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RESEARCH ARTICLE

Space-time clusters of severe acute respiratory syndrome and COVID-19 and hierarchical urban network in the state of Mato Grosso, Brazil, 2020-2021

Clusters espaço-temporais de síndrome respiratória aguda grave e COVID-19 e rede urbana hierárquica no estado de Mato Grosso, Brasil, 2020-2021

Agrupaciones espacio-temporales de síndrome respiratorio agudo severo y COVID-19 y red urbana jerárquica en el estado de Mato Grosso, Brasil, 2020-2021

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ABSTRACT

Objective: to analyze the space-time distribution of COVID-19 in the state of Mato Grosso, Brazil. **Methods:** Weekly case records of Severe Acute Respiratory Syndrome were obtained from the Ministry of Health's Database related to this syndrome, including data from COVID-19. Temporal and spatiotemporal analysis using scanning statistics to identify clusters of severe acute respiratory syndrome cases were performed with the software SaTScan. **Results:** A total of 27,093 cases was observed, with an incidence of 768.33/100,000 inhabitants. The spatial distribution considering the period of study evidenced the heterogeneity of values in the state. The highest incidence rates were observed in more populous municipalities. **Conclusion:** We highlight priority areas for interventions, aiming at controlling the transmission of the disease and reducing transmission risks to more remote areas of the state of Mato Grosso.

Keywords: Pandemics. SARS-CoV-2. COVID-19. Cluster Sampling.

RESUMO

Objetivo: Analisar distribuição espaço-temporal de COVID-19 no estado de Mato Grosso, Brasil. **Métodos:** Registros de casos semanais de Síndrome Respiratória Aguda Grave foram obtidos junto ao Banco de Dados dessa síndrome do Ministério da Saúde, incluindo dados de COVID-19. Análises temporal e espaço-temporal utilizando varreduras estatísticas para identificação de *clusters* de casos de síndrome respiratória aguda grave foram realizadas com o programa SaTScan. **Resultados:** Foram observados 27.093 casos, com incidência de 768,33/100.000 habitantes. A distribuição espacial considerando o período de estudo evidenciou heterogeneidade de valores no estado. As maiores taxas de incidência foram observadas em municípios mais populosos. **Conclusão:** Destacam-se áreas prioritárias para intervenções, priorizando controle da transmissão da doença e redução dos riscos de transmissão para áreas mais remotas do estado de Mato Grosso.

Palavras-chave: Pandemias. SARS-CoV-2. COVID-19. Amostragem por Conglomerados.

RESUMEN

Objetivo: Analizar la distribución espacio-temporal de COVID-19 en la provincia estado de Mato Grosso, Brasil. **Métodos:** Se obtuvieron registros semanales de casos de Síndrome Respiratorio Agudo Severo (SRAG) de la Base de Datos SRAG del Ministerio de Salud, incluyendo datos de COVID-19. Se realizaron análisis temporales y espaciotemporales utilizando exploraciones estadísticas para identificar grupos de casos SRAG con el programa SaTScan. **Resultados:** se observaron 27.093 casos, con una incidencia de 768,33 / 100.000 habitantes. La distribución espacial considerando el período de estudio mostró heterogeneidad de valores en el estado. Las tasas de incidencia más altas se observaron en los municipios más poblados. **Conclusión:** Se destacan las áreas prioritarias para las intervenciones, priorizando el control de la transmisión de enfermedades y la reducción de los riesgos de transmisión a áreas más remotas del estado de Mato Grosso.

Palabras clave: Pandemias. SARS-CoV-2. COVID-19. Mustreo por Conglomerados

INTRODUCTION

In December 2019, a new coronavirus (SARS-CoV-2), identified in Wuhan (China), was transmitted, causing COVID-19, which was disseminated and transmitted from person to person. The disease causes from asymptomatic infections to respiratory conditions that can vary from a cold to a Flu Syndrome, and can even cause severe pneumonia[1,2].

The Respiratory Syndromes Surveillance System was created in 2000 to monitor the situation of influenza viruses in Brazil, using Sentinel Surveillance for Influenza Syndrome (IS). In 2009, with the pandemic due to the Influenza (H1N1) pdm09 virus, surveillance of Severe Acute Respiratory Syndrome (SARS) was implemented, strengthening the surveillance of respiratory viruses[3]. With the emergence of the new coronavirus pandemic, this infection was incorporated into the surveillance network for Influenza and other respiratory viruses[4].

Updated data (06/17/2021) from the Brazilian Ministry of Health reveal 17,702,630 confirmed cases of COVID-19, with an incidence of 8423.9 cases. Of the total cases, 16,077,483 recovered. There were 496,004 confirmed deaths, with a mortality rate of 236.0 and lethality of 2.8%. The second highest incidence rate among the five Brazilian regions was observed in the country's Midwest (11,183.2), with 1,822,541 cases, 46,379 deaths, and a mortality rate of 284.6 per 100,000 inhabitants[5].

In the state of Mato Grosso, in the Midwest region of Brazil, 433,393 cases were recorded, with an incidence of 1243,7.9 per 100,000 inhabitants. Up to 06/17/2021, 11,379 deaths occurred, with a mortality rate of 326.6 per 100,000 inhabitants[5]. Studies highlight the identification of areas at risk of disease transmission from clusters, allowing the recognition of priority areas for disease control[6], including COVID-19[7].

