjusted for age, sex and education individual-level and country fixed effects.

VARIABLES	Model A		Model B		Model C		Model D	
	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value	OR (95%CI)	p-value
Social environment characteristics								
Living conditions	0.86 (0.81–0.91)	<0.001	0.99 (0.90–1.09)	0.893			0.98 (0.88–1.08)	0.618
Services provision	0.88 (0.84–0.92)	<0.001	0.94 (0.88–0.99)	0.037			0.93 (0.87–0.99)	0.029
Pop. educ. attainment	0.91 (0.88–0.95)	<0.001	0.96 (0.90–1.02)	0.175			0.96 (0.90–1.02)	0.229
Social Environment Index	0.84 (0.79–0.89)	<0.001	0.89 (0.82–0.98)	0.014			0.90 (0.82–0.99)	0.036
Built environment and demographic characteristics								
Intersection density	0.98 (0.94–1.03)	0.390			1.01 (0.95–1.06)	0.833	1.01 (0.96–1.07)	0.680
Population density	0.95 (0.90–1.01)	0.077			0.95 (0.89–1.02)	0.139	1.02 (0.95–1.10)	0.553
Isolation	1.06 (1.01–1.13)	0.035			1.06 (0.99–1.13)	0.064	1.03 (0.97–1.09)	0.360
Fragmentation	1.00 (0.89–1.11)	0.950			1.02 (0.90–1.14)	0.798	1.06 (0.95–1.17)	0.315
Total population	0.95 (0.87–1.03)	0.222			1.00 (0.86–1.16)	0.974	0.97 (0.85–1.11)	0.652
Population growth	1.01 (0.95–1.07)	0.801			0.99 (0.93–1.05)	0.695	0.99 (0.93–1.05)	0.630

OR = odds ratio; 95% IC = 95% confidence interval; MOR = median odds ratio.
Null model MORs = 1.32 (city level) and 1.15 (sub-city level).
Model A: univariable associations. Fragmentation adjusted for percentage of urban area.
Model B: multivariable (social environment exposures only) associations. MORs = 1.26 (city level) and 1.15 (sub-city level).
Model C: multivariable (built environment and demographic exposures only) associations. Adjusted for percentage of urban area. MORs = 1.31 (city level) and 1.15 (sub-city level).
Model D: full model. Adjusted for percentage of urban area. MORs = 1.25 (city level) and 1.14 (sub-city level).

poor self-rated health, after adjustment for individual factors. Our findings add to the work by documenting these associations using data from a large number of cities across several countries and by examining associations at the sub-city and city level. Interestingly we found that both sub-city service provision and a summary index of the city social environment were independently related to poor self-rated health.

It is well established that contextual factors influence the development of individual habits that can be favorable or harmful to health, especially those related to smoking, physical activity and food habits (Sharp et al., 2015). Higher levels of deprivation and inequality have been linked to unhealthy diets, smoking, being overweight, as well as obesity and physical inactivity (Franzini et al., 2005). In addition, poorer areas usually present characteristics that are unfavorable to good health such as inadequate healthcare networks, environments that are not conducive to physical activity, a poorly organized physical environment (accumulated garbage, dirtiness, pollution, noise), lack of public transport, insufficient levels of social cohesion and participation, greater exposure to violence, as well as overcrowding, deficient basic sanitation and lack of education (Santos et al., 2018; Cremonese et al., 2010; Wong et al., 2009; Poortinga et al., 2007; Cummins et al., 2005; Diez-Roux and Am, 2001). All these factors can result in poorer health reflected in participant reports.

It is relevant to highlight that all social environment variables, at sub-city and city levels, were negatively associated with poor self-rated health in the first model, adjusted only for the individual age, sex, and education, showing the relationship between better social environment condition and health. However, after simultaneous adjustment for these variables, only services provision at sub-city level and social environment index at city level remained associated with self-rated health. These associations persisted even after controlling for built environment and demographic characteristics, suggesting that other mechanisms, unrelated to the adjustment of variables, may be involved in potentiating an unfavorable health report. These findings also suggest that, for this dataset water and sewage were more strongly related to deprivation and poor health than population educational attainment, for example. It is documented in the literature that lower education in a region promotes unhealthy habits related to food and physical activity, as well as interfering in the use of health services, contributing to an increase in the risk of chronic diseases. In addition, lower education in a region has been related to social stressors, such as violence, which also can impact the population's health.

Few studies have investigated the associations of built environment and city demographic characteristics with self-rated health. Results regarding the association between population density and poor self-rated health are conflicting. Findings from a study conducted in Brazil showed that a higher population density, at neighborhood level, was associated with poor health (Cremonese et al., 2010). On the other hand, in Colombia, one study did not find an association between population density, at the local level, and poor health (Caicedo-Velásquez and Restrepo-Méndez, 2020). When investigating other health outcomes, a recent study showed that higher fragmentation was associated with higher amenable mortality in larger cities (Mullachery et al., 2021). Fragmentation of the urban development can represent geographic barriers to accessing health services, especially for city residents living in peripheral areas of large urban centers (Carrasco-Escobar et al., 2020; Mullachery et al., 2021). In our analyses, associations of population density and isolation with poor health disappeared when social environment variables were controlled. In the final models, we observed weak connections between increased isolation and fragmentation with an increased likelihood of poor health. However, the confidence intervals encompassed the null, indicating a lack of conclusive evidence. Suggesting that the relation of city urban form with poor health still thus deserves further exploration.

