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HEALTH ECONOMY: A STUDY ON THE RELATIONSHIP OF WATER AND SANITARY WATER SERVICES IN THE COSTS OF PUBLIC HEALTH IN THE NORTHEAST REGION OF BRAZIL

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Abstract

Health services are characterized as meritorious goods, a type of semipublic good that, given its social character, the allocation of resources in these activities becomes socially desirable by the government so that they are allocated efficiently. One of the ways to control and reduce unnecessary health expenditures is the population's access to basic sanitation services that, when inefficient, cause negative externalities to the exposed population. In this sense, the objective of this study is to analyze the relationship between coverage of basic sanitation services and the costs of hospital admissions for waterborne diseases in the Northeast Region of Brazil, from 2005 to 2015. In order to do so, we used secondary data from the Department of Informatics of the Brazilian Unified Health System (DATASUS), the National Household Sample Survey (PNAD) and Finance of Brazil (FINBRA) for the construction of panel regression models with fixed effects. The main results indicate that access to sanitation services, mainly from the sewage collection network, reduces the costs of hospitalizations for Diseases Related to Inadequate Environmental Sanitation (DRSAI) of the Unified Health System (SUS).

Keywords: *Health costs, waterborne diseases, externalities*

1. INTRODUCTION

Basic sanitation services include, among all public health activities, one of the most important mechanisms for disease prevention and health promotion. This includes several definitions that should be considered.

Among the most important is that of the World Health Organization (WHO), which defines basic sanitation as the control of all the physical means of man, which causes or can cause harmful effects on physical, mental and physical well-being. Social. Its main objective is the promotion of human health, which WHO defines as being not only the absence of diseases, but also the state of complete physical, mental and social well-being (Heller, 1998).

According to Rosen (1994) and Fernandes (1997), these studies emerged in the 19th century, with emphasis on English Snow with proof of the origin of cholera through contact with contaminated water and Edwin Chadwick, who in his study emphasized the use of basic sanitation as an instrument of preventive health. In addition to this, it has been approached by several authors (Souza, Freitas and Moraes 2007, Mendonça and Motta, 2008, Saiane and Júnior, 2010, Saucha, Silva and Amorim, 2015, among others) that demonstrate the effect of sanitation on the health of the Brazilian population.

According to PNAD data, in 2015, the proportion of Brazilian households that had a network of water supply by general network was 88.42% and only 60.01% had a sewage collection network. In the Northeast Region data are even more worrying: only 87.53% of the households had a water supply network and 39.96% had a sewage collection network. Thus, the needs of the sanitation services suggest a significant investment in the sector in order to achieve the reasonable goals of gradually increasing the access of all occupied households, according to Law No 11,445 / 2007.

In addition, although the Northeast is a region with five hydrographic basins, it has the lowest water availability, only 3.3% of the national total, being the second most populous region, concentrating around 28% of Brazilians. Moreover, the public health sector in this region with regard to size, location and management is not enough to meet the demands. It has the lowest numbers of doctors and other health professionals when compared to the most developed economic centers of the country. This makes it necessary to better manage the resources that are allocated to these sectors in this region.

The main discussion in the economic view is that the best use of resources in prevention can achieve more comprehensive results precisely because they are public goods (meritorious, in the case of health) that imply non-exclusion and universalization, besides presenting itself as less costly alternative when compared to expenses with the treatment of diseases (Ramalho, 2003). From the assumption that basic sanitation is a preventive health measure, this corresponds to an investment for health, and a return of that investment in various socioeconomic aspects. Costs that are reduced with the universalization of sanitation can be reallocated to other priority needs by making the management of health services efficient. It is precisely the introduction of economic instruments in the strategic and operational issues in the health sector that originates the health economy. The government has responsibilities when it comes to the rational use of resources that are invested, so that positive results can be obtained in health indicators (Del Nero, 2002).

In this sense, the general objective of this work is to analyze the relationship between access to water supply and sanitary sewage services and the costs of the public health system in the Northeast Region, between 2005 and 2015. In order to achieve the proposed objective, used secondary sources of quantitative character and approach based on descriptive and exploratory research, based on a bibliographic survey aiming at the theoretical basis and base the results obtained. Data were collected from DATASUS, PNAD and FINBRA for the construction of panel regression models with fixed effects. This model is a classic procedure for the study of this type of problem, since it allows a relationship between access to sanitation services and health costs through a "dose-response" function.

