Original articles

Cervical cancer and sanitation components in the municipalities of the state of Mato Grosso do Sul: would it be a question of poor water quality?

Câncer de colo de útero e componentes de saneamento nos municípios do estado do Mato Grosso do Sul: seria uma questão de má qualidade da água?

Julio Cesar Barreto Silva[a]
https://orcid.org/0000-0003-1811-683X
E-mail: barretojcs@gmail.com

Carlos José Saldanha Machado[b]
https://orcid.org/0000-0001-7642-1379
E-mail: carlos.saldanha@fiocruz.br

Daniele Gonçalves Nunes[c]
https://orcid.org/0000-0001-7644-3770
E-mail: daniele.nunes@ifrj.edu.br

[a]Universidade do Estado do Rio de Janeiro. Programa de Pós-Graduação em Meio Ambiente. Rio de Janeiro, RJ, Brasil.

[b]Fundação Oswaldo Cruz. Instituto de Comunicação e Informação Científica e Tecnológica em Saúde. Rio de Janeiro, RJ, Brasil.

[c]Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro. Rio de Janeiro, RJ, Brasil.

Abstratct

This article investigates relationships between the incidence of cervical cancer (CCI) and the water components and quality indicators, in the municipalities of Mato Grosso do Sul, between 2014 and 2017, by statistical (Pearson's Determinant) and spatial (k-means Clustering) correlation. There was a greater statistical response of CCI in relation to the average tariff of the practiced supply (-36.28%) and water (-34.15%) services; the number of their systematic interruptions (28.3%) and outages (22.28%); the average per capita consumption of water (20.74%); and the number of services performed (-17.98%), all answers under p-value ≤ 0.001. In Costa Rica, city with the highest average CCI, the spatial clustering identified a greater effect of those interruptions (z-value = 8.741) and outages (z = 7.6097); whereas, in Rochedo, also under high CCI, the analyses showed greater effect with non-standard results for total coliforms (z = 8.6803) and turbidity (z = 5.7427), under a statistical correlation of 12.05% (p-value = 0.032) and 15.18% (p-value = 0.007), respectively. Data from SISAGUA revealed the presence of coliforms and high levels of turbidity, for example, in Antônio João and Tacuru, cities with high average ICC. We recommend further investigation into the relationships presented here between CCI and water.

Keywords: Cervical Cancer; Spatial Clustering; Pearson's Correlation; k-means; Environmental Sanitation.

Correspondence
Julio Cesar Silva
Rua São Francisco Xavier. 524, Bloco F sala 12.005. Rio de Janeiro, RJ, Brazil, CEP 20550-900.

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Resumo

Este artigo investiga relações entre a incidência de câncer de colo de útero (ICC) e os componentes e indicadores de qualidade da água nos municípios do Mato Grosso do Sul, entre 2014 e 2017, por correlação estatística (Determinante de Pearson) e espacial (agrupamentos por *k*-médias). Houve maior resposta estatística de ICC em relação à tarifa média dos serviços de abastecimento praticado (-36,28%) e de água (-34,15%); à quantidade de suas interrupções sistemáticas (28,3%) e paralizações (22,28%); ao consumo médio per capita de água (20,74%) e à quantidade de serviços executados (-17,98%), todas as respostas sob *p*-valor ≤ 0,001. Na Costa Rica, cidade sob maior ICC média, os agrupamentos espaciais identificaram maior efeito daquelas interrupções (z-valor = 8,741) e das paralizações (z = 7,6097); enquanto em Rochedo, também sob alta ICC, houve maior efeito à incidência de análises com resultados fora do padrão para coliformes totais (z = 8,6803) e turbidez (z = 5,7427), sob correlação estatística de 12,05% (p-valor = 0,032) e 15,18% (p-valor = 0,007), respectivamente. Dados do SISAGUA revelaram a presença de coliformes e de altos níveis de turbidez, por exemplo, em Antônio João e Tacuru, cidades sob altas ICC médias. Recomenda-se maiores investigações sobre as relações aqui apresentadas entre ICC e água.

Palavras-chave: Câncer de Colo de Útero; Clustering Espacial; Correlação de Pearson; *K*-médias; Saneamento Ambiental.

Introduction

Cervix uteri cancer, also called cervical cancer (CC), is a malignant neoplasm that affects 570,000 new cases per year worldwide. It is the fourth most frequent type of cancer among women, including in the number of deaths, with about 311 thousand deaths per year worldwide. 90% of these, above all, in women belonging to countries with a low human development index; although there is a reduction in its incidence in countries undergoing economic development and/or whose government has implemented effective prevention and control programs for the disease, such as in Brazil (INCA, 2021; Bray *et al.*, 2018).

While this neoplasm has several aspects involved in its etiology, the infection is primarily caused by the Human Papillomavirus (HPV), especially the types HPV-16 and HPV-18, responsible for about 70% of cervical cancers (Bruni *et al.*, 2019).

In Brazil, in 2020, there were 626,030 new cases of cancer per year, 50.52% of these in women, with CC being the fourth-highest rate, with 16,710 new cases (7.5%) and estimated risk of disease incidence (CCI) of 15.38 cases per 100,000 women, with emphasis on the Brazilian North region (CCI = 23.97), followed by the Central-West (CCI = 20.72), Northeast (CCI = 19.49), Southeast (CCI = 11.3), and South (CCI = 15.17) (INCA, 2021).

