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Space-time scan for identification of risk areas for hospitalization of children due to asthma in Mato Grosso, Brazil

Varredura espaço-temporal para identificação de áreas de risco para hospitalização de crianças por asma em Mato Grosso

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ABSTRACT: ***Introduction:*** Asthma is the result of a complex interaction between genetic, environmental and socioeconomic factors. It represents a serious global public health problem. The goal of this study was to identify geographic areas for priority actions in order to control of asthma in children. ***Method:*** Ecological study that space-time statistic Scan was used. Non-elective, short-stay (type 1) paid authorizations of hospitalizations were selected according to hospitalizations year and children place of residence. ***Results:*** In the two periods of the study, the high risk primary cluster was located in the region of Barra do Bugres (relative risk = 8.17, in the first period, and 10.37, in the second). The number of high-risk clusters increased from 8, in the period 2001–2004, to 9, in 2005–2012; while low-risk clusters decreased from 6, in the initial period, to 4, in the latest. The priority geographic areas for attention and intervention for children with asthma are the region around Barra do Bugres, which remained in the two periods with high risk primary clusters and the southwest border of the State that presented increase of the risk. Furthermore, there was an increase of 87% in the number of high risk counties and a reduction of 28% of the counties of protection. ***Conclusion:*** In conclusion, the surroundings areas of Barra do Bugres and Porto Estrela and the east and northeast border of the state are priority for health care, once there was an increased risk of hospitalization of children due to asthma.

Keywords: Asthma. Child. Spatial-temporal analysis. Spatial analysis.

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RESUMO: ***Introdução*:** A asma resulta de complexa interação entre fatores genéticos, ambientais e socioeconômicos e representa um importante problema de saúde pública mundial. O objetivo deste trabalho foi identificar áreas prioritárias para ações de controle de asma em crianças. ***Método*:** Estudo ecológico no qual foi utilizada a varredura espaço-temporal. Selecionaram-se as autorizações de internação hospitalar pagas, não eletivas, de curta permanência (tipo 1), segundo o ano de ocorrência e o local de residência. Os períodos de análise compreendem os anos de 2001–2004 e 2005–2012. ***Resultados*:** O *cluster* primário de alto risco esteve localizado na região do entorno de Barra do Bugres nos dois períodos de estudo (risco relativo = 8,17, no primeiro período, e 10,37, no segundo). O número de *clusters* de alto risco aumentou de 8, no período 2001–2004, para 9, entre 2005–2012; enquanto os *clusters* de baixo risco diminuíram de 6, no período inicial, para 4, no último. As áreas prioritárias para atenção e intervenção às crianças com asma são a região do entorno de Barra do Bugres, que se manteve nos dois períodos com *clusters* primários de alto risco, e a borda leste e nordeste do estado, que apresentou aumento do risco. Além disso, houve aumento de 87% do número de municípios de alto risco e diminuição em 28% dos municípios de proteção. ***Conclusão*:** Conclui-se que as áreas prioritárias para a atenção à saúde, nas quais aumentou o risco de internação por asma em crianças, são o entorno de Barra do Bugres e Porto Estrela e a borda leste e nordeste do estado.

Palavras-chave: Asma. Criança. Análise espaço-temporal. Análise espacial.

INTRODUCTION

Asthma is one of the most common chronic diseases of childhood and it represents an important global public health problem. When appropriately treated, a child can have symptoms minimized and normal daily activities restored, with lung function closer normality, without exacerbations or hospitalizations, which leads to mortality prevention[1].

Most hospitalizations occur due to exacerbations of asthma and represent failure of treatment or disease control. These hospital admissions are considered markers of primary health care quality and are preventable through adequate disease management[2].

Asthma is the result of a complex interaction between genetic, environmental and socioeconomic factors. Thus, Geographic Information System (GIS) in combination with spatial analysis techniques to monitor the locations of occurrence of asthma in children is relevant, since the maps resulting from this analysis can help one understand the geographical distribution of diseases and identify areas with greater and lower risk, thus contributing to the planning of public health policies and the monitoring of this condition[3].

Silva et al.[4] and Rodrigues et al.[5] analyzed the spatial distribution of hospital admissions for asthma in the Amazonia region using the Kernel density estimation as spatial analysis technique. Other studies[6,7] have reported efficacy of spatial interpolation for studies on the influence of variables on asthma occurrence. The Moran Index, which is based on spatial autocorrelation and aims to identify areas with similar and interrelated characteristics, has been used in studies on asthma in the cities of Chicago[8] and Taiwan[9]. However, the Kernel density estimation for spatial interpolation and the Moran Index have one limitation in common: difficulty in handling the time variable. These techniques are limited to treating information as two-dimensional and non-temporal factor, that is, the analysis of occurrence frequency of the phenomenon studied is made exclusively in function of location and geographic neighbors. If there is a need to analyze multitemporal variation, several maps need to be built, each picturing a given moment in time[10].