Besides this introduction, corresponding to section 1, this work is composed of four more parts. Section 2 identifies the methodology and the econometric model; the following section presents the relationship between sanitation and health, as well as the evolution of sanitation

indicators and DRSAl; Section 4 presents the econometric results; and section 5 presents the conclusions of the study.

2. METHODOLOGY

In the present study, secondary data were selected based on the literature that covers this theme. Of particular note are the studies by Uhr, Schmechel, and Uhr (2016) that evaluated how basic sanitation services in Brazil affect the health of the population, with dependent hospital admissions due to waterborne endemics; and Scriptori (2016) who investigates the effects of basic sanitation on the education of children who are in a state of health because they have contracted some DRSAl.

Thus, were collected the variables that are most representative in the literature on the impacts of basic sanitation on public health and its costs in the period between 2005 and 2015. Regarding the sources of the data, these were collected on official sites that information. DATASUS was used for data on hospitalization costs by DRSAl; for the indicators of households with a general water supply network, sewage collection network and the economic variable of average household income, the IBGE PNAD database was used; and the indicators of expenditures with basic sanitation and health were taken from FINBRA.

The table below presents in detail the characteristics of the variables that this study deals with.

Table 1 Description of the variables¹

Dependent Variable	Initials	Description	Source / Statistics	Expected Signals
Total cost of hospitalizations	TCH	Value referring to the total hospitalizations for DRSAl approved, deflated by the IPCA of 2015.	DATASUS (2005 a 2015)	-
Dependent Variable	Initials	Description	Source / Statistics	Expected Signals
General water network	WATER	Proportion of households connected to the general water supply network	PNAD /IBGE (2005 a 2015)	Negative
Sewer collection network	SEWER	Proportion of households connected to sewage collection by general network	PNAD /IBGE (2005 a 2015)	Negative
Average household income per capita	INCOME	Average household income per capita. Deflated by the IPCA of 2015	PNAD /IBGE (2005 a 2015)	Negative
Health expenditure	HEALTH	Public expenditure on health per capita, deflated by the IPCA of 2015	FINBRA/STN (2005 a 2015)	Negative
Expenditure on sanitation	SAN	Public expenditure on sanitation per capita, deflated by the IPCA of 2015	FINBRA/STN (2005 a 2015)	Negative

Source: Own elaboration

¹ It is worth noting that the PNAD database does not provide data for the year 2010, since it refers to the year of the Demographic Census. However, a simple arithmetic mean of the years 2009 and 2011 of the variables drawn from this base was made in order to complete the year 2010. It can also be said that the expected signs of the explanatory variables are in agreement with the literature that addresses this thematic.

The research is characterized as a quantitative study. The causal relationship of interest between water distribution, sewage collection, household income, and expenditures for sanitation and health on the costs of hospitalizations for DRSAI can be described by the following general equation²:

$$\text{LogTCH}_{it} = \alpha_i + \beta_1 \text{WATER}_{it} + \beta_2 \text{SEWER}_{it} + \beta_3 \text{LogINCOME}_{it} + \beta_4 \text{LogHEALTH}_{it} + \beta_5 \text{LogSAN}_{it} + u_{it} \quad (1)$$

Where: LogTCH_{it} represents the variable dependent on state *i* in period³ *t*; α_i represents the parameter that captures the specific effects for each state; β_1 to β_5 are the parameters to be estimated; WATER_{it}, SEWER_{it}, LogINCOME_{it}, LogHEALTH_{it}, LogSAN_{it} are the explanatory variables, and u_{it} is the error term.

Given the time (years) and spatial dimension (Northeastern states) of the sample, the analysis with panel techniques is indicated. Among the advantages of this method in relation to cross-sectional or time-series Gujarati (2011), it is highlighted that: the panel data model controls the heterogeneity present in individuals; combines series of time and cut so that it offers more informative data, with greater variability, less colinearity among the variables, more degree of freedom and efficiency; examines the dynamics of change; detects and measures better the effects that cannot be observed in a pure transverse section or a pure time series; and allows to study more complicated models of behavior.

