Human development index in municipalities with the integrated rural sanitation system: a comparative analysis

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Abstract *This study investigated the human development of eight rural municipalities in the state of Ceará that have the Integrated Rural Sanitation System (SISAR) and 170 that do not. The study was developed based on the Municipal Human Development Indicators (MHDIs), which feature in the Atlas of Human Development, by drawing data from the 1991, 2000 and 2010 Demographic Censuses. The R software was used to carry out the statistical analyses. The results found for the general MHDI showed a significant difference between the means of the two groups, which did not occur when the income, longevity, and education dimensions were analyzed. In sum, it was verified that, in general, implementing water supply systems contributes to increasing human development levels, but as regards the more specific dimensions, this premise was not statistically confirmed.*

Key words *Rural Sanitation, Sewage System, Water Supply, Human Development*

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Introduction

In Brazil, there is a set of laws that seek to ensure citizens have the right to the basic services that directly affect the population's quality of life. The fundamental principles of the Federal Constitution, for example, present one of the Union's objectives as being "to eradicate poverty and marginalization and reduce social and regional inequalities", in article 3, paragraph II. Specifically, in article 21, it states that it is the Union's responsibility "to establish guidelines for urban development, including housing, basic sanitation, and urban transport"[1].

In turn, article 3 of Law No 10,257/2001, which establishes the guidelines for Urban Policy, mentions sanitation as being essential for the "full development of the social functions of the city and of the urban property". Given that the right to health is also considered one of the fundamental principles, the creation of the Unified Public Health System (abbreviated to SUS in Portuguese) based on Organic Law No 8,080/1990, within the context of the Sanitary Reform Movement and geared towards developing a new health policy, aimed to achieve this premise and place within the scope of public health the system's obligation to promote, prevent, and recover, taking into account that its indices represent the social and economic organization of the Country and are directly influenced by, among other factors, basic sanitation and access to essential goods and services. Thus, various passages of the Law point to the need to establish actions that focus on basic sanitation, giving it a key role in public health policy and explicitly recognizing the importance of these services in improving the health conditions of the population.

Finally, Law No 1,445/2007, which establishes national guidelines for basic sanitation, and Decree No 7,217/2010, which regulates it, constitute the regulation in the area of basic sanitation in the Country, indicating the need to develop an instrument for implementing the Federal Basic Sanitation Policy, via the National Plan for Basic Sanitation (PLANSAB), which should focus on principles such as universalization; that is, access to the public services of water supply, sewage collection and treatment, rain water management, and solid waste management should be provided to both the urban and rural population[2].

Despite the efforts undertaken by PLANSAB through the various programs and projects created to meet the various sanitary requirements of the national states, rural areas still remain far from achieving the goal of national universalization of the services, foreseen to occur within 20 years of it coming into effect in 2014. According to the National Sample of Households Survey - PNAD (2015)[3], among the rural population of more than 29 million people, only 34.51% of rural households are connected to the water distribution network, and 66.6% use alternative solutions, such as collective/individual sources of supply, compared with the 93.87% of urban households that are connected to the water distribution network.

When the data is verified regarding coverage of the public services of basic sanitation, the panorama becomes even more critical than the one presented for water supply. Here, only 5.45% of rural households are interlinked with a general collection network, 33.25% have a septic tank (connected or not to the collection network), 43.7% adopt rudimentary cesspits, and 7.3% choose other solutions, such as open sewage, ditches, and dumping raw sewage directly into rivers, lakes, and reservoirs.

In light of this, it can be observed that the usual technologies still encounter difficulties in integrating with and reaching the daily life of the rural population. It is known that public health is included within the scope of public policies and, as a social right, it is understood as a social policy for protecting people. The importance of water treatment and sewage networks is well known with regards to the population's health, featuring among services that are essential to life and to environmental quality.

The rural sanitation model thus emerged via initiatives by the governments of Bahia and Ceará, funded by KFW bank, whose consultancy was responsibility for formulating the management of the services in rural areas. The first experiment was applied in 1995 in the municipality of Seabra, in the center-south of Bahia, but it is in Ceará that there has been the greatest expansion of the model. The first Integrated Rural Sanitation System (SISAR) in Ceará was implemented in 1996 in the municipality of Sobral and, from 2001 onward Cagece began to expand the model to the whole State. Currently, 146 municipalities are served by SISAR and 1,439 rural localities benefit from water treatment and/or sewage networks.