This study aims to analyze the spatiotemporal distribution of COVID-19 in the state of Mato Grosso, Midwest Region of Brazil, contributing to the construction of health situation scenarios about the disease and directing public policies for decision making.

METHODS

Epidemiological, observational, descriptive and ecological study, using temporal and spatiotemporal approaches and secondary data. Epidemiological weeks and municipalities were considered as units of analysis. The study was conducted in the state of Mato Grosso, located in the Midwest Region of Brazil, with a population of 3,484,466 inhabitants, comprising 141 municipalities[8].

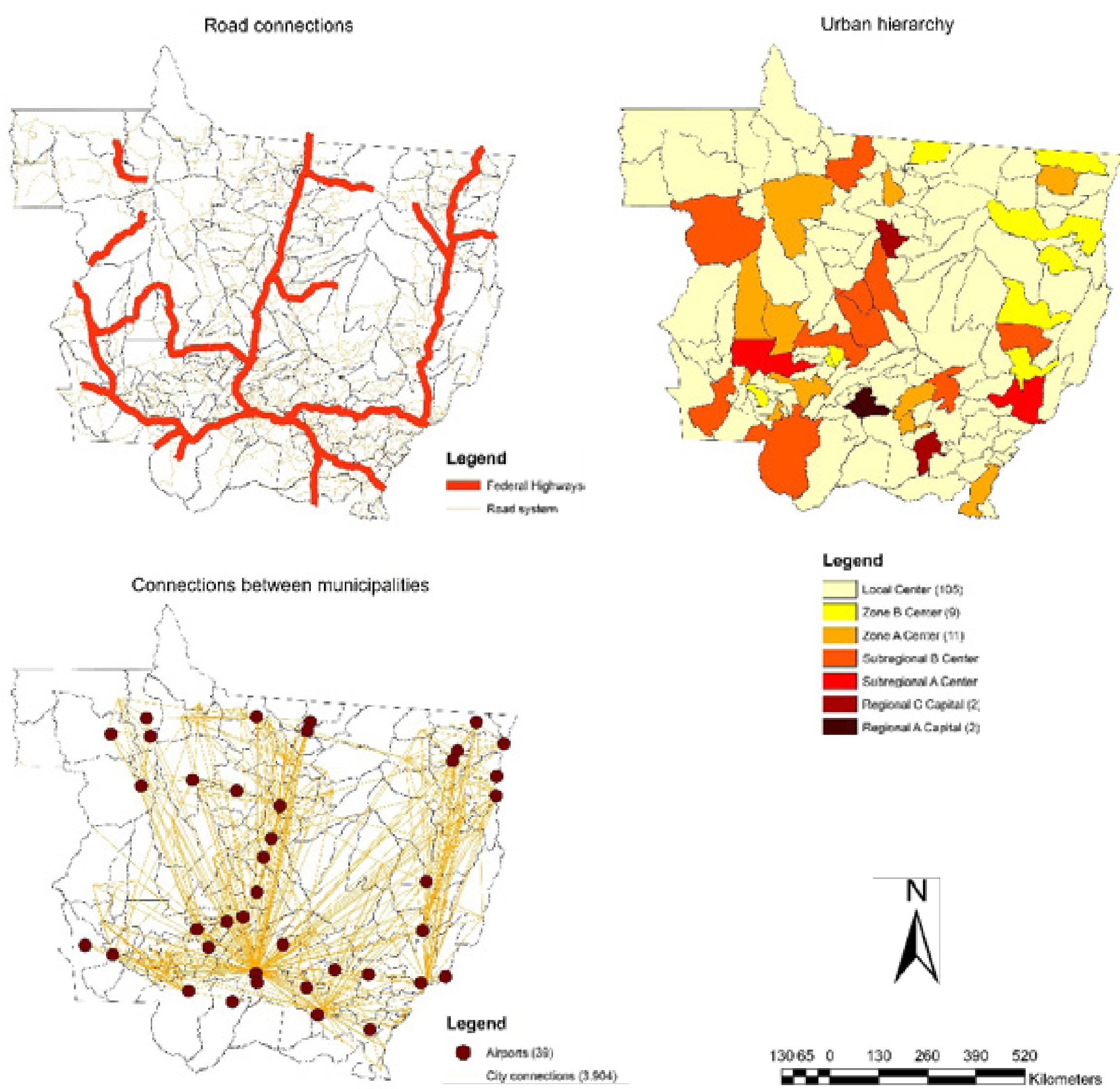
The weekly case records of SARS for the period from 07/07/2020 to 01/07/2021, of free access, were collected on 06/14/2021, from the SARS Database of the Ministry of Health[9], including data from COVID-19.

The estimated population data (2020) was obtained from the Brazilian Ministry of Health[10] and the digital meshes of the municipalities for the state of Mato Grosso were obtained from the Brazilian Institute of Geography and Statistics (IBGE)[11].