For Soares, Bernardo, and Netto (2002), understanding the triad “sanitation-public health-environment” is fundamental for planning supply systems in urban centers. Evaluating their combined effects ensures correct analysis of the possible alternatives, both from the environmental and public health point of view (primary object of sanitation). It gathers essential elements for formulating a model that promotes well-being and improves the population’s quality of life.

Over the years, it can be seen that the purpose of sanitation projects has moved from its classical sanitary conception (which considers it only a matter of public health) to a predominantly environmental one. It aims to promote the individual’s health and the conservation of the physical and biotic environment), using criteria, for example, related to socioeconomic issues (Pimentel; Cordeiro Netto, 1998).

In Brazil, fundamental and environmental sanitation actions are well defined, especially concerning the recommendations for their implementation and management, in a sustainable way to promote health and reduce social inequalities (Brasil, 2007; 2020). However, their application is still insufficient, with 35 million Brazilians without access to treated water (Carneiro *et al.*, 2018; SNIS, 2019) and, sometimes, with a precarious structure, state omission, and interests disconnected from the provision of services (Prado, Meneguim, 2018, p. 25).

Concerning public health, vulnerable and disadvantaged groups are the most affected by waterborne diseases (UNESCO, 2019).

In 2007, the Brazilian Congress approved Law No. 11,445, which establishes national guidelines for basic sanitation, intending to ensure, among others, water supply and sanitary sewage. Furthermore, in an attempt to coordinate efforts, the law gave the Union the competence to prepare the National Basic Sanitation Plan. Although its current version, written in 2014, sets the universalization of water supply and the service of 92% of the population with a sanitary sewage network, with deadlines in 2023 and 2033, everything indicates that these will not be fulfilled.

In 2015, the UN recognized basic sanitation as a human right. The public authorities had the duty to make investments in the sector viable, given that the maintenance of the current infrastructure is blatantly insufficient and a national shame (PSB, 2019). According to the National Health Foundation (FUNASA, 2004), associated with this right, the concept of health promotion, proposed by the WHO, is seen worldwide as the guiding principle of health actions. It assumes that the environmental conditions are its most important determinants, being understood as a state of complete physical, mental, and social well-being, which does not restrict the health problem to diseases.

Also, according to FUNASA (2004), the use of sanitation as a health promotion tool presupposes overcoming the technological, political, and managerial obstacles that have made it difficult to extend the benefits to residents in rural areas and small towns.

Nationally, Trenkel and Chaves Maia (2016) observed, between 2003 and 2014, a considerable increase in the number of new cases of cancer in the state of Mato Grosso do Sul (MS) compared to recent years (2012-2014). Concerning the female gender, the most frequent neoplasms were non-melanoma skin cancer, breast câncer, and CC.

This work seeks to investigate the relationships of the CCI to the water components and their quality indicators, by statistical correlation (via Pearson's determinant) and spatial correlation (through clusters by k-means, via GeoDa), in the municipalities of the State of MS, between 2014 and 2017. The information used here is part of a study that is characterized as a quantitative-qualitative, cross-sectional, and descriptive epidemiological study.

Materials and methods

Characterization of the study area: Mato Grosso do Sul

According to the IBGE (2019), the state of MS had, in 2019, about 2,773,590 inhabitants (50.37% female), equivalent to 1.32% of the Brazilian population (51.10% female), and a growth rate of 1.13%, while the Brazilian one was 0.79%. With 68.51% of its population aged between 15 and 64 years old, 22.89% were young people aged up to 14 years old, which reflected the Brazilian reality, with 69.38% and 21.10%, respectively. Life expectancy was 79.94 years for women and 72.88 for men, i.e., very similar to the Brazilian life expectancy of 80.03 and 73.0, respectively. The same trend was also reflected in the crude birth and mortality rates, 15.97% and 6.08% (MS) and 14.2% and 6.51% (Brazil). The MS aging rate is less pronounced (37.55%) than the Brazilian rate (45.02%); opposite to the fertility rate, 2.02% and 1.77%, respectively.

Data collection

Annual data referring to each of the 79 municipalities in the MS, from 2014 to 2017, were used in this study, namely:

a) Diagnosed cases of CC from the Cancer Information System - SISCAN, of the Department of Informatics of the Unified Health System – DATASUS[1];
b) Population size, per resident (inhabitant) population; information belonging to the IBGE but collected via SNIS (2019);
c) Two hundred twenty indicators on sanitation, also from the SNIS (2019). Information (definitions, calculations, and constitutions) referring to the indicators used here are available on the SNIS page[2].

Quantitative monthly control data on water quality (in number of samples) were also collected from SISAGUA[3], in 2014, to verify, in the distribution system and at the exit of the treatment, aspects such as heterotrophic bacteria, total coliforms, water coloring, free residual chlorine, *Escherichia coli,* fluoride, and turbidity; all following Ordinance No. 2,914/2011 (Brasil, 2011), which provides for procedures for controlling and monitoring the quality of water for human consumption and its potability standards.

Statistical correlation – Pearson's correlation determinant

Using the R-Project free software[4], version 3.0.3, we verified the statistical correlation between the CCI and the environmental variables, via "product-moment correlation coefficient" or simply "Pearson's ρ" (Mukaka, 2012), which allowed measure the degree of this association (and its direction, positive or negative), expressed by (1):

$$\rho = \frac{\sum_{i=1}^{n} (x_i - \underline{x})(y_i - \underline{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \underline{x})^2} \cdot \sqrt{\sum_{i=1}^{n} (y_i - \underline{y})^2}} = \frac{cov(X, Y)}{\sqrt{var(X) \cdot var(Y)}} \quad (1)$$

Its correlated variables are highlighted by x_i (CCI from each municipality, calculated from the coefficient between its number of cases and population size, multiplied by 100 thousand) and y_i, the sanitation - water component; and $\overline{x}$ and $\overline{y}$, their arithmetic means. As for the value of ρ, it varies between +1 and -1 and tends to have a perfect correlation as it approaches these values, although it is weaker when moving to zero.

