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Does Education Influence Housing Choices in Areas with Basic Sanitation?

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Abstract

This article endeavors to explore and analyze the relationship between individuals' education levels and their housing decisions, with a particular focus on the choice of residences served by basic sanitation networks. The study employs a multinomial logit model using data from the 2019 PNAD continua survey. A household in which the individual has achieved postgraduate education is 15.268 times more likely to utilize garbage collection coverage compared to a household where the head has only attained primary education level and where garbage is discarded in vacant lots or public thoroughfares. Regarding the processes of direct and indirect collection, an additional year of education results in approximately a 20% increase in the relative probability of a person relocating from their dwelling where residents dispose of their family's garbage in rivers and/or seas to another residence where this does not occur due to the availability of direct collection services.

Keywords: education and housing decisions, basic sanitation, garbage collection, the Multinomial Logit Model, environmental, public health

1. Introduction

The intersection between education and housing decisions, particularly regarding access to basic sanitation infrastructure, emerges as a theme of growing relevance in contemporary urban and socioeconomic discourse. The significance of this theme lies not only in its ability to unveil the underlying dynamics that influence the residential choices of families but also in its potential to reveal the layers of inequality that permeate the social fabric. Within this context, education stands as a pivotal vector, whose impact on individual and familial decisions regarding residence can offer valuable insights into the strategies employed to navigate the complexities of accessing essential basic sanitation services.

In contemplating the relationship between education and the choice of residences served by adequate basic sanitation infrastructure, it becomes imperative to acknowledge how information and knowledge, direct products of the educational process, equip individuals with the necessary tools to make informed decisions. These decisions, in turn, reflect not merely personal preferences but also a profound understanding of the impacts of these choices on health, well-being, and quality of life. Education, therefore, transcends its traditional role of fostering personal development, acting as a catalytic element that empowers people to demand and prioritize access to basic services, including sanitation, as an integral part of their housing requirements.

In this context, investigating how education influences the choice of residences serviced by basic sanitation networks not only illuminates the priorities and aspirations of educated individuals but also accentuates the existing disparities in access to these crucial services. Education, therefore, emerges as a key determinant in the battle against inequality in sanitation access, suggesting that public policies focused on educational expansion could be effective strategies for fostering a more equitable distribution of sanitation services. This nexus between education and housing choices carries significant potential to shape targeted interventions that not only address basic needs but also lay the groundwork for the fulfillment of fundamental human rights and the support of resilient and inclusive communities.

This inquiry seeks to discern how education shapes individuals' capacity to make informed decisions regarding their housing conditions, emphasizing the significance of access to information and knowledge in prioritizing aspects vital to health and well-being. Through this examination, the paper endeavors to enhance understanding of the manner in which educational policies can be strategically deployed to elevate the quality of life. This is achieved by fostering residential choices that secure access to indispensable infrastructure services, notably basic sanitation. The overarching aim is to furnish insights conducive to the formulation of public policies that synergize the educational and housing spheres. Such policies are intended to ameliorate disparities in sanitation service access and, consequently, to contribute toward mitigating social inequalities. By presenting contemporary empirical data on the nexus between education and access to basic sanitation within the ambit of housing choices, the manuscript has the potential to proffer evidence that either corroborates or interrogates prevailing suppositions within the scholarly corpus. This proves especially salient in a domain where economic and social milieus are subject to incessant transformation.

The manuscript is structured as follows. Beyond the introduction in Section 1, Section 2 delves into matters concerning stylized facts of basic sanitation in Brazil. Section 3 conducts a review of the principal scholarly articles on the subject. Section 4 introduces the data and empirical methodology employed. Section 5 presents the findings and robustness checks, and Section 6 provides a summary of the results encountered.

2. Stylized Facts of Basic Sanitation in Brazil

Amid the contemporary context imposed by the COVID-19 pandemic, the relevance of basic sanitation has emerged as an even more critical and unavoidable aspect. The global health emergency has underscored the urgent need for increased investment in hygienic sanitation infrastructure. Improvements in water supply, ensuring its quality and potability, alongside the enhancement of sewage treatment and urban drainage systems, take on paramount importance, especially in the most vulnerable regions. In these areas, a significant portion of the Brazilian population resides, exposed to a heightened risk of infectious diseases.

The inadequacy of basic sanitation in these localities creates a conducive environment for the spread of the SARS-CoV-2 virus and its variants. Thus, substantial investments in this sector would not only contribute to the mitigation of COVID-19 case numbers but also reinforce the foundations for robust and resilient public health.

Concurrently, the pandemic has reignited the appreciation for fundamental hygienic practices, such as frequent handwashing, reiterating the importance of health education in the prevention of contagion. This collective awareness of personal and community hygiene emerges not just as a means of survival in the current pandemic scenario but also as an essential vector for the safeguarding of public health.

The intersection between adequate sanitation and health education underscores the pivotal role of these elements in combating infectious diseases. The harrowing experience faced by countries with deficient sanitation infrastructure throughout this pandemic has highlighted the devastating impacts of contamination and reinforced the inextricable link between sanitation and public health.

Therefore, it is evident that health education constitutes a sine qua non condition in the fight against the COVID-19 pandemic. The current global health crisis underscores the imperative urgency to rethink and restructure public policies related to basic sanitation and health education, aiming not only at effectively addressing current crises but also at preventing future pandemics.

Table 1 refers to the general characteristics of households estimated by the Continuous National Household Sample Survey (PNAD-C) in the period 2016-2019 by Brazilian regions. In 2016, Brazil had 69.2 million households, of which about 65.9% were served by a general sewage network or septic tank connected to the network. In 2019, the country reached the mark of 72.4 million households, of which 70.7 million households, approximately 68.3% had sewage. The survey produces relevant information that serves as a basis for the development of public policies on basic sanitation infrastructure, which generate positive impacts on the well-being of society, such as the quality of services from the general water supply network, sewage and septic tank, with garbage collection, which has strong repercussions on the mortality rate, disease rates, and patient recovery.

The data produced by the Continuous National Household Sample Survey (PNAD-C) showed the proportion of households connected to the general sewage network in the North and Northeast regions, which have the most striking differences among Brazilian regions. They have the lowest coverage of sewage services. In 2019, the North and Northeast regions had a proportion of 27.4% and 47.2%, respectively. On the other hand, the proportion of households in the Southeast, South, and Midwest regions covered by the general sewage network reached 88.9%, 68.7%, and 60.0%, respectively. Of the five regions, the South was the only one where the proportion of households with connection to the general sewage network reached a coverage of 88.9%, a value well above the others. Looking at the period 2016-2019, all Brazilian regions reported growth, with the exception of the Southeast region.

Table 1. Proportion of permanent private households with a general water supply network, sewage and septic tank, with garbage collection, according to the major regions (2016-2019)

Region	Water supply				Sanitary sewer				Garbage collection			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Brazil	85,8	85,7	88,3	88,5	65,9	66,0	66,3	68,3	82,6	82,9	83,6	84,4
North	88,1	88,0	87,7	87,7	18,9	20,3	21,8	27,4	70,2	69,8	70,8	72,4
Northeast	66,6	66,0	69,1	69,0	44,2	44,9	44,6	47,2	67,5	69,6	69,6	70,8
Southeast	93,3	94,7	95,4	94,8	89,0	88,9	88,6	88,9	91,3	91,7	91,1	92,1
South	98,1	97,5	97,5	97,0	64,8	66,0	66,8	68,7	87,7	86,3	87,3	89,6
Midwest	94,7	81,7	87,1	94,9	54,7	52,6	55,6	60,0	87,4	85,1	85,7	87,4

Source: PNAD-C, 2020.