To perform the hierarchical urban network of the state cities, data referring to the Regions of Influence[12-13] of each municipality, to connections between municipalities[14] (connections between cities of origin and cities of destination), state airports, and the digital mesh of the road system of Mato Grosso[15] were obtained.

The selections were connections between cities that had only Mato Grosso municipalities as their destination; the main airports in the state (an international airport and regional airports); and federal highways (showing the most important road connections in the state) (Figure 1).

Figure 1 – Hierarchical urban network of municipalities of the state of Mato Grosso, Brazil.



SARS data were filtered by residents of the state of Mato Grosso and later organized by municipalities in the state in the software Excel 2013. The incidence rate was calculated by dividing all cases of SARS by the estimated population for each municipality in the state, multiplied by 100,000.

Temporal and spatiotemporal analyses were performed using scanning statistics to identify clusters of cases of SARS and considering the population of each municipality. A Kulldorff statistical cylindrical scan was used, with a discrete Poisson probability distribution, identifying high-risk clusters by comparing the number of cases observed with the number of cases expected in the SaTScan software (version 9.6). The Relative Risk (RR) for each cluster was also calculated, based on the underlying population. The clusters were ordered according to the Log-Likelihood Ratio (LLR) Rate, with the maximum LLR cluster being the least likely cluster to have occurred by chance. Monte Carlo simulations (n=999) were used to analyze statistical significance. The significant clusters (p-value <0.05) had no geographical overlap and included a maximum of 50% of the city's population[16]. A radius of 200,000 Cartesian units was used, with a maximum spatial cluster size of 50% of the population at risk. For temporal scanning, 50% of the study period was used as the maximum size of the temporal cluster, and the clusters were considered with a minimum of 2 cases.

In the QGis software (version 2.18.20), the results of the spatiotemporal analysis were organized and tabulated. Based on the municipal digital grid of Mato Grosso, a map of the SARS incidence rates, a map of spatiotemporal clusters of the SARS data, and an overlay of the digital grid of the main highways on the cluster map were created.

RESULTS

A total of 27,093 cases were observed between 01/07/2020 and 01/07/2021, with an incidence of 768.33 / 100,000 inhabitants. Of the 141 municipalities in the state, only one (Araguainha) did not have a record of cases of SARS.

Between weeks 2 (January) and 8 (February), 12 cases were observed. In week 9, still in February, there were 10 cases. The number increased consecutively from week 18 (end of April and beginning of May), reaching the highest number in week 26 (June), from 142 to 2,332 cases. From week 27, end of June, and beginning of July, successive reductions were observed until week 38, varying from 2,143 to 420 cases.

The analysis of SARS incidence rates, for the entire period studied, did not show a visual pattern of spatial distribution, presenting heterogeneity of values in different areas of the state. Higher rates were observed in the municipalities of Nova Olímpia, Primavera do Leste, Querência, Nossa Senhora do Livramento, Nova Mutum, Sapezal, Lucas do Rio Verde, Sorriso, Porto Esperidião and Nova Maringá. The Central, South, and West parts stand out. Rates (under minor values) were also highlighted in the North part (Figure 2).

The time scan identified only one cluster that starts at week 21 (May) and ends at week 31 (July), with RR of 5.71 and observed/expected case ratio of 2.89. There was an increase in the value of the ratio between observed cases and expected cases from week 17, in April, (0.23) until week 26, in June (4.56, being its highest value). Subsequently, there were consecutive decreases in values from week 27, in June (4.19) to week 38, in September (0.82) (Figure 3).

Figure 2 – SARS incidence rates (per 100,000 inhabitants) of municipalities in the state of Mato Grosso, Brazil, 2020.