An alternative technique is the space-time scan[10], applied to the SaTScan software aiming to identify spatial and time-space clusters and their statistical significance. In studies specifically on asthma in New York[11] and in South Korea[12], the authors used space-time scanning to identify areas of priority for disease control.

The goal of this study was to identify areas of priority for asthma control actions intended for children in Mato Grosso, based on the indicator "rate of hospitalizations due to this disease in children under 5 years of age".

METHOD

STUDY DESIGN

This is a descriptive epidemiological study with ecological design, in which space-time scanning was used. It was conducted in the state of Mato Grosso, in the Center-West region of Brazil. Paid Inpatient hospital authorizations (IHAs), non-elective, short-stay (type 1) admissions were selected and analyzed according to year of occurrence and place of residence of children composing the study population[13]. The periods of analysis were 2001-2004 and 2005-2012.

POPULATION AND AREA COVERED

The unit of analysis consisted of 141 municipalities that make up the State of Mato Grosso, with population estimated in 3,344,544 inhabitants in 2017. During the study period, the population under 5 years of age in the State went from 265,217 inhabitants in 2001 to 250,639 in 2012[14].

The northern part of the State of Mato Grosso is part of the so-called Deforestation Arc, a well-known Brazilian region where there is intense tree felling. The main areas of sugarcane plantation are located in the south-central and south-west regions of the State (Figure 1). Biomass burning from both deforestation and the handling of sugarcane, which occurs mainly between May and September, extensively impacts the quality of the air[15].

SOURCE OF DATA

For this investigation, data about hospital admission related to asthma were obtained from the database of the Hospital Information System (SIH) of the Department of Information and Informatics of the Brazilian Public Health System (SUS), Ministry of Health, through the IHAs. We adopted as case definition the registry of hospitalization with main diagnosis of asthma in children aged up to 4 years, 11 months and 29 days, and living in the municipalities of the State on the date of admission. Data regarding hospitalizations with primary diagnosis of asthma (International Classification of Diseases, ICD-10 codes: J45.0, J45.1, J45.8 and J45.9) were collected. The period of study comprised January 1, 2001 to December 31, 2012. Population data, that is, the number of children under 5 years of age living in each municipality were obtained from the Department of Informatics of the Public Health System (DATASUS)[13] for each year studied. In order to build the maps, the digital system of municipal boundaries was used, available on the website of the Brazilian Institute of Geography and Statistics (IBGE)[14].

SPACE-TIME SCANNING TECHNIQUE

Under the hypothesis that the municipalities with the highest hospitalization rates of children by asthma would form space-time clusters, data were analyzed by the

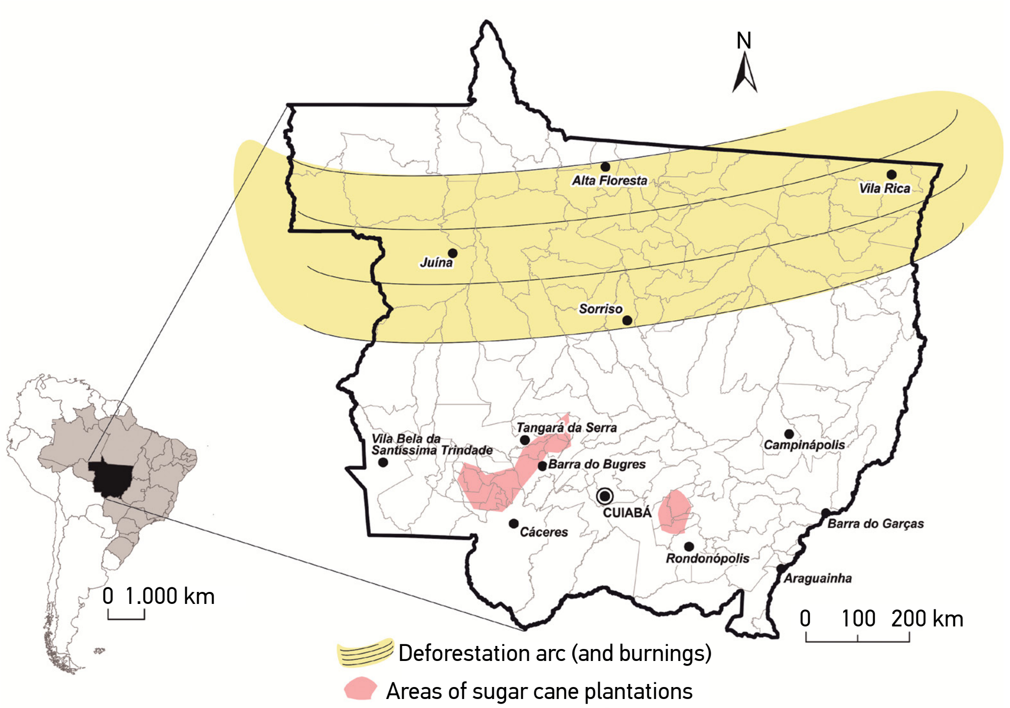

Figure 1. Study area: State of Mato Grosso and identification of the deforestation arc and areas of sugarcane production.

space-time scanning technique. The SaTScan v9.4.4[16] program was used to this end. SaTScan software can be downloaded directly from the developer group's website. The application is free and widely used by major Health Studies Centers such as the Center for Disease Control and Prevention of the USA (CDC-USA) and the Ministry of Health in Brazil. The Kulldorff Scan method[10,16,17] recognizes the spatial cluster that most likely violates the null hypothesis of non-agglomeration; so, it identifies the primary and secondary clusters.