The North region showed a proportion of households connected to the general sewage network that went from 18.4% in 2016 to 27.4% in 2019, with an average growth rate of 9.9% per year. The Midwest region recorded the percentage of households connected to the general sewage network of 54.7% in 2016 and 60.0% in 2019 with an average growth rate of 2.34% per year. The Southeast region showed a decline in the percentage of households with access to sewage services when it went from 89.0% in 2016 to 88.9% in 2019, representing a negative average growth rate of -0.03% per year.

The demand for garbage collection from households in Brazil is carried out through direct and indirect collection by the cleaning service, both in urban and rural areas. Garbage collection is done almost entirely in a direct way, it is a service that grows annually, going from 82.7% of households demanded by this service in 2016 to 84.4% in 2019. The second way to collect garbage is indirectly, done by garbage truck. This garbage collection service in an indirect way decreases every year, going from 7.7% of households demanded by this service in 2016 to 7.0% in 2019. The movement of these two services occurred in parallel in an inverse way, as direct garbage collection grew, indirect garbage collection decreased. According to the estimated data from the Continuous National Household Sample Survey (PNAD) Continuous 2019, they pointed out that about 10% of Brazilian households still dump garbage directly into public roads, rivers and “environment”.

The number corresponds to approximately 9 million households that do not have access to the sewage network and has been growing since 2016. Despite the growth, this picture reveals itself as alarming as already stated about a probable / possible depletion of water resources, which worsens and can be accentuated to the extent that the deposition of garbage in natura directly into rivers and seas as well as in public areas, degrading public health.

The Table 2 summarizes the demographic and socioeconomic situation of the regions in terms of the level of basic sanitation of households in Brazil in 2019. For a household to have a water supply standard in its essence, it is necessary that there is a piped water system that is connected to the general distribution network, in at least one of the household environments. To meet the second item in the full basic sanitation criterion, it is necessary that it has at least one private bathroom in the household, and that it is assisted by a general sewage network. About garbage collection, it is necessary that the household meets the criterion of direct or indirect garbage collection and the service is performed by a cleaning company.

With these approaches, variables are constructed to define a scale of values to assess the level of basic sanitation of a household. There is a certain reasonableness to say that a person’s well-being can be directly related to variables that affect the choice of basic sanitation infrastructure in the household in which they are inserted. In this context, the objective of the study will be to investigate the impact of certain socioeconomic variables, from the point of view of environmental sanitation conditions, with different levels of basic sanitation, as well as to relate these indicators to the individual’s choice.

The data from the PNAD surveys of 1998 and 2019 provide the basis for the argument that follows. The level of basic sanitation is the variable of interest used in this study. This variable is constructed from the condition of the basic sanitation services demanded by households. The variable determined by the condition of the level of basic sanitation assumes four situations of the type: if the household does not have any of the three distinct components of basic sanitation, it will be equal to 0; the household assumes a value of 1 if the demand is only for one of the three basic sanitation services; the value will be equal to 2 if it has 2 of the basic sanitation activities and, in the fourth classification, if the household consumes all 3 basic sanitation services, it assumes the value of 3.

Table 2. Level of basic sanitation in Brazilian households in the years 1998 and 2019

Level of Basic Sanitation	1998		2019	
	Percentage	Accumulated	Percentage	Accumulated
0	7, 1%	7, 1%	5, 1%	5, 1%
1	7, 3%	14, 4%	5, 4%	10, 5%
2	30, 6%	45, 0%	22, 0%	32, 5%
3	55, 0%	100, 0%	67, 5%	100, 0%

Source: Original work.

Table 2 shows that the proportion of households that did not have access to the full level of sanitation increased from 45% in 1998 to 67.5% in 2019, with an average growth rate of 1.86% per year. According to the data from PNADC2019, about 97.8% of households in Brazil had an exclusive use bathroom in the 70.8 million household units. In terms of regions, the North and South regions had an exclusive use bathroom in the household in about 90.2% and 99.8%, respectively. These are information that express that the determination of the demanders can qualify the offer, expanding it.

Table 3 presents data that shows the positive correlation between education and the level of sanitation, expressing the relevance of the production factor in the quality of sanitation. The composition of the sample to be analyzed includes two characteristics of households to be observed. The household units where the reference person has at least a complete elementary school education four years of study, and the households where the person has an elementary level - less than four years of study. Table 3 presents the situation of these two groups with reference to two specific years, 1998 and 2019. For the year 1998, according to the estimated data from the PNAD, the group with at least a complete elementary school education comprises more than 60% of the household units that have full sanitation. On the other hand, the group with an elementary level - less than four years of study, concentrates less than 40% of the households that have full sanitation.

Table 3. The effects of education on the level of sanitation in Brazil in the years 1998 and 2019.

Level of Basic Sanitation	At least 4 year of study		Less than 4 year of study	
	Percentage %	Accumulated %	Percentage %	Accumulated %
1998				
0	5, 89%	5, 89%	11, 30%	11, 30%
1	5, 05%	10, 83%	14, 87%	26, 16%
2	28, 58%	39, 52%	37, 16%	63, 32%
3	60, 48%	100, 0%	36, 68%	100, 0%
2019				
0	3, 67%	3, 67%	9, 82%	9, 82%
1	6, 01%	9, 68%	15, 07%	24, 89%
2	27, 11%	36, 79%	41, 01%	65, 99%
3	63, 21%	100, 0%	34, 01%	100, 0%

Source: Original work.

Table 4 shows that all Brazilian regions recorded growth in the period 1998-2019, except for the North region, which does not have data. The regions with the highest proportion of households with full sanitation were precisely those that recorded the highest average production factors. In the two years examined, it was observed that the Southeast region has the highest proportion of fully sanitized households, among all Brazilian regions, when it registered 77.77% in 1998 and grew to 91.29% in 2019. This is equivalent to an average growth rate of 1.62% per year. The estimated data from the PNAD point to the South region as the second largest concentration of fully sanitized households, about 55.7% in 1998 and 80.89% in 2019. Note that in this period, the South region grew, on average, at a growth rate of almost 3.80% per year.

The Midwest region reported a proportion of households with full sanitation with rates of 41.2% in 1998 and 57.15% in 2019. This indicates that in these twenty-two years the region has evolved at an average growth rate of approximately 3.33% per year. The Northeast region showed the lowest percentages of households with full sanitation, with about 34.5% in 1998 and 51.55% in 2019, with an average growth rate of 4.10% per year. The consequences of these referenced factors, highlight the importance of the degree of economic modernization in the Southeast and South regions, considering qualitative differences in labor, technological knowledge, business capacity, and market size, to explain regional productivity differences.