Based on the *hypothesis* that access to minimum basic sanitation services, such as water treatment and collection and sewage treatment and disposal, directly affects health by reducing the rates of water-related diseases and, conse-

quently, increases the longevity of the population that has access to these services, this study's *general aim* was to investigate the human development of those municipalities considered as rural that have the Integrated Rural Sanitation System (SISAR) by comparing them to those that do not.

For this, an empirical study of a hypothetical-inductive nature was developed, seeking inferences based on Municipal Human Development Indicators (MHDIs). Access to these indicators was enabled by the Atlas of Human Development, a consultation platform of 5,565 Brazilian municipalities, which features more than 180 human development indicators relating to population, education, housing, health, employment, income, and vulnerability, with data taken from the 2000 and 2010 Demographic Censuses.

Regarding the *specific aims*, the study sought to (1) analyze the three dimensions (income, longevity, and education) of human development of the municipalities in Ceará based on the Municipal Human Development Index (MHDI) of the Atlas of Human Development; (2) compare the human development indicators of the municipalities in Ceará that have SISAR with those that do not; and (3) analyze the behavior of the human development indicators of the municipalities in Ceará over time.

This study is warranted for its empirical contribution to academia regarding evidence related to the impact of implementing SISAR on the population's quality of life and public health, giving continuity to the literature concerning the effects of adopting public policies in the Brazilian sanitation sector.

The impact of implementing SISAR on the municipal human development indicators can be observed by the sanitation companies and regulatory agencies, seeking the publication of guidelines in an effort to improve collective health, through the adoption of alternatives for the public sanitation of the rural population.

In the academic context, the result of this research may contribute to the discussion regarding disciplines, projects, and research that identify alternatives for achieving sanitation in remote municipalities and localities, especially those that do not have access to water and sewage systems.

Finally, this paper also aims to add to the Brazilian literature concerning the association between public health and access to the public services of water supply, sewage collection and treatment, rain water management, and solid waste management, as no Brazilian studies were found that have related the effects of adopting SISAR on human development indicators of rural municipalities.

Material and methods

The sample was composed of municipalities in Ceará and was characterized as non-probabilistic, which makes it impossible to generalize the results of this research. So as not to bias the results, besides the state capital Fortaleza, the decision was made to exclude the five municipalities with the highest GDP in the state (Maracanaú, Caucaia, Sobral, Juazeiro do Norte, and Eusébio), which together accounted for 60.73% of Ceará's GDP in 2014. Thus, eight municipalities that implemented SISAR between 2000 and 2010 were chosen to make up the sample, as well as 170 municipalities that up to 2010 did not have SISAR.

The study in question is quantitative in nature and its methodology can be classified within the empirical-analytical and documental typology, since it includes quantitative data collection, treatment, and analysis techniques, presenting a strong concern about the causal relationship between the variables and seeking validation of the scientific proof through level of significance tests. A descriptive study is concerned, in which one of the aims is to describe the characteristics of a particular population, in this case represented by Ceará's municipalities.

This research is also considered documental, since it adopted the procedure of collecting secondary data from the Atlas of Human Development in Brazil, published by the United Nations Development Program (UNDP). For the years the Censuses were used (2000 and 2010), General MHDI, Income MHDI, Longevity MHDI, and Education MHDI data were collected relating to each municipality in the sample. The data were taken from the Atlas Brazil website in January of 2018 (http://www.http://atlasbrasil.org.br), from the consultation section, indicators subsection, MHDI dimension. The obtained information was inserted into electronic spreadsheets, grouped by year the Census was carried out and according to the presence or not of SISAR in the municipality.

The data collected were subjected to statistical procedures. First a descriptive analysis of the data was conducted, calculating the mean and standard deviation, and then hypothesis tests were carried out. To compare the human development indicators of municipalities that have SISAR with those that do not, the *t* test and Wilcoxon differ-

ences of means test were carried between the two independent samples. All the statistical analyses were conducted using the R software (R Core Team, 2016)[4]. For the descriptive statistics and the *t* test and Wilcoxon test the *stats* package was used. The statistical tests were carried out using a 95% confidence level.