Spatial correlation: clusters by k-means and distribution maps

According to Ribeiro (2017), maps in environmental health go beyond the cartographic representation of events and processes. It presents inequalities and inequities in health, among other potentials, identifying their possible risks, understanding the processes of time-space disease diffusion, and understanding social and environmental determinants in health. Thus, it provides their relationships with the geographic space and bases that can contribute to territorial planning to face complex and dynamic problems regarding inequalities and vulnerabilities.

We selected the most statistically correlated water components with a certain degree of significance (via Pearson's determinant) to the CCI to analyze their spatial correlations jointly. We developed two models, each with average values per municipality, between 2014 and 2017, containing the CCI and six of those components. Model A presents those with a positive statistical response and B with a negative answer.

After the selection, we identified the ideal number of clusters (k) for each model by the elbow method – using *k*-means and the total sum of squares, through the "fviz_nbclust" function, contained in the "factoextra" package of R- Project[5]. The value of k is introduced in the analysis module of the spatial statistical tool in GeoDa, for cluster plotting (Anselin, 2020) - methodology demonstrated by Silva (2020). In this test, each observation is allocated to the closest cluster. The distance between them

1 DATASUS. Data collected on January 5, 2019. Available at https://bit.ly/2GgF5VB
2 SNIS. Data collected on January 5, 2019. Available at https://bit.ly/2xEjuBv.
3 SISAGUA. Data collected on May 10, 2019. Available at https://bit.ly/2NDur1b
4 *R-Project.* Data collected on January 5, 2019. Available at https://cran.r-project.org/
5 Available at https://bit.ly/3zHHykP. Accessed on July 16, 2021.

is calculated using the Euclidean distance between the observation and the center of the grouping or cluster, classified from the *k*-means of *n* observations.

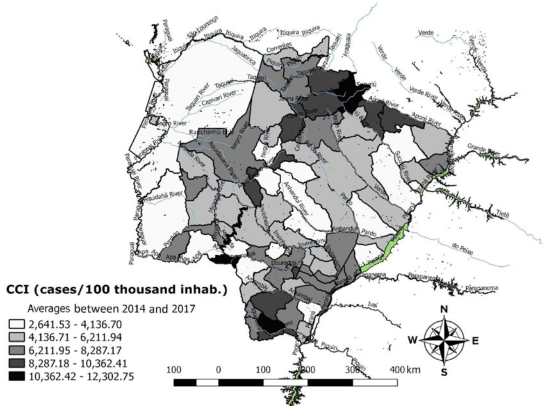
The test ends when the maximum number of iterations is reached, or the change in the within-cluster sum of squares (WCSS) in two successive iterations is less than the threshold value. Thus, the *z* values are provided for each variable tested by cluster. Furthermore, the total sum of squares (TSS), within (WCSS) and between (BCSS) clusters are provided. Also, the TSS/BCSS ratio, the higher, the better the measure of fit of the model. Higher WCSS values exhibit more significant variability of observations within each identified cluster, while smaller values, a more compact grouping. BCSS, on the other hand, measures the variation between all clusters; therefore, high values indicate scattered clusters, while lower values indicate greater proximity between clusters (Anselin, 2020).

Additionally, we used the QGIS free software, version “Las Palmas” 2.18.22, to plot distribution maps and to highlight specificities of CCI and the most correlated water components, both by statistical and spatial analysis.

Results and discussion

Between 2014 and 2017, there were 557,185 total records on diagnoses of CC cases in the state of MS, 24.49% only in its capital - Campo Grande. The highest occurrence was in 2014, with 28.54% of the total, compared to the capital, with 9.02%. As for its CCI, there was an average in MS of 6,211.9 cases per 100,000 inhab., with the highest rate in Costa Rica (CCI = 12,302.75), and with emphasis on seven other cities: Antônio João, Tacuru, Dois Irmãos do Buriti, Rochedo, Vicentina, Cassilândia, and Chapadão do Su (average CCI = 10,043.93). From a geographical point of view, four of these cities surround the Serra de Maracaju.

Figure 1 – Incidence of cervical cancer (CCI), by mean values extracted for the period beetween 2014 and 2017, distributed by the municipalities of Mato Grosso do Sul.



Source: own elaboration, with the image generated in the QGIS software, based on data from cervical cancer cases extracted from SISCAN - DATASUS/MS and population size from SNIS.

Souza *et al.* (2018), when studying the types of cancer in MS between 2008 and 2016, observed an increase in the number of neoplasms, with CC being the second most incident.

Pearson’s determinant shows more significant associations of CCI to the average tariff charged on sanitation services, especially on the water tariff, with a respective response of 36.28% and 34.15%, both at a value of $p<0.001$ and negatives. It supports the negative responses found to the number of services performed (17.98%; $p \leq 0.001$), the extension of the water network (14.25%; $p \leq 0.001$), and the volume of water, whether this is a macro measurement or treated in WTSs, with about 12.9% ($p \leq 0.02$). These associations lead to the understanding that more significant financial resources applied to the service supply allow greater investment in human and material resources. It implies a greater amount of services performed and, in turn, better infrastructure with the supply of a greater volume of water with quality to the population and, consequently, lower CCI.