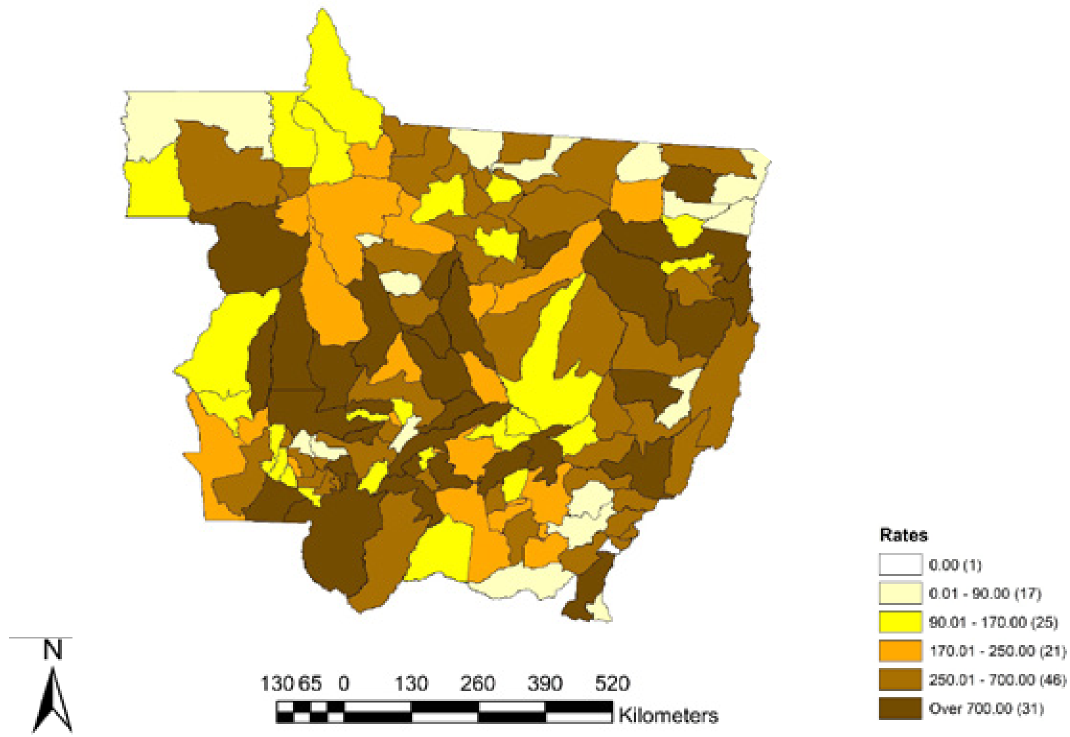
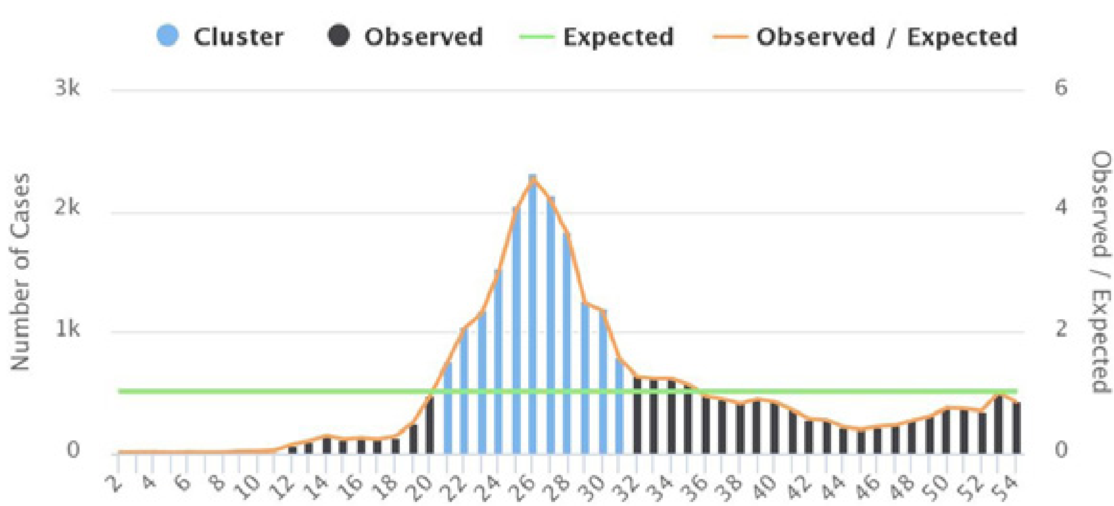


Figure 3 – Time cluster and numbers of observed, expected, and observed/expected cases of SARS, Mato Grosso, Brazil, 2020.DISCUSSION