According to Wooldridge (2002), there are some estimation techniques for panels in the literature. Among them: fixed effects model within a group and random effects model. The main difference between the two models is that the unobservable effects are related to the explanatory variables. Thus, the main determinant for choosing the best method is the effect not observed. If it is not correlated with all the explanatory variables, the random effects estimator is consistent and efficient and the fixed effects estimator is consistent but not efficient, so the random effects model is the most appropriate one. Otherwise, if it is correlated with some explanatory variables, the fixed effects model must be used because the estimator of this model becomes consistent and efficient, but now the random effects estimator is not consistent.

From this, the fixed-effects model was chosen because the regression result showed a relevant correlation "[corr (u_i , Xb)]" between the observed unobserved effects and the explanatory variables. In the next section, the relationship between sanitation and health, as well as the evolution of health care, will be presented in the next section. indicators of sanitation and DRSAI.

3. GENERAL ASPECTS OF HEALTH AND HEALTH

As mentioned previously, the absence of basic sanitation services results in social cost, for example, there is no sewage collection in a given locality and it is released directly into the environment, contaminating water resources and causing impacts both in the environment the health of the exposed population. Such conditions increase the demand for hospital medical care and perhaps hospitalizations, medications, etc., which will lead to increased financial health costs.

Many diseases can be associated with water either as a result of contamination by human or other excreta or by the presence of chemicals present that can be harmful to human health. As a

² It is important to note that the TCH, INCOME, HEALTH and SAN variables were logarithmized for a better understanding of the results obtained, since these are presented in rates or monetary units and WATER and ESGOT are in percentage terms. The application of logarithm allows these variables to be interpreted in percentages, which improves both the interpretation and the visualization of the variable, besides causing a decrease of the outliers and the variance.

³ The period is comprised between 2005 and 2015, marked by the legal advance in the basic sanitation sector through Law No. 11,445 / 2007, which established strategies for the universalization of the sector and allows to analyze if there is a relation with possible decreases of hospitalizations by DRSAI and consequently their costs in those years.

result of the use of water, there is the generation of sewage that, if not properly disposed, ends up polluting the soil, contaminating the water, and frequently flowing out into the open, forming dangerous foci for the propagation of diseases (Bovolato, 2010).

This analysis is important because it deals with pathologies that can be avoided and consequently able to reduce health expenditures when prevented and thus improve the allocation of resources in this area, as it treats the public sector and health economics.

In Brazil, hospital admissions have a high unit cost, however, they are concentrated in hospitals (private and university hospitals), in which the control of expenses is indirect, by means of only the limitation of the number of hospitalizations and the definition of costs for each type of procedure. In this context, the situation of the country is similar to that of many others, who are worried about the growing demand for health resources, and need to establish priorities and mechanisms for controlling expenditures (Espigares, 1999, Medici, 1994 apud Calvo, 2002).

Thus, the analysis of social interventions represents an important activity for taking actions and measures. For providing information that can guide managers and funders, to prioritize and to present to society the results of the investments made, in addition to pointing out modifications and adaptations necessary to the interventions that already exist. These interventions lead to a longer and healthier life and strengthen the basis for economic growth and development (Brasil, 2004).

The following will present some indicators of basic sanitation and health, which will be used in this study, to address the reality of these sectors in the Northeast Region.

3.1. Indicators of basic sanitation in the Northeast

The increase in access to basic sanitation services reached its peak in the 1970s, when the National Sanitation Plan (PLANASA) was created. This plan was used to finance the investments provided by the National Housing Bank (BNH) with funds from the FGTS for water supply and sanitary sewage. These services were carried out by the State Basic Sanitation Companies (CESBs), mainly in urban areas, in order to meet the urbanization of the country due to the extensive industrialization that had been taking place in the period. In the 1980s, these investments became smaller than in the previous decade, as a consequence of the country's economic problems, such as the increase in state indebtedness, the scarcity of public resources that were formerly destined for investments and extinction of BNH, which consequently led to the extinction of PLANASA in the 1990s, leaving the country once again without a well-defined plan for the sanitation sector (Brasil, 2004, Saiani & Júnior, 2010).