Concerning the positive associations to the CCI, the number of systemic interruptions and outages on the supply service stands out at 28.3% and 22.28%, respectively, with a p-value <0.001. It supports the answers found on the duration of interruptions and outages, respectively, at 15.42% and 17.26%, both at a significance level above 99.99% ($p \leq 0.02$). The responses to water consumption are also evidenced, either concerning its per capita average (20.74%; $p<0.001$) or to the billed by the economy - number of homes affected by the supply (14,51%; ≤ 0,01), and the incidence of analyses on water samples collected with non-standard results for turbidity (15.18%; $p \leq 0.007$) and for the presence of total coliforms (12.05%; $p \leq 0.03$).

There was no significance in the CCI responses regarding the non-standard water sample for residual chlorine (QD007) or the fluoridation index (IN057). It is important to note that the response to the volume of fluoridated water (AG028; -11, 44% and p-value of 0.042) is due to the influence of the volume of water on that CCI. It is evidenced, for example, by the percentages of response to AG007 and AG012, all according to Table 1.

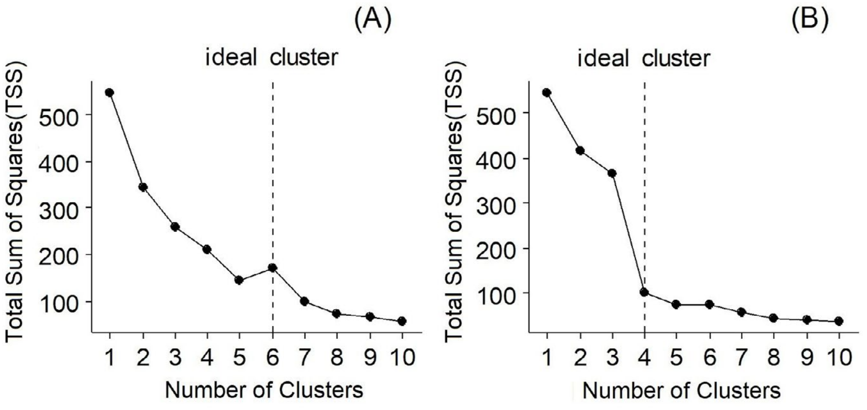
Table 1 - Statistical correlation with 95% confidence interval and significance level (p-value), by Pearson's determinant, between the incidence of cervical cancer and water components, for each of the 79 municipalities in Mato Grosso do Sul in the period between 2014 and 2017.

Code	Description of the water component	Pearson (%)	CI limits at 95%		p-valor
			Lower (%)	Upper (%)	
QD021	No. of systematic interruptions in supply	28.3	17.82	38.14	0,000
QD002	No. of interruptions in supply	22.28	13.34	52.55	0,000
IN022	Average per capita water consumption	20.74	9.93	31.06	0,000
QD003	Duration of supply interruptions	17.26	6.35	27.77	0,002
QD022	Duration of systematic interruptions	15.42	4.47	26.01	0,006
IN076	Incidence of non-standard turbidity analyses	15.18	4.22	25.79	0,007
IN017	Water consumption billed by the economy	14.51	3.53	25.14	0,010
IN021	Extension of the sewage network by connection	13.8	2.81	24.46	0,014
IN084	Incidence of non-standard total coliform analyses	12.05	1.03	22.78	0,032
IN057	Water fluoridation index	2.65	-8.41	13.64	0,639
QD007	No. of samples for non-standard residual chlorine	1.41	-9.64	12.43	0,803
IN075	Incidence of non-standard residual chlorine analyses	-3.61	-14.59	7.45	0,523
QD027	No. of samples for non-standard total coliforms	-8.56	-19.41	2.49	0,129
IN006	Average tariff on sanitary sewage service	-9.77	-20.58	1.28	0,083
AG028	Fluoridated water volume	-11.44	-22.19	-0.41	0,042
AG007	Volume of treated water in WTSs	-12.8	-23.51	-1.8	0,023
AG012	Macromeasured water volume	-13.01	-23.7	-2	0,021
AG005	Extension of the water network	-14.25	-24.89	-3.26	0,011
QD024	Number of services performed	-17.98	-28.45	-7.09	0,001
IN005	Average rate on water service	-34.15	-43.54	-24.02	0,000
IN004	Average tariff charged (water and sewage)	-36.28	-45.49	-26.3	0,000

Caption: CI = Confidence IntervalSource: own elaboration, with statistical correlation values calculated via the R-Project Software, from the "cor.test()" function, based on data on cases of cervical cancer extracted from SISCAN - DATASUS/MS; population size and water components from SNIS.

The Elbow Method identified the ideal value of the number of *k* clusters for the spatial models built and tested here, between CCI and six water components selected from those under statistical correlation and the degree of significance with p-value ≤0.03, Table 1. Therefore, models A and B were distributed across different sets of municipalities with 6 and 4 clusters (Fig. 3), with their z-values shown in Table 2.

Figure 2 - Ideal number of clusters for models tested by the elbow method using the "fviz_nbclust" function associated with k-means and the total sum of squares (TSS) between CCI and water components under statistical correlation: (A) positive and (B) negative.



Source: own elaboration, with values of the n-clusters and referred images provided by the R-Project Software, from the "fviz_nbclust()" function, based on data on cervical cancer cases from SISCAN - DATASUS/MS; population size and water components from SNIS.