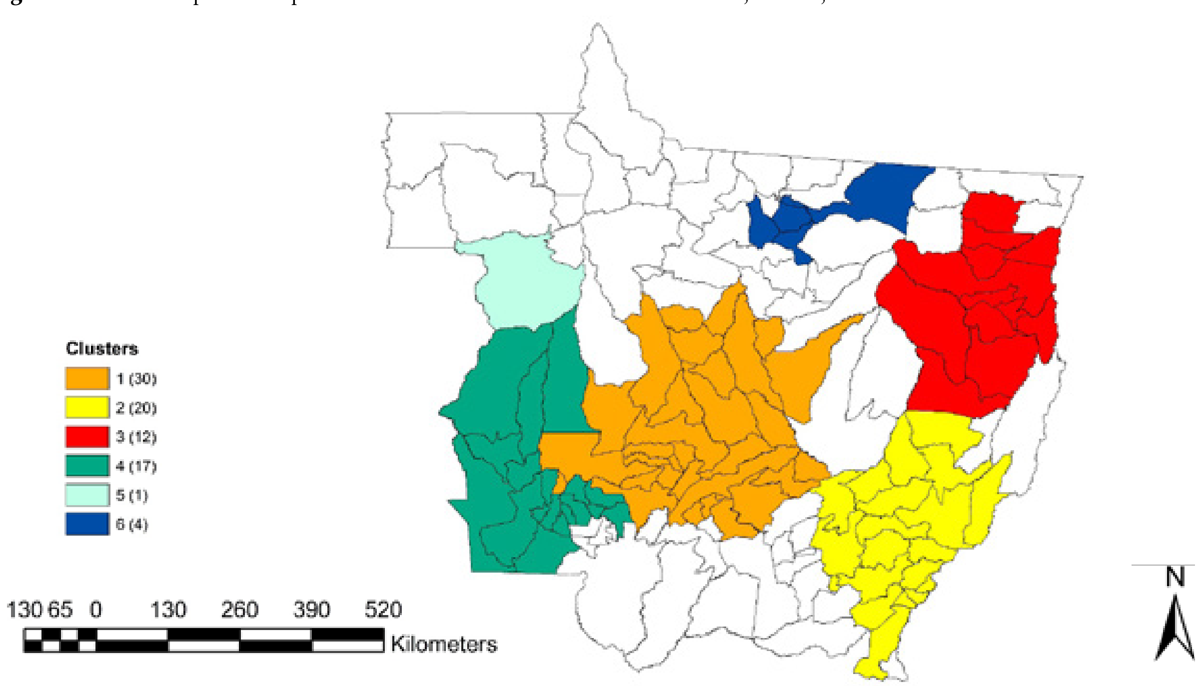


Regarding the space-time scan, 6 significant clusters were identified. Cluster 1, with the highest LLR (7672.47), had RR of 6.29 (like Cluster 5). Cluster 1 is located in the central part of Mato Grosso and includes the state capital, Cuiabá, occurring from week 21 to 31. Cluster 2 had the longest time window (week 23 to week 36, May/June to Aug/Sep). Cluster 3 had the highest RR, 7.44, located in the Northeast part of the state of Mato Grosso. Clusters 1, 2, and 3, with the highest LLR, were those that started from weeks 21 to 23, in May / June. Cluster 6 had lower RR and LLR, with a period from weeks 23 to 26 (late May/early June to June), respectively. Clusters 1 and 2 comprised the largest number of municipalities, 30 and 20, respectively. The results show that the clusters are connected by the federal highways, city connections, and hierarchical urban network, with temporal spreading of the clusters from the Central part of the state to the edges (Table 1 and Figure 4).

Table 1 – Parameters of significant spatiotemporal clusters, Mato Grosso, Brazil.

	Part of the state	**Period (for weeks)**	**Cases observed / expected**	**Relative Risk**	**LLR**	**Number of municipalities (by *cluster*)**
Cluster 1	Central	21 to 31	4.53	6.29	7672.47	30
Cluster 2	Southeast	23 to 36	3.59	3.81	1236.12	20
Cluster 3	Northeast	22 to 27	7.24	7.44	931.86	12
Cluster 4	West	24 to 27	5.95	6.07	635.06	17
Cluster 5	Northwest	26 to 28	6.27	6.29	111.60	1
Cluster 6	North	23 to 25	2.66	2.66	33.66	4

Figure 4 – SARS spatiotemporal clusters in the state of Mato Grosso, Brazil, 2020.



DISCUSSION

The diffusion of COVID-19 is a global public health problem that presents itself as a challenge to be faced today. Thus, a new look at new problems became necessary[17]. In Brazil, the main entry points of the virus were the airports, through trips from Europe. Subsequently, the disease spread through connections between middle and upper classes through airports, respecting the proper hierarchy of the Brazilian urban network, also with a contribution from road transport and, later, spread through closer labor relations. Transmission via road transport has some levels, such as commuting (home-work), interregional/interstate, that of some pole-cities to smaller municipalities within their region of influence, and intra-urban (via public mass transit)[18].

The spatiotemporal clusters in our study were related to the incidence rates observed in the municipalities since clusters 1 and 2 (largest LLR) were located in the Central and Southeast portions of the state. Cluster 1 contains the municipality of Nova Olímpia, where the highest incidence rate was observed (4848.51). The high LLR observed in Cluster 2 is probably explained by the presence of the municipality of Primavera do Leste (2808.69), being composed of other municipalities with lower incidence rates.

Our findings are in agreement with other studies on COVID-19 in Brazil, as clusters with RR of 7.97 (North Region) and 4.70 (Northeast Region) were observed. When organized by states, RRs of 21.85 and 16.54 (Amapá), 13.14 (Amazonas), 8.06 and 6.79 (Paraíba) were observed. However, the aforementioned work did not highlight clusters with high RR in the Midwest Region[16]. This can be explained by the country's large territorial dimension, which can mask spatiotemporal analyses, by the influence of the geographical scale considered in the study[19, 20], generating analysis with large territorial units, which makes it difficult to differentiate smaller risk areas (such as regions within a state or even municipalities) . Other authors[21] observed clusters in the state of Bahia with RR of 19.46 (LLR of 32.31) and 12.33 (LLR of 2834.3), showing the internalization of the disease in the Northeast of the country.

The municipalities of Sorriso, Lucas do Rio Verde, Nova Mutum, Sinop, Vera and Jangada (both belonging to the Central portion), Peixoto de Azevedo and Nova Santa Helena (North) are connected to BR-163 (Cuiabá-Santarém), a federal highway connecting the states of Mato Grosso and Pará and which recently had its asphalting completed[22]. Due to the presence of this highway, they end up receiving populations of high geographical mobility[23], suggesting that the circulation of the virus may be being facilitated by the greater accessibility to these municipalities. Thus, the Ministry of Health should increase preventive measures aimed at long-distance truck drivers, leading to a reduction in disease transmission[24].