The primary cluster is the maximum likelihood window, which has the lowest probability of occurring at random. A p-value is assigned to this cluster. For purely spatial and space-time analyses, SaTScan also identifies secondary clusters in data set, in addition to the most likely cluster, and sorts them according to Likelihood Ratio Analysis[10,16].

Between 2001 and 2012, there was a decrease in the number of hospitalizations due to asthma in children of the State of Mato Grosso, mainly from 2005. From 2001 to 2004, the number of records remained high and constant; starting in 2005, a pattern of decline was identified[18]. As space-time analysis, the volume of data from 2001 to 2004 could easily camouflage possible clusters from 2005 on. Therefore, the data set was divided into two time series, with the first period comprising 2001 to 2004 and the second period, 2005 to 2012. The Poisson probabilistic model was used to analyze the population at risk – the whole sample of the area covered by the study and the population of each location within the whole the area –, with the full number of cases in the whole area and in each locality[10,16].

For this model, statistic scan adjusts for the irregular population density present in all populations, including the difference between the number of people per gender and age. In this study, the number of hospitalization cases were adjusted by the co-variable gender. The space-time scan is made in a round or elliptical window whose base is spatial and height refers to time.

Points with flat coordinates (X, Y) of the core of municipalities were used. It is possible to feed the model with the geographical coordinates of each municipality, but by using this type of coordinate, the software is limited to looking for clusters in round format, while flat coordinates allow for clusters in other formats (linear or elongated ellipses). In order to not limit the shape of clusters to circles, we opted for the elliptical window[10,16,17].

In addition to identifying spatial clusters, the method provides a powerful measure of presence or absence of the event, or relative risk (RR). A value that represents how much an area is more or less likely to have an event in relation to the other areas of the entire territorial extension studied is calculated. RR indicates the incidence of hospitalization of children with asthma in the cluster relating to the incidence outside the cluster. To assess significance at $p<0.01$, the Monte Carlo simulation was replicated 999 times.

Based on the assumption that there was a significant difference in occurrence of hospitalizations for asthma between 2001-2004 and 2005-2012, data were analyzed according to these periods with monthly precision. The Poisson probability model was used for statistic scanning in an elliptical window, with monthly precision and retrospective analysis. Separate analyses were performed to identify the high- and low-risk clusters in both periods. The following parameters were also considered: maximum population size in each cluster — 30% of the population under risk — and maximum cluster size — 50 km radius on the minor axis of the cluster.

ETHICAL CONSIDERATIONS

Since databases used are secondary and available online, with free and unrestricted access by the general public, in which there is no identification of subjects, the study was exempted submitting a report to the Research Ethics Committee; however, the researchers used caution and respect to research ethical standards, as recommended by Resolution No. 466 of the National Health Council (CNS), December 12, 2012.

RESULTS

In Figure 2, space-time clusters of children hospitalization for asthma in Mato Grosso and respective RRs of both periods (2001-2004 and 2005-2012) are listed. The primary high-risk cluster was located in the same geographic region in both periods, with RR changing from 8.17 to 10.37 in the second period. One may also see an increase in both RR and clusters' extension in the east and northeast regions of Mato Grosso, as well as in the Southwest (cluster 7 in the second period). Only clusters 4 in the north and 10 in the south of the State (in 2005-2012, named clusters 3 and 8, respectively) had RR decrease. In both periods of analysis, the low-risk primary cluster is spotted in the center-south region: cluster 1 in 2001-2004 and cluster 2 in 2005-2012 (Figure 2). All clusters were statistically significant ($p < 0.01$).

Eight high-risk and six low-risk clusters were identified in the first period, with primary cluster presenting RR of 8.17, that is, children living in this area have a 8-fold risk of hospitalization for asthma than those living in other regions of the State. Among low-risk ones, the primary cluster was spotted in the center-south region of the State with RR of 0.2. The municipalities composing it are Cuiabá, Várzea Grande, Jangada, Acorizal, Rosário Oeste and Nossa Senhora do Livramento. Table 1 lists the municipalities belonging to each cluster in 2001-2004.