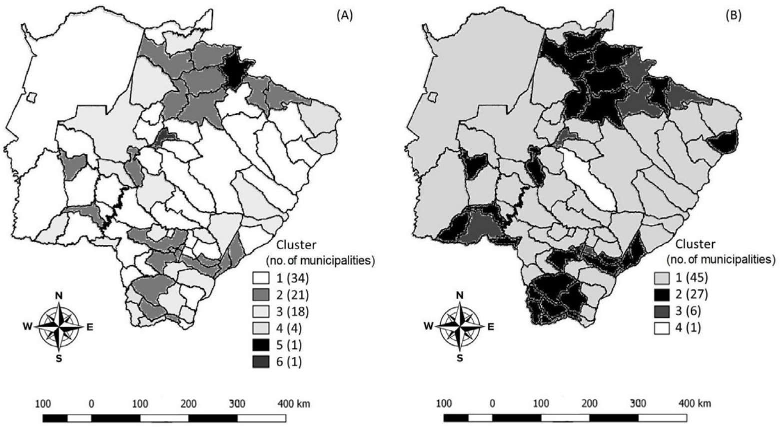
Model A shows higher CCI z-values in Cluster 5 (consisting only of Costa Rica; z=2.91636) under the more significant effect of the number of systemic interruptions (QD021; z=8.741) and outages (QD002; z=7, 6097); followed by Cluster 6 (represented by the city of Rochedo; z=1.69043), under higher z-values on the incidence of analyses in water samples, with non-standard results, for total coliforms (IN084; z=8.6803) and turbidity levels (IN076; z=5.7427). Cluster 1, with 34 municipalities, has the lowest CCI rates (z=-0.74216), with a direct response; however negative, of all sanitation components included in this Model, especially under the more significant effect of the extension of the sewage network per connection (IN021; z=-0.54397), Figure 3A and Table 2.

As for model B, it has the highest CCI z-values in Cluster 2 (z = 0.915174), distributed across 27 municipalities (which include the city of Costa Rica, with the highest average CCI, followed by Cluster 3 (z = 0.872857), with six municipalities. Cluster 4 (represented only by the city of Campo Grande; z = -1.06406) has the lowest CCI z-values and the highest z-values for all water components tested in this model. However, under the opposite sign, i.e., as they increase, there is a reduction in that CCI, Figure 3B and Table 2.

Both models had a TSS of 546, under a better fit of Model B than Model A, given their respective TSS/BCSS ratios of 81.82% and 79.44%; above all, under more significant variability of the *n* observations within each cluster (WCSS = 112.206). In Model B, although there is a greater spread of municipalities within all the Model A clusters, the highest BCSS value presented is 446.761, Table 2.

The spatial analysis enables us to verify a high variance in the water components' response to the CCI, established according to the cluster in which they are inserted, regardless of the model applied. In other words, the response sign - positive or negative – depends both on the degree of association with the other components in a given cluster and on the set of municipalities in which they are grouped, see Table 2.

Figure 3 - Spatial models, by the k-means method and Euclidean distance, on the municipalities of Mato Grosso do Sul, by joint analysis between the incidence of cervical cancer and water components, under statistical correlation: (A) positive, under 6 Clusters, in Model A and (B) negative, under 4 Clusters, in Model B.



Source: own elaboration, with the image generated in the GeoDa software, based on data from cervical cancer cases, extracted from SISCAN - DATASUS/MS; population size and water components from SNIS.

Table 2 - Z-values (arranged by k clusters, TWSS and BCSS), for the spatial models, by the k-means method and Euclidean distance, via GeoDa, proposed between cervical cancer incidence and water components, all in mean values for the period between 2014 and 2017, on the 79 municipalities of Mato Grosso do Sul. Both models under a total sum of squares (TSS) of 546.

Model A								
ClusterVariable	CCI	QD021	IN022	QD002	IN021	IN076	IN084	TWSS
C1	-0.7422	-0.1038	-0.0519	-0.1248	-0.5440	-0.2794	-0.1087	30.8204
C2	0.9538	-0.1141	0.1243	0.0599	-0.1876	-0.1840	-0.1186	37.4235
C3	-0.0524	-0.1328	-0.2067	-0.2095	1.2731	-0.1685	-0.0944	37.2088
C4	0.3853	-0.0711	-0.7588	-0.1597	0.1109	2.7532	-0.1458	6.7529
C5	2.9164	8.7410	7.5165	7.6097	0.0120	-0.3583	-0.2115	0.0000
C6	1.6904	-0.1405	-1.6061	-0.2135	-0.9371	5.7427	8.6803	0.0000
$\sum$ TWSS								112.2060
BCSS								433.7940
BCSS/TSS								0.7945
Model B								
ClusterVariable	CCI	AG005	QD024	IN005	IN004	AG007	AG012	TWSS
C1	-0.6418	-0.0368	-0.0159	0.2787	0.2921	-0.0602	-0.0567	61,1014
C2	0.9152	-0.1953	-0.1936	0.1881	0.1471	-0.1730	-0.1782	19,0890
C3	0.8729	-0.2075	-0.3283	-3.1580	-3.0316	-0.1319	-0.1834	19,0489
C4	-1.0641	8.1759	7.9120	1.3291	1.0762	8.1720	8.4618	0,0000
$\sum$ TWSS								99,2390
BCSS								446,7610
BCSS/TSS								0.8182

Caption: Sum of squares: totals (TSS); totals within clusters (TWSS) and between clusters (BCSS); water components described in Table 1.
Source: own elaboration, with values extracted using the GeoDa Software, from the "clusters"k-means" function, based on data: cases of cervical cancer from SISCAN - DATASUS/MS; population size and water components from SNIS.

Table 3 shows the quantitative monthly control of analyses in the number of samples for water quality in data from SISAGUA, in the municipalities of MS, in the year 2014. A brief analysis of the results reveals the presence of heterotrophic bacteria and coliforms (total and thermotolerant) and on potability standards above those recommended by Ordinance No. 2,914/2011 identified for coloring and turbidity in cities surrounding Amambaí River (Amambaí, Aral Moreira, Laguna Carapá, Caarapó, Juti, Naviraí) and Iguatemi River (Coronel Sapucaia, Paranhos, Sete Quedas, Tacuru, Eldorado, Iguatemi, Japorã, and Mundo Novo), cities possibly supplied by these tributaries. Still, in Table 3, 16 cities under CCI above the average observed for MS in the period from 2014 to 2017 stand out in bold, with emphasis on Antônio João and Tacuru with, respectively, second (CCI = 11,324.65) and third (CCI = 11,115.16) higher rates.

Table 3 - Indicators outside the water quality standards (Brasil, 2011) in the municipalities of Mato Grosso do Sul in 2014.

Indicators	Measured values	Municipalities / no. of samples found	Potability Standards (Brasil, 2011)
Heterotrophic bacteria	> 500 CFU/mL	in up to 10 samples: Ladário; in up to 3: Jutí, **Caarapó**; in up to 2: **Naviraí**; Mundo Novo; in up to 1: **Tacuru**, Eldorado, **Iguatemi**, Campo Grande, **Sete Quedas**	≤ 500 CFU/mL
Total coliforms	present	in up to 5 samples: Mundo Novo; in up to 4: **Iguatemi**; in up to 3: Campo Grande, **Coronel Sapucaia**; in up to 2: **Caarapó**, **Naviraí**, **Tacuru**; in up to 1: Angéica, **Antônio João**, Aral Moreira, Deodápolis, Eldorado, **Iguatemi**, **Japorã**, Jutí, Laguna Carapá, Ponta Porã	< 40 samples: positive result in 100 mL; absence in 100 mL in 95% of 40 or + samples
Water coloring	≤15.0 uH	in up to 704 samples: Campo Grande; in up to 496: **Coronel Sapucaia**; in up to 390: Corumbá, Ladário; in up to 360: **Jardim**; in up to 312: Mundo Novo; in up to 23: **São Gabriel do Oeste**; in up to 20: Três Lagoas; in up to 12: Ponta Porã; in up to 10: Angélica, Ivinhema; **Sete Quedas**; in up to 8: **Amambaí**, Anaurilândia, **Antônio João**, Aral Moreira, **Bataypora**, **Caarapó**, Deodápolis, Eldorado, **Iguatemi**, Itaquiraí, **Japorã**, **Jateí**, Jutí, Laguna Carapá, **Naviraí**, **Nova Andradina**, Novo Horizonte do Sul**, Paranhos**, **Tacuru**, **Taquarussú**	≤ 5.0 uH
Escherichia coli or thermotolerant coliforms	present	in up to 2: **Caarapó**; in up to 1: **Tacuru**	Absence in 100 mL
Turbidity	> 5.0 uT	in up to 8 samples: **Jateí**; in up to 4: campo Grande; in up to 3: Ladário, **Coronel Sapucaia**; in up to 2: Angélica, Corumbá, **Jardim**, Laguna Carapá, **Naviraí**, **Sete Quedas**; in up to 1: Anaurilândia, **Antônio João**, Eldorado, **Nova Andradina**	≤ 0.5 uT for fast filtration and ≤ 1.0 uT for slow filtration ≤ 5.0 uT in the distribution system (reservoir and network)

Note: Municipalities in bold with a CCI rate above the averages observed in the MS (2014-2017), of 6,2011.9 cases per 100,000 inhab.
Source: own elaboration, based on data extracted from SISAGUA.

According to Hess in an interview with Rede Brasil Atual (Oliveira, 2018), cancer is a disease that comes from pollution, and water is very relevant, as it is our leading food.

Silva (2017), when studying the profile of women in a prison environment, vulnerable to risk factors for the control of CC in the state of MS, showed that the majority were of mixed race, aged between 18 and 34 years, with a low level of schooling and susceptible to various diseases due to their inadequate living conditions, while subject to prison.

According to Alves *et al.* (2016 *apud* Silva *et al.* 2018), the increase in obligate anaerobic agents in the vaginal mucosa, such as bacteria and fungi, may promote a greater risk of HPV infection and, in turn, a higher rate of CCI.

Silva *et al.* (2018), when analyzing the cytopathological morphology of the microorganisms present in the vaginal mucosa of patients diagnosed with CC, identified the predominance of bacteria (66.67%) in the form of cocci and/or bacilli; above all, in women aged between 40 and 49 years (20.83%), and with a higher percentage in the reports as a result of high-grade squamous intraepithelial lesion - HSIL (33.33%), which led them to show that it is one of the characteristics most related to the incidence of CC in the population studied.

According to Midiamax (2016), Sanesul, the MS sanitation company, faces serious accusations that attest to inadequacies in the standards of the final effluents released by it, which could lead to diseases such as cancer. The judicial expertise showed above-tolerable tailings rates in the Água Boa, Laranja Doce, and Rego D'água streams, which were contested by the company, with differences recognized even by the State Public Ministry about the parameters used. Sanesul denies such irregularities and guarantees to maintain constant control over the water quality it supplies to the municipalities under its concession.

This alarming scenario is reflected in complaints (supported by technical laboratory reports) already formalized by a judicial process opened in 2012, with the 5th Civil Court of the District of Dourados, based on the dumping of sewage without proper treatment in streams that flow into the Dourados River, the primary source of supply for the municipality (MIDIAMAX, 2016).

