ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Basic sanitation and self-reported health in Brazilian capitals: a multilevel analysis

Saneamento básico e saúde autoavaliada nas capitais brasileiras: uma análise multinível

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ABSTRACT: *Objective:* This study aimed to analyze the association between the contextual determinants related to basic sanitation and self-reported health in Brazilian capitals. *Methods:* The sample consisted of 27,017 adults (≥18 years) residing in the 27 Brazilian capitals in 2013, from the National Health Survey (PNS). The association between self-reported health and sanitation (sewage system, water supply and garbage collection) was analyzed using Bayesian multilevel models, controlling for individual factors (first level of the model) and area-level socioeconomic characteristics (second level). *Results:* We found a consistent association between better self-reported health and better sanitation levels, even after controlling for individual and contextual characteristics. At the contextual level, lower odds of poor self-reported health was observed among those living in areas with medium (OR = 0.59, 95%CI 0.57 – 0.61) or high (OR = 0.61, 95%CI 0.57 – 0.66) sewage system level; medium (OR = 0.77, 95%CI 0.71 – 0.83) coverage of water supply; and high (OR = 0.78, 95%CI 0.69 – 0.89) garbage collection level. *Conclusion:* The positive association between better sanitation conditions and health, independently of the individual factors and the socioeconomic characteristics of the place of residence, confirms the need to consider sanitation in the planning of health policies.

Keywords: Basic Sanitation. Health. Water Supply. Sewage. Solid Waste Collection.

RESUMO: *Objetivo:* Analisar a associação entre os determinantes contextuais referentes ao saneamento básico e a autoavaliação de saúde nas capitais brasileiras. *Métodos:* Analisaram-se 27.017 adultos (≥ 18 anos) residentes nas 27 capitais brasileiras em 2013, utilizando dados da Pesquisa Nacional de Saúde (PNS). Ajustaram-se modelos multiníveis logísticos bayesianos para analisar a associação entre a autoavaliação de saúde e a cobertura dos serviços de saneamento básico (rede de esgoto, abastecimento de água e coleta de lixo), controlando a análise por fatores individuais (primeiro nível do modelo) e renda *per capita* da cidade de residência (segundo nível). *Resultados:* A maior cobertura de serviços de saneamento básico esteve consistentemente associada à melhor percepção da saúde, mesmo após o controle pelas características individuais e contextuais. Observou-se menor chance de autoavaliação ruim de saúde entre indivíduos que viviam em capitais com média (*odds ratio* — OR = 0,59; intervalo de confiança — IC95% = 0,57 – 0,61) e alta (OR = 0,61; IC95% = 0,57 – 0,66) cobertura da rede de coleta de esgoto; média (OR = 0,77; IC95% = 0,71 – 0,83) cobertura de serviço de abastecimento de água; e alta (OR = 0,78; IC95% = 0,69 – 0,89) proporção de coleta de lixo. *Conclusão:* A associação positiva entre melhores condições de saneamento básico e a autoavaliação da saúde, independentemente dos fatores individuais e das condições socioeconômicas do local de residência, confirma a necessidade de se considerar o saneamento básico na elaboração de políticas de saúde.

Palavras-chave: Saneamento Básico. Saúde. Abastecimento de Água. Esgotamento Sanitário. Coleta de Lixo.

INTRODUCTION

Basic sanitation is a major public health concern, especially in low- and middle-income countries[1]. Basic sanitation has been shown to control physical factors that exert or have the potential to exert harmful effects on social well-being, both physical and mental[2], and it has been considered an important environmental determinant of health[1]. Mainly related to services for drinking water availability and sewage and solid waste management services, sanitation problems are aggravated by the unplanned growth of urban centers[3], currently affecting an important part of the total disease burden in the world[4]. In this context, it is estimated that about 10% of all diseases can be prevented by improving sanitation conditions[4].

Exposure to environmental risk factors, such as housing, water supply and sanitation conditions, is closely linked to social determinants of health[1]. Less developed regions, with lower per capita income and education level, for example, have greater sanitation deficits[5]. Another factor that can influence the coverage of sanitation services is unsustainable urbanization, which results in increased housing in places without adequate infrastructure[6].