Between 2001 and 2004, the high-risk primary cluster was in the region of Barra do Bugres (RR = 7.34) and Porto Estrela (RR = 12.97), while the low-risk primary clusters were in the capital and surroundings (Jangada, Cuiabá, Várzea Grande, Acorizal, Rosario Oeste and Nossa Senhora do Livramento).

As shown in Table 2, in the second period studied, there was a decrease in total clusters from 14 to 13, but an increase in high-risk clusters (8 to 9). In the first period, the ratio of high-risk to low-risk clusters was 1.33. In the second period, this ratio increased to 2.25. The number of municipalities that are part of a high-risk cluster increased from 23 in the first period to 43 in the second. On the other hand, the number of municipalities comprised by a low-risk cluster decreased from 29 to 20. In the second period, Barra do Bugres remained as a high-risk primary cluster (RR = 10.37), while the two largest cities in the State remained in low-risk clusters (Cuiabá, RR = 0.25 and Várzea Grande, RR = 0.44).

Looking at Table 3, where one can see the results of scans, all clusters had statistical significance $p<0.001$. In the first period (2001-2004), the highest incidence was recorded in cluster 4, composed of the municipalities of Carlinda (RR = 3.74) and Alta Floresta (RR = 25.26), which also had the highest RR among all clusters in the period and was active during July of 2004. It was therefore a peak incidence of hospitalizations for asthma in Alta Floresta in this time cut. High-risk clusters with longer duration were cluster 2, which persisted for two years (2003 and 2004), composed of the municipalities of Barra do Bugres (RR = 7.34) and Porto Estrela (RR = 12.97), as well as cluster 3, spotted in the second and third years of study, with more than 500 hospitalizations recorded for a population of less than 9 thousand children.

In the second period studied, the high-risk primary cluster was composed of Barra do Bugres between 2005 and 2007. One may consider that this area remained as high-risk for five years when joining both periods of analysis. No other high-risk cluster remained the same uninterruptedly for so long.

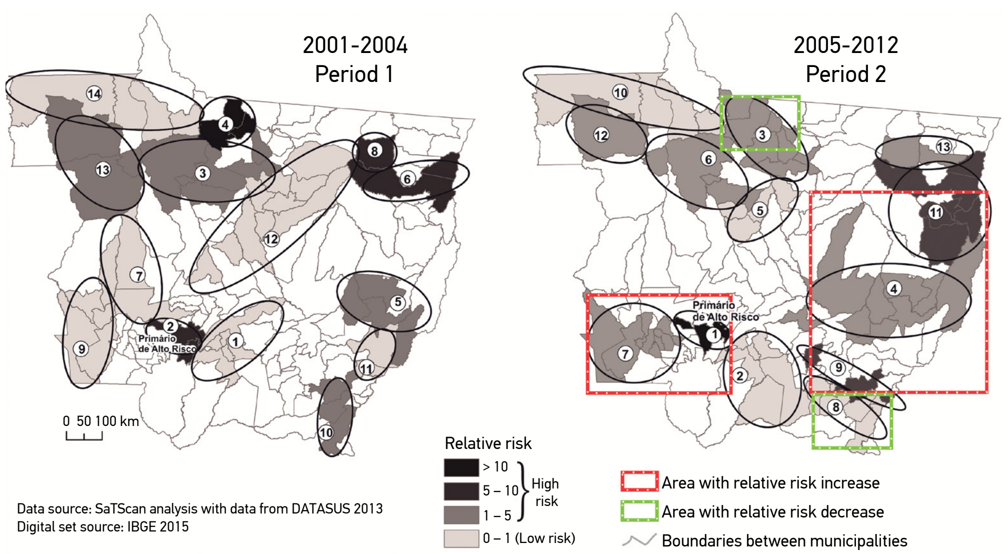

Figure 2. Space-time clusters of children hospitalization for asthma in the State of Mato Grosso: 2001-2004 and 2005-2012.

DISCUSSION

Although the number of hospitalizations across the State was lower in the second (2005-2012) than in the first analysis (2001-2004), there was an increase in clusters of risk for hospitalization by asthma in the second period. That is, the risk of children under 5 years of age being hospitalized due to asthma is higher in some regions of the State.

The increase in RR in the southwest, east and northeast regions of the State coincides with the proximity of sugarcane plantation areas or intense burning of forest biomass.

Table 1. Mato Grosso municipalities in space-time clusters from 2001 to 2004 (first period) and respective relative risks of hospitalizations for asthma in children under five years.