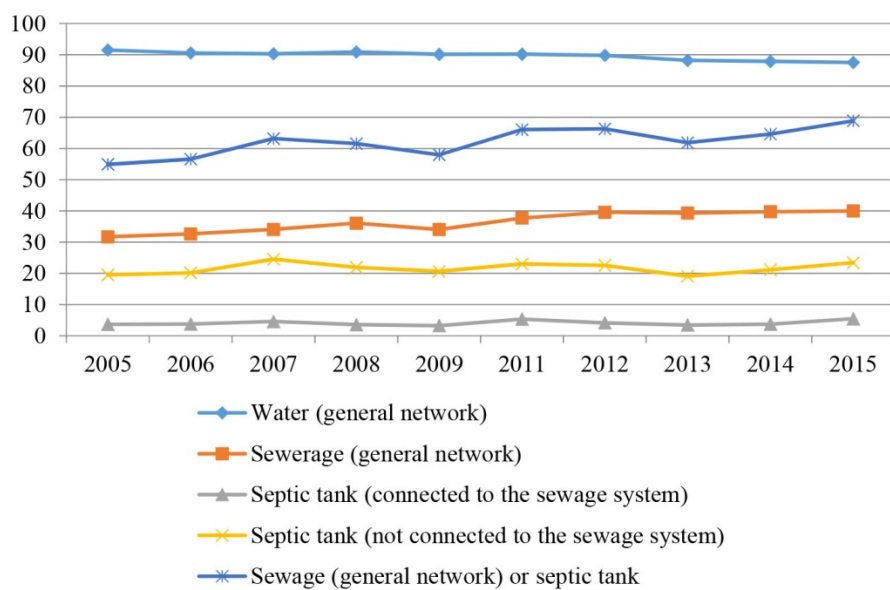
Subsequent to the extinction of PLANASA, other changes continued to occur in an effort to reduce the precariousness and negative externalities caused by deficits in sanitation. According to Brasil (2004), in 1990, an administrative reform was carried out in the Ministry of Health, which included the creation of the National Health Foundation (FUNASA) through the joining of several Ministry bodies. FUNASA now has a National Department of Sanitation that has the responsibility of formulating policies and management of the resources allocated in the budget of the Ministry of Health for the area of basic sanitation that works until today.

Moreover, since the 1990s and especially in the 2000s, there has been an evolution in the legal aspect with regard to basic sanitation in Brazil. In 1997, Water Law No. 9,433 / 1997 was promulgated, which created the National Water Agency (ANA), responsible for water resources management policies. Concession laws (No. 8,987 / 1995) and public-private partnerships (No. 11,079 / 2004) have made the public and private sector more involved in providing a more efficient service. And Law No. 11,107 / 2005 of public consortia that created relationships between public companies that started to contract this type of consortium to achieve objectives of common interest (Turolla, 2012).

Despite all this progress, only in 2007, with the creation of Law No. 11,445 / 2007 of the National Sanitation Policy, is that the sector has gained a regulatory framework, reinforced by Decree No. 7,217 / 2010. This law has played a central role for the regulatory agencies of mechanisms that lead the government in making decisions aimed at the efficiency and universalization of the sector.

However, the advances made (whether economic or legal) have not been enough to universalize access to basic sanitation services. In the Northeast the deficiencies of this sector are worrisome.

The graph below shows the evolution of these services in the Northeast Region between 2005 and 2015.