Brazil has shown notable progress in reducing health inequities in the last decades, but it is a country that is still faced with substantial challenges related to inequalities in the coverage of sanitation services[7]. In 2016, only 19 capitals had water supply networks greater than 90%, and variations were observed even in capitals of the same region, such as Macapá (39.1%), Rio Branco (54.6%) and Palmas (97.4%). In the case of sewage services, less than half of

the capitals had coverage greater than 90%, with capitals covering less than 75% of service in all regions, such as Boa Vista (56.7%), Fortaleza (49.7%), Vitória (71.1%), Florianópolis (60.2%) and Cuiabá (51.4%)[8].

Although both the availability of drinking water and the extent of sanitary sewage have increased in recent decades in Brazil[9], inefficiency in basic sanitation networks and inequalities in the availability of these services still represent an important area for public health policies to be implemented[10]. In 2013, the National Basic Sanitation Plan (PLANSAB)[11] was introduced, which established goals for 2018, 2023 and 2033, with the objective of reducing the present deficits in sanitation services and with the aim of universal water supply, sewage service and garbage collection.

Deficiency in basic sanitation services in the place of residence is related to an increased susceptibility of individuals to diseases related to inadequate environmental sanitation (DRSAI)[12]. Among the main diseases associated with environmental sanitation conditions are diarrhea and dengue, responsible for more than 93% of hospitalizations for DRSAI between 2001 and 2009 in Brazil [13]. In 2013, substantial hospitalization rates for diarrheal diseases were seen in the city of Belo Horizonte, with a mortality rate of 1.57 per 100,000 people[14.] Dengue is another disease that has been a major public health concern, and there has been an increase in its occurrence in cities such as Porto Alegre[15] and Rio de Janeiro[16]. The increase in the incidence of these diseases, in turn, has the capacity to significantly influence the quality of life and health conditions of the population[17].

Therefore, knowledge of the association between contextual determinants related to basic sanitation and the perception of health can contribute to the identification of groups of more vulnerable individuals and to the reduction of inequalities in the availability of these services. Self-rated health (SRH), a robust indicator for assessing the health of populations[18] and recently considered the best predictor of mortality in a study that analyzed 655 variables[19], stands out for allowing direct assessment of health status, in addition to aspects not caught by other instruments, such as psychological and social factors [20].

Recent trends regarding the influence of contextual factors and health determinants have encouraged the development of new studies that take into account the environmental characteristics related to the place of residence. However, studies investigating the effect of coverage of basic sanitation services on SRH, regardless of the individual and socioeconomic characteristics of the place of residence, are still scarce in Brazil. Thus, we aimed to determine the association between contextual determinants regarding basic sanitation and SRH in Brazilian capitals, after controlling for individual factors and socioeconomic characteristics of the place of residence.

METHODS

The present study used data from the National Health Survey (PNS), a multistage probabilistic sample representative of the adult population (≥18 years) in Brazil, large regions,

capitals and other municipalities, carried out in 2013. PNS data were obtained through home interviews, using questionnaires that collected information on socioeconomic characteristics, SRH, presence of diseases and lifestyle. The households selected for the sample followed the simple random sampling method, according to the minimum size of 1,800 defined by Federation Unit and totaling 81,167 households. After conducting the interviews with the selected residents in the households, the sample consisted of 64,348 households and 60,202 responses to the individual questionnaire[21]. PNS was coordinated by the Brazilian Institute of Geography and Statistics (IBGE) and received approval from the National Research Ethics Committee (Conep).

STUDY DESIGN

A multilevel cross-sectional study was conducted that analyzed the association between contextual determinants related to basic sanitation and SRH in the 27 Brazilian capitals.

VARIABLES

The dependent variable used was SRH, obtained by the individuals' report according to the classification of their own health as "very good", "good", "satisfactory", "poor" or "very poor". For the analysis, this classification was separated into two categories: good health (including satisfactory, good and very good responses) and poor health (for poor and very poor ratings)[22].

At the individual level, socioeconomic and behavioral variables were analyzed: sex, age in years (18–24; 25–39; 40–59; 60 or more), race/color (white, brown, black and others), schooling (categorized according to the last level of formal education completed), living without or with a partner, smoking (never smoked, smoked or currently smokes).