Period		*Cluster*	RR	Population	Municipality (RR)
2001-2004	high-risk cluster	2*	8.17	3,736	Barra do Bugres (7,34) and Porto Estrela (12,97)
		3	4.38	8,627	Tabaporã (1,08), Novo Horizonte do Norte (3,02), Porto dos Gaúchos (2,54), Juara (5,65), Colíder (4,56) and Itaúba (3,75)
		4	21.13	6,085	Carlinda (3,74) and Alta Floresta (25,26)
		5	4.04	4,997	Nova Xavantina (4,54), Araguaiana (8,39), Água Boa (2,90) e Campinápolis (3,50)
		6	5.70	1,325	Luciara (6,47) and São Félix do Araguaia (5,48)
		8	6.10	698	São José do Xingú (6,09)
		10	2.95	2,752	Alto Garças (1,68), Alto Araguaia (3,61) and Guiratinga (3,14)
		13	2.14	6,910	Aripuanã (0,98), Juína (2,46) and Castanheira (2,92)
	low-risk clusters	1*	0.20	72,788	Jangada (0,19), Acorizal (0,23), Várzea Grande (0,36), Cuiabá (0,13), Rosário Oeste (0,13) and Nossa Senhora do Livramento (0,11)
		7	0.03	7,955	Sapezal (0,10), Campos de Júlio (0,00) and Tangará da Serra (0,01)
		9	0.10	6,514	Vila Bela da Santíssima Trindade (0,03), Conquista D'Oeste (0,00), Nova Lacerda (0,00) and Pontes e Lacerda (0,14)
		11	0.14	5,406	Barra do Garças (0,15) and Pontal do Araguaia (0,00)
		12	0.48	25,482	Vera (0,39), Sorriso (0,90), Santa Carmem (0,50), Lucas do Rio Verde (0,35), Cláudia (0,67), União do Sul (0,00), Feliz Natal (0,15), Marcelândia (0,42), Sinop (0,43) and São José do Rio Claro (0,16)
		14	0.23	4,553	Colniza (0,04), Cotriguaçú (0,58), Nova Monte Verde (0,00) and Nova Bandeirantes (0,25)

RR: relative risk; *primary.
Source: SaTScan analysis with data from DATASUS[13].

The decrease trend in asthma hospitalizations during the period studied in Mato Grosso[18] did not mean a reduction in the risk of hospitalization.

The municipality of Barra do Bugres corresponds to the primary cluster in the first and second periods, besides having shown an increase in relative risk in the second period.

Table 2. Mato Grosso municipalities in the space-time clusters from 2005 to 2012 (second period) and respective relative risks of hospitalizations for asthma in children under five years.

Period		Cluster	RR	Population	Municipality (RR)
2005–2012	high-risk clusters	1*	10.38	3,250	Barra do Bugres (10,37)
		3	4.06	10,732	Nova Canaã (3,42), Colíder (4,21), Itaúba (5,03), Alta Floresta (3,63), Carlinda (2,19), Nova Santa Helena (1,29), Nova Guarita (0,78) and Paranaíta (8,63)
		4	4.03	8,884	Campinápolis (2,83), Santo Antônio do Leste (1,55), Nova Xavantina (4,92), Água Boa (3,35), Nova Nazaré (10,38), Cocalinho (5,06), Nova Brasilândia (2,60), Paranatinga (4,63) and Novo São Joaquim (1,74)
		6	3.77	4,693	Castanheira (1,02), Juara (4,13), Novo Horizonte do Norte (3,58) and Porto dos Gaúchos (4,61)
		7	2.87	9,178	Pontes e Lacerda (2,58), Vale de São Domingos (1,87), Jauru (1,21), Figueirópolis D'Oeste (1,34), Vila Bela da Santíssima Trindade (0,90), Reserva do Cabaçal (2,73), Indiavaí (5,61), Araputanga (5,58) and Rio Branco (9,89)
		9	6.13	1,715	Guiratinga (5,91), Ponte Branca (7,07) e Dom Aquino (6,13)
		11	5.17	2,864	São Félix do Araguaia (4,93), Luciara (9,94), Serra Nova Dourada (0,00), Bom Jesus Araguaia (0,55), Novo Santo Antônio (0,00) and Ribeirão Cascalheira (9,53)
		12	2.38	2,042	Aripuanã (2,38)
		13	2.72	1,684	São José do Xingu (3,32) and Porto Alegre do Norte (2,22)
	low-risk clusters	2*	0.32	70,849	Nossa Senhora do Livramento (0,81), Santo Antônio do Leverger (0,79), Várzea Grande (0,44), Cuiabá (0,25), Barão do Melgaço (0,19) and Jangada (0,05)
		5	0.03	12,432	Ipiranga Norte (0,35), Itanhagá (0,11), Sinop (0,01) and Tapura (0,00)
		8	0.16	18,561	Alto Garças (0,00), Alto Araguaia (0,37), Araguainha (0,00), Pedra Preta (0,05), São José do Povo (0,00) and Rondonópolis (0,16)
		10	0.10	6,309	Colniza (0,17), Cotriguaçu (0,07), Nova Bandeirantes (0,00) and Nova Monte Verde (0,00)

RR: relative risk; *primary.
Source: SaTScan analysis with data from DATASUS[13].

Table 3. Characteristics of high-risk and low-risk clusters for hospitalization for asthma in children under five in Mato Grosso, 2001 to 2012.

