Original Article

The relationship of built environment to health-related behaviors and health outcomes in elderly community residents in a middle income country

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Significance for public health

The health outcomes for which we found most consistent evidence of associations with the built environment index (BEI) included respiratory conditions (bronchitis, pneumonia), urinary and renal conditions, gastrointestinal problems, headache, visual impairment and stroke. These health outcomes in the elderly may reflect exposures in the household environment associated with inadequate housing, such as mold, dust and damp. They may also be influenced by poor sanitary conditions, reflected in the absence of indoor plumbing and inadequate waste disposal facilities. Poor vision, headache and depression may all be associated with chronic exposure to poverty and stress, for which the measures of the household and neighborhood environmental conditions used in the BEI may be indicators. Assuring that the elderly in Brazil have access to adequate housing located in neighborhoods with access to basic sanitary conditions, water and lighting, will be increasingly important as the average age of Brazilians continues to increase, and increasing proportions of the population experience the adverse health effects associated with these conditions.

Abstract

Background. Few studies have examined the impact of the built environment (BE) on health behaviours and health outcomes in middle income countries. This study examines associations between self-assessed characteristics of the home and neighbourhood environment and health-related behaviours and health outcomes in an elderly population in Brazil

Design and methods. In a community sample of 6963 community dwellers 60 years old and older living in the state of Rio Grande do Sul, Brazil, associations between self-reported BE conditions and health behaviours and health outcomes were assessed using a structured questionnaire. Multivariate analysis was conducted to investigate these associations while accounting for other relevant characteristics.

Results. We found significant positive associations between adverse BE conditions and pulmonary, urinary conditions, gastrointestinal, problems, headache and depression. There were mixed associations between adverse BE conditions and musculoskeletal and sensory conditions, inverse associations with metabolic disorders. and no associations with dermatologic problems and cancer. After accounting for health related behaviours, results suggest a modest association between adverse BE conditions and hypertension, with no significant associations with other indicators of cardiovascular conditions (heart problems, stroke, varicose veins).

Conclusions. The findings in this study suggest links between adverse conditions in the BE and health related behaviours in the hypothesized direction. Associations with the health conditions examined here are mixed. We find the strongest evidence for effects of adverse BE conditions for pulmonary and infectious conditions. Significant associations between the adverse BE indicators and health outcomes persist after accounting for health related behaviours, suggesting that BE conditions are linked to health pathways above and beyond the health related behaviours assessed in this study.

Introduction

Investigations of the relationship between the neighbourhood characteristics and residents' health and health behaviour have increased considerably in recent years. Associations have been found between neighbourhood characteristics and health,[1,2] physical activity or walkability,[3,4] cardiovascular diseases,[5] infections,[6] psychological distress,[7,8] depression,[9] visual impairment,[10] and alcohol consumption.[11]

Although research supporting relationships between the built environment (BE) and health behaviours is accumulating, there are gaps in the evidence. These include questions about the extent to which associations between neighbourhood characteristics and health related behaviours and outcomes differ for older adults versus the broader adult population. There is some evidence to suggest that older adults may react differently to changes in their neighbourhoods, or to neighbourhood conditions more broadly.[12-14]

In the last decade, there has been increasing interest in the impact of the BE on health among the elderly. Most studies have been conducted in the United States and European countries.[15] However, few studies have examined the association between characteristics of the built environment and health and health behaviours in older adults in developing countries. A recent study reported the need to develop studies and methods to study the linking between the BE and health outcomes in Latin America.[16,17] In Brazil, a middle income country, the majority of studies examining associations between the BE and health have been carried out with adult populations.[18-21] One recent study examined associations between the BE and urinary infections in an elderly population.[6] Marques *et al*.[6] found the high prevalence of urinary infection among elderly women in poorer areas. We found no papers examining associations between the BE and multiple health outcomes in middle income countries. There is a need for theoretically informed empirical research in this area in order to understand more clearly the pathways through which characteristics of neighbourhood BE may influence the health of elderly residents. In this paper we aim to contribute to that literature through examination of associations between characteristics of the BE, health related behaviours, and health outcomes, drawing on data from a sample of elderly community residents in Brazil. In this paper we conceptualize the built environment as an intermediate factor that may be associated with multiple

proximate factors linked to health outcomes.