As Jardim suggests in an interview with Agência Pública (Vigna, 2014):

> the best thing an individual can do is pressure their city's utility to provide better water. It is necessary to exercise citizenship [...]. Brazilians consume like a European country and have the sanitation of an African country. We have fecal coliforms as in Haiti and emerging contaminants as in the United States.

According to FUNASA (2004), building a world where the man learns to live with his habitat in a harmonious and balanced relationship requires building a new model of development with purposes leading to improvement in the quality of life of the population, the preservation of the environment, and the search for creative solutions that meet the needs of the population in terms of access conditions and certain comforts of modern society. Water is an essential element for plant and animal life. Man needs water of adequate quality and sufficient quantity to meet his needs, protect his health, and provide economic development (Machado, 2003).

Here, we emphasize the responsibility of the municipalities for the guidelines aimed at basic sanitation, regarding the formulation of actions and policies, the provision of services, and the definition of the regulatory and supervisory entity, all established in Law No. 11,445/2007. According to Souza *et al.* (2015), this is a stance that, when combined with the institution of social control (established by this same law, restricted by the fundamental principle of sanitation), goes beyond prevention and reveals itself to be much closer to promotion in health, meeting the natural influx of social and political events.

In this sense, we highlight here the achievements obtained by the Brazilian Movement for Sanitary Reform and the 8th National Health Conference, responsible for introducing, in the national agenda of discussions, guidelines that were strongly reflected on environmental sanitation, such as universal access, strengthening the role of the municipality, equity, and social participation. When analyzing these guidelines with the idea of health promotion, they are not derived from a conscious attitude from their proponents (Souza *et al.*, 2015, p. 97 and 98).

Conclusions

This study characterized the relationships of the CCI to the water components and their quality indicators, with statistical correlations with a high degree of significance (p-value0.001) presented to the average tariffs applied to supply services, especially water; the number of its systematic interruptions and outages; to the average per capita consumption of water, and the number of services performed on the supply system.

The joint spatial correlation by groups of municipalities on the state of MS, distributed by *k*-means, together with models A and B, showed that the CCI varies according to the specificities of each region (grouping) under the combination and interdependence of different aspects involved, sometimes under positive and sometimes negative effects. This study demonstrates this variation by the association of CCI with water components. However, these present a specific statistical correlation under a certain degree of significance when tested independently (ungrouped) to that CCI.

While a straightforward association between sanitation factors and CC is not observed in the literature and, as this is a multifactorial disease, we cannot ignore the statistical and spatial correlations presented here, which suggest that the poor quality of the water served to the population is potentially favorable to the disease development. Therefore, it is necessary to investigate their relationships in more detail, considering the effects of interruptions and systemic outages in the supply service, the volume and extent of water and sanitary sewage, the expenses and revenues on the services performed, and the presence of coliforms in the supply network.

The effective realization of this study will bring gains to the public health of the population of this state of the Federation.

References

ALVES, J. A. B et al. Frequency of Gardnerella vaginalis, Candida spp., Trichomonas vaginalis and pill use or copper intrauterine device use. *International Archives of Medicine*, Londres, v. 9, n. 360, p. 1-6, 2016.

ANSELIN, L. *Cluster Analysis (3)*: Advanced Clustering Methods. 2020. Disponível em: https://bit.ly/2SeyhNK. Acesso em: 01 jul. 2021.

BRASIL. Lei nº 14.026, de 15 de julho de 2020. Atualiza o marco legal do saneamento básico. *Diário Oficial da União*, Brasília, DF, 16 jul. 2020. Disponível em: https://www.in.gov.br/en/web/dou/-/lei-n-14.026-de-15-de-julho-de-2020-267035421. Acesso em: 01 jul. 2021.

BRASIL. Lei nº 11.445, de 5 de janeiro de 2007. Estabelece diretrizes nacionais para o saneamento básico. *Diário Oficial da União*, Brasília, DF, 8 jan. 2007. Disponível em: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445.htm. Acesso em: 01 jul. 2021.

BRASIL. Ministério da Saúde. Lei nº 2.914, de 12 de dezembro de 2011. Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade. *Diário Oficial da União,* Brasília, DF, 13 dez. 2011. Disponível em: https://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914_12_12_2011.html. Acesso em: 01 jul. 2021.

BRAY, F. et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A Cancer Journal for Clinicians*, Atlanta, v. 68, n. 6, p. 394-424, 2018.

BRUNI, L. et al. *Human Papillomavirus and Related Diseases Report.* Barcelona: HPV Information Centre, 2019. Disponível em: https://bit.ly/2XBmLRn. Acesso em: 19 jun. 2019.

CARNEIRO, M. C. M. O et al. A gestão do saneamento no Brasil e sua relação com a gestão de recursos hídricos. *Journal of Engineering and Technology Innovation*, São Paulo, v. 6, p. 100-116, 2018.

FUNASA – FUNDAÇÃO NACIONAL DE SAÚDE E SANEAMENTO. *Manual de Saneamento.* Brasília, 2004.

IBGE – INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTÁTISTICA. *Estimativas da população residente no Brasil e unidades da Federação com data de referência em 1º de julho de 2019.* Rio de Janeiro, 2019. Disponível em: https://bit.ly/3fCREfz. Acesso em: 01 jul. 2019.