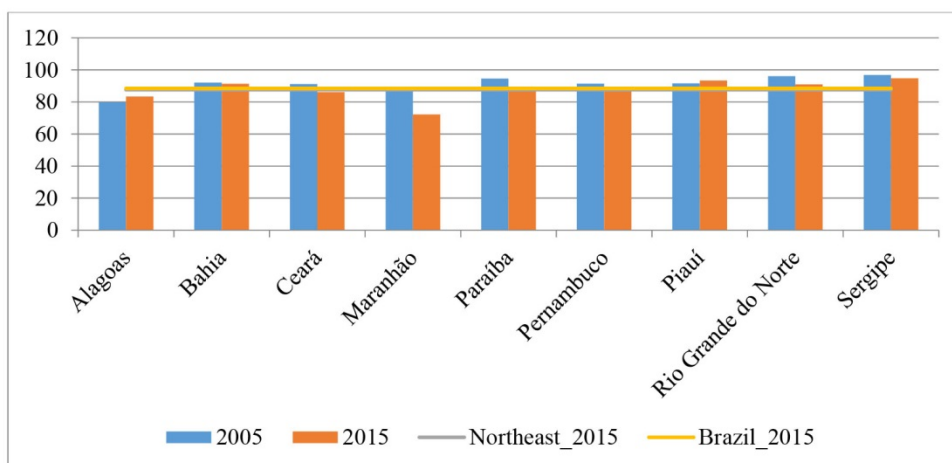


Source: own elaboration based on PNAD data

Graph 1 Northeast: evolution of the proportion of households with access to basic sanitation services (2005-2015)

It is observed that the proportion of northeastern households with water supply through the general network did not change significantly, having a slight decrease in recent years. On the other hand, the proportion of households with sanitary sewage by general collection network showed a significant increase in the period, of around 10 percentage points, however, a service still very deficient. It is also possible to highlight the superiority, in all years, of access to water in relation to access to the sewage network, including when considering the sewage network and the septic tank jointly.

Looking for a more in-depth analysis for the states of the Northeast Region, it is noticed that the deficits in the sanitation sector are a reality. Graph 2 shows the proportion of households with access to water in the Northeastern states.

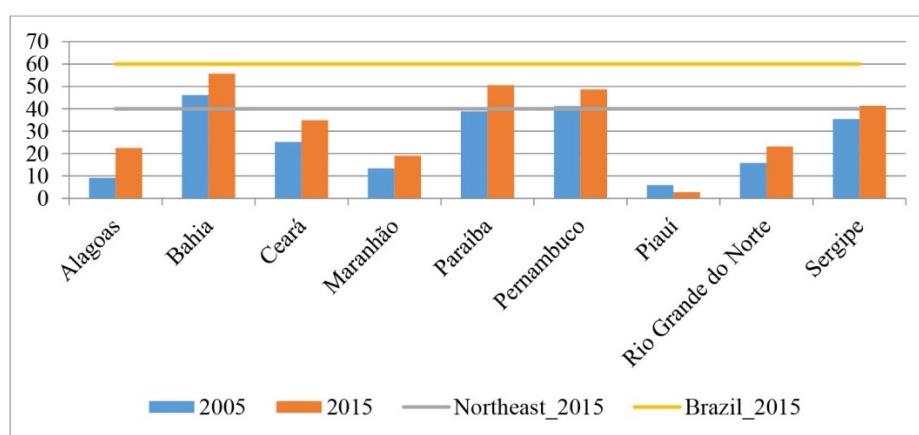


Source: own elaboration based on PNAD data

Graph 2 Northeast: proportion of households with access to water supply by general network, according to the states (2005 and 2015)

From the analysis of the graph above it is possible to verify that, except for Piauí and Alagoas, when comparing the years 2005 and 2015, the proportion of households with access to water supply by general network decreased in all the states. In addition, it is possible to analyze that, in general, there is a convergence in proportion when comparing state data with that of the Northeast Region and Brazil as a whole in 2015, with the exception of Alagoas and Maranhão.

In the case of sewage collection through the general network, Chart 3 shows that, with the exception of Piauí, when compared to 2005 and 2015, the proportion of households with access evolved. Despite the growth during the studied period, it can be seen that the states of Alagoas, Ceará, Maranhão, Piauí and Rio Grande do Norte have not even reached the level of the total proportion of the Northeast Region in 2015. In addition, all states are far below the national proportion that same year.



Source: own elaboration based on PNAD data

Graph 3 Northeast: proportion of households with access to sewage collection by general network, according to the states (2005 and 2015)

3.2. Health indicators in the Northeast

The analysis of the impact of access to basic sanitation services on health can be observed by the number of hospitalizations of individuals who contracted some disease related to the precariousness in the

provision of these services. The synthesis presented by categories of diseases has broadened the analysis of the impacts of sanitation, while the indicators may point out a better orientation of public policies to solve these problems.

Table 1 compares the hospitalization rate with the proportion of households with access to water and sewage in the Brazilian regions in 2015.