Table 4. Basic sanitation by region - 1998 e 2019

Basic Sanitation		Northeast		Southeast		South		Midwest
Level	%	Accumulated	%	Accumulated.	%	Accumulated	%.	Accumulated
1998								
0	9, 38	9, 38	2, 94	2, 94	4, 40	4, 40	15, 2	15, 2
1	13, 99	23, 37	4, 53	7, 47	3, 16	7, 56	4, 98	20, 14
2	42, 10	65, 47	14, 76	22, 23	36, 74	44, 30	38, 64	58, 78
3	34, 53	100, 00	77, 77	100, 00	55, 70	100, 00	41, 22	100, 00
2019								
0	21, 59	21, 59	0, 55	0, 55	0, 39	0, 39	1, 09	1, 09,
0	9, 02	30, 61	5, 11	5, 66	8, 02	8, 41	5, 02	6, 11
0	17, 84	48, 45	3, 05	8, 71	10, 73	19, 14	36, 74	42, 85
0	51, 55	100, 00	91, 29	100, 00	80, 89	100, 00	57, 15	100, 00

Source: Original work.

For the year 2019, it is noticed that the picture of this difference remained practically the same in these 22 years. The PNAD recorded a proportion of more than 63% of households that have full sanitation services and have a responsible person who has at least the level of complete elementary school - at least four years of study. On the other hand, the group with an elementary level - less than four years of schooling, full sanitation obtained less than 35%. This corroborates the statement that education, the educational level interferes in the demand for infrastructure services such as water, garbage collection and treatment as well as sewage and garbagewater treatment.

As stated earlier, Brazil is characterized by a large socioeconomic inequality and a deficit in access to infrastructure, especially to basic sanitation. In regional terms, it is obvious that these issues are marked by significant inequalities. However, the occurrence of natural events can negatively impact basic sanitation, affecting the environment and harming the quality of life, causing productivity losses and job market opportunities, which would certainly further increase regional inequalities.

Table 5 draws attention to the huge discrepancy in the number of households with access to sanitation services between urban and rural areas. The value of sanitation services in urban and rural areas helps to understand these inequalities. According to the estimated data from the PNAD - of 1998 and 2019, the proportion of urban households with full sanitation services increased from 56.74% in 1998 to 72.4% in 2019. On the other hand, the percentage of rural households with access to sanitation services expanded from 17.14% in 1998 to 26.1% in 2019. These percentages are much lower than in urban areas, exposing that this deficit is greater in rural areas. According to Mendonça et al. (2004), about rural areas, the deficit is proportionally much higher than that observed in urban areas. It is also known that urban areas have the households with the highest level of sanitation, possibly due to the lower marginal cost of obtaining such services in urban areas.

Table 5. Basic sanitation by urban and rural areas - 1998 e 2019

Basic Sanitation Level	Area-1998				Area-2019			
	Urban		Rural			Urban		Rural
	%	Acum.	%	Acum.	%	Acum.	%.	Acum.
0	6, 6%	6, 6%	19, 1%	19, 1%	4, 3%	4, 3%	16, 2%	16, 2%
1	6, 0%	12, 6%	35, 1%	54, 2%	4, 0%	8, 4%	31, 3%	47, 3%
2	30, 7%	43, 3%	28, 6%	82, 9%	19, 2%	27, 6%	26, 4%	73, 9%
3	56, 7%	100%	17, 1%	100%	72, 4%	100%	26, 1%	100%

Source: Original work.

3. Literature Review

Mangyo (2008) suggests that households with a high level of education have positive effects on changes in community-level water acquisition and changes in water-related symptoms. This is highlighted by the fact that local authorities in these communities set selective conditions for water projects where the level of health was inadequate. “This implies that our estimated impact of water accessibility on children’s health may be underestimated if selective placement of water projects were to distort our results, suggesting that the true impact could be greater.”

The articles by Basta et al. (1979), Bhargava (1997), and Bhargava et al. (2001) highlight the demand for sanitation as a demand for inputs that qualify a person’s life. Carrera-Fernandez and Menezes (1999) estimated the demand for sewage using the contingent valuation method. Studies such as Minh and Hung (2011), Cameron et al. (2021), and Zhang (2012) reveal that investments made in improving sanitation services are reflected in the quality of health and economic growth of people. Minh and Hung (2011) also found that the slow process in halving the proportion of people without access to safe drinking water is due to a lack of sanitation education among policymakers and the population.

There are abundant studies in the areas of biological and social sciences (Basta et al., 1979; Spurr, 1983; Bhargava, 1997; Strauss & Thomas, 1998) conducted in developing countries, which deal with the positive relationship between the quality of health and economic productivity. This is a relationship that can be observed at different levels, whether in regional studies, individual studies, or even at a national level. The work of Bhargava et al. (2001) highlights as essential factors for the growth of life expectancy, investments in public health infrastructure, improved nutrition, advances in sanitation, and innovations in medical technologies, gradually making life expectancy longest human lifespan.

The articles in this work highlight the extreme need to qualify service demanders to increase supply and, through this, implement the conditions for improving health and longevity rates.

Improving access to basic sanitation services is a priority for the health of the general population. It is necessary to evaluate the perception of sanitation demanders in rural and urban environments as a mechanism capable of providing information on consumer demand, so that it can foster the expansion of sanitation coverage through private and/or public services.

The emphasis placed by development economists on the strategic role played by an efficient and active infrastructure sector has led to an increasing diversification of studies. The purpose and perspective differ greatly from research to research, as highlighted by Mendonça et al. (2004). On the one hand, there are reports of work as a mere analysis of institutional characteristics and the functioning of the components of economic infrastructure. On the other hand, there are studies that address the flows through which inputs-products reach the market, indicating the factors that promote or reduce flow, efficiency, tenacity, among other things. However, all studies highlight the connection between infrastructure effectiveness and economic development.

4. Method

4.1 Econometric Model

4.1.1 Random Utility Model

As discussed briefly above, sanitation is a complex issue with implications for health, human behavior and socioeconomic development. Although it is demanded by many, it is defended by few. Jenkins and Scott (2007) developed an approach to sanitation adoption stages, and they indicate where marketing approaches can be useful in improving behavioral indicators of sanitation demand. Rothschild (1999) developed a framework for the strategic use of marketing along with two other basic tools for behavior change - education and regulation - to achieve social or public health goals. Therefore, this article investigates the potential effects of residential choices in areas supported by the basic sanitation network using a multinomial logit model with panel data from 2016-2019. The multinomial logit (MNL) model is one of many methods used to model categorical outcomes that do not have a natural ordering.

It is well known since 1948 that adequate housing is a human right enshrined in the Universal Declaration of Human Rights. However, despite being one of the fundamental rights, access to housing and, especially, the qualification, the human adequacy of this housing has not been realized so consequently. Individuals are compelled to make choices in a limited and inadequate range of housing offers due to the costs of access as well as maintenance. Family income as well as the level of educational and cultural formation will give the contours of the possible housing choice. Cities are organizing themselves in such an exclusionary way that they inhibit low-wage earners from accessing fully sanitized urban areas, for example. It is worth noting the costs of accessing public transportation, even though it is not the subject of this study, as they will also affect the choice of housing. Thus, individuals who are unable to choose housing that is adequately suited to human beings may tend to choose housing near their work and/or schools for their children, renouncing other conditions such as: the provision of sewage and garbage collection, for example, restricting the supply of drinking water, and opting for garbage burning or transportation to collection points.