INCA – INSTITUTO NACIONAL DE CÂNCER. *Controle do Câncer de Colo de Útero:* Conceito e Magnitude. Rio de Janeiro, 2021. Disponível em: http://bit.ly/2Nk2Ku7. Acesso em: 19 jun. 2019.

MACHADO, C. J. S. Recursos Hídricos e Cidadania no Brasil: limites, alternativas e desafios. *Ambiente e Sociedade*, São Paulo, v. 6, n. 2, p. 121-136, 2003.

MUKAKA, M. M. Statistics Corner: A guide to appropriate uso of Correlation coefficient in medical research. *Malawi Medical Journal*, Malawiv. 24, n. 3, p. 69-71, 2012.

O DEVER do saneamento. *Estadão.* São Paulo, 30 abr. 2019. Disponível em: https://opiniao.estadao.com.br/noticias/notas-e-informacoes,o-dever-do-saneamento,70002808133. Acesso em 19 jun. 2019.

OLIVEIRA, C. de. Alerta: Metais pesados, hormônios e agrotóxicos estão na água que chega às torneiras. *Rede Radio Brasil Atual*, São Paulo, 02 mar. 2018. Disponível em: https://bit.ly/2XxwRSE. Acesso em: 19 jun. 2019.

PIMENTEL, C. E. B.; CORDEIRO NETTO, O. M. *Proposta Metodológica de Classificação e Avaliação Ambiental de Projetos de Saneamento.* Brasília:IPEA, 1998.

PRADO, I. P.; MENEGUIM, F. B. *Os serviços de saneamento básico, sua regulação e o federalismo brasileiro.* Brasília: Senado Federal, 2018.

RIBEIRO, H. *Geoprocessamento em saúde:* muito além de mapas. Barueri: Manole, 2017.

SANESUL enfrenta denúncias de poluir córregos e de servir água com agrotóxico. *Midiamax*, Campo Grande, 1 ago. 2016. Disponível em: https://bit.ly/2XXi80p. Acesso em: 19 jun. 2019.

SILVA, E. R. P. H. *Controle do câncer do colo do útero em mulheres privadas de liberdade em Mato Grosso do Sul.* 2017. Dissertação (Mestrado em Enfermagem). Programa de Pós-Graduação em Enfermagem da Universidade Federal de Mato Grosso do Sul, Campo Grande, 2017.

SILVA, J. C. B. *Dengue no Nordeste brasileiro: aspectos climáticos e socioambientais em áreas de influência sob alto risco e recomendações para políticas públicas.* 2020. Tese (Doutorado em Meio Ambiente). Programa de Pós-Graduação em Ciências Ambientais da Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2020.

SILVA, R. C. G. et al. Perfil de mulheres com câncer de colo do útero atendidas para tratamento em centro de oncologia. *Revista Brasileira de Saúde Materno Infantil*, Recife, v. 18, n. 4, p. 703-710, 2018.

SNIS – SISTEMA NACIONAL DE INFORMAÇÕES SOBRE SANEAMENTO. Série Histórica. Brasília: *Ministério do Desenvolvimento Regional*, 2019. Disponível em: http://app4.mdr.gov.br/serieHistorica/ . Acesso em: 01 mar. 2019.

SOARES, S. R. A.; BERNARDES, R. S.; NETTO, O. de M. C. Relações entre saneamento, saúde pública e meio ambiente: elementos para formulação de um modelo de planejamento em saneamento. *Cadernos de Saúde Pública*, Rio de Janeiro, v. 18, n. 6, p. 1713-1724, 2002.

SOUZA, C. M. N. et al. *Saneamento:* promoção da saúde, qualidade de vida e sustentabilidade ambiental. Rio de Janeiro: Editora FIOCRUZ, 2015.

SOUZA, R. F. et al. A situação do câncer em Mato Grosso do Sul: avaliação epidemiológica das neoplasias na região leste do estado no periodo de 2008 a 2016. In: CONGRESSO BRASILEIRO DOS ACADÊMICOS DE MEDICINA, 3., 2018, Ribeirão Preto. *Anais...* Ribeirão Preto: CREMESP, 2018. Disponível em: www.even3.com.br/Anais/cbmedcoemed/138674-A-SITUACAO-DO-CANCER-EM-MATO-GROSSO-DO-SUL--AVALIACAO-EPIDEMIOLOGICA-DAS-NEOPLASIAS-NA-REGIAO-LESTE-DO-ESTADO-NO-. Acesso em 11 jun. 2019.

TRENKEL, F. A.; CHAVES MAIA, S. G. Estudo Epidemiológico de Casos de Câncer no Estado de Mato Grosso do Sul - MS. *Cadernos de Agroecologia*, Recife, v. 11, n. 2, 2016.

VIGNA, A. No Brasil, contaminação da água é pior. *Publica - Agência de Jornalismo Investigativo*, São Paulo, 18 mar. 2014. Disponível em: https://bit.ly/2X3uqTm. Acesso em: 19 jun. 2019.

UNESCO – UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION. *Relatório mundial das Nações Unidas sobre o desenvolvimento dos recursos hídricos 2019*: não deixar ninguém para trás. UNESCO 2019. Disponível em: https://bit.ly/3Mfm9WQ. Acesso em: 17 jun. 2019.

Authors' contribution

Silva was in charge of obtaining, analyzing, and interpreting the data, responsible for the accuracy of the statistical and spatial tests performed. Nunes and Silva participated in elaborating the manuscript with a literature review and theoretical and methodological framework. Machado was predominantly responsible for leading the research, with supervision and critical content review. All authors approved the final version to be published and agreed to be responsible for the accuracy and integrity of the entire work.

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