Maternal mortality and social vulnerability in a Northeast State in Brazil: a spatial-temporal approach

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Abstract

Objectives: to analyze the epidemiological profile and the spatial-temporal dynamics on maternal mortality in Alagoas and its relationship with social vulnerability and income inequality.

Methods: a mixed ecological study involving maternal deaths who resided in Alagoas from 1996 to 2016. Sociodemographic variables (age, race/color, education, marital status), clinical (type of obstetric cause, death by category and ICD group) were analyzed, besides the indicators (Maternal Mortality Ratio- MMR, Social Vulnerability Index and Gini Index). For the temporal analysis, we used the inflection point regression model and for the spatial analysis, the local empirical Bayesian model, Moran Global and Local statistics, and the bivariate local spatial autocorrelation analysis.

Results: a total of 586 deaths (47.63/100 thousand live births) were registered, with a trend of MMR growth (APC 2.8%), with a heterogeneous distribution between health regions and cities. The profile was characterized by the predominance of young, black / mixed skin color women with low schooling. Eight cities were considered priority. There was spatial correlation with the Social Vulnerability Index and income inequality.

Conclusions: identifying priority areas may contribute to planning and targeting interventions.

Key words *Maternal mortality, Epidemiology, Social vulnerability*

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Introduction

The World Health Organization (WHO) defines a woman's death during pregnancy or up to 42 days after childbirth as maternal death, regardless of duration or location of the pregnancy, due to the cause related to or aggravated by the pregnancy or in relation to by its action, except for accidental or incidental causes.[1]

Maternal mortality is one of the most severe human rights violations, preventable in 92% of the cases, focusing mainly in developing countries. In Brazil, from 1996 to 2016, there were 35,546 maternal deaths. The Southeast Region occupied the first position in the country with 12,686 cases and the Northeast, in second position with 11,777 deaths.[2]

The Maternal Mortality Ratio (MMR) is an important predictor in the quality of women's healthcare, from prenatal care to puerperium. High MMR are indicative of poor socioeconomic conditions, low level of information and education, family dynamics in which violence is present and, above all, difficulties in accessing quality in the health services.[3] This predictor is also used for epidemiological, trend and territorial inequality analyzes, and assisting the planning in health policies.[4]

In view of the worldwide severity in maternal mortality, the United Nations (UN) developed in 2000, the Millennium Declaration that addresses the "Millennium Development Goals". The fifth objective presents the goals for improving women's health by 2015, including the reduction of maternal mortality by three quarters, as well as universal access to reproductive health.[5] Despite the efforts, Brazil did not achieve this goal, maintaining in 2015 a maternal death rate of 57.59 for every 100 thousand Live Births (LB).[6]

In 2015, the 2030 Agenda for Sustainable Development was released.[7] It outlined 17 objectives to transform the world by 2030. The third objective is about health and well-being, with a goal in reducing global Maternal Mortality (MM) in less than 70 deaths per 100 thousand LB, having universal access to sexual and reproductive health services, family planning and the expansion to confront communicable and non-communicable diseases, besides to ensure the investment in policies that permit the reduction of maternal and child mortality, but also to put an end on deaths of preventable obstetric causes.[7]

Healthcare for pregnant women in Brazil gained strength after the implementation of the *Sistema Único de Saúde* (SUS) (Public Health Service) and the creation of the *Estratégia Saúde da Família* (ESF) (Strategy in Family Health) in the 1990s. It was consolidated with the implementation of the *Programa de Humanização no Pré-natal e Nascimento* (PHPN) (Prenatal and Birth Humanization Program) in 2000, which aimed to reduce maternal and child morbidity and mortality through qualitative improvement in prenatal, childbirth and postpartum care and, later with the implantation of the *Rede Cegonha* (Stork Network) in 2011, which implemented an organizational model for the maternal and child health network, ensuring prenatal care up to 24 months post-birth.[8-9]

This spatial-temporal type study carried out in Alagoas, over a time span of twenty-one years, may help in understanding the dynamics of maternal mortality in the State, presenting as a possible facilitator for decision-making in health and the adoption of strategies that can reduce maternal mortality in areas of risk. Thus, this study aimed to analyze the epidemiological profile and the spatial-temporal dynamics of maternal mortality in the State of Alagoas (1996-2016) and the relation with social vulnerability and income inequality.

Methods

This is a mixed ecological study involving maternal deaths in women living in the State of Alagoas, which occurred in the period of 1996 and 2016. A unit of analysis was adopted in the entire State of Alagoas, which is located in the Northeast of Brazil. The State territory is of 27,848,140 km^2, comprising 102 cities with an estimated population of 3,322,820 inhabitants in 2018.[10] The State territory is divided into two Health Macro-regions (HM), each with a city pole, and in ten micro-regions. Approximately 95.0% of Alagoas cities are found to be in a high or extremely high vulnerability.[11]