At the contextual level, socioeconomic characteristics and those related to basic sanitation in the place of residence were according to the data provided by the 2010 Census23 for each of the 27 Brazilian capitals, including the Federal District, totaling 33,423,348 adults, an average of 1,237,902 residents per capital. The contextual variables of interest were coverage of basic sanitation services (sewage system, water supply and garbage collection) and income *per capita*. Due to the presence of non-linearity, all contextual variables were divided into tertiles and categorized into lower, middle and upper levels.

STATISTICAL ANALYSIS

Multilevel regression models were used to analyze the association between SRH and the coverage of basic sanitation services, controlling the analysis by individual factors

(first level of the model) and income *per capita* of the capital of residence (second level). In the multilevel models, the lower tertiles of sewage system, water supply, solid waste collection and income *per capita* were used as reference categories for the respective contextual variables. To quantify the proportion of SRH variance to be explained at the individual and contextual levels, the interclass correlation coefficient (ICC) was estimated in the multilevel models. The model parameters were estimated using Bayesian inference, a recommended approach to reduce the bias inherent in the use of maximum likelihood procedures in multilevel analyses[24]. In addition, it allows the fit of the models to be assessed, comparing the values of the Bayesian information criterion (BIC), in which the decrease in the coefficient indicates a better fit of the model in relation to the response variable[24].

The analyses were performed using the Stata 13.1 program (Stata Corporation, College Station, TX, USA, 2013). Descriptive analyses of socioeconomic characteristics and SRH were performed using the survey mode, which considers the complex design of the sample in the data analysis: sampling weight and organization of individuals (secondary sample units) according to the capital of residence (primary sample units). Multilevel models used the *gllamm* mode, a command for multilevel analyses that allows the inclusion of weights for complex sample design.

RESULTS

The sample consisted of 27,017 individuals at least 18 years old, of both sexes, residing in one of the 27 Brazilian capitals, including the Federal District, in 2013. The descriptive analysis of socioeconomic characteristics allowed us to observe that most individuals were female (54.9%), aged between 25 and 59 years (66.6%) and lived with a partner (55.9%). According to their skin color, most individuals reported white (47.2%), followed by brown and black (40.8 and 9.9%, respectively). The analysis of the level of education indicated that the majority of the population had at least completed elementary school (75.9%). Regarding behavioral characteristics and SRH, more than 70% of the individuals never smoked and a small proportion of the sample reported that they were still smokers (12.7%). According to the perception of health, most individuals rated their health as good and 4.5% rated their health as poor (Table 1).

There were statistically significant associations between socioeconomic and behavioral characteristics and SRH in bivariate analyses. The greater presence of poor health rating was associated with females, higher age groups, low level of education and with smoking history (Table 1).

The distribution of coverage of sanitation services, specifically sewage system, water supply and solid waste collection in the Brazilian capitals shown in Table 2, indicates variations between capitals of the same and different regions. Sewage system, with the exception of the capitals of the Southeast region, showed levels of service coverage in different

Table 1. Socioeconomic and behavioral characteristics and self-reporting of health of adult residents in Brazilian capitals, 2013, Brazil.

Characteristics	Total		Poor health rating		p[b]
	n*	%[a]	n*	%[a]	
Total	27.017	100	1.367	4.54	
Sex					
Male	11.091	45.05	428	3.61	0.000
Female	15.926	54.95	939	5.30	
Age (years)					
18–24	3.513	15.39	58	1.79	0.000
25–39	9.440	32.61	222	2.26	
40–59	9.152	33.96	569	5.47	
60 or +	4.912	18.04	518	9.25	
Race/skin color					
While	11.202	47.21	467	3.67	0.001
Brown	12.650	40.80	689	5.09	
Black	2.704	9.96	179	5.48	
Other	459	2.04	32	9.03	
Schooling					
Fundamental not completed	6.052	24.10	593	9.54	0.000
Fundamental completed	3.504	15.37	161	3.77	
Secondary completed	8.553	38.68	265	3.19	
Higher education completed	4.733	21.84	91	1.70	
Lives with partner					
No	12.694	44.07	737	4.89	0.097
Yes	14.323	55.93	630	4.26	
Smoking					
Never smoked	19.212	70.82	796	3.94	0.000
Used to smoke	4.347	16.48	348	6.48	
Currently smokes	3.458	12.70	223	5.38	

*Total number of individuals in sample; [a]percentage in the weighted sample; [b]χ test.
Source: National Health Survey (PNS), 2013[21].

classification tertiles for capitals of the same region. Regarding the water network, capitals classified in different supply tertiles were observed in all regions of the country. In the collection of solid waste, with the exception of the South region, the capitals of the same region were also classified in different tertiles of service coverage.