Period	*Cluster*	Period	Population	Cases seen	Expected cases	Incidence[a]	RR	LR	p-value[b]
2001-2004	Primary *	01/2003 a 12/2004	72,795	266	1.199.1	179.6	0.2	588.5	0.000
	2§	02/2003 a 12/2004	3,737	459	58.8	6,311.2	8.1	551.8	0.000
	3	12/2001 a 11/2003	8,630	577	138.7	3,366.7	4.3	395.4	0.000
	4	07/2004 a 07/2004	6,085	87	4.1	16,944.4	21.1	182.1	0.000
	5	10/2001 a 09/2003	4,999	319	81.1	3,183.3	4.0	202.1	0.000
	6	02/2003 a 11/2004	1,326	110	19.4	4,570.0	5.7	100.3	0.000
	7	02/2002 a 01/2004	7,958	4	129.3	25.0	0.0	112.3	0.000
	8	01/2001 a 12/2002	699	65	10.7	4,904.2	6.1	62.9	0.000
	9	06/2002 a 04/2004	6,517	10	101.8	79.5	0.1	69.1	0.000
	10	06/2002 a 05/2004	2,752	130	44.5	2,362.1	2.9	54.1	0.000
	11	11/2001 a 09/2003	5,407	12	83.5	116.2	0.1	48.5	0.000
	12	08/2003 a 12/2004	25,490	150	308.5	393.7	0.4	51.8	0.000
	13	02/2001 a 07/2002	6,912	174	82.0	1,717.9	2.1	39.3	0.000
	14	01/2003 a 12/2004	4,556	18	77.4	188.1	0.2	33.4	0.000
2005–2012	Primary§	01/2005 a 09/2007	3,250	427	42.9	4,353.9	10.3	604.9	0.000
	2*	02/2005 a 01/2009	68,483	462	1.317.9	153.4	0.3	415.9	0.000
	3	01/2005 a 07/2008	10,732	702	183.5	1,674.3	4.0	438.3	0.000
	4	01/2005 a 05/2008	8,890	505	130.7	1,690.1	4.0	315.7	0.000
	5	11/2008 a 10/2012	12,433	6	207.5	12.7	0.0	182.4	0.000
	6	01/2005 a 12/2008	4,701	333	90.6	1,607.5	3.7	194.0	0.000
	7	04/2005 a 07/2008	9,182	407	145.8	1,221.2	2.8	160.2	0.000
	8	07/2009 a 12/2012	18,565	48	289.1	72.7	0.1	158.1	0.000
	9	02/2009 a 12/2012	1,716	170	28.1	2,643.2	6.1	164.9	0.000
	10	04/2008 a 03/2012	6,324	12	118.5	44.3	0.1	79.7	0.000
	11	01/2005 a 08/2005	2,865	44	8.5	2,253.4	5.1	36.7	0.000
	12	01/2008 a 11/2011	2,042	80	33.7	1,037.3	2.3	22.8	0.000
	13	01/2005 a 09/2007	1,684	63	23.2	1,184.0	2.7	23.0	0.000

RR: relative risk; LR: likelihood ratio; [a]cases per year/10 thousand inhabitants; [b]determined by 999 Monte Carlo replications; *low-risk primary cluster; §high-risk primary cluster.
Source: SaTScan analysis with data from DATASUS[13].

High-risk primary clusters remained the same in both periods, with increase in risk of 8.17 to 10.37 in the second period.

From 2001 to 2004, the municipality of Alta Floresta had more than twice-risked clusters (RR = 25.26) compared to the cluster of Barra do Bugres and Porto Estrela (RR = 8.17), two other municipalities with high risk of hospitalization for asthma. Freitas et al.[15] reported that, in 2004, heat sources concentrated in the area of deforestation were accentuated with intense biomass burning, which is mainly associated with the expansion of agriculture. In the present study, we found an interposition between the clusters of risk for hospitalization for asthma with sugar cane plantation regions in Mato Grosso. However, there was also increased risk of hospitalization at the eastern and northeastern borders of the State — part of this area is included in the so-called "deforestation arc", but part is located below it and above the sugar cane plantation regions. Factors such as direction of winds and local geography may, therefore, be hampering the dispersion of pollutants, increasing the risk of hospitalization due to asthma among children of these regions.

Between 2003-2004 and 2011-2012, the sugarcane plantation area in Barra do Bugres increased from 37,817 to 52,958 hectares[19], not considering areas in the surroundings. The municipality of Barra do Bugres houses one of the main sugarcane beneficiation plants and the largest planted area in the State. Altogether, Barra do Bugres and surrounding municipalities represent 63% of the plantation area in Mato Grosso[20]. The sugarcane burning activity carried out at the plant places the municipality among the first positions when it comes to burnings in Mato Grosso.

According to Magalhães and Werle[21], the burnings reduce the costs of the sugar industry and increase their profits, but society suffers damages from it. Particulate matter from biomass burning is irritating to the respiratory system and has chemical compounds known to be harmful to respiratory health, causing an increase in the rates of asthma exacerbations in children[22].