High rates of SARS were also observed in municipalities with high accessibility/connectivity in the hierarchical urban network of Mato Grosso. Cuiabá and Várzea Grande enclose Regional A Capitals, centers with a high concentration of management activities, but with less reach of the region of influence than larger metropolises, such as Rio de Janeiro and São Paulo[13]. Barra do Garças and Tangará da Serra encompass Subregional A Centers, cities with smaller populations and areas of influence than Regional Capitals[13]. Cáceres, Juína, Lucas do Rio Verde, Nova Mutum, Primavera do Leste and Sorriso are part of Subregional B Centers and Confresa is a Zone A Center, with lower levels of management activities, attracting population for commerce and services[17]. São Félix do Araguaia is a Zone B Center, equipped with airports and a large flow of connections with other municipalities in the state. Nevertheless, high rates were observed in municipalities that do not have regional airports, but a large number of connections with other cities in the state, being classified as Local Centers, exerting influence only on their territorial limits[9]: Nova Maringá, Querência, Ribeirão Cascalheira, and União do Sul (Figure 1).

When transmitted by social contacts, it is assumed that groups with a larger demographic dimension would tend to be more affected over time[25]. Our findings suggest the same, because although the highest incidence rate was observed in Nova Olímpia (which has 20,563 inhabitants), in general, the highest incidence rates were observed in more populous municipalities. As the majority of the population resides in urban spaces, health problems are relevant in these locations[26], since population density increases the risk of transmission of contagious diseases, as is the case of COVID-19. Therefore, home isolation is essential and may contain the spread of the disease even to municipalities where there are no case reports[27].

Many municipalities in Mato Grosso stand out economically (Cuiabá being the political and administrative center of the state), as many are large agricultural producers, notably of corn, soybeans, and cotton[28]. This can be evidenced by the high Gross Domestic Products (GDP) per capita[29]. Based on findings from other studies, it can be suggested that cities that have greater economic activity tend to have more people circulating, which would facilitate the circulation of the virus at home or work.

Furthermore, there are slaughterhouses[30] in many of these municipalities where high rates of SARS were observed, such as Barra do Garças, Cáceres, Confresa, Cuiabá, Juína, Lucas do Rio Verde, Nova Santa Helena, Peixoto de Azevedo, Primavera do Leste, Sinop, Sorriso, Tangará da Serra, and Várzea Grande. It was observed that municipalities with slaughterhouses can be assumed to be COVID-19 propagation centers, as there is a connection with neighboring municipalities of the productive sector[31] and movement of workers, a major factor for the spread of the disease[32].

This can be aggravated if there are migrant workers, who are in frequent contact with people from different regions, contributing to greater transmission of diseases[33]. In this way, identifying people with flu syndrome and their consequent isolation (if feasible, as soon as possible) can block transmission to other individuals[34].

This reasoning reinforces the need to promote health education practices, understood as the union of concepts from the educational and health areas. Endowed with knowledge, agents, and practices linked to public health actions, they make up health practices in general, seeking to transform habits through guidelines, aiming to promote the individual's autonomy and self-care[35].

Through increasing levels of information and integration with other content, preventive actions related to the transmission of COVID-19 can be prioritized, aiming to reduce illnesses and strengthen the fight against the pandemic. Integrations among community health agents, members of local communities, teachers, and students are also suggested, allowing comprehensive care and exchange of information regarding the pandemic, valuing the knowledge of the territory involved[36-37].

Medium and large cities have higher demographic density and capillarized and internalized transport networks, favoring the spatial spread of COVID-19[38]. These findings corroborate the results of our study, as it is clear that there is a road junction near the capital, connecting it to different regions of the state.

This could be seen from the space-time scan, when clusters 1 and 2 lasted from week 21 to 31 and week 23 to 36, respectively, suggesting that the disease had spread to other regions of Mato Grosso from these locations, because cluster 4 started from week 24 and Cluster 5, from week 26. A similar scenario was identified in cities from Rio de Janeiro and São Paulo, as it was observed that from June 2020, the spread of the disease showed changes within the urban network, with stabilization of the number of cases and deaths in these cities and the consequent increase in these numbers in inland cities and other parts of Brazil[18]. As already noted, our findings are also in line with the spread of the disease in most states in the Brazilian Northeast Region, where there was a rapid spread of cases from metropolitan areas to municipalities in the interior of the states, leading to a possible collapse in the public health system[21].

CONCLUSIONS

Although every epidemiological study tends to have underreporting of cases, the SARS data, through its surveillance system, is being relevant in a scenario where there is still insufficient data to contribute to health prevention actions and where little is known about the course of this epidemic.

We sought to highlight municipalities with higher incidence rates of COVID-19 in the state of Mato Grosso, identifying clusters of greater and lesser risks for the transmission of the disease. The aim was to identify priority areas of attention and health intervention, with the possibility to reduce transmission in high-risk municipalities and to prevent the transmission of the disease in lower-risk municipalities, considering links between different regions of the state through highways, city connections, and hierarchical urban network, facilitating the work of health managers.

Due to its characteristics, the new coronavirus pandemic has become a challenge in scenarios of inequalities, producing profound impacts on public health in different countries. Therefore, the methodology of the present study can contribute to the construction of prevention strategies, contributing to the monitoring of the disease in question, in addition to facilitating actions linked to health education.

As limitations of this study, we can mention possible biases or confusions generated from ecological data, given the lack of statistical association between incidence rates and possible explanatory variables. The present study may also present biases due to the possible underreporting of cases, common in studies using secondary data.