Table 3 presents the results of the multilevel analysis for the association between SRH, sewage system, water supply and garbage collection, adjusted according to individual variables. Compared to men, women rated their health more often as being poor (odds ratio — OR = 1.50; 95% confidence interval — 95%CI 1.23 – 1.84). There was also a higher probability of poor SRH with advancing age. Regarding marital status and schooling, a poor SRH was reported less often among those living with a partner (OR = 0.82; 95%CI 0.73 – 0.91) and among those who completed some level of education. Regarding the characteristics of basic sanitation, the increase in the level of coverage in all services was significantly associated with a lower probability of poor SRH, even after controlling for individual characteristics.

To control for the socioeconomic characteristics of the municipalities that could influence health, besides basic sanitation, an additional control was used, namely the contextual income *per capita* of the municipalities (Table 4). When adjusting the multilevel models for income *per capita*, the lower reporting of poor SRH remained consistently associated with greater coverage of sanitation services. There were also significant associations between income and SRH. Compared to individuals who lived in capitals with the lowest level of sewage network, residents in places with medium (OR = 0.59; 95%CI 0.57 – 0.61) and high (OR = 0.61; 95% CI 0.57 – 0.66) levels had a lower chance of poor SRH. Similar results were observed among those who lived in the capitals with a medium level of water supply (OR = 0.77; 95%CI 0.71 – 0.83) and a high level of garbage collection (OR = 0.78; 95% CI 0.69 – 0.89) (Table 4).

DISCUSSION

The present study points to the consistent association between coverage of basic sanitation services and SRH among the adult population living in Brazilian capitals. At the individual level, female gender, advanced age, low education level and living with no partner were statistically associated with a greater presence of poor SRH. At the contextual level, higher levels of coverage of sewage, water supply and garbage collection services were significantly associated with a lower likelihood of poor SRH, even after controlling for individual factors and contextual income *per capita*.

Although inadequate coverage of basic sanitation services or their lack is recognized as two of the main health risk factors[1,25], studies on sanitation and health in Brazil, even with a recent increase in number, are still scarce[21], and they often performed on populations with specific characteristics[27-29]. Therefore, our findings on the influence of basic sanitation coverage on the perception of health of the adult population in Brazilian capitals contribute

Table 2. Distribution of coverage of sewage system, water supply and solid waste collection in Brazilian capitals, 2010, Brazil.

Region	Capital	Sewage system		Water supply		Solid waste collection	
		%	Tertile	%	Tertile	%	Tertile
North	Porto Velho	42.82	B	37.73	B	89.51	B
	Rio Branco	56.69	B	52.74	B	92.50	B
	Manaus	62.35	B	76.03	B	97.91	M
	Boa Vista	54.05	B	95.95	M	96.16	B
	Belém	67.88	M	76.41	B	96.66	B
	Macapá	26.75	B	55.70	B	95.42	B
	Palmas	67.58	M	95.18	M	96.66	B
Northeast	São Luís	65.42	B	76.58	B	90.89	B
	Teresina	61.56	B	93.47	M	92.81	B
	Fortaleza	73.98	M	93.41	M	98.66	M
	Natal	61.81	B	98.42	A	98.85	M
	João Pessoa	70.82	M	96.66	M	99.14	M
	Recife	69.23	M	87.33	B	97.74	M
	Maceió	47.06	B	74.27	B	97.38	M
	Aracaju	87.17	M	97.90	M	98.97	M
	Salvador	92.82	A	98.91	A	96.53	B
Southeast	Belo Horizonte	96.20	A	99.71	A	99.44	A
	Vitória	98.07	A	99.26	A	99.76	A
	Rio de Janeiro	94.37	A	98.32	M	99.16	M
	São Paulo	92.60	A	98.96	A	99.75	A
South	Curitiba	96.34	A	99.16	A	99.90	A
	Florianópolis	87.78	M	93.15	M	99.80	A
	Porto Alegre	93.00	A	99.27	A	99.65	A
Central-West	Campo Grande	58.73	B	90.35	B	98.90	M
	Cuiabá	80.21	M	93.98	M	96.74	B
	Goiânia	76.05	M	92.45	B	99.80	A
	Brasília	87.87	M	94.81	M	97.65	M

B: lower tertile; M: middle tertile; A: upper tertile. Source: Census, 2010[23].