These pathways include, for example, effects of the built environment on health related behaviours (*e.g.,* physical activity), stress (*e.g.*, associated with crowding and inadequate living conditions), falls (*e.g.* due to poor lighting), and housing conditions (*e.g.,* exposure to mould, damp and associated allergens, lack of access to sanitary facilities). Each of these pathways is associated with health outcomes, including both chronic and acute conditions. For example, characteristics of the BE may influence a number of behaviours that have been linked to health outcomes, including for example, physical activity, a major modifiable risk factor associated with cardiovascular disease,[22] type II diabetes,[23] osteoporosis,[24] some forms of cancers,[25] and mental and social well-being.[26] Similarly, characteristics of the BE may be indicative of environmental conditions conducive to stress. Physiological responses to stress are a second pathway through which neighbourhood environmental characteristics may be linked to important health outcomes.[27-31] A third pathway involves exposure to allergens in the home environment may be associated with pulmonary conditions such as asthma, bronchitis or pneumonia.[32-35] Finally, access to basic sanitary conditions such as indoor plumbing, and crowding can influence exposure to infectious disease agents, These suggest that conditions in the built environment may affect heath through pathways that extend considerably beyond their effects on health related behaviours, which have been the focus of many studies conducted in higher income countries. The extent to which associations between BE with health outcomes remain after accounting for health-related behaviours is unclear, and has been largely unexamined in middle income countries such as Brazil. We address these research questions using data from The elderly of Rio Grande do Sul survey, sponsored by the State Council on Aging.[36]

Our overarching goal in this paper is to examine associations between self-reported characteristics of the BE and health outcomes above and beyond health related behaviours in an elderly population in Brazil.

Design and Methods

Setting

The sample consisted of 6963 elderly participants living in Rio Grande do Sul, Brazil. The survey focused on assessing the health and living conditions of community-residing adults aged 60 years and older. All respondents completed a face-to-face household survey administered by health professionals, who had received training and completed practice interviews before beginning field work. Data was collected in 1996 and this analysis was carried out in 2014. More details can be seen elsewhere.[37] No proxy information was collected and the study reached an overall response rate of 99%, as high as observed in other investigations.[38] Recruitment and consent procedures were approved by the ethics committee of the Federal University of São Paulo. During the study period 7040 subjects were assessed. 1.1% did not take part in the assessment, mainly refusals, yielding an overall sample of 6963 participants.

Measures

Built environment

The selection of indicators of the built environment used in this analysis was guided by previous neighbourhood based research and theory linking neighbourhood stressors to poor health.[39,40] The literature on deprivation and household and neighbourhood environments informed the factors identified. Indicators of the *house environment* available in *The elderly of Rio Grande do Sul* survey included self-reported presence of: an indoor shower or toilet [no (presence of a shower or a toilet), yes (absence of both shower and toilet); indoor electric supply with meter (yes/no); proper sleeping arrangements [no (alone or with spouse); yes (with children, grandchildren or other people)]; and type of physical residence (house-apartment /room-slum). Indicators of the *neighbourhood environment* included presence of: garbage collection [collected (no)/burned or discharged (indicates no formal means of disposal) (yes); public water supply with indoor plumbing (yes/no); public sewer supply (yes/no); and proper public street illumination (indicates that the municipality has not run electric lines to the area) (yes/no)]. An index was generated by including all available information on the 8 self-reported indicators of household and neighbourhood environment items described above. Each variable was coded in a *zero or one* fashion indicating the presence (0) or absence (1) of the condition. An overall score aspect of the built environment was created by adding the number of positive answers obtained in the interview. The score can range from 0 to 8, with a higher score indicative of a greater number of adverse built environment characteristics. Because the distribution of the total index was skewed, we created a categorical version for use in the logistic regression models, as follows: 0 (49.2%), 1 (33.1%), 2 (10.3%) and 3+ (7.2%).