The outbreak of COVID-19 is a reminder that dealing with infectious pathogens and the need for constant surveillance and robust diagnosis are ongoing challenges, as well as understanding the biology of new organisms and their susceptibilities and the development of effective countermeasures.

The diffusion of COVID-19 is closely related to the territorial division of labor, evidenced by the urban network, which has hierarchies. In this way, we sought to highlight priority areas for interventions, aiming at controlling the transmission of the disease, consequently reducing transmission risks to more remote areas of the state of Mato Grosso.

REFERENCES

1. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. N Engl J Med. 2020;382:1199–207. https://doi.org/10.1056/NEJMoa2001316

2. Acter T, Uddin N, Das J, Akhter A, Choudhury TR, Kim S. Evolution of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as coronavirus disease 2019 (COVID-19) pandemic: A global health emergency. Sci Total Environ. 2020;730:138996. https://doi.org/10.1016/j.scitotenv.2020.138996

3. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Guia de vigilância epidemiológica [Internet]. [cited 2020 Oct 02]. Available from: https://coronavirus.saude.gov.br/guia-de-vigilancia-epidemiologica-covid-19. Brasília, 2020.

4. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Banco de Dados de Síndrome Respiratória Aguda Grave – incluindo dados da COVID-19 [Internet]. [cited 2020 Oct 01]. Available from: https://opendatasus.saude.gov.br/dataset/bd-srag-2020

5. Brasil. Ministério da Saúde. Coronavírus Brasil [Internet]. [cited 2021 Jun 18]. Available from: https://covid.saude.gov.br

6. Resendes APC, Da Silveira NAPR, Sabroza PC, Souza-Santos R. Determinação de áreas prioritárias para ações de controle da dengue. Rev SaúdePública. 2010;44(2):274-82. https://doi.org/10.1590/S0034-89102010000200007

7. Masrur A, Yu M, Lu W, Dewan A. Space-time patterns, change, and propagation of COVID-19 risk relative to the intervention scenarios in Bangladesh. Int J Environ Res Public Health. 2020;17:5911. https://doi.org/10.3390/ijerph17165911

8. IBGE - Instituto Brasileiro de Geografia e Estatística. Rio de Janeiro: IBGE; 2019.

9. Brasil. Ministério da Saúde. Banco de Dados de Síndrome Respiratória Aguda Grave – incluindo dados da COVID-19 [Internet]. [cited 2021 Jun 16]. Available from: https://opendatasus.saude.gov.br/dataset/bd-srag-2020

10. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Coordenação Geral de Informações e Análises Epidemiológicas [Internet]. [cited 2021 Jun 15] Available from: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?popsvs/cnv/popbr.def

11. IBGE. Instituto Brasileiro de Geografia e Estatística. Malha municipal [Internet]. [cited 2021 Jun 01] Available from: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/15774-malhas.html

12. IBGE. Instituto Brasileiro de Geografia e Estatística. Regiões de influência das cidades 2007. IBGE, 2008.

13. IBGE. Instituto Brasileiro de Geografia e Estatística. Regiões de influência das cidades 2018. IBGE, 2020.

14. Brasil. Ministério da Infraestrutura. Mapas e bases dos modos de transportes [Internet]. [cited 2021 Jun 15]. Available from: http://www.gov.br/infraestrutura/pt-br/assuntos/dados-de-transportes/bit/bitmodosmapas

15. INTERMAT. Instituto de Terras de Mato Grosso. Bases cartográficas [Internet]. [cited 2020 Aug 02]. Available from: http://www.intermat.mt.gov.br

16. Kulldorff M. SaTScanTMuserguide for version 9.6 [Internet]. 2018. [cited 2020 Jun 27] Available from: https://www.satscan.org/cgi-bin/satscan/register.pl/SaTScan_Users_Guide.pdf?todo=process_userguide_download.pdf

17. Guimarães RB, Catão RC, Martinuci OS, Pugliesi EA, Matsumoto PSS. O raciocínio geográfico e as chaves de leitura da Covid-19 no território brasileiro. Estud Av. 2020;34(99):119-39, 2020a. https://doi.org/10.1590/s0103-4014.2020.3499.008

18. Silveira MR, Felipe Junior NF, Cocco RG, Felácio RM, Rodrigues LA. Novo coronavírus (Sars-CoV-2): difusão espacial e outro patamar para a socialização dos investimentos no Brasil. RevBrasEstud Urbanos Reg. 2020;22:e202024pt. https://doi.org/10.22296/2317-1529.rbeur.202024pt

19. Gracie R, Barcellos C, Magalhães M, Souza-Santos R, Barrocas PRG. Efeitos da escala geográfica na análise dos determinantes da leptospirose. Int J Environ Res Public Health. 2014;11(10):10366-83. https://doi.org/10.3390/ijerph111010366

20. Matsumoto PSS, D'Andrea LAZ. O uso da escala geográfica na saúde pública: as escalas da leishmaniose visceral. Ciênc Saúde Colet. 2019;24(10):3825-36. https://doi.org/10.1590/1413-812320182410.25452017