An additional aspect to address pertains to the unexpected findings in Chile, which displays the highest prevalence of poor self-rated health despite being recognized as one of the countries with the highest human development index in Latin America (UNDP, 2022). Our study revealed that Chile exhibited the greatest levels of services provision and a high social environment index. Paradoxically, it also exhibited the highest prevalence of poor self-rated health. This incongruity could potentially be attributed to increased healthcare accessibility (and subsequent disease diagnosis) in regions of elevated socioeconomic development, which might provide a partial explanation for this observation (Almeida et al., 2013; Barraza-Lloréns et al., 2013).

Our study is unique and unprecedented in that we have compiled and harmonized data on urban environment and self-rated health in more than 110 cities in Latin America. We were able to study how a range of sub-city and city-level factors may be related to self-rated health. Although many studies have focused on health status in urban areas, to our knowledge, this is the first investigation examining the influence of social and built environments and demographic features on self-rated health across multiple cities in the region, with a large sample size. The study of sub-city and city level factors is especially relevant to developing local interventions to improve people's health in the cities.

On the other hand, some limitations should be considered when interpreting our results. First, despite careful data harmonization, we still have some limitation of comparability of self-rated health measures across countries. For example, poor health was much higher in Chile despite better levels of many of the predictors related to self-rated health, as discussed above. Adjustment for country as a fixed effect at least partly addresses this issue. Second, the cross-sectional design of our study does not allow us to draw causal inferences and confounding remains a possibility. Correlations between some variables (e.g., multiple social environment measures at the sub-city level) also make it difficult to identify causal processes. Third, there was a difference in timing between the surveys (they ranged from as early as 2007 in Colombia to 2013 in Argentina and Brazil) and the timing of the census data. Fourth, it should be noted that the limited number of countries analyzed in this study may not provide a comprehensive representation of the entire Latin American region. Nevertheless, it is worth mentioning that despite their heterogeneity, these countries share similarities, particularly in terms of health inequalities. This suggests that there may be comparable links between these countries and their respective environments. Fifth, regarding self-rated health, the question asked was similar across the four countries, but the response options in Argentina and Chile differed from Brazil and Colombia. The analytical strategy used to allow comparisons between countries was to dichotomize the responses. Although widely used in the literature, this strategy may not capture differences between all response options. Finally, the areas we examined, even sub-cities, were large and prominent in geographic size. Investigations of smaller areas more akin to neighborhoods may find different associations. Differences in the sizes or areas of studies also limit comparisons across studies. For example, in our study, environmental characteristics were described at the sub-city and city levels. In other studies, the environmental characteristics were described at neighborhood, local, state, and country levels.

5. Conclusion

In rapidly urbanizing low- and middle-income countries, it is urgent to identify which urban policies are necessary to improve population health. Using a large sample size in four Latin American countries we showed that better sub-city services provisions and a better overall social environment at the city level were related to lower odds of poor self-rated health. These results were observed even after controlling for individual and other environmental features. Our study corroborates with other studies conducted in the region based in only one city, region, or country. These findings highlight the importance of prioritizing urban policies and interventions related to improving sanitary services and education and reducing overcrowding to improve health and decrease health inequity in the region.

Continuing to investigate the relationship between urban environment and self-rated health in a large sample size in Latin America would be very useful and informative. Further research may include objective and subjective measures of the urban environment simultaneously, more local variables, and equally important and essential variables of an urban environment, such as climate, services, and urban equipments, like parks. In addition, using the non-dichotomized self-rated health scale can help capture differences between response options unobserved when using a dichotomized variable.

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Author contributions

CTV, DMC, ACSA, AVDR and WTC conceived the study. CTV drafted the manuscript. DMC and UMS performed the statistical analyses and contributed to draft the manuscript. ACSA, FGL, OLSD, AVDR, AALF and WTC participated in or supported data collection. All authors participated in the interpretation of results and approved the final version of the manuscript.

Ethics approval

The SALURBAL study protocol has been approved by the Drexel University Institutional Review Board with ID #1612005035.

Availability of data and materials

This study used data from SALURBAL project. These data are not publicly available. The SALURBAL project welcomes queries from anyone interested in learning more about its dataset and potential access to data. To learn more about SALURBAL's dataset, visit https://drexel.edu/lac/or contact the project at salurbal@drexel.edu.

Declaration of competing interest

We declare no competing interests.

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Appendix A. Supplementary data

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