Table 1 Rate of incidence of DRSAL and the proportion of households with access to water and sewage collection by large Brazilian regions (2015)

Region	DRSAL hospitalization rate per 10,000 inhabitants	Proportion of households with access to water supply (General Network)	Proportion of households with access to sewage collection (General Network)
1 North Region	32.52	65.75	14.16
2 Northeast Region	28.78	87.54	39.97
3 Midwest region	20.89	86.61	46.79
4 South region	12.49	88.72	49.23
5 Southeast region	8.53	92.73	85.77

Source: own elaboration based on PNAD and DATASUS data

From the analysis, we can see a relationship between sanitation indicators and the disease incidence rate. The hospitalization rates are higher the lower the sanitation indicators, especially the indicator of the proportion of households with access to sewage collection by general network. In addition, it can be seen that the Northeast Region has the second highest hospitalization rate, behind only the Northern Region. Table 2 shows the total cases of hospitalizations and deaths for each category of DRSAL in the Northeast Region in 2015.

Table 2 Number of hospitalization cases by category of DRSAL for the Northeast Region in 2015

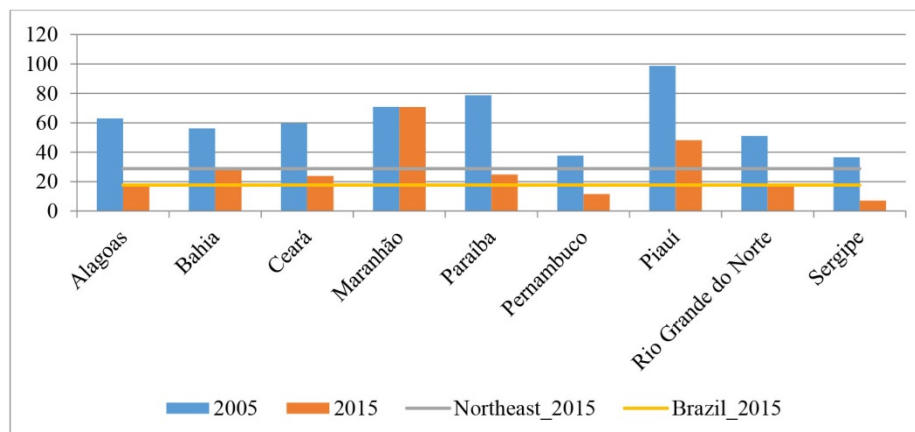
Category DRSAL	Num casos	%	Deaths	%
1. Fecal-oral transmission diseases	132,825	81.6	905	67.74
2. Diseases transmitted by insect vector	26,391	16.2	204	15.27
3. Diseases transmitted through contact with water	457	0.3	39	2.92
4. Diseases related to hygiene	2,775	1.7	179	13.4
5. Geohelminths and streaks	322	0.2	9	0.67
Total Northeast	162,770	100	1,336	100

Source: Own elaboration based on DATASUS data

It is noticeable that the greatest number of hospitalizations and deaths is in the category of oral-fecal transmission diseases. Within this group, the greatest number of occurrences is that of diarrheal diseases, which presented 130,999 cases. Another category that draws attention is that of diseases transmitted by insect vector. In this classification, dengue is highlighted, with a total of 23,644 hospitalizations.

With a more detailed analysis for the states of the Northeast Region, figure 4 presents the incidence rate of DRSRI per 10,000 inhabitants in the respective states of this Region. It is noticeable that when comparing the year 2005 and 2015, the rate of hospitalizations decreased in all Northeastern states. In spite of this, it can be observed that the Northeastern Region presented a hospitalization rate higher than that of Brazil in 2015. The states of Bahia, Ceará, Maranhão, Paraíba and Piauí reported rates of hospitalizations higher than those in the Northeast. It is still possible to

analyze that the states of Maranhão and Piauí indicated the highest rates of hospitalization and when compared to figure 3, these are precisely the states that presented the lowest rates of sewage collection by general network.



Source: Own elaboration based on data from DATASUS

Graph 4 DRSAl incidence rate per 10,000 inhabitants in the states of the Northeast Region (2005 and 2015)

4. RESULTS AND ANALYSIS

Table 3 presents the results of the estimates for equation (1), with the dependent variable being the costs of hospitalizations for DRSAl called LogTCH.