Table 3. Multilevel regression models for poor health rating according to socioeconomic and behavioral characteristics, sewage system, water supply, and solid waste collection, 2013, Brazil.

1st level	Empty model (n = 27,017)		Model 1 (n = 22,840)		Model 2 (n = 22,840)		Model 3 (n = 22,840)		Model 4 (n = 22,840)	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Intercept	0.06**	**0.05 – 0.06**	0.03	**0.02 – 0.04**	0.03	**0.02 – 0.04**	0.03	**0.02 – 0.05**	0.03	**0.02 – 0.04**
Sex										
Female			1.50**	**1.23 – 1.84**	1.50**	**1.23 – 1.84**	1.50**	**1.23 – 1.84**	1.50**	**1.22 – 1.84**
Age (years)										
25–39			1.41	0.86 – 2.29	1.41	0.86 – 2.29	1.41	0.87 – 2.30	1.40	0.87 – 2.27
40–59			2.98**	**2.05 – 4.33**	2.98**	**2.06 – 4.33**	2.99**	**2.07 – 4.34**	2.97**	**2.07 – 4.27**
60 or +			4.06**	**2.84 – 5.79**	4.06**	**2.85 – 5.77**	4.07**	**2.85 – 5.81**	4.03**	**2.86 – 5.69**
Race/skin color										
Brown			1.22	0.92 – 1.62	1.25	0.93 – 1.67	1.25	0.94 – 1.66	1.24	0.91 – 1.67
Black			1.04	0.77 – 1.41	1.08	0.79 – 1.47	1.08	0.78 – 1.51	1.04	0.77 – 1.42
Other			2.76*	**1.09 – 6.95**	2.78*	**1.11 – 6.96**	2.82*	**1.13 – 7.03**	2.76*	**1.08 – 6.98**
Schooling										
Fundamental completed			0.48**	**0.42 – 0.55**	0.48**	**0.42 – 0.55**	0.48**	**0.42 – 0.56**	0.48**	**0.42 – 0.56**
Secondary completed			0.43**	**0.36 – 0.51**	0.43**	**0.36 – 0.51**	0.43**	**0.36 – 0.51**	0.43**	**0.36 – 0.51**
Higher education completed			0.20**	**0.16 – 0.23**	0.20**	**0.16 – 0.23**	0.20**	**0.16 – 0.26**	0.20**	**0.16 – 0.26**
Lives with partner										
Yes			0.82**	**0.73 – 0.91**	0.82**	**0.73 – 0.91**	0.82**	**0.73 – 0.91**	0.82**	**0.73 – 0.91**
Smoking										
Used to smoke			1.14	0.79 – 1.65	1.13	0.78 – 1.64	1.13	0.78 – 1.64	1.14	0.79 – 1.65
Currently smokes			1.19	0.91 – 1.56	1.18	0.90 – 1.54	1.18	0.90 – 1.56	1.18	0.90 – 1.55
2nd level: Capital										
Sewage system, tertile										
Middle					0.50**	**0.46 – 0.53**				
Upper					0.83**	**0.75 – 0.92**				
Water supply, tertile										
Middle							0.88*	**0.81 – 0.96**		
Upper							0.91	0.83 – 1.01		
Solid waste collection, tertile										
Middle									0.83**	**0.75 – 0.91**
Upper									0.82*	**0.72 – 0.93**
BIC (ICC)	13,224.534	(0.007)	10,254.007	(0.012)	10,253.238	(0.025)	10,255.672	(0.018)	10,253.724	(0.016)

*p < 0.05; **p ≤ 0.001; OR: odds ratio; 95%CI: 95% confidence interval BIC: Bayesian information criterion; ICC: interclass correlation coefficient.

to the expansion of scientific knowledge in the area of social and environmental determinants of health.