Although already described above, it is reiterated that the components of drinking water supply, sewage treatment, and garbage collection, which are the elements of basic sanitation, have clear and distinct classification characteristics, which represent the various alternative possibilities available to the individual. However, all the details will be in Appendix 1. Having explained the data to deal with the issue of sanitation, it is now framed in the same category as the category used to deal with the choice of housing, which places us in the need to use the random choice model to address the problem. In the following, the method will be discussed, albeit briefly.

In general, discrete choice models are based on the random utility theory that results in the most likely choices of a consumer from a set of available alternatives. It can be assumed that the utility function of individual i, for the choice of alternative activity type *n* is.

$$U_{in} = V_{in} + \epsilon_{in} \tag{1}$$

where V_{in} is a systematic utility for choosing the type of activity n and ϵ_{in} is the unobservable random error component of the preferred choice of the type of activity.

The individual consumer *i*, (*i* = 1, ...*I*) will select an alternative *n*, (*n* = 1, ...*N*) from all N_i alternatives in the choice set C_n, in a way that maximizes their utility, U_{in}. Thus, consumer *i* chooses alternative *n* if $U_{in} \geqslant U_{ik}$, $\forall k \neq j$.

The probability P_{in} of consumer *i* making a certain choice *n* as opposed to the other alternatives is the probability of raising their obtained utility that is higher than the others, $U_{i1}, \cdots, U_{in}$.

Denoting $x \in (1, \ldots \mathrm{N})$, the probability that individual *i* chooses alternative *n* is

$$\begin{gathered} P_{in} = P_r(x_i = n) = \\ P_r = U_{in} > U_{ik}, \forall k = 1, \cdots, N: k \neq j) = \\ P_r = \varepsilon_{ik} - \varepsilon_{in} \leq V_{in} - V_{ik}, \forall k = 1, \cdots, N: k \neq n) = \end{gathered} \tag{2}$$

The utility of individual *i* for choice alternative *n* is assumed to consist of a deterministic component, $(V_{i1}, \ldots, V_{in})$, and a random utility component, $(\varepsilon_{i1}, \ldots, \varepsilon_{in})$, where V_{in} is a function of a set of independent variables and unknown parameters to be estimated, and εin, is the random error component that contains all the unobserved determinants of utility.

Due to the systematic parts of the utility functions $(V_{i1}, \ldots, V_{in})$, there will be a variation in the probability due to the assumptions about the distributions of the random terms $\varepsilon_{i1}, \ldots, \varepsilon_{in}$. Thus, the systematic part V_{in} will suffer changes due to different types of determinants. In this way, it can be defined as follows:

z_i represents the vector of attribute variables and x_{in} is the vector of characteristic variables, which can vary depending on the individual due to the choice made by him, β is a conforming vector of constant parameters. The constant term α_n is configured according to each alternative. The information treated in this study was captured from PNAD, where there is no availability of information of the x_{in} type. In this way, all data are configured as being of the attribute type. In this way, it has:

$$V_{in} = \alpha_n + z_i`\gamma_n \qquad i = 1, \cdots I, n, \cdots N \tag{3}$$

Taking into account all the features of this model, it is understood that the most consistent way to estimate the parameters is from the application of the mathematical structure of MNL, which gives the probability of individual *i* choosing alternative n, is given by the multinomial logit formula, where:

$$Pr(Y_i = n) = \frac{exp^{\beta_i^{`} z_n}}{\sum_{k=1}^{n} exp^{\beta_k^{`} z_n}} \tag{4}$$

In which: P_{in}=probability of choosing alternative *n* for individual *i*;

V_{in}=observable part of utility, which depends on parameter β;

β_i=coefficients that correspond to the individual.

The multinomial logit (MNL) model is one of the most used methods of discrete random utility theory that proposes to model the choices of individuals between sets of alternatives. MNL model is one of the most commonly used methods of discrete random utility theory that proposes to model the choices of individuals between discrete sets of alternatives. It is known that in MNL, when the equations are estimated, they will generate a set of probabilities for N + 1 choices and i for the individual. The removal of this indeterminacy can be done by introducing a normalization up to the reference alternative, such as the vector $\beta = 0$. Thus, we have that

$$Pr(Y_i = n) = \frac{1}{\sum_{k=1}^{n} exp^{\beta_k^{'} z_i}} \quad para \quad n = 2, \cdots, N-1 \tag{5}$$

$$Pr(Y_i = n) = \frac{exp^{\beta_n^{'} z_i}}{\sum_{k=2}^{n} exp^{\beta_k^{'} z_i}} \quad para \quad n = 2, \cdots, N-1 \tag{6}$$

Using the maximum likelihood method and the nonlinear optimization technique, it is possible to estimate the coefficients that appear in (5). Greene (1993) records that interpreting the coefficients of equations (5) – (6) is a difficult task, but, however, it is possible to obtain from them the logs for N − 1 probability ratios,

$$ln\left[\frac{P_{in}}{P_{ik}}\right] = \beta_n^{'} z_i, \quad para \quad n = 2, \cdots, N-1 \tag{7}$$

Therefore, there are always N − 1 equations and from these it is possible to interpret the coefficients. In the case above, one would have an idea of the effect on the probability of choosing alternative *N* compared to alternative *K*, which is due to an increase in a certain variable. To develop an analysis of the multinomial model, there is an interesting instrument, *RRR* called the relative risk ratio.

$$RRR = P(Y = n \mid z + 1)/(P(Y = k \mid z + 1)) \,/\, P(Y = n \mid z)/(P(Y = k \mid z)) \tag{8}$$

To comment, analyze the *RRR* one can follow similar paths to those immediately above used for the equations that appear in (8), except when the *RRR* operates with relative changes in probabilities. It is, therefore, a concept cognate to that of elasticity in microeconomics. It should also be noted that, in the face of contexts in which multiple choices are made, the point of view of measurement becomes valid since the $P_{n/}P_k$ ratios are independent of other choices. This happens when the hypothesis of independent disturbances is assumed, thus outlining the “axiom of irrelevant alternatives”.

Within the context of the economics of basic sanitation, the Relative Risk Ratio (RRR) emerges as a statistical tool capable of assessing the impact of sanitation improvements on the risk of public health issues. Let’s dissect this concept, adapting it to the economic field and sanitation.

Consider a scenario where a study is conducted to evaluate the effect of implementing an enhanced basic sanitation system within a community that previously relied on low-quality water sources. The aim is to reduce the incidence of water-borne diseases such as cholera or diarrhea. In the group that received the intervention (i.e., access to the improved sanitation system), the incidence of water-borne diseases stands at 1%, while in the control group (without the improved sanitation system), the incidence is 5%.

In this scenario, the Risk Ratio (RR) would be calculated as the ratio of the risk of becoming ill in the intervention group to the risk in the control group, yielding 0.2 (i.e., 1% / 5%). The RRR is derived by subtracting this RR from 1, resulting in 1 - 0.2 = 0.8, or 80%. This indicates that the introduction of the improved sanitation system reduced the relative risk of water-borne diseases by 80% compared to the control group.