For the sociodemographic and epidemiological characterization of maternal deaths, the variables age group of the mother, race / skin color, education, marital status, type of obstetric cause (direct, indirect and unspecified), deaths investigated, death according to International Classification of Diseasecategory and group were analyzed, and including MMR. In addition, the Social Vulnerability Index and its three dimensions (education, human capital and income and work) and the Gini Index were included in the study. The *Índice de Vulnerabilidade Social* (IVS) (Social Vulnerability Index) was prepared by the *Instituto de Pesquisas Econômicas Aplicadas* (IPEA) (Applied Economic Research Institute) to indicate contexts of vulnera-

bility and social exclusion in the Brazilian territory.[11]

To calculate the Maternal Mortality Ratio, women's deaths at childbearing age (10 to 49 years) in the group "pregnancy, childbirth and puerperium" from the International Classification of Disease (ICD-10) were considered: i) Pregnancy ending in abortion (O00-008); ii) Edema, proteinuria and hypertensive disorders at pregnancy, childbirth and puerperium (O10-016); iii) Other maternal disorders predominantly related to pregnancy (O20-029); iv) Care given to the mother for reasons related to the fetus and amniotic cavity and for possible problems related to childbirth (O30-048); v) Complications of labor and childbirth (O60-075); vi) Childbirth (O80-084); vii) Complications related predominantly to puerperium (O85-092); viii) Other obstetric conditions not classified elsewhere (O95, O98, O99). In addition to ix) Disease caused by HIV (B20-B24); x) Malignant or invasive hydatidiform mole (D39.2); and xi) Postpartum pituitary necrosis (E23.0), as long as the woman is pregnant at the time of death or has been pregnant up to 42 days before death. And the following causes: xii) Puerperal osteomalacia (M83.0); xiii) Obstetric tetanus (A34); and xiv) Mental and behavioral disorders associated with puerperium (F53), in cases where death occurred within 42 days after termination of the pregnancy or in cases of no information at the elapsed time between termination of the pregnancy and death. The ICDs death from any obstetric cause, which occurs more than 42 days, but less than a year, after childbirth (O96) and death of sequels from direct obstetric causes (O97) as these are referred to death over 42 days, were excluded from the research.

Death data was extracted from the *Sistema de Informações sobre mortalidade* (SIM) (Mortality Information System) (http://www2.datasus.gov.br/DATASUS/index.php?area=0205&id=6939&VObj=http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sim/cnv/mat10), the data on the number of live births, necessary to calculate MMR, were obtained from the *Sistema de Informações de Nascidos Vivos* (SINASC) (Live Birth Information System) (http://www2.datasus.gov.br/DATASUS/index.php?area=0205&id=6936) and the social indicators were obtained from the *Atlas de Vulnerabilidade Social* (Social Vulnerability Atlas) (http://ivs.ipea.gov.br/index.php/pt/).

After collecting the data, the MMR was calculated using the following equations:

A) Annual MMR: number of maternal deaths on location and year / number of live births on location and year X 100 thousand;

B) Periodic MMR: average of maternal deaths in the period studied and location / number of live births in the middle of the period X 100 thousand;

The statistical treatment was contained in three stages. The first consisted of a descriptive analysis of sociodemographic characteristics, which were presented through absolute number, relative frequency, and MMR.

The second stage was consisted of the trend analysis. For this purpose, the inflection point regression model (Joinpoint regression model) was used. The model tests whether a line of multiple segments is statistically better suited to describe the temporal evolution of the data than a straight line or a line with fewer segments, using the Monte Carlo permutation method. Each inflection point indicates a change in the trend.[12] The Joinpoint allows the classification of the trend into stationary, increasing, or decreasing, allowing the identification of the point at which there is a modification of this trend and the annual percentage variation (APC, Annual Percentage Change). A significance level of 5% and a 95% confidence interval (CI95%) were adopted. In this stage, the Joinpoint Regression Program 4.5.0.1 (National Cancer Institute- USA) was used.

The third stage consisted of spatial modeling. This analysis was divided into two stages. The first was the smoothing of mortality rates with the use of the local empirical Bayesian model. The model restricts the random fluctuation of data, providing greater stability. Its use was justified by the existence of cities with a very reduced population, as well as by the possible fragility of mortality data. This model aims to identify the posterior distribution (unobserved quantities of a given phenomenon) from the application of Bayes' theorem involving sample data (likelihood function) and a set of observed data (a priori distribution).[13]

After obtaining the smoothed rates, the spatial dependence was initially assessed by using the Moran Global statistic and the pseudo-significance test. The Moran Index varies between -1 and +1, with values close to zero indicating spatial randomness; positive values suggest positive spatial autocorrelation and negative values, negative spatial autocorrelation. Once the global spatial dependence was verified, Moran's local statistics (Local Index of Spatial Association - LISA) was applied. From LISA, each city was positioned in a quadrant of the Moran scattering diagram: Q1- high / high (positive values and positive means), Q2- low / low (negative values and negative means), Q3- high / low (positive values and negative means) and Q4- low / high (negative values and positive means). Based on the

results obtained from the spreading graph of Moran and LISA, thematic maps were made of Moran Map. The Moran Map considers only the areas where Moran indexes are significant (p<0.05) (19,20). Additionally, the analysis of bivariable local spatial autocorrelation between the smoothed MMR and the social indicators was carried out to identify common spatial clusters.[14]

For these analyzes, Terra View software 4.2.2 (*Instituto Brasileiro de Pesquisