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Influencing Factors for Sanitary Sewage in Brazilian Municipalities

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Summary- The objective of this work is to identify the main influential factors for the attendance of sanitary sewage in Brazilian municipalities, through a survey and quantitative analysis of secondary data. The justification is to contribute to a more systemic and integrated view of sanitary sewage services in the country and their potential causes linked to the context of infrastructure in the country. The conceptual framework pre-establishes relationships between total sanitary sewage care and independent variables related to the availability of sustainable inputs/technologies, nature and quality of institutions, human competences, financing, socio-environmental governance and sanitary administration. The methodology adopted is quantitative research, with random and stratified sampling of municipalities, applying correlation analysis and multivariate regression. The results of the research point to a positive correlation between the total sanitary sewage service and variables associated with the physical governmental structure and human relations existing in the health area.

Keywords: *sanitation, legislation, quantitative research.*

GJMBR-A Classification: *LCC Code: TD319.B6*

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Influencing Factors for Sanitary Sewage in Brazilian Municipalities

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Keywords: sanitation, legislation, quantitative research.

I. Introduction

The objective of this research is to identify the main influential factors for sanitary sewage care in Brazilian municipalities based exclusively on secondary data from the SNIS, [1]IBGE[2] and ANA[3]. It has the purpose, therefore, of better exploring the information contained in these secondary sources of high relevance to the database system of the Brazilian State.

Information collected from the SNIS (Brazil, 2022) confirms the magnitude of the deficit in sanitary sewage service, especially for the north and northeast regions of Brazil. Table 1 below presents the indicator of sanitary sewage service by region of the country, which consists of sanitary sewage service referred to the population that has water supply. The source of this indicator is the SNIS (Brazil, 2022), with 2021 data as the reference year.

Table 1: Sanitary Sewage Service by Region in 2022

Region	Total Service
North	13,98%
Northeast	30,20%
Central-West	61,88%
Southeast	81,67%
South	48,43%

Source: prepared by the author (2023)

It is noted that the percentages of sanitary sewage service remain very low in the North and Northeast regions and still below 50% in the South region. This scenario configures a still very strong demand for sanitary sewage services in the country.

What factors may be most related to this deficit of sanitary sewage in Brazil? Several authors point to causal factors related to the implementation of infrastructures, which requires a degree of concertation between organizations and institutions to materialize. There are four main factors: 1) Availability of sustainable inputs and technologies (John et.al., 2001; John, 2017; Hepburn et.al, 2020; Banhe & Lopes, 2019); 2) Nature and Quality of Institutions (Kelly, 2016; Acemoglu & Robinson, 2012; Eisler, 2008; Zylberstain, 2005; North, 1990; Ostrom, 1990); 3) Human Competencies (Novelli, 2004; Pires, 2004; Lotta & Favareto, 2016) and 4) Socio-environmental governance to be conceived and practiced in a systemic way (Dias & Seixas, 2018; Ferreira & Seixas, 2017; Badalotti & Carmelatto, 2016; Davis, 2005), with the assumption of developing around the concept of generating shared value, based on the coordination of institutional arrangements (Kramer & Pfizer, 2017; Villar, 2016; Pires, 2004; McCain, 2017; Lotta & Favaretto, 2016). For the specific case of sanitary sewage infrastructures, it is worth adding an equally relevant causal factor: sanitary administration, deeply analyzed by Uhr, et.al. (2016).

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[1] SNIS – National Sanitation Information System. Linked to the Ministry of Integration and Regional Development - http://antigo.snis.gov.br/
[2] IBGE – Brazilian Institute of Geography and Statistics. Linked to the Ministry of Planning and Budget - https://www.ibge.gov.br/estatisticas/sociais/saude/9221-sintese-de-indicadores-sociais.html
[3] ANA – National Water and Basic Sanitation Agency. Linked to the Ministry of Integration and Regional Development - https://www.gov.br/ana/pt-br

By evaluating a set of indicators related to the factors pointed out above, all referring to the year 2021, this quantitative research contributes to a more systemic and integrated view of sanitary sewage services in the country and their potential causes, which may subsidize more effective public policies to achieve the universalization goals set for 2033.

II. Methodology

a) Sample Size

The definition of the sample size followed the methodological guidelines derived from Oliveira (2018), according to which the sample size N is given by:

$$N = \alpha^2 X z/ \xi^2 \qquad \text{Equation (1)}$$

α = standard deviation of a stratified random sample of 60 values of sanitary sewage service for 60 municipalities. The value obtained was 29.57.

z = 1.645 for a significance level of 90% for the results;

ξ = maximum allowable percentual error (+- 5%)

Substituting these values into the equation, we get an N = 94.6. Thus, a sample size of 100 municipalities will be used.

b) Definition of Sampling

Once the sample size was obtained, the municipalities that will constitute it were defined. For this, the stratified random sampling method was used (Cohen, 1988), which consists of the random selection of municipalities within each Brazilian region and state. This selection followed the proportionality of municipalities according to their population ranges, by state and Brazilian regions, according to data from the SNIS (Brasil, 2022). The specific selection of municipalities according to the criteria defined above was made based on a random function existing in Excel.

Table 2 below presents the definition of the sample of 100 municipalities and the respective values of total sanitary sewage service.

Table 2: Total Sewage Service Values (Population Served by Total Population Receiving Water Supply) for the Sample of 100 Brazilian Municipalities.

REGIÃO	ESTADO	MUNICÍPIO	Número de habitantes	INDICADORES - SNIS - 2021*
				Atendimento total (%)
SUDESTE	MINAS GERAIS	Itinga	10 a 20 mil	33,97
		Novo Cruzeiro	20 a 50 mil	30,40
		Formiga	50 a 100 mil	91,75
		Leopoldina	50 a 100 mil	99,13
		Betim	100 a 500 mil	78,11
		Ituiutaba	100 a 500 mil	95,84
		Nova Serrana	100 a 500 mil	73,56
		Belo Horizonte	Mais de 500 mil	93,98
		Contagem	Mais de 500 mil	81,32
		Juiz de Fora	Mais de 500 mil	94,67
		Uberlândia	Mais de 500 mil	98,24
	SÃO PAULO	Araçoiaba da Serra	20 a 50 mil	92,16
		Pirajuí	20 a 50 mil	99,22
		Lençóis Paulista	50 a 100 mil	97,76
		Mococa	50 a 100 mil	100,00
		Atibaia	100 a 500 mil	74,10
		Itatiba	100 a 500 mil	85,29
		Jaú	100 a 500 mil	97,94
		Pindamonhangaba	100 a 500 mil	100,00
		Santos	100 a 500 mil	99,93
		Campinas	Mais de 500 mil	94,77
		Guarulhos	Mais de 500 mil	92,29
		Mauá	Mais de 500 mil	92,91
		Osasco	Mais de 500 mil	100,00
		Ribeirão Preto	Mais de 500 mil	99,31
		Santo André	Mais de 500 mil	100,00
		São Bernardo	Mais de 500 mil	98,53
		São José dos Campos	Mais de 500 mil	99,60
		São Paulo	Mais de 500 mil	100,00
		Sorocaba	Mais de 500 mil	98,22
	RIO DE JANEIRO	Arraial do Cabo	20 a 50 mil	80,12
		Rio Bonito	50 a 100 mil	72,38
		Resende	100 a 500 mil	95,08
		São Pedro da Aldeia	100 a 500 mil	80,12
		Duque de Caxias	Mais de 500 mil	37,49
		Rio de Janeiro	Mais de 500 mil	89,95
		Nova Iguaçu	Mais de 500 mil	55,93
	ESPIRITO SANTO	Vitória	100 a 500 mil	60,52
NORDESTE	BAHIA	Itagueçu da Bahia	10 a 20 mil	41,36
		Camamu	20 a 50 mil	6,26
		Santa Cruz Cabrália	20 a 50 mil	44,84
		Irecê	50 a 100 mil	15,03
		Alagoinhas	100 a 500 mil	36,07
		Santo Antonio de Jesus	100 a 500 mil	21,31
		Salvador	Mais de 500 mil	88,36
		Feira de Santana	Mais de 500 mil	55,37
	CEARÁ	Jijoca de Jericoacoara	20 a 50 mil	9,78
		Boa Viagem	50 a 100 mil	39,40
		Iguatu	100 a 500 mil	15,63
		Juazeiro do Norte	100 a 500 mil	24,14
		Fortaleza	Mais de 500 mil	55,95
	PERNAMBUCO	Panelas	20 a 50 mil	54,45
		Paulista	100 a 500 mil	54,21
		São Lourenço da Mata	100 a 500 mil	30,06
		Jaboatão dos Guararapes	Mais de 500 mil	21,64
		Recife	Mais de 500 mil	44,99
	MARANHÃO	Pedreiras	20 a 50 mil	30,26
		Bacabal	100 a 500 mil	4,60
		São Luís	Mais de 500 mil	49,85
	PIAUÍ	José de Freitas	20 a 50 mil	4,41
		Teresina	Mais de 500 mil	38,79
	PARAÍBA	São José de Piranhas	20 a 50 mil	49,56
		João Pessoa	Mais de 500 mil	83,55
	ALAGOAS	Igaci	20 a 50 mil	19,53
		Maceió	Mais de 500 mil	23,73
	RIO GRANDE DO NORTE	Currais Novos	20 a 50 mil	63,06
		Natal	Mais de 500 mil	43,78
	SERGIPE	Nossa Senhora do Socorro	100 a 500 mil	32,32
NORTE	PARÁ	Ponta de Pedras	20 a 50 mil	15,93
		Redenção	50 a 100 mil	5,34
		Castanhal	100 a 500 mil	0,73
		Belém	Mais de 500 mil	17,12
	AMAZONAS	Carauari	20 a 50 mil	20,89
		Manaus	Mais de 500 mil	25,45
	RONDÔNIA	Porto Velho	Mais de 500 mil	5,80
	TOCANTINS	Palmas	100 a 500 mil	29,15
SUL	SANTA CATARINA	Mafra	50 a 100 mil	27,66
		Itajaí	100 a 500 mil	28,16
		Jaraguá do Sul	100 a 500 mil	84,97
		Florianópolis	Mais de 500 mil	65,71
	RIO GRANDE DO SUL	Frederico Westphalen	20 a 50 mil	34,07
		Ijuí	50 a 100 mil	19,66
		Viamão	100 a 500 mil	5,97
		Rio Grande	100 a 500 mil	31,76
		Santa Maria	100 a 500 mil	62,90
		Caxias do Sul	Mais de 500 mil	89,10
		Porto Alegre	Mais de 500 mil	91,62
	PARANÁ	Francisco Beltrão	50 a 100 mil	84,63
		Guarapuava	100 a 500 mil	94,71
		Toledo	100 a 500 mil	93,68
		Umuarama	100 a 500 mil	99,99
		Curitiba	Mais de 500 mil	99,98
		Londrina	Mais de 500 mil	99,98
CENTRO-OESTE	GOIÁS	Ipora	20 a 50 mil	49,19
		Valparaíso de Goiás	100 a 500 mil	51,80
		Aparecida de Goiania	Mais de 500 mil	58,69
	MATO GROSSO	Peixoto de Azevedo	20 a 50 mil	48,01
		Cuiabá	Mais de 500 mil	76,43
	DISTRITO FEDERAL	Brasília	Mais de 500 mil	91,77
	MATO GROSSO DO SUL	Dourados	100 a 500 mil	85,90

Source: prepared by the author (2023)

To arrive at the data presented in Table 2, it was necessary to redo random series as follows:

1) Of the 100 municipalities initially selected, 13 did not present data on total sanitary sewage attendance, and of these 13, 9 had no response to this specific item and 4 did not respond to the IBGE questionnaire.
2) In the states of Pará and Maranhão, 8 random programs were needed to reach municipalities with the necessary data;

Other states presented a need for 1 to 3 new randomizations to reach municipalities with the necessary data.

c) Definition of the Analytical Model

From the definition of the causal factors described in item 1 – Introduction – the most specific causal components were established, according to the main elements existing in the theoretical framework related to such causal factors. Due to these causal components, we searched among the secondary data existing in the IBGE (Brazil, 2021b) and ANA (Brazil, 2021a), the indicators that could best measure such causal components. The correspondence between the indicators used from the IBGE and ANA and the causal factors is presented in Chart 1 below. Among all the indicators, the only indicator obtained from ANA (Brasil, 2021a) was the one described in the causal factor "Governance", in the causal component "Coordination Capacity", called "Entity providing the service (State, municipality, private)".

TARGET	CAUSAL FACTORS	CAUSAL COMPONENTS	INDICATORS (IBGE)	
			DESCRIPTION	CODE
ACCESS TO SUSTAINABLE SANITATION	INSTITUTIONS	Regulation and Legal Security	Existence of Master Plan	MLEG01
			Year of the creation of the law	MLEG011
			Revised Plan	MLEG012
			Year of the last revision	MLEG013
			Plan in preparation	MLEG014
			Existence of Legislation - area and/or special zone of social interest (ZEIS)	MLEG02
			Year of the law	MLEG021
			Existence of Legislation - zoning or land use and occupation (ZUOS)	MLEG06
			Year of the law	MLEG061
			Existence of Legislation - environmental/economical/ecological zoning	MLEG12
			Year of the law	MLEG121
	HUMAN SKILLS	Interpersonal and interinstitutional relationships of trust	Existence of Education Municipal Counsil	MEDU22
			Year of creation	MEDU221b
			Education counsil: number of meetings in the last 12 months	MEDU24
			Existence of Cultural Municipal Counsil	MCUL19
			Year of creation	MCUL191b
			Cultural counsil: number of meetings in the last 12 months	MCUL21
			Existence of local radio	MCUL373
			Existence of local communitary radio	MCUL375
			Existence of Sport Municipal Counsil	MESP10
			Year of creation	MESP101b
			Sport counsil: number of meetings in the last 12 months	MESP12
			Existence of Health Municipal Counsil	MSAU10
			Year of creation	MSAU101b
			Health counsil: number of meetings in the last 12 months	MSAU12
		Managerial and technical training	Number of training programs for Education Counsil (last 2 years)	MEDU26a
			Frequent training for Health Counsil	MSAU141
		Management of Intersectoral Partnerships	Existence of Health Communitary Agents Program	MSAU28
			Number of Health Communitary Agents	MSAU281
			Existence of Family Health Program	MSAU29
			Existence of similar program as Family Health Program	MSAU31
	FINANCING	Attractiveness to the investors	Existence of Construction Code	MLEG11
			Year of the law	MLEG111
	SUSTAINABLE INPUTS/TECHNOLOGIES	Technologies and Inputs	Existence of Internet Provider	MCUL378
		Sanitary Administration	Health surveillance	MSAU541
			Epidemiological surveillance	MSAU542
			Endemic disease control	MSAU543
	GOVERNANCE	Coordination Capacity	Service provider entity (Estate, Private, Municipal)	Prest.Serv.
			The public healty sector takes part in some Regional Management Meeting	MSAU19
			Number of Regional Management Meetings in the last 12 monts	MSAU191

Source: prepared by the author (2023)

Chart 1: Indicators Derived from IBGE and ANA Data Corresponding to the Components and Causal Factors of Total Sanitary Sewage Service in Brazilian Municipalities.

The relationships between the indicators from the IBGE and ANA with the components and causal factors of the analytical model adopted are as follows:

1) *Regulation and Legal Certainty:* This component will be measured through the existence of legislation relevant to the subject of sanitary sewage, such as those related to the Master Plan, Special Zones of

Social Interest (ZEIS), Zoning or Land Use and Occupation (ZUOS) and Ecological-Economic Zoning (ZEE).

2) *Interpersonal and Inter-institutional Relationships of Trust:* this component will be measured through data on the existence and functioning of Municipal Councils of Education, Health, Culture and Sport, in addition to local radio stations. The existence and functioning of such councils and local radios are related to the social capital that exists in the municipality, to the extent that they are spaces for social participation where connections are established and developed. The relationship between social capital and trust follows, in turn, the orientation of Putnam (2006) who demonstrates that "stocks of social capital, such as trust, norms and systems of participation, tend to be cumulative and mutually reinforcing" (Putnam, 2006, p. 186). From this perspective, a virtuous development would result from high levels of cooperation, trust and reciprocity, built from the capacity of society to organize itself with a view to collective well-being (Ortega & Matos, 2013).
3) *Managerial and Technical Training:* This component will be measured through the data on the existence of training in the municipalities, especially in the areas of education and health. Such areas tend to have greater influences on the development of local infrastructures.
4) *Management of Intersectoral Partnerships:* This component will be measured through data on the existence and operation of City Hall Programs that require the concertation of alliances between members of the government and organized civil society, as is the case of Family Health Programs and Community Health Agents.
5) *Attractiveness for the Investor:* This component will be measured through the existence and operation of the municipality's Construction Code, considering that this procedure is fundamental for the attraction and consolidation of housing and sanitation investments in the municipalities.
6) *Technology and Inputs:* This component will be measured through the existence and operation of a minimum technological infrastructure for the organization of information, which, in this case, refers to the municipality having an internet provider available for the platform of its services.
7) *Sanitary Administration:* This component will be measured through the existence of adequate controls for sanitary surveillance, epidemiology and endemic control.
8) *Coordination Capacity:* This component will be measured through the existence and functioning of the type of entity providing sanitary sewage service present in the municipality and the existence of interdisciplinary discussion spaces such as the Regional Management Collegiate.

d) Statistical Procedures

Based on the data regarding sanitary sewage present in the SNIS, by municipality - sewage collection, treated sewage, urban sanitary sewage service and total sanitary sewage service - it was decided to define the dependent variable as only the total sanitary sewage service, as it expresses the desired final result regarding the implementation of the service. The independent variables were collected from the IBGE and ANA and presented in Chart 1. The following statistical procedures were necessary to prepare the database relating the dependent variable to the independent variables, by municipality in the sample:

1) Transformations of categorical variables into numerical variables. Chart 2 below shows the transformation of categorical variables into numerical variables. After these transformations, the assigned values were entered into the database.

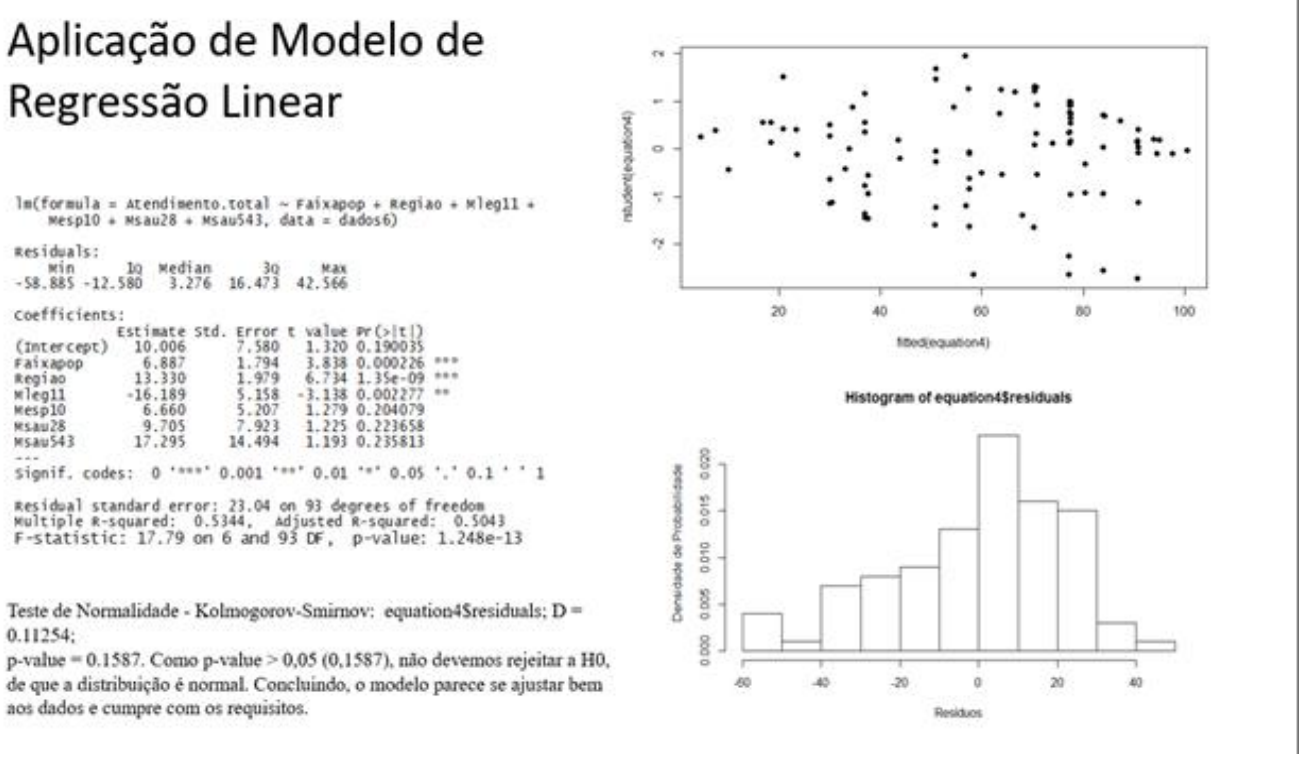
Codificação variáveis categóricas			
Variável	Código variável	Valores	Descrição
Faixa de população	Faixa_pop	0	10000 a 20000
		1	20001 a 50000
		2	50001 a 100000
		3	100001 a 500000
		4	Maior que 500000
Região	Região	0	Norte
		1	Nordeste
		2	Centro-oeste
		3	Sudeste
		4	Sul
Prestador do serviço	Prestador	0	Estatal
		1	Prefeitura
		2	Privada
Existência Plano Diretor	MLEG01	0	Sim
		1	Não
Plano Diretor revisto	MLEG012	0	Sim
		1	Não
Existência ZEIS	MLEG02	0	Sim, legislação específica
		1	Não
		2	Sim, parte Plano Diretor
Existência ZUOS	MLEG06	0	Sim, legislação específica
		1	Não
		2	Sim, parte Plano Diretor
Existência Código de Obras	MLEG11	0	Sim, legislação específica
		1	Não
		2	Sim, parte Plano Diretor
Existência ZEE	MLEG12	0	Sim, legislação específica
		1	Não
		2	Sim, parte Plano Diretor
Existência Conselho Municipal Educação	MEDU22	0	sim
		1	não
Existência Conselho Municipal Cultura	MCUL19	0	sim
		1	não
Existência Radio AM local	MCUL373	0	sim
		1	não
Existência Rádio Comunitária local	MCUL375	0	sim
		1	não
Existência provedor de internet	MCUL378	0	sim
		1	não
Existência Conselho Municipal Esportes	MESP10	0	sim
		1	não
Existência Conselho Municipal Saúde	MSAU10	0	sim
		1	não
Realização periódica de capacitação para o Conselho da Saude	MSAU141	0	sim
		1	não
Órgão gestor saúde parte Colegiado Regional	MSAU19	0	sim
		1	não
Existência Agentes Comunitários Saúde	MSAU28	0	sim
		1	não
Existência Programa da Saúde da Família	MSAU29	0	sim
		1	não
Vigilância Sanitária	MSAU541	0	sim
		1	não
Vigilância Epidemiológica	MSAU542	0	sim
		1	não
Controle de endemias	MSAU543	0	sim
		1	não