Social demographics

Social demographics included gender (reference group, female), age (60-69, reference group, 70+), education (<4 years, reference group *vs.* ≥4 years), income (< twice the monthly minimum wage, reference group *vs.* ≥ 2 minimum wage).

Health behaviours

Health behaviours included whether physically active [yes (exercises 3+times/week)/no], current tobacco use (yes/no), any use of alcohol (yes/no).

Health conditions

Inquiry into health conditions for which treatment had been sought in the previous six months included hypertension, heart problems, stroke, varicosities, diabetes, arthritis, back problems, osteoporosis, bronchitis, pneumonia, urinary infection, renal problems, dermatologic problems, headache (in the previous week), gastro-intestinal problems and cancer. Each condition was coded yes (treatment sought in the previous six months) or no (no treatment sought within that time period).

Sensory impairments

Vision was assessed by asking participants *How would you rate your visual ability?* Response was on a 6-point scale, dichotomized as impaired (blind, very bad, bad) *vs*. non-impaired (fair, good, very good).

Hearing was assessed by asking participants *How would you rate your hearing ability?* Response was on a 5-point scale, dichotomized as impaired (deaf, very hard to hear, hard to hear) *vs*. non-impaired (minimal or no difficulty hearing).

Depression

Depression was evaluated by a validated Brazilian version of the Short Psychiatric Evaluation Schedule.[41] The questionnaire is composed of six items

Each question requires a yes/no answer regarding presence in the past 30 days. The total score reflects the number of positive answers, yielding a potential scoring range of 0 to 6. Subjects with a score or 3+ are considered potential depressive cases. Performance on the Short-SPES is not affected by sex, age, marital status, income, education, or minority status.[41]

Statistical analysis

Exploratory data analysis techniques such as frequencies, means and χ^2 tests were used to characterize the sample. Associations of health behaviours with BE were calculated including controls for socio-demographic characteristics comparable with other reports on this area. Associations of health outcomes with BE were assessed using multivariate linear models controlling for socio-demographic characteristics; and then, further controlling for all health-related behaviours. This two-step process allowed us to disentangle the extent to which associations between the BE and health outcomes operate independent from associations with health related behaviours. All analyses were performed using the SPSS-20 statistical program. Multivariate significance tests were carried out using Wald χ^2 tests. Statistical significance was evaluated using 2-tailed tests, with P<0.05 for significance to control for Type I error.

Results

Sample characteristics

Table 1 displays socio-demographic characteristics of the sample. Approximately two thirds of the participants were female, a similar proportion had low education and income, and just over half were between 60-70 years of age.

Association between built environment index and health behaviours

Table 2 shows the results of the logistic regression models testing the association between the built environment index (BEI) and health related behaviours. Because income and education were highly correlated, education was dropped from the model to avoid multicolinearity.

The BEI was significantly associated with each of the indicators of health behaviour assessed independently of each other, and controlling for socio-demographic variables. In particular, those reporting three or more adverse BE conditions were 33% less likely to report adequate physical activity, compared to those with no adverse BE conditions (OR=0.67, P<0.01). Participants reporting 2 (OR=1.72, P<0.01) or ≥3 (OR=2.38, P<0.001) adverse BE conditions were significantly more likely to report tobacco use. Similarly, those reporting 1 (OR=1.32, P<0.01), 2 (OR=1.69, P<0.001) or ≥3 (OR=2.95, P<0.001) adverse BE conditions were significantly more likely than those reporting no adverse BE conditions to report alcohol use.

Association between built environment index and health conditions

The BEI was significantly associated with 12 of the 19 health conditions assessed independently of each other (Table 3). The majority of these were in the expected direction, with higher BEI associated with poorer health. Specifically, higher BEI scores were associated with increased odds of having sought treatment in the previous six months for gastrointestinal problems (OR=1.16, P=0.04), urinary infection (OR=1.21, P=0.01), arthritis (OR=1.34, P=0.001), bronchitis (OR=1.34, P=0.01), pneumonia (OR=1.26, P=0.05), renal problems (OR=2.00, P=0.001), headache (OR=2.03, P=0.001), and with self-rated visual impairment (OR=1.73, P=0.001) and self-reported symptoms of depression (OR=1.35, P=0.01). For two health indicators, increased BEI was associated with decreased odds of having sought treatment in the previous six months: osteoporosis (OR=0.64, P=0.01)

Table 1. Sample characteristics (n=6963).

Characteristic	%
Gender	
Female	66.0
Male	34.0
Age category	
60-69	56.7
70+	43.2
Education	
<4 years	66.0
≥4 years	33.7
Income	
Low income	62.1
Higher income	34.7
Physical activity	37.5
Use of tobacco	18.7
Use of alcohol	10.5
Perceived self reported indicators built environment	
Sewer	62.7
Proper sleeping arrangements	86.1
Public water support/indoor plumbing	92.8
Shower or toilet at home	92.8
Street lights	94.7
Garbage collection	95.5
Indoor electric supply with meter	95.9
Type of residence: room/slum	1.7
Medical conditions for which treatment was sought in the previous 6 months	
Hypertension	49.2
Heart problems	28.2
Varicose veins	17.3
Stroke	3.6
Diabetes	11.0
Bronchitis	27.7
Pneumonia	6.5
Back problem	43.2
Osteoporosis	15.1
Arthritis	43.3
Urinary infection	17.6
Renal problems	12.9
Visual impairment	24.3
Hearing impairment	15.4
Gastrointestinal problem	18.3
Dermatologic problem	10.5
Headache*	32.4
Cancer	1.4
Depression	21.0

*Evaluated in the last week.

Table 2. Logistic regression investigating the association of build environment index (BEI) with health behaviours.

Health behaviours: adjusted for demographic variables	BEI Score 1		BEI Score 2		BEI Score 3	
	OR	95%CI	OR	95%CI	OR	95%CI
Physical activity, % yes	0.97	(0.85-1.10)	0.83	(0.68-1.02)	0.67	(0.52-0.87)**
Use of tobacco, % yes	1.33	(0.94-1.27)	1.72	(1.40-2.12)***	2.38	(1.90-2.99)***
Use of alcohol, % yes	1.32	(1.09-1.62)**	1.69	(1.26-2.25)***	2.95	(2.20-3.99)***

BEI index score 0 = reference category. OR, Odds ratio; CI = Confidence interval. P-value: ***<0.001, **<0.01 and *<0.05.

and diabetes (OR=0.62, P=0.05).

There were no significant associations between BEI and seven health indicators, including having sought treatment for heart problems, varicose veins, stroke, back pain , dermatologic problems, cancer, or with self-rated hearing. Similar patterns were observed when health behaviours were removed from the models (Table 3 – Model 1).

Discussion

There are three main findings from the series of analyses presented here. First, the BEI is significantly associated with health related behaviours, with increasing numbers of adverse built environment characteristics associated with decreased physical activity, and increased tobacco and alcohol use. Second, the BEI is significantly associated with increased risk of 9 of 19 health outcomes tested in these models, representing both chronic and acute conditions, and with decreased risk of two chronic conditions. Third, associations remain statistically significant after accounting for health related behaviours, suggesting that effects of the built environment on health extend beyond the effects of the built environment on health related behaviours. We discuss each of these findings in detail below.

Built environment and health-related behaviours

Consistent with previous studies,[11] those with higher BEI score reported increased odds of tobacco (238%) and alcohol (295%) use, and decreased odds of adequate physical activity. These results are consistent

Table 3. Logistic regression investigating the association build environment index (BEI) score with health conditions.

Health conditions	BEI Score 1		BEI Score 2		BEI Score 3+	
	OR	95%CI	OR	95%CI	OR	95%CI
Cardiovascular conditions						
Hypertension (M1)	1.11	(0.99-1.24)	0.97	(0.82-1.15)	0.84	(0.69-1.02)
Hypertension (M2)	1.12	(1.00-1.25)	1.01	(0.86-1.20)	0.92	(0.75-1.12)
Heart problems (M1)	0.97	(0.87-1.09)	0.99	(0.83-1.20)	1.08	(0.87-1.35)
Heart problems (M2)	0.97	(0.86-1.09)	0.99	(0.83-1.20)	1.08	(0.87-1.34)
Varicose veins (M1)	1.00	(0.87-1.16)	0.99	(0.80-1.24)	0.90	(0.69-1.17)
Varicose veins (M2)	1.01	(0.87-1.17)	1.02	(0.82-1.27)	0.94	(0.72-1.22)
Stroke (M1)	1.05	(0.79-1.14)	0.63	(0.38-1.06)	0.94	(0.57-1.56)
Stroke (M2)	1.05	(0.79-1.40)	0.62	(0.37-1.03)	0.90	(0.54-1.50)
Metabolic conditions						
Diabetes (M1)	0.92	(0.77-1.10)	0.79	(0.60-1.04)	0.58	(0.40-0.83)***
Diabetes (M2)	0.93	(0.78-1.10)	0.82	(0.62-1.08)	0.62	(0.43-0.90)*
Pulmonary conditions						
Bronchitis (M1)	1.09	(0.96-1.23)	1.31	(1.10-1.57)***	1.53	(1.25-1.88)***
Bronchitis (M2)	1.07	(0.95-1.22)	1.23	(1.02-1.47)*	1.34	(1.09-1.65)**
Pneumonia (M1)	1.27	(1.02-1.60)*	1.28	(0.93-1.77)	1.46	(1.02-2.07)*
Pneumonia (M2)	1.26	(1.01-1.59)*	1.23	(0.89-1.70)	1.33	(0.93-1.90)
Musculoskeletal conditions						
Back problem (M1)	1.00	(0.90-1.12)	0.94	(0.80-1.12)	1.15	(0.95-1.41)
Back problem (M2)	0.90	(0.89-1.11)	0.93	(0.78-1.11)	1.12	(0.92-1.37)
Osteoporosis (M1)	0.91	(0.77-1.10)	0.73	(0.57-0.93)*	0.66	(0.48-0.90)*
Osteoporosis (M2)	0.90	(0.77-1.05)	0.72	(0.56-0.92)*	0.64	(0.47-0.87)**
Arthritis (M1)	1.16	(1.04-1.30)*	1.06	(0.89-1.25)	1.40	(1.14-1.70)***
Arthritis (M2)	1.16	(1.03-1.30)*	1.04	(0.88-1.24)	1.34	(1.09-1.64)***
Urinary conditions						
Urinary infection (M1)	1.21	(1.05-1.39)*	0.97	(0.78-1.21)	1.25	(0.98-1.56)
Urinary infection (M2)	1.21	(1.05-1.38)**	0.98	(0.78-1.23)	1.27	(0.98-1.56)
Renal problems (M1)	1.26	(1.06-1.49)**	1.21	(0.95-1.55)	2.05	(1.60-2.62)***
Renal problems (M2)	1.25	(1.06-1.48)**	1.19	(0.93-1.52)	2.00	(1.52-2.51)***
Sensory conditions						
Visual impairment (M1)	1.06	(0.93-1.21)	1.08	(0.89-1.31)	1.83	(1.49-2.26)***
Visual impairment (M2)	1.05	(0.92-1.20)	1.06	(0.87-1.29)	1.73	(1.41-2.14)***
Hearing impairment (M1)	1.07	(0.92-1.25)	0.92	(0.73-1.18)	1.25	(0.96-1.61)
Hearing impairment (M2)	1.06	(0.91-1.24)	0.92	(0.72-1.17)	1.21	(0.94-1.57)
Other health outcomes						
Gastrointestinal problems (M1)	1.16	(1.01-1.33)*	1.02	(0.82-1.27)	1.24	(0.97-1.58)
Gastrointestinal problems (M2)	1.16	(1.01-1.33)*	1.02	(0.82-1.26)	1.23	(0.96-1.57)
Dermatologic problem (M1)	1.04	(0.87-1.24)	0.85	(0.64-1.13)	0.78	(0.56-1.10)
Dermatologic problem (M2)	1.04	(0.87-1.24)	0.85	(0.64-1.13)	0.78	(0.55-1.10)
Headache (M1)	1.24	(1.10-1.40)***	1.30	(1.09-1.55)***	2.06	(1.68-2.53)***
Headache (M2)	1.23	(1.09-1.40)***	1.29	(1.08-1.54)**	2.03	(1.65-2.49)***
Cancer (M1)	1.06	(0.66-1.71)	1.02	(0.49-2.13)	1.87	(0.93-3.75)
Cancer (M2)	1.08	(0.66-1.74)	1.04	(0.49-2.18)	1.97	(0.98-3.97)
Depression (M1)	1.07	(0.93-1.23)	1.32	(1.09-1.60)**	1.50	(1.20-1.87)***
Depression (M2)	1.06	(0.92-1.22)	1.26	(1.04-1.54*)	1.35	(1.08-1.69)**

BEI index score 0 = reference category. OR, Odds ratio; CI, Confidence interval; M1, Model 1 (Adjusted for demographic characteristics); M2, Model 2 (Adjusted for Model 1 + health behaviours such as physical

with findings reported elsewhere in the literature, with adverse built environment characteristics associated with reductions in health-protective behaviours such as physical activity, and increases in behaviours that are associated with poorer health outcomes, such as tobacco use.[3,4]

Built environment and health outcomes

Controlled analysis found that the odds of bronchitis, pneumonia, arthritis, urinary infection, renal problems, visual impairment, gastrointestinal problems, headaches, and depression were each significantly and positively associated with the number of adverse conditions in the built environment. Accounting for health related behaviours, major modifiable risk factors associated with chronic disease.[22-24,42] Found very little effect. Specifically, behavioural indicators did not substantially attenuate existing associations, and increased odds of hypertension became statistically significant. In other words, as the number of adverse built environmental characteristics increased, so did the odds of multiple chronic (*e.g.*, hypertension, arthritis, visual) and acute (*e.g.* bronchitis, pneumonia, urinary tract) physical health conditions, as well as indicators of emotional distress (*e.g.*, depression).

The fact that associations between BEI and health outcomes persist after accounting for health related behaviours suggests that these associations operate through pathways above and beyond the health related behaviours assessed in this study. These may include underlying effect mechanisms such as exposure to allergens or infectious agents, poor sanitary conditions due to lack of indoor plumbing or running water, overexposure to sunlight, and compromised immune systems, inflammation as well as many other physiological responses to stress. On the other side, the stress response might be associated with hypertension, renal problems, headaches, depression, gastrointestinal problems and visual impairment.[10,27-31,43]

Adverse BE conditions were inversely associated with self-reports of having sought treatment in the previous six months for two chronic conditions diabetes and osteoporosis, and no significant associations were found for several other indicators, including cardiovascular conditions (*e.g.,* heart pain, varicose veins, stroke), back pain, self-rated hearing, dermatologic conditions, and cancer. Minimal associations between adverse BEI conditions and cardiovascular conditions, and inverse associations with metabolic indicators, commonly considered to be indicative of physiologic response to chronic stress, are in contrast to findings reported in higher income countries.[44,45] These may be indicative of the measures used in this study – self reported visits to a doctor for the health condition – which may reflect access to health care or economic resources, with participants more likely to visit doctors for acute conditions such as pulmonary or urinary infections, than for chronic conditions that are often asymptomatic, such as diabetes or hypertension. This could indicate a true cohort effect or, alternatively, an undercount among older cohorts due to differential mortality or poor recall of remote events. Non-significant associations with health conditions including back pain, self-rated hearing, dermatologic conditions and cancer may be indicative of other factors that influence these health outcomes, beyond conditions in the immediate home and neighbourhood environments.

The findings reported here are among the first results from middle income developing contexts to examine built environment among the elderly that may be important predictors of health behaviours and health outcomes. They are consistent with theoretical and empirical evidence emerging from studies in higher income countries, and in non-elderly adult samples, that suggest that exposure to conditions that are conducive to hazardous environmental conditions can lead to poorer health outcomes. These effects may travel through many pathways, including but not limited to, their effects on health related behaviours. Specifically, results reported here suggest the potential importance of housing conditions that may be conducive to the spread of infectious diseases, such as dampness, lack of running water, crowding, or absence of indoor sanitary facilities. Some of these same conditions may contribute to increased risk of pulmonary conditions, such as bronchitis and pneumonia.

Strengths and limitations

This study has several strengths. The richness, representativeness, and size of the sample enabled us to address environmental conditions not previously studied on a middle income country, and to test its association with specific medical conditions likely to be associated with environment and biological risk.

There are also a number of limitations to this study. The interpretation of findings is limited due to the cross-sectional study design. Participants were selected on the community excluding homeless people where the impact of environment is likely to be higher. The information on health conditions is based on self-report, as is common in epidemiological surveys in middle income contexts. In addition, social desirability might have threatened the validity of the assessment as subjects might be embarrassed to report underserved conditions. One implication of this might be that associations between BEI and health behaviours and health outcomes reported here may be understated, due to underreporting of these conditions. Thus our findings may underestimate both the level of adverse built environment conditions, and the strength of relationships to the outcomes assessed. A second limitation is that failure to observe statistical significance in some of the health variables such as stroke and cancer may be attributable to small numbers of cases in the sample. A third limitation is that the data used for this analysis was collected in 1996, nearly two decades ago. However, the proportion of elderly living with low income, up to two minimum wage, remains high (65.8% in 1991; 55.2% in 2000) and according to latest census the medium income of elderly is still below two minimum wages.[46,47]

In addition according to the 2000 census, 44.2% of the households, in which the elderly are responsible for the household, did not have adequate sanitation, water supply and garbage treatment. There are regional disparities in the country but in South Region where Rio Grande do Sul state is the percentage of people without adequate sanitation, water supply and garbage treatment reaches 30%.[48]

Given the large proportions of the population as a whole, and even larger proportions of the elderly population, who remain without access to basic sanitation in their residential neighbourhoods, it is reasonable to suppose that the findings reported here remain relevant. The variables assessed (for example: water supply, garbage services, electric lines, house conditions etc.) are still representative of the poorer neighbourhoods in our region and still hold for current assessments.

The associations reported here lend support for the need for future research is needed to more clearly document the current state of the elderly, the conditions of their housing and neighbourhoods, and their implications for health. Documenting trends over time in these conditions and their associations with change over time in the health of the elderly population can provide crucial information to inform on-going efforts to promote the health of the elderly, particularly the large proportion of the elderly living in underserved neighbourhoods, in Brazil.

Conclusions

There is a growing body of evidence examining associations between BE characteristics, mobility and health in developed countries.[2-4] This study is one of only a handful to examine these associations within the context of a middle income country, and among older adults. Our finding that the BEI used in these analysis is significantly associated with health-related behaviours, with an increasing number of adverse built environmental characteristics associated with

more harmful/less protective health related behaviours, is consistent with a growing body of evidence from developed and developing contexts. Furthermore, the finding that the BEI is associated with a wide range of acute and chronic indicators of health in this population, even after accounting for health related behaviours, is consistent with a wide range of literature, across various economic and political contexts, suggesting that environmental characteristics are associated with health. Finally, our finding that the health effects associated with adverse BE characteristics in this context are strongest for infectious and pulmonary conditions suggests that the specific characteristics of the built environment that matter, and their specific effects on health, vary. Understanding the specific pathways through which these effects travel is essential for interventions that focus on health improvements. Specifically, our findings suggest that investments in neighbourhood sanitation and adequate housing conditions may be important priorities in supporting the health of the elderly population in Brazil.

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