Results and discussion

Initially, the Shapiro-Wilk normality test was used on the collected samples, determining that the samples have a normal distribution. Nonetheless, the authors chose to also calculate the Wilcoxon test for non-parametric data, considering the reduced sample of municipalities with SISAR in 2010, which contained only eight municipalities.

Next, the means and standard deviations were calculated for the 2010 MHDIs of both groups of municipalities in Ceará being studied: those that had SISAR in 2010 and those that did not. In this first analysis, it was possible to verify that the mean of the general MHDI (M = 0.63, *sd* = 0.03) of the municipalities that had SISAR was higher than the mean of those that did not have SISAR (M = 0.61, *sd* = 0.02), thus indicating, even if preliminarily, better performance in the human development of those municipalities that benefit from the Integrated Rural Sanitation System. The results of this first analysis are compiled in Table 1.

Next, the statistical tests of differences between the two means in the general MHDI of the two groups of municipalities were processed. As can be observed in Table 1, the p-value presented a value below 0.05, indicating a statistically significant difference between the means, which supports the assumption that implementing water supply systems contributes to increasing human development levels, as indicated by Barreto et al.[5], Heller[6], and Teixeira and Guilhermino[7].

Subsequently, it was also verified that the income, longevity, and education dimensions of the MHDI of those municipalities that have SISAR are better than those that do not, with a similar result being found to that of the general MHDI regarding the preliminary analyses.

However, when the statistical difference of means tests were applied between the MHDI means, the results did not reveal significant differences between the two groups for the longevity and education dimensions, as can be verified in Table 2.

By comparing the data available in 2000 and 2010, the MHDI of Ceará's municipalities over time was also analyzed. The means, intervals, and standard deviations of the 2000 and 2010 MHDIs of all 178 municipalities in Ceará were calculated, as well as those of the eight that had SISAR in 2010 and the 170 that did not.

In an initial analysis, it was possible to verify that *the mean* of the general MHDI of the 178 municipalities rose from 0.45 in 2000 to 0.61 in 2010 (interval = 0.16, *sd* = 0.03), indicating an clear increase in the performance of the human development of all these municipalities in Ceará (Table 3). With regards to the mean of the general MHDI of the municipalities with no SISAR, the results showed an interval of 0.17, rising from 0.44 in 2000 to 0.61 in 2010 (interval = 0.17, *sd* = 0.03). This finding reveals higher growth than that presented for all the municipalities (interval = 0.16, *sd* = 0.03) (Table 3).

On the other hand, the mean of the general MHDI of the municipalities with SISAR revealed lower growth, rising from 0.49 in 2000 to 0.63 in 2010 (interval = 0.14, *sd* = 0.02), when comparing the performance of the 178 municipalities in Ceará with the 170 municipalities that do not have SISAR (Table 3).

It is important to highlight that, according to this analysis, the mean of the general MHDI of the municipalities with SISAR presented lower growth than the mean of the general MHDI of the municipalities with no SISAR, thus partly rejecting the assumption that implementing water supply systems contributes to increasing human development levels. Next, statistical tests of *differences* between the means of the general MHDI of 2000 and 2010 were processed.

According to Table 3, the results revealed significant differences between the means of the general MHDI of 2010 in relation to 2000 in the three groups analyzed, indicating a significant increase in the performance of human development in the municipalities in Ceará. We also analyzed the income, longevity, and education dimensions of the MHDI in 2000 and 2010 in the municipalities.

Table 4 shows a significant increase in the MHDI in the period studied in all three dimensions investigated, with a much greater interval for the education dimension when compared with the income and longevity dimensions. In the income dimension there was no difference between the growth in the MHDI of municipalities with SISAR and that of those that do not have it. On the other hand, both in the longevity and

Table 1. General result of the differences of means tests for the general MHDI of the municipalities in Ceará that have SISAR and those that do not.

Year	Indicator	Municipality type	N. of municipalities	Difference of means test			
				Mean	SD	t	Wilcoxon
2010	IDHM	With SISAR	8	0.63375	0.0194	0.0183	0.0145
		Without SISAR	170	0.6127	0.0272		

Source: Elaborated by the authors (2018).

Table 2. Results of the differences of means tests for MHDI dimensions.