As can be seen in the table, the proportion of households with sanitary sewerage by general network (SEWER) and average real household income per capita (LogINCOME) are significant and have the expected signal. Where the coefficients presented by these variables reflect that as the SEWER increases by 1% the LogTCH decreases by 3.52% in the Northeast Region and to the extent that the income increases by 1% LogTCH decreases by 1.11% in the Region Northeast.

Table 3 Regression for the dependent variable LogCIN

Fixed-effects (within) regression						
R-sq: within = 0.4768						
corr(u _i , Xb) = -0.5621						
LogTCH	coef.	Robust Std. Err.	t	P> t	[95% conf. Interval]	
WATER	1.391259	1.173841	1.19	0.270	-1.315624	4.098142
SEWER	-352977	.7320089	-4.82	0.001	-5.217785	-1.841754
LogINCOME	-1.112005	.3728438	-2.98	0.018	-1.971784	-.2522257
LogCHERRS	.1615016	.0942687	1.71	0.125	-.0558824	.3788857
LogSAN	-.0087812	.0684438	-0.13	0.901	-.1666129	.1490505
_const	22.24179	2.498688	8.90	0.000	16.4798	28.00377
sigma_u	1.1252525					
sigma_e	.31156113					
Rho	.92879562	(fraction of variance due to u _i)				

Note: significant at the level of 5%

Source: Own elaboration from STATA software 14

The results obtained by the research corroborate with those found in the literature. With regard to the sewage collection system and its relation with UHR water-borne diseases, Schmechel

and Uhr (2016) found that the addition of 1% of the households connected to the sewerage network causes a reduction of about 1.74 % in the hospitalization rate per 100,000 inhabitants in Brazil.

In the case of the income and health relation Mendonça and Motta (2008) say that there is a clear correlation between the social condition and health. The families that are most susceptible to these problems of sanitation and health are those that live in situations of economic vulnerability, which contributes to the regionalization of diseases. For these authors, disease rates are lower in the South and Southeast regions of the country when compared to the North and Northeast regions.

However, contrary to many studies, it can be pointed out that the proportion of households linked to the general water supply network and public expenditure per capita with sanitation and health were not relevant in the model, so that the following hypotheses can be drawn:

1. The proportion of households with water supply did not change significantly and presented relatively high indicators in all states, almost universalized, so that this service may not be influencing the occurrence of DRSAl.

2. With regard to public expenditures on basic sanitation, these may be being allocated inefficiently and in different ways among the different states of the Northeast Region.

3. Regarding public health expenditures, it is questioned how much of these resources are earmarked for effective combat and prevention against DRSAl.

Therefore, access to sanitary sewage is essential to reduce hospitalizations. Although it is difficult to make an accurate measurement of the incidence of a particular disease with respect to its specific contamination factor, its removal is certainly a prerequisite for the success of disease control interventions and consequently the reduction of public health costs.

5. FINAL CONSIDERATIONS

This study aimed to study the relationship between basic sanitation and health services in Brazil. In order to verify the relationship between access to water supply and sanitary sewage services with the costs of hospitalizations of Diseases Related to Inadequate Environmental Sanitation (DRSAI) in the Northeast Region, an econometric model was estimated with the panel data methodology, for the period 2005 to 2015.

The results obtained by the Fixed Effects Panel methodology reveal that the reduction in hospitalization costs is associated, firstly, to the proportion of households served by the sewage collection network and, secondly, to the average household income per capita.

In that, as the SEWER increases by 1% the TCH decreases by 3.52%. That is, the greater the access to these services, the lower the health costs. This result refers to how the association of these services is treated in Brazil and how society is apparently accommodated in the sense of claiming a right guaranteed in the Constitution, which is access to health in all its aspects.

Similarly, to the extent that income increases by 1% the TCH decreases by 1.11%. That is, as the population has higher income, it seeks to acquire elements that can generate a better quality of life and social well-being. The concern about the consequences of sanitation on health is not only financial, but also, the consequences related to economic development, environment, tourism, well-being of the individual, among others.

It is of fundamental importance to reverse the negative impact of basic sanitation on public spending. Thus, this research assists in the conduct of public policies through the establishment of

priorities, since when these services are financed by taxes, the population assumes responsibilities in the management of resources and believes that these are reverted in the best possible way.

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