Subjects in social and economic vulnerability may be more exposed and suffer more from the action of environmental pollutants,[23] resulting in higher rates of hospitalization in nearby areas, especially when they do not have adequate access to primary care services. Ignotti et al.[24] proposed the use of combined indicators of morbidity and mortality from respiratory diseases in children under 5 years of age to identify municipalities that should be priority in the State of Mato Grosso to study the effects of air pollution on human health. These authors identified Alta Floresta, Barra do Bugres, Barra do Garça, Juara and Tangará da Serra as main targets.

Respecting differences in methodology between the study by Ignotti et al.[24] and ours, and the disease analyzed, in which case it was not related to the set of diseases affecting the respiratory system, but specifically asthma, the distribution pattern is very similar, with the advantage of using non-fatal event, the indicator of hospital morbidity. Admissions by asthma are considered indicators of quality of primary care and part of the checklist of "hospitalizations for conditions sensitive to primary care".

Compared with other space statistical methods, the statistic Scan has advantages that make it suitable for the location of clusters:

- can be adjusted for population density;
- can be adjusted by confounding variables;
- minimizes pre-selection bias, since it searches for clusters without defining size and location;
- the likelihood ratio statistical test takes multiple tests into account, reporting a single p-value when testing the null hypothesis[10].

A disadvantage of previous versions of SaTScan was that clusters would always be designed as circles; this could be a problem, as there may be clusters in contiguous areas with narrow and elongated shape in the latitudinal or longitudinal extent. In recent versions, this was corrected[25].

It is understood that studies on the time-space risk variability play an important role in diagnosis and recognition of patterns of distribution when it comes to hospitalization of children by asthma in the State of Mato Grosso, being an important step in understanding the determining factors of the health-disease process and introducing space as a multidimensional factor to enable a collective-risk view. Space-time analysis allows to identify as priority areas requiring attention and interventions aimed at children with asthma in the region surrounding Barra do Bugres, which remained as high-risk primary cluster in both periods, and the southwest border of the State, which had the risk increased. In terms of public policies, investments in the mechanization of farming, fire-fighting policies and surveillance systems, health promotion and protective measures for people in general are required.

Some of the limitations of this study are the use of secondary databases related to hospitalizations, in which under-registration may have occurred. In addition, it is an ecological study, so it does not allow extrapolations to individuals, because it would be an ecological fallacy.

It is convenient to analyze in further studies both the dose-response relationship of the impact of pollution from the burning of biomass (sugar cane or forest) on the respiratory system and the quality of primary care in these localities.

CONCLUSION

Using the space-time scanning technique, we could identify areas of high and low risk of hospitalization of children due to asthma in the State of Mato Grosso between 2001 and 2012. This technique also helped to identify the high-risk cluster that was maintained for both periods, in addition to pointing out an increase of 87% in the number of high-risk municipalities and a decrease of 28% in protection municipalities. It is, therefore, imperative to improve the access to health care in the southwest of the State, in the surroundings of

Barra do Bugres and Porto Estrela, and in the northeast and east edges of the State, where an increased risk of hospitalization of children due to asthma was detected.

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REFERENCES

1. Global Initiative for Asthma. Global strategy for asthma management and prevention: Online Appendix 2018 [Internet]. Global Initiative for Asthma; 2018 [acessado em 5 abr. 2017]. Disponível em: http://ginasthma.org/2017-online-appendix-global-strategy-for-asthma-management-and-prevention/
2. Alfradique MA, Bonolo PF, Dourado I, Lima-Costa MF, Macinko J, Mendonça CS, et al. Internações por condições sensíveis à atenção primária: a construção da lista brasileira como ferramenta para medir o desempenho do sistema de saúde (Projeto ICSAP – Brasil). Cad Saúde Pública 2009; 25(6): 1337-49. http://dx.doi.org/10.1590/S0102-311X2009000600016
3. Hino P, Villa TCS, Sassaki CM, Nogueira JÁ, Santos CB. Geoprocessamento aplicado à área da saúde. Rev Latino-am Enferm [Internet] 2006 [acessado em 10 out. 2017]; 14(6): 939-43. Disponível em: www.eerp.usp.br/rlae https://doi.org/10.1590/S0104-11692006000600016
4. Silva PR, Rosa AM, Hacon SS, Ignotti E. Hospitalization of children for asthma in the Brazilian Amazon: trend and spatial distribution. J Pediatr (Rio J) 2009; 85(6): 541-6. https://doi.org/doi:10.2223/JPED.1952
5. Rodrigues PCO, Ignotti E, Rosa AM, Hacon SS. Distribuição espacial das internações por asma em idosos na Amazônia Brasileira. Rev Bras Epidemiol 2010; 13(3): 523-32. http://dx.doi.org/10.1590/S1415-790X2010000300015
6. Lu H, Qiu F, Cheng Y. Temporal and Spatial Relationship of Ozone and Asthma. In: ESRI, editor. Esri International User Conference. San Diego; 2003. p. 14.
7. Sahsuvaroglu T, Jerrett M, Sears MR, McConnell R, Finkelstein N, Arain A, et al. Spatial analysis of air pollution and childhood asthma in Hamilton, Canada: comparing exposure methods in sensitive subgroups. Environ Health 2009; 8: 14. https://dx.doi.org/10.1186%2F1476-069X-8-14
8. Gupta RS, Zhang X, Sharp LK, Shannon JJ, Weiss KB. Geographic variability in childhood asthma prevalence in Chicago. J Allergy Clin Immunol 2008; 121(3): 639-645.e1. https://doi.org/10.1016/j.jaci.2007.11.036
9. Tsai P-J, Lin M-L, Chu C-M, Perng C-H. Spatial autocorrelation analysis of health care hotspots in Taiwan in 2006. BMC Public Health 2009; 9(1): 464. https://doi.org/10.1186/1471-2458-9-464
10. Kulldorff M. A spatial scan statistic. Commun Stat [Internet] 1997 [acessado em 5 out. 2017]; 26(6): 1481-96. Disponível em: http://www.satscan.us/papers/k-cstm1997.pdf https://doi.org/10.1080/03610929708831995
11. Corburn J, Osleeb J, Porter M. Urban asthma and the neighbourhood environment in New York City. Health Place 2006; 12(2): 167-79. https://doi.org/10.1016/j.healthplace.2004.11.002
12. Lee H, Kim GS. Geographical and sociodemographic risk factors for allergic diseases in Korean children. Asian Nurs Res 2011; 5(1): 1-10. https://doi.org/10.1016/S1976-1317(11)60008-X
13. Brasil. Ministério da Saúde. Datasus. Informações de Saúde. Demográficas e Socioeconômicas [Internet]. 2016 [acessado em 10 out. 2017]. Disponível em: http://www.datasus.gov.br
14. Instituto Brasileiro de Geografia e Estatística. Estimativas da população residente no Brasil e unidades da federação com data de referência em 1º de julho de 2017 [Internet]. 2017 [acessado em 10 out. 2017]. Disponível em: ftp://ftp.ibge.gov.br/Estimativas_de_Populacao/Estimativas_2017/estimativa_dou_2017.pdf
15. Freitas SR, Longo KM, Dias MAF, Dias PL. Emissões de queimadas em ecossistemas da América do Sul. Estud Av 2005; 19(53): 167-85. http://dx.doi.org/10.1590/S0103-40142005000100011
16. SaTScan™. Software for the spatial, temporal and space-time scan statistics. SaTScan v9.4.4 [Internet]. 2016 [acessado em 5 out. 2017]. Disponível em: https://www.satscan.org/
17. Kulldorff M, Nagarwalla N. Spatial disease clusters: Detection and inference. Stat Med. 1995; 14(8): 799-810.
18. Souza EC de O. Distribuição espacial da hospitalização de crianças com asma em Mato Grosso [dissertação]. Cuiabá: Instituto de Saúde Coletiva da Universidade Federal de Mato Grosso; 2013.

19. Canasat. Monitoramento da cana-de-açúcar [Internet]. [acessado em 5 abr. 2017]. Disponível em: http://www.dsr.inpe.br/laf/canasat/tabelas.html
20. Sindicato das Indústrias Sucroalcooleiras do Estado de Mato Grosso. Setor sucroenergético [Internet]. [acessado em 5 abr. 2017]. Disponível em: http://www.sindalcool-mt.com.br/setor.php?texto=casasindalcool_setor_3setor_mt%3E
21. Magalhães LZ de, Werle HS. Problemas Ambientais de uma Cidade Média de Mato Grosso: O Caso de Barra do Bugres. Planej Políticas Públicas [Internet]. 2009 [acessado em 5 abr. 2017]; 33: 79-101. Disponível em: https://desafios.ipea.gov.br/ppp/index.php/PPP/article/view/154
22. Jacquemin B, Sunyer J. Asthma and air pollution: where are we? BRN Rev 2015; 1(2): 78-91. http://doi.org/10.23866/BRNRev:2015-M0008
23. Organización Panamericana de la Salud. Evaluación de los efectos de la contaminación del aire en la salud de América Latina y el Caribe. Organización Panamericana de la Salud; 2005.
24. Ignotti E, Hacon SS, Silva AMC, Junger WL, Castro HA. Efeitos das queimadas na Amazônia: método de seleção dos municípios segundo indicadores de saúde. Rev Bras Epidemiol 2007; 10(4): 453-64. http://dx.doi.org/10.1590/S1415-790X2007000400003
25. Iyengar VS. Space-time clusters with flexible shapes. MMWR 2005; 54: 71-6.

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