The advances in the availability and access of the Brazilian population to the use of sanitary facilities and drinking water in the last 25 years have enabled the country to meet the Millennium Development Goals outlined by the World Health Organization[10]. However, the existing inequality in coverage of basic sanitation services in the country[7] and its relationship with health, as evidenced by the findings of this study, are an important aspect to be considered in planning strategies that aim to improve the health conditions of the population.

The impacts of the lack or deficiency of sanitation on health have been an ongoing discussion in society since antiquity[30] and can directly affect both the health of individuals, especially with regard to infectious and parasitic diseases[31], regarding public spending on doctor visits and hospitalizations for these diseases [13,32]. In a study involving 21 countries in

Table 4. Multilevel logistic regression models for poor health evaluation adjusted for individual factors according to socioeconomic and behavioral characteristics, sewage system, water supply, solid waste collection, and contextual income per capita, 2013, Brazil.

1st level	Model 1 (n = 22.840)		Model 2 (n = 22.840)		Model 3 (n = 22.840)	
	OR	95%CI	OR	95%CI	OR	95%CI
Intercept	0.03**	0.02 – 0.05	0.03**	0.02 – 0.05	0.03**	0.02 – 0.04
2nd level: Capital						
Sewage system, tertile						
Middle	0.59**	**0.57 – 0.61**				
Upper	0.61**	**0.57 – 0.66**				
Water supply, tertile						
Middle			0.77**	**0.71 – 0.83**		
Upper			0.97	0.87 – 1.07		
Solid waste collection, tertile						
Middle					0.93	0.83 – 1.05
Upper					0.78**	**0.69 – 0.89**
Income per capita, tertile						
Middle	1.05*	**1.01 – 1.10**	0.92	0.84 – 1.01	1.73**	**1.53 – 1.97**
Upper	1.14*	**1.06 – 1.22**	0.89*	**0.81 – 0.98**	0.89	0.76 – 1.05
BIC (ICC)	10,250.792	(0.016)	10,253.789	(0.038)	10,258.198	(0.058)

*p < 0.05; **p ≤ 0.001; †sex, age, race/skin color, schooling, lives with partner and smoking; OR: odds ratio; 95%CI: 95% confidence interval; BIC: Bayesian information criterion; ICC: interclass correlation coefficient.

Latin America, Teixeira et al. [33] analyzed the association between coverage of basic sanitation services and epidemiological indicators, and they pointed out as a condition for improving public health the expansion of access to sanitation and availability of water. Our results point in this direction, indicating that even after controlling for individual and contextual characteristics, inadequate sanitation services or those with low coverage have a negative effect on health perception. The results of the study, which analyzed a representative sample of adults living in the 27 capitals of Brazil, suggest the possibility that the reduction of inequalities in the coverage of these services in Brazil directly contributes to the improvement of the population's health conditions[34].

The findings of the present study must be interpreted considering some limitations. First, although the results indicate a consistent association between a lower likelihood of poor SRH and greater coverage of sanitation services, specifically, a significant association was not observed in relation to the upper tertile for water supply. One hypothesis that can help to understand this result is that, in capitals with greater coverage of this service, greater than 98.4% in the case of the present study, other contextual factors not observed have a greater effect on the perception of health than sanitary sewage and garbage collection. Second, the sample used was representative of the adult population residing in the 27 Brazilian capitals, not allowing the interpretation of results for other areas of the country. Third, the cross-sectional characteristic of the study did not allow us to establish causal inferences of the results, which should be regarded only as associations. Fourth, although the response rate was relatively acceptable (86%), the possibility of response bias cannot be ignored.

CONCLUSION

This study is the first to analyze the association between contextual determinants related to basic sanitation and SRH in Brazilian capitals, after considering the influence of individual characteristics and contextual income *per capita*. The results of this study indicate that inadequate coverage in sewage, water supply and solid waste collection services can be a detrimental factor for SRH, even after considering the effect of individual and contextual characteristics. The results for the 27 capitals of the largest country in Latin America suggest the need to reduce inequalities in the coverage of basic sanitation services, aiming at improving the self-perception of the population's health conditions.

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