Application in the Economics of Basic Sanitation. From an economic perspective, the RRR provides valuable insights into the value of investments in basic sanitation. It enables economists and planners to:

-The magnitude of the RRR can assist in determining the effectiveness of different sanitation strategies in terms of health risk reduction. This is crucial for the efficient allocation of limited resources.

-By comparing the RRRs of various sanitation projects, decision-makers can prioritize those with a greater relative impact on public health, optimizing the return on investment.

-Data on the relative effectiveness of sanitation interventions can underpin public policies, encour- aging investment in infrastructures that yield the greatest health benefits for the community.

Therefore, in the context of the economics of basic sanitation, the Relative Risk Ratio is not merely a statistical indicator of medical efficacy; it is an essential tool for understanding the economic and social impact of investments in sanitation infrastructure, supporting decisions that can significantly improve the quality of life and health of populations.

5. Empirical Application

The theoretical framework outlined here to deal with random choices, in which various unordered alternatives can be observed, poses another problem, namely the applicability of the multinomial model in the scenario where individuals need to make choices about their place of residence and related basic sanitation services, such as the supply of treated water and garbage collection. The question that arises is to understand the performance of the participants in this choice concerning the availability of basic sanitation services when seeking housing. What are the factors that influence the demanding individuals, and which inputs defined earlier will have an influence on individuals when making their choices?

Therefore, it is necessary to develop studies that can define the probabilities of an individual deciding between choosing housing with a supply of treated water, sanitation, and garbage collection or housing with a supply of drinking water, septic tank, and garbage incineration.

In this context, what is proposed is a study to determine the probability of an individual being placed in one of the available alternatives: remaining single, opting for cohabitation, or getting married. In the multinomial model, the analysis of the results should be conducted in comparison to a specific reference alternative (Reference Group)-Table 6. The single status alternative was used as the base. In this case, regressions were estimated for the cohabiting and married states. Therefore, a negative coefficient for a particular variable in both equations implies that the variable has an adverse effect on the probability of transitioning from a single state to either a cohabiting or married union. Conversely, such a result can be interpreted as having a favorable effect on remaining in the single state.

Undoubtedly, the analysis of sanitation demand is intrinsically linked to the demand for housing, as it is a qualifying attribute of housing. Several elements need to be taken into account when choosing a place of residence, including the availability of drinking water, the presence of sanitation, garbage collection, among other collective consumption goods such as electricity supply, proximity to public transportation services, and more. Important factors such as proximity and the costs of commuting to work and school significantly influence housing choices. For illustrative purposes, this theme aligns with the history of the birth of numerous informal settlements referred to by IBGE as ’subnormal clusters’ due to their lack of the necessary standard urban amenities, although they are close to the job market.

Therefore, it is necessary to contemplate and understand many of the reasons why individu- als/families opt for housing that is not integrated with sets of collective consumption goods but is close to work and school, has access to clean water and electricity. Other issues such as sanitation and garbage collection are still pending. During this wait, alternative solutions are sought, such as the use of public dumpsters for garbage disposal and, in some cases, the installation of septic tanks, for example. It is important to note that modernity has expanded the range of these collective consumption goods and has recently added the provision of optical cable services for internet access, which also enables participation in courses and schools. Thus, individuals and families negotiate the services that best suit their needs and make their housing choices.

As outlined previously, the variables will be grouped into three different clusters. The first cluster encompasses the set of defining variables related to the characteristics of the individuals making housing choices, such as the average family income in the household and the educational level of the head of the family. The second cluster encompasses all the distinctive features of the dwelling itself, including its size in square meters, the number of rooms, bathrooms, bedrooms, and other factors such as the availability of drinking water, sewage services, direct garbage collection, electricity supply, and so on. Finally, the third and last cluster compiles characteristics of the neighborhood, the location of the property, whether it is in an urban or rural area, or classified as a ’subnormal cluster’ according to the IBGE

5.1 Database, Sample Description, and Utilized Variables

Given all this methodological discussion, it is now appropriate to align how the dependent variables will be treated in the current model. Sanitation and garbage collection will have their various alternatives specified in paper. Each of the elements will have its selection and delineation of four options, even though this quantity is greater in PNAD. The decision was made to reduce it for the sake of a more accurate analysis of the multinomial model. The following alternatives were selected for sanitation: San_RG, San_FSRG, San_FSSEf, and San_V RL, and for garbage collection: Garbage_CD, Garbage_CC, Garbage_QE, and Garbage_TBL.

The data used for this study, related to individuals and households, are derived from the quarterly longitudinal microdata of the Continuous National Household Sample Survey (PNAD Contínua), conducted by IBGE (Brazilian Institute of Geography and Statistics). The survey is carried out through a quarterly selected sample of households, with each household being interviewed once every quarter, for five consecutive quarters. The Continuous National Household Sample Survey (PNADC) is a rotating panel. The geographical coverage of PNAD Contínua encompasses the entire national territory, excluding areas with special characteristics (IBGE). In this system, a household is visited for one month and is not visited for the following two months before being visited again in the subsequent quarter. This process is repeated five times. In other words, each household is visited over five quarters. The database comprises 211,344 households (N) surveyed in the five interviews (T), starting in the year 2019.

Table 6 presents the definitions of the variables used in the Multinomial Model. Dependent Variables: Our first dependent variable in the Basic Sanitation Demand is the supply of water from the general network, which is interpreted as an input that improves the quality of life of individuals, labor productivity, and optimizes economic activity, but also serves to assess the well-being level of society. Eight factors were used as indicators of household characteristics. Urban region (urban), metropolitan region (metropolitan), and regions were employed as location variables. In addition to the distribution of water supply from the general distribution network, three indicators of sanitation and three classifications regarding garbage collection were used as indicators of basic sanitation. Household consumption measures in terms of goods are represented by seven products representing household assets.

6. Analysis of Results and Tables

The Multinomial Logit Model (MNL) is one of the many methods used to model categorical outcomes that lack a natural order. This article aims to model the role of education in influencing residential choices in areas supported by the basic sanitation network. It employs the multinomial logit model, using data from the year 2019, which is of particular interest for addressing the topic of basic sanitation.

Tables 7, 8, and 9 present the estimated coefficients of the multinomial logit model for the selection of domestic sanitation components (water supply, sanitary sewage services, and garbage collection), along with other control variables. These tables have been separated due to the large number of results generated. The tables display the outcomes of the multinomial model procedures applied to two basic sanitation demand equations, including coefficient values and their significance tests.

By employing various methods and variations, we obtain results that are numerically small compared to the average survival rate. Furthermore, almost all of the results are statistically significant. A model was estimated for each sanitation application, with the category of “unused sanitation method” serving as the reference. However, it is necessary to provide some preliminary elements for clarification.