Source: prepared by the author (2023)

Chart 2: Coding of the Categorical Variables of the Model

1) *Application of Correlations between Variables in the R Programming Language:* From the first application of the correlations between variables of the model, the following removal of indicators was made:
   a. *Indicators without Correlation:* indicators that had a correlation very close to zero were removed. The correlation tool itself eliminates the variables without any correlation.
   b. *Indicators of Dependent Variables with Correlation between them – Collinearity Test:* Dependent indicators that present a strong correlation with each other were removed.
   c. *Outlier Present in the Variable Msau191:* After removing this outlier, this variable no longer showed correlation and was eliminated from the model.

After adjustments to the database reported in items 1 and 2 above, a multivariate regression analysis was performed with the remaining dependent and independent variables. Figure 1 below presents the main results of the regression analysis, normality tests and respective graphs that support the feasibility of using the proposed model:



Aplicação de Modelo de Regressão Linear

```
lm(formula = Atendimento.total ~ Faixapop + Regiao + Mleg11 +
    Mesp10 + Msau28 + Msau543, data = dados6)

Residuals:
     Min       1Q   Median       3Q      Max
-58.885 -12.580   3.276  16.473  42.566

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   10.006      7.580   1.320 0.190035
Faixapop       6.887      1.794   3.838 0.000226 ***
Regiao        13.330      1.979   6.734 1.35e-09 ***
Mleg11       -16.189      5.158  -3.138 0.002277 **
Mesp10         6.660      5.207   1.279 0.204079
Msau28         9.705      7.923   1.225 0.223658
Msau543       17.295     14.494   1.193 0.235813
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 23.04 on 93 degrees of freedom
Multiple R-squared:  0.5344,    Adjusted R-squared:  0.5043
F-statistic: 17.79 on 6 and 93 DF,  p-value: 1.248e-13
```

Teste de Normalidade - Kolmogorov-Smirnov: equation4$residuals; D = 0.11254;
p-value = 0.1587. Como p-value > 0,05 (0,1587), não devemos rejeitar a H0, de que a distribuição é normal. Concluindo, o modelo parece se ajustar bem aos dados e cumpre com os requisitos.

Source: Prepared by the author (2023)

Figure 1: Application of the Linear Regression Model

III. Results and Discussion

a) Analysis of Correlations

All the results obtained in the correlation analyses are presented in Table 3 – which shows the most representative correlation coefficients between the variables of the model. In view of the selection of only the dependent variable "total sanitary sewage attendance" as representative, Figure 2 consolidates the possible causal relationships between this dependent variable and the independent variables. It was decided to consider correlations > 0.30 to identify significant and explanatory relationships for the phenomenon of total sanitary sewage attendance. According to Cohen (1988), values between 0.10 and 0.29 can be considered small; values between 0.30 and 0.49 can be considered moderate; and values between 0.50 and 1 can be interpreted as strong. Dancey and Reidy (2005) point to a more rigorous classification: r = 0.10 to 0.30 (weak); r = 0.40 to 0.6 (moderate); r = 0.70 to 1 (strong). Considering that we are facing an integrated and interdisciplinary phenomenon, correlations between variables > 0.30 were defined as significant for the analysis, which for both authors frame the correlations obtained in this study as between moderate and strong.

Table 3: Most Representative Pearson's Correlation Coefficients between Variables

Correlações	Pearson
Coleta de esgoto X Atendimento Total	0,8549
Coleta de esgoto X Região	0,4122
Coleta de esgoto X Atendimento Urbano	0,8960
Atendimento Urbano X Atendimento Total	0,9363
Atendimento Urbano X Região	0,5828
Atendimento Total X Faixapop	0,4464
Atendimento Total X Região	0,6226
Atendimento Total X Mleg06	-0,3171
Faixapop X Msau13	0,5045
Faixapop X Mleg06	-0,3262
Faixapop X Medu24	0,3487
Mleg02 X Mleg06	0,3630
Mleg02 X Mleg12	0,4143
Mleg06 X Mleg12	0,3684
Mleg11 X Medu22	0,3994
Mleg11 X Msau10	0,3994
Mesp10 X Região	0,3192
Mesp10 X Msau13	-0,3459
Msau191 X Msau28	0,3282
Msau191 X Msau29	0,5964
Msau28 X Msau543	0,3129
Msau541 X Msau542	0,7035
Msau542 X Msau543	0,3936

Source: Prepared by the author (2023)

Based on these main Pearson correlation coefficients, it was possible to establish a graph of possible causal relationships between the dependent variable "total sewage attendance" and the independent variables with the highest correlation.

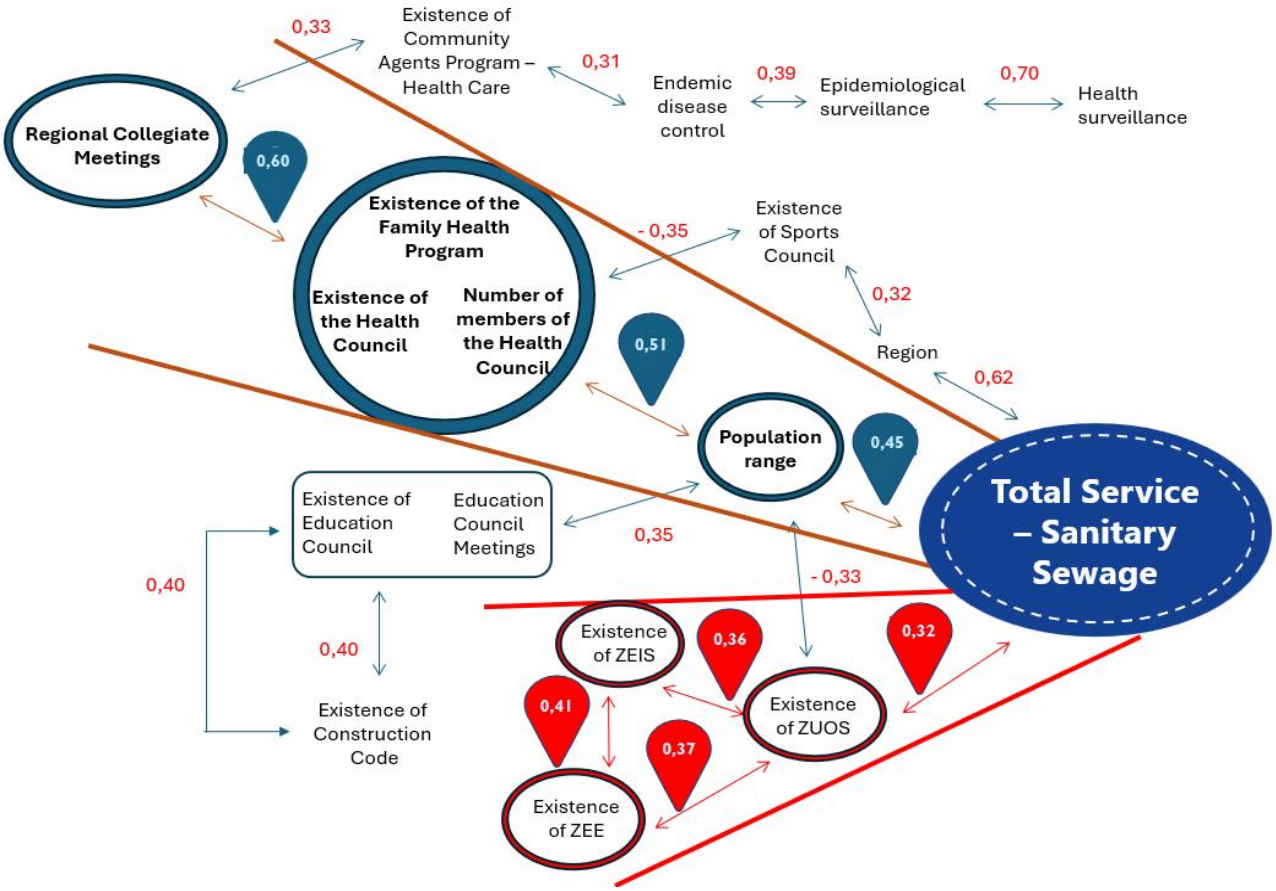


Figure 2: Main Correlations between Variables of the Applied Model

Figure 2 shows two causal analytical propositions (green and red paths identified) of the phenomenon of total sanitary sewage service in Brazilian municipalities.

The first (green), with positive correlations, attests to a direct positive relationship between the population groups and the total sanitary sewage service, which points in the direction that more populous municipalities tend to have better sanitary sewage service. The population ranges also have a positive correlation with existing health structures in operation in the municipalities. The existence of the Family Health Program, the existence of the Health Council, with the number of its respective members, denote, in turn, a certain degree of social capital in the health area. Finally, this health structure in the municipalities has a strong correlation with the participation of these professionals and their institutions in territorial collegiate meetings, which may be related to a more adequate design of intersectoral governance.

A second analytical proposition (red), with a negative correlation, presents a negative relationship between the total sanitary sewage service and the existence and operation of the Land Use and Occupation Zoning. This legislation, in turn, has positive planning (Special Zones of Social Interest and Ecological-Economic Zoning). This may be related to the fact that, although the municipalities have been evolving from the institutional point of view, regarding the enactment of zoning laws and building codes, this evolution does not seem to be integrated into effective sanitary sewage projects in the municipalities.

b) Multivariate Linear Regression Analysis

After the methodological procedures described, it was possible to propose a linear regression model, with the following equation, to estimate the Total Sanitary Sewage Service (ATES):

$$ATES = 10{,}006 + 6{,}887*Faixapop + 13{,}330*Região - 16{,}189*Mleg11 + 6{,}660*Mesp10 + 9{,}705*Msau28 + 17{,}295*Msau543 \quad \text{Equation (2)}$$

Rangepop = Population range

Region = Region of Brazil to which the municipality belongs

Mleg11 = Existence of the Construction Code in the municipality

Mesp10 = Existence of a Municipal Sports Council in the municipality

Msau28 = Existence of a Community Health Agents Program in the municipality

Msau543 = Endemic disease control

It should be noted that the proposed equation can explain about 53% of the variation in the total sewage service, but it was presented, in the Kolmogorov-Smirnov normality test, as adjusted to the data and complying with the requirements of normality in the distribution of variances.

IV. Conclusions

Specifically dealing with total sanitary sewage care in Brazilian municipalities, it is appropriate to frame the analysis of its causes in a theoretical-conceptual framework that provides a systemic, integrated and interdisciplinary view. In the end, it is not only good sanitary sewage infrastructure projects that are missing to achieve universalization in the care of the Brazilian population. There is a need to evaluate variables of the institutional spectrum, attractiveness for investment, human relations, availability of inputs/technologies and governance standards.

The present study aimed to make a quantitative analysis of interdisciplinary variables in order to identify the main factors that contribute to the effective implementation of sanitary sewage in Brazilian municipalities. The results confirm a positive correlation with variables associated with social capital and trust relationships in the municipalities, especially in the areas of health and education. This demonstrates that the municipality's capacity to implement sanitary sewage is also associated with the physical and human structure of related areas such as health, where sanitary administration plays an important role in endemic controls, which are directly related to the lack of basic sanitation. The data, therefore, indicate that adequate health infrastructures can support the implementation of sanitary sewage.

On the other hand, negative correlations between total sanitary sewage service and legislation aimed at the ecological, economic and social zoning of localities may signal how much these laws are failing to be integrated into sanitation infrastructures and, thus, guarantee, in fact, better living and housing conditions for the populations.

In view of the indication that human relations variables are influential in the process, it is suggested that future referrals of this research include a quantitative study with a larger number of municipalities and, mainly, that the quantitative studies be complemented with qualitative analyses that can deepen the understanding of the relationships involved. In addition, it is necessary to investigate more deeply the theoretical-conceptual framework of trust relationships in order to have a greater and more accurate understanding of their influence on the process.

Despite the limitations of the models used - as well as relative imprecision in the measurement of some causal components, such as trust/social capital relations, managerial and technical training, partnership management, inter-institutional coordination capacity and data availability/processing - the research presented here represents a kick-off in the holistic and integrated understanding of the phenomenon of sanitary sewage in the country and its causes.

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