21. Gomes DS, Andrade LA, Ribeiro CJN, Peixoto MVS, Lima SVMA, Duque AM, Cirilo TM, Góes MAO, Lima AGCF, Santos MB, Araújo KCGM, Santos AD. Risk clusters of COVID-19 transmission in the northeastern Brazil: prospective space-time modelling. Epidemiolinfect. 2020;148(e188):1-8. https://doi.org/10.1017/S0950268820001843

22. Brasil. Departamento Nacional de Infraestrutura de Transportes. Ministério da Infraestrutura [Internet]. [cited 2020 Apr 20]. Available from http://www.dnit.gov.br/noticias/governo-federal-conclui-asfaltamento-da-br-163-pa

23. Magno L, Castellanos MEP. Significados e vulnerabilidade ao HIV/aids entre caminhoneiros de rota longa no Brasil. Rev Saúde Pública. 2016;50:76. https://doi.org/10.1590/S1518-8787.2016050006185

24. Donalisio MR, Cordeiro R, Lourenço RW, Brown JC. The AIDS epidemic in the Amazon region: a spatial case-control study in Rondonia, Brazil. Rev Saúde Pública. 2013;47(5):873-80. https://doi.org/10.1590/rsp.v47i5.76697

25. Santos JAF. Covid-19, causas fundamentais, classe social e território. TrabEduc Saúde. 2020;18(3):e00280112.

https://doi.org/10.1590/1981-7746-sol00280

26. Guimarães RB, Da Costa NM, Nossa PN. Saúde urbana e território: dos desafios pré e durante a pandemia às respostas pós-pandemia. Saúde Soc. 2020;29(2):e000002, 2020b. https://doi.org/10.1590/S0104-129020200000002

27. Silva JH, De Oliveira EC, Hattori TY, De Lemos ERS, Terças-Trettel ACP. Descrição de um cluster da COVID-19: o isolamento e a testagem em assintomáticos como estratégias de prevenção da disseminação local em Mato Grosso, 2020. EpidemiolServSaude. 2020;29(4):e2020264, 2020a. https://doi.org/10.5123/S1679-49742020000400005

28. IBGE. Instituto Brasileiro de Geografia e Estatística. Produção Agrícola Municipal [Internet]. [cited 2020 Oct 05]. Available from: https://sidra.ibge.gov.br/research/pam/tables

29. IBGE. Instituto Brasileiro de Geografia e Estatística. IBGE Cidades [Internet]. [cited 2020 Oct 02]. Available from: https://cidades.ibge.gov.br

30. Econodata. Ranking das 100 maiores empresas de frigorífico em Mato Grosso [Internet]. [cited 2021 Feb 07]. Available from: https://www.econodata.com.br/guia-empresas/maiores-empresas-INDUSTRIA-ALIMENTOS-CARNE-FRIGORIFICO/MATO-GROSSO

31. Heck FM, Nascimento Júnior L, Ruiz RC, Menegon FA. Os territórios da degradação do trabalho na Região Sul e o arranjo organizado a partir da COVID-19: a centralidade dos frigoríficos na difusão espacial da doença. Metodologias e aprendizado. 2020;3:54-68. https://doi.org/10.21166/metapre.v3i0.1332

32. Serra HRH, Oliveira VS. Circulação espacial da COVID-19 através dos frigoríficos no Sul e no Sudeste do Pará: impactos espaciais de uma "atividade essencial" em meio à pandemia. G&DR 2020; 16(4):206-221. ISSN: 1809-239X.

33. Alkhamis MA, Youha SA, Khajah MM, Haider NB, Alhardan S, Nabeel A et al. Spatiotemporal dynamics of the COVID-19 pandemic in the State of Kuwait. Int J InfectDis. 2020;98:153-60. https://doi.org/10.1016/j.ijid.2020.06.078

34. Sales CMM, Da Silva AI, Maciel ELN. Vigilância em saúde da COVID-19 no Brasil: investigação de contatos pela atenção primária em saúde como estratégia de proteção comunitária. EpidemiolServSaude. 2020;29(4):2020373. https://doi.org/10.5123/s1679-49742020000400011

35. Melo LP, Oliveira ALO. Viver através de projetos de saúde: práticas de educação em saúde no Brasil. Educ Real. 2017;42(3):961-980. https://doi.org/10.1590/2175-623656335

36. Diniz MCP, Oliveira TC, Schall VT. Saúde como compreensão de vida: avaliação para inovação na educação em saúde para o ensino fundamental. Rev. Ensaio. 2010;12(1):119-144. https://doi.org/10.1590/1983-21172010120108

37. Santos RS, Carmo LA, Jorge JTB, Faria L. Equipes de aprendizagem ativa na educação em saúde: ensino-serviço-comunidade na prevenção da contaminação por Covid-19. Interface (Botucatu). 2021;25(Supl.1):e210047. https://doi.org/10.1590/interface.210047

38. Barrozo LV, Serafim MB, De Moraes SL, Mansur G. Monitoramento espaço-temporal das áreas de alto risco de COVID-19 nos municípios do Brasil. Hygeia (Uberlândia). 2020;Ed esp:COVID-19:417-425. https://doi.org/10.14393/Hygeia0054547

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