The LR chi-squared test (LR chi2(51)) is the Likelihood Ratio Chi-squared test (LR) in which, for the three equations (San_RG of sewage relative to San_V RL, San_FSRG relative to San_V RL, and San_FSSE relative to San_V RL), at least one of the parameters of the multinomial logit model of predictors is not equal to zero. The number within parentheses indicates the degrees of freedom of the Chi-squared distribution used to test the LR Chi-squared statistic and is determined by the number of estimated equations (3) times the number of predictors in the model (17). The LR Chi-Squared statistic can be calculated as $-2\cdot$(L(null model) - L(adjusted model)) = -2 ((-124.240) - (-103077)) = 43.004, where L(null model) is the log-likelihood with only the response regressors in the model (Iteration 0), and L(adjusted model) is the log-likelihood of the final iteration (assuming model convergence) with all coefficients.

“Sanea” (Sanitation) is the response variable in the multinomial logistic regression. The coefficients and p-values are in column 1, and the RRR (Relative Risk Ratio) is presented in column 2. It should be noted that results are displayed, even though there are a few non-significant regressors remaining in the model. It is worth mentioning that it was not deemed necessary to present the aforementioned restricted model since the presence of these non-significant regressors did not cause any significant changes in the parameters of the remaining regressors.

Similarly, elements of the restricted model will not be presented, nor will the coefficients of the control dummies related to different regions of Brazil and metropolitan areas be displayed, in order to ensure the expression of the most relevant results. However, the model was estimated for all regions. It should be noted that nearly all parameters are statistically non-zero, and they all exhibited the expected signs. Also, household average income was logarithmically transformed to mitigate the difference between extreme values and others. This logarithmic transformation helps stabilize the variance and nonlinearity of the model. Finally, it is worth noting that each regression analyzed was made in reference to a specific base category or support.

Regarding the results of the model in Table 7, it is worth highlighting certain relevant elements. In terms of the sanitation model, income is an essential variable in the estimated equation. All three results from the categories of the multinomial model show that those with higher incomes are more likely to report good sanitation infrastructure, and therefore, better health for the family.

In column (2), it is shown that an increase of one unit in the natural logarithm of real household income results in an approximately 1.910 times increase in this value when considering the relative probability of a specific resident choosing to move to a residence with a general sewage network, as opposed to the other option in the San_V RL category. Other factors can also affect sanitation success.

The variable “education,” broken down into certificate levels - primary, secondary, undergraduate, and postgraduate, has shown statistical significance at the 1% significance level, being as significant as the “income” variable. Therefore, it needs to be observed because it proves to be highly relevant. It is evident that as the level of education increases, the possibility of an individual with an additional year of education significantly increasing the probability of moving from a residence in the San_V RL category to one where the possibility of a general sewage network exists. The potential for education to be used as a mechanism for promoting sustainable sanitation must also be considered.

Table 7 shows a slight advantage of households with a general sewage network in terms of educational levels. These households have a greater impact of educated individuals, whereas subsequent household categories consistently exhibit lower relative probabilities. The use of a domestic bathroom is a “sine qua non” condition for ensuring high-quality family health.

In terms of regional areas, households in capital cities are more likely to use a general sewage network compared to households located outside metropolitan regions. Compared to areas where the household is located in the Rest of the State (Resto da UF), the use of a general sewage network (San_RG) in capital cities and metropolitan regions (excluding capitals) is nearly 1.984 and 1.767 times higher, respectively.

Regarding electricity availability and the number of rooms in the household, these variables attempt to reflect various features related to the comfort desired by families when seeking their housing. The availability of electricity and the quantity of rooms have had positive impacts on the likelihood of choosing housing with access to a collective sewage network over open sewage, trenches, rivers, seas, or other alternatives. This condition, combined with the positive effect that strengthens the probability that individuals who have chosen housing with more comfort and better installation conditions may be the same families who prefer housing with better sanitation service infrastructure.

This is the multinomial logit estimation for a one-unit increase in electricity consumption for San_RG users compared to those whose alternative is San_V RL, given that the other variables in the model are held constant. If a subject increased their electricity consumption by one unit, the multinomial log odds for San_RG users relative to San_V RL types would be expected to increase by 1.209 units, while keeping all other variables in the model constant. In terms of relative risk ratio, if a household increased its score in electricity consumption by one unit, the relative risk for San_RG users compared to San_V RL would be expected to increase by a factor of 3.349, assuming all other variables in the model are held constant.

Regarding a group of residents in a specific household, it can be observed that the presence of an additional individual generates an effect that is less than proportional to the probability of a family living in a household of the San_V RL class moving to reside in a dwelling with sewage connected to the general network. The multinomial logit for women compared to men is 0.252 units higher when in Garbage_CD compared to Garbage_TBL, provided that all other predictor variables in the model are held constant. This is the multinomial logit estimate for Garbage_CD compared to Garbage_TBL when the predictor variables in the model are evaluated at zero. For women compared to men, the relative risk for Garbage_CD compared to Garbage_TBL would be expected to increase by a factor of 1.287, given that all other variables in the model are held constant.

In Table 7, some information related to the choice for domestic sanitation is also presented. The coefficient of the residents’ years of education indicates that as the level of education increases, residents are more likely to live in a household with garbage collection coverage provided directly by a cleaning service. A household in which the individual has a postgraduate degree is 15.268 times more likely to use garbage collection coverage compared to a household in which the head of the household has only reached primary education, where garbage is discarded in vacant lots or public areas.

This is the multinomial logit estimate for a one-unit increase in the logarithm of real household wage score for Garbage_CD compared to the Garbage_TBL level, assuming all other variables in the model are held constant. If a subject increased the logarithm of the real household wage score by one unit, the multinomial log odds for Garbage_CD compared to Garbage_TBL would be expected to increase by 0.588 units, while keeping all other variables in the model constant. The RRR (Relative Risk Ratio) is the relative risk rate for a one-unit increase in household wage score for Garbage_CD compared to the Garbage_TBL type, assuming all other variables in the model are held constant. If a subject increased their household wage by one unit, it would be expected that the relative risk for Garbage_CD compared to Garbage_TBL would increase by a factor of 1.800, given that all other variables in the model are held constant.

The information in Table 8 allows us to draw some conclusions about the sanitation process compared across various sanitation methods. In terms of other aspects, it is worth noting that the number of residents generally acts as an obstructive element in promoting improvements in a family's overall living conditions. Except for the case of Garbage_CC, which is not particularly significant, the number of residents influences a family's decision to continue living in inhospitable and/or poor sanitation conditions. This may be the price paid for community services.

Another noteworthy point that needs to be observed is the attention to the variable comodo, just as in the case of San_RG options for sewage and Garbage_CC. Perhaps this scenario occurs due to the preference revealed for comfort and/or appearance. Finally, it should be mentioned that water and sanitation services are complementary goods, and thus the cost of expansion can be minimized by universalizing water services, as private agents who do not have a general sewage network may choose alternatives, even if they do not provide the same level of well-being as San_RG and San_FSRG, as they tend to be more favorable than San_VRL.

Regarding the results related to garbage, there are some points that require emphasis. It should be noted that despite income being a significant factor, it does not affect the garbage scenario in the same way it does for sanitation. This is because a marginal increase in income results in a relative change of about 1.387 in the probability of a person choosing to move from a residence with the Garbage_TBL option to one with the Garbage_CC option. This is consistent with that half of the relative probability of the individual choosing to live in a residence with the option of a general sewage network compared to another where the alternative is of the San_V RL type when there is a marginal change in income.