Year	Indicator	Municipality type	N. of municipalities	Difference of means test			
				Mean	SD	t	Wilcoxon
2010	Income MHDI	With SISAR	8	0.5766	0.0203	0.0188	0.0231
		Without SISAR	170	0.5548	0.0317		
	Longevity MHDI	With SISAR	8	0.7705	0.0189	0.1391	0.1509
		Without SISAR	170	0.7592	0.0204		
	Education MHDI	With SISAR	8	0.5731	0.0271	0.0332	0.0701
		Without SISAR	170	0.5475	0.0461		

Source: Elaborated by the authors (2018).

Table 3. General result of the tests of differences between means of the general MHDI.

Municipality type	Year	N. of municipalities	Difference of means test				
			Mean	Interval	SD	t	Wilcoxon
All	2010	178	0.6136	0.1683	0.0272	0.0000	0.0000
	2000	178	0.4452		0.0443		
With SISAR	2010	8	0.6338	0.1428	0.0195	0.0000	0.0000
	2000	8	0.4909		0.0191		
Without SISAR	2010	170	0.6127	0.1696	0.0272	0.0000	0.0000
	2000	170	0.4431		0.0440		

Source: Elaborated by the authors (2018).

in the education dimensions, the MHDI of the municipalities with SISAR revealed lower growth than that of those that do not have SISAR, thus partly refuting the assumption that implementing water supply systems contributes to increasing human development levels.

Conclusion

Historically, the public services of basic sanitation have always been directly or indirectly linked to the question of health and, consequently, to improving the population's quality of life.

Investments in basic sanitation are always very high as they involve infrastructure projects, where a huge initial amount of money is needed to implement the systems and where the financial return almost always occurs in the medium and long term. This makes their implementation difficult and diverts investments to urban areas where the payback may occur more quickly as a result of accessing a greater population and, consequently, the increased probability of demand

Table 4. Result of the tests of differences between means of the MHDI dimensions.

Municipality type	Year	N. of municipalities	Difference of means test				
			Mean	Interval	SD	t	Wilcoxon
Panel A - Income Dimension							
All	2010	178	0.5558	0.0815	0.0316	0.0000	0.0000
	2000	178	0.4743		0.0404		
With SISAR	2010	8	0.5766	0.0808	0.0203	0.0000	0.0000
	2000	8	0.4958		0.0308		
Without SISAR	2010	170	0.5548	0.0815	0.0317	0.0000	0.0000
	2000	170	0.4732		0.0406		
Panel B - Longevity Dimension							
All	2010	178	0.7597	0.0745	0.0204	0.0000	0.0000
	2000	178	0.6852		0.0372		
With SISAR	2010	8	0.7705	0.0583	0.0189	0.0000	0.0000
	2000	8	0.7121		0.0328		
Without SISAR	2010	170	0.7592	0.0752	0.0204	0.0000	0.0000
	2000	170	0.6839		0.0370		
Panel C - Education Dimension							
All	2010	178	0.5487	0.2736	0.0456	0.0000	0.0000
	2000	178	0.2750		0.0570		
With SISAR	2010	8	0.5731	0.2367	0.0271	0.0000	0.0000
	2000	8	0.3364		0.0269		
Without SISAR	2010	170	0.5475	0.2754	0.0461	0.0000	0.0000
	2000	170	0.2721		0.0564		

Source: Elaborated by the authors (2018).

for and adhesion to the service, thus marginalizing rural areas compared to the supply of the public services of basic sanitation in large and medium-sized cities.

In light of the above, the usual technologies still encounter difficulties in integrating and reaching the daily life of the rural population. SISAR emerged as an alternative for the social inclusion of scattered populations, which require particular forms of intervention in basic sanitation, seeking to guarantee the constitutional right of access to healthcare and basic services, as well as achieving the universalization aims proposed by PLANSAB.

The results found in the study support the importance of having treated water and sewage systems in order to increase some of the human development indicators, such as the longevity and education dimensions, which were shown to be better for the municipalities that had SISAR, thus contributing to an increase in the MHDI of these municipalities.

It is indicated, however, that this is only one of the relevant aspects for ensuring a population's good quality of life. Thus, for future studies, it is suggested that more robust analyses be carried out that can confirm the interaction of other environmental variables with the presence or not of SISAR in a rural community.

Collaborations

All authors participated equally in all stages of preparation of the article.

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