More significantly, in the case of sanitation services, education has proven to be a highly important factor with the trend towards universalization in the provision of this service, especially after the promulgation of the 1988 Constitution.

It should also be noted that there is greater ease of access to garbage services, as the supply has been expanded due to the trend towards the universalization of services, which began in the period between the 1980s and 1990s when the private sector expanded the provision of these services, enabling a more pronounced increase in the effect of increasing education on the demand for such services. In terms of direct and indirect collection processes, an additional year of study resulted in an increase of approximately 20% in the relative probability of a person moving from their residence where residents discharge garbage into rivers and/or seas to another residence where this does not occur due to access to the direct collection service.

According to the data reported in Table 9, it is observed that in the case of the septic tank, this also applies to the choice of San_FSSE. This is because it is a very feasible alternative. This connection is quite accessible to individuals. This is the multinomial logit estimation comparing electricity consumption for San_FSSE to San_VRL, given that the other variables in the model are held constant.

The multinomial logit for households that use at least one source of electricity compared to those who do not use at least one source is 1.286 units higher for being at the San_FSSE level compared to the San_VRL level, as all other predictor variables in the model are held constant.

When calculating the relative risk ratio comparing electricity use to non-use for San_FSSE levels compared to San_VRL levels, given that the other variables in the model are held constant. For electricity users compared to households that do not use this source of energy, the relative risk relative to San_VRL would be expected to increase by a factor of 3.617, as- suming that the other variables in the model are held constant. As for direct garbage collection and general water supply services, these are highly complementary for the sanitation category.

Table 6. Multinomial model for Sanitation: Sanitary Sewer and Garbage Collection

Variables	Sanitary Sewer		Garbage	
Independents	Coef. (z)(1)	RRR (2)	Coef. (z)(3)	RRR (4)
Choice	San_RG	San_RG	Garbage_CD	Garbage_CD
Education				
1st Grade	0.254(6.01)***	1.29	0.208(1.42)	1.231
2nd Grade	0.419(9.94)***	1.52	0.606(3.98)***	1.834
Higher Education	0.472(9.34)***	1.603	1.190(4.78)***	3.287
Postgraduate Apt	0.830(3.28)***	2.292	2.726(0.89)	15.268
Room	1.813(23.89)***	6.132	0.621(2.03)**	1.861
Bathroom	−0.080(−5.04)***	0.923	−0.105(−1.58)	0.9
Electrical	−0.004(−0.31)	0.996	−0.010(−0.17)	0.99
Residents	0.464(18.69)***	1.59	0.935(7.78)***	2.546
Female	1.209(3.42)***	3.349	2.514(7.25)***	12.356
Sanitation	−0.103(−2.09)**	0.903	−0.613(−3.70)***	0.541
Garbage_cd	0.083(3.81)***	1.087	0.252(2.76)***	1.287
Water_rg	1.547(53.48)***	4.696	1.390(15.13)***	4.015
San_rg Housing	2.651(77.85)***	14.168	2.131(15.19)***	8.421
Type Capital	0.685(21.4)***	1.984	−0.852(−7.56)***	0.427
Rest_RM	0.569(18.07)***	1.767	−0.427(−3.84)***	0.652
Rest_RIDE	−1.953(−21.48)***	0.142	0.249(0.48)	1.283
Salary	0.647(46.75)***	1.91	0.588(11.79)***	1.8
Constant	−9.363(−25.31)***	0	−4.847(−9.49)***	0.008
Reference Group	San_VRL	San_VRL	Garbage_TBL	Garbage_TBL
Pseudo-R2	0.1724	0.1724	0.2827	0.2827
Observations	125,837	125,837	125,837	125,837

Source: PNADC/IBGE. The z-tests are in parentheses. ***p<1%,**p<5%,*p<10%.

Table 7. Continuation of Table 6

Variables	Sanitary Sewer		Garbage	
Independents	Coef. (z)(1)	RRR (2)	Coef. (z)(3)	RRR (4)
Choice	San_FSRG	San_FSRG	Garbage_CC	Garbage_CC
Education				
1st Grade	0.127(1.99)**	1.136	0.363(2.37)***	1.437
2nd Grade	0.246(3.90)***	1.279	0.574(3.62)***	1.775
Superior	0.316(4.35)***	1.371	1.188(4.68)***	3.281
Postgraduate Apt	0.598(2.09)**	1.819	2.822(0.93)	16.819
Room Space	1.439(16.95)***	4.216	0.802(2.60)***	2.23
Bathroom	−0.127(−5.64)***	0.881	−0.102(−1.50)	0.903
Electric	0.014(0.68)	1.014	0.018(0.29)	1.018
Residents	0.421(12.73)***	1.524	0.807(6.63)***	2.242
Female	2.416(2.56)***	11.199	3.039(5.34)***	20.878
Sanitation	−0.040(−0.58)	0.961	−0.469(−2.73)***	0.625
Garbage_cd	0.049(1.59)	1.051	0.222(2.38)***	1.249
Water_rg	0.959(22.07)***	2.61	0.482(5.05)***	1.619
San_rg Housing	0.504(12.97)***	1.656	1.458(10.24)***	4.295
Type Capital	0.256(5.75)***	1.291	−1.154(−9.96)***	0.315
Rest_RM	0.697(17.09)***	2.007	−1.061(−9.17)***	0.346
Rest_RIDE	−2.828(−8.80)***	0.059	−0.930(−1.69)*	0.395
Salary	0.516(25.20)***	1.675	0.327(6.37)***	1.387
Constant	−8.921(−9.33)***	0	−4.474(−6.51)***	0.011
Reference Group	San_VRL	San_VRL	Garbage_TBL	Garbage_TBL
Pseudo-R2	0.1724	0.1724	0.2827	0.2827
Observations	125,837	125,837	125,837	125,837

Source: PNADC/IBGE. The z-tests are in parentheses. ***p<1%,**p<5%,*p<10%.

Table 8. Continuation of Table 7

Variables	Sanitary Sewer		Garbage	
Independents	Coef. (z)(1)	RRR (2)	Coef. (z)(3)	RRR (4)
Choice	San_FSSE	San_FSSE	Garbage_QE	Garbage_QE
Education				
1st Grade	0.063(1.54)	1.065	−0.222(−1.49)	0.801
2nd Grade	0.153(3.70)***	1.165	−0.334(−2.14)**	0.716
Superior	0.285(5.59)***	1.33	0.115(0.45)	1.122
Postgraduate Apt	0.697(2.64)***	2.007	1.592(0.52)	4.915
Room Space	0.417(4.98)***	1.518	−2.745(−4.53)***	0.064
Bathroom	0.023(1.45)	1.024	−0.046(−0.68)	0.955
Electric	−0.036(−2.40)***	0.964	0.107(1.72)*	1.113
Residents	0.364(14.27)***	1.439	−0.069(−0.56)	0.934
Female	1.286(5.86)***	3.617	1.210(4.07)***	3.353
Sanitation	−0.143(−2.76)***	0.866	−0.310(−1.79)*	0.733
Garbage_cd	0.017(0.74)	1.017	0.097(1.02)	1.101
Water_rg	0.510(19.21)***	1.666	−1.059(−11.14)***	0.347
San_rg Housing	0.004(0.17)	1.004	−1.331(−7.72)***	0.264
Type Capital	0.074(2.09)*	1.077	−2.764(−19.63)***	0.063
Rest_RM	−0.065(1.89)*	0.937	−2.176(−17.58)***	0.114
Rest_RIDE	−0.802(9.26)***	0.448	−0.130(−0.24)	0.878
Salary	0.181(13.16)***	1.198	−0.027(−0.53)	0.973
Constant	−2.988(−12.33)***	0.05	2.455(5.08)***	11.643
Reference Group	San_VRL	San_VRL	Garbage_TBL	Garbage_TBL
Pseudo-R2	0.1724	0.1724	0.2827	0.2827
Observations	125,837	125,837	125,837	125,837

Source: PNADC/IBGE. The z-tests are in parentheses. ***p<1%,**p<5%,*p<10%.

7. Conclusion

The core of this study is the detailed examination of the intrinsic connection between the educational sphere and housing decisions that benefit from basic sanitation infrastructure in a broad and significant manner. This analysis is justified by the imperative need for a deep understanding of development policies, with a special focus on sectoral policies. It emphatically demands the recognition and understanding of the various stakeholders involved in the process, particularly highlighting the ultimate beneficiaries of the services enabled through public state policies. This study, therefore, aims to underline the importance of efficacy in the public resource allocation, seeking to ensure efficiency and equity in the use of these resources.

This study presents data that shows the positive correlation between education and the level of sanitation, expressing the relevance of the production factor in the quality of sanitation. For the year 1998, according to the estimated data from the PNAD, the group with at least a complete elementary school education comprises more than 60% of the household units that have full sanitation. a household where the resident has attained postgraduate education is 2.292 times more likely to reside in a dwelling connected to a general sewage network (San_RG) compared to a household where the resident has achieved education up to the primary level. The potential for education to serve as a mechanism for transforming sustainable sanitation must also be taken into consideration.

Throughout this study, it becomes evident that there is a growing demand for basic sanitation services in Brazil, which includes the supply of clean water, sanitary sewage, and garbage collec- tion/treatment. This demand is driven by population growth and an increase in service availability, albeit unevenly distributed across different regions of the country. Notably, metropolitan areas of major urban centers are the most favored in terms of infrastructure service availability.

It's in these very regions where higher levels of education are observed, further stimulating the pursuit of improved housing conditions with basic sanitation services. This, in turn, contributes to increased demand. However, the article also reveals an expansion of sanitation services in other regions of the country, as seen in Table 3, irrespective of educational levels.

Table 6 highlights a positive correlation between education and sanitation, emphasizing the importance of implementing public education policies to enhance both the availability and quality of these services. Tables 7, 8, and 9 clearly demonstrate how each additional year of education significantly influences household choices regarding their housing location and style. It's evident that factors such as electricity supply, public transportation availability, proximity to workplaces, and schools play roles in families' decisions to choose residences that provide clean water but may lack sewage systems, leading to the occasional use of septic tanks and nearby garbage disposal.

Upon examining the data presented throughout this study, along with the concurrently developed analyses, it is reaffirmed that the findings of this research establish a solid understanding of the pivotal role played by basic sanitation services (sanitary sewage, the supply of clean water, and garbage collection) in ensuring public health, economic development, and overall progress in a country.

There exists a close and inseparable relationship between public health and basic sanitation, a nearly symbiotic connection between infant mortality and basic sanitation, and, of course, a significant link between structural and transformative basic sanitation and social inequality. According to the data presented, we can further observe the interconnection between the subject of basic sanitation and the exacerbation of environmental issues, specifically, the environmental degradation resulting from excessive garbage disposal and imbalanced resource allocation.

This knowledge provides valuable insights for policymakers and stakeholders seeking to address the complex challenges associated with public health, sanitation, environmental preservation, and social equity.

It is evident that education, along with environmental and sanitary education, has the potential to drive the demand for an expanded sanitation service network and the secure implementation of environmental protection policies. This could set the pace and orchestration for a productive chain of providing a diversified, widespread network of basic sanitation services, encompassing the three pillars: the supply of clean water, sanitary sewage, and garbage collection.

Several articles that emphasize the critical need for the qualification of demanders were reviewed. Such qualification can stimulate the expansion of services and, as a positive outcome, enhance health indices, thereby extending longevity.

The estimated model for assessing the demand for basic sanitation aimed to model the closest determinants of this demand, using variables such as health, education, public health, and environmental and sanitary education. These variables constitute the framework defining the volume, significance, and magnitude of the demand for these services, reflecting the level of educational maturity and the exercise of citizenship within a society.

This underscores the significance of education, along with environmental and sanitary education, in driving the demand for an expanded sanitation service network and the secure implementation of environmental protection policies. This leads to an extensive demand line, setting the rhythm and coordination for a productive chain offering a diversified network of basic sanitation services, covering clean water supply, sanitary sewage, and garbage collection.

In this way, this article emphasizes that education is a determining factor in the choice of residences served by the basic sanitation network, as well as the need to ensure the right to collective consumption goods that drive development and improve the quality of life of a population.

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Authors Contributions

Dr. Paulo Loureiro and Dr. Mario Mendonça were responsible for study design and revising. Prof. Michel Constantino was responsible for data collection. Prof. Paulo Loureiro drafted the manuscript and Prof. Tito Moreira, Joaquim Ramalho e George Cunha revised it. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table 9. Variables from the 2019 PNAD in the multinomial model

Variable	Definition
Household Residents' Characteristics	
Sreal	Household per-capita monthly income
Education	Levels: primary, 1st degree, 2nd degree, higher and postgraduate
Household Characteristics	
House	1 if a house, 0 otherwise
Apartment	1 if an apartment, 0 otherwise
Electric	1 if electric power available, 0 otherwise
Water_MG	1 if water supply from the main grid, 0 otherwise
Sanitation_M G	1 if sanitation service from the main grid, 0 otherwise
Garbage_CD	1 if direct garbage collection, 0 otherwise
Bathroom	Number of exclusive-use bathrooms

Room	Rooms excluding bedrooms and bathrooms
Bedroom	Number of bedrooms
Regional Variables	
Urban	1 if in an urban area, 0 otherwise
MetroRegion	1 if in a Metropolitan Region, 0 otherwise
Northeast	1 if in the Northeast region, 0 otherwise
Southeast	1 if in the Southeast region, 0 otherwise
South	1 if in the South region, 0 otherwise
Midwest	1 if in the Midwest region, 0 otherwise
Sanitation Disposal	
San_RG	Sewage to the main grid
San_FSRG	Septic tank to the main grid
San_FSSE	Septic tank not to the grid
San_VRL	Disposal into ditches/sea/river (Reference Group)
Garbage Collection	
Garbage_CD	Direct collection
Garbage_CC	Collected in dumpster
Garbage_QE	Burned/buried on property
Garbage_TBL	Dumped in vacant lots/public areas (Reference Group)
Location	
Capital	1 if in the capital, 0 otherwise
Rest_MR	1 if in Rest of MR, 0 otherwise
Rest_RIDE	1 if in Rest of RIDE, 0 otherwise
Rest_State	1 if in Rest of State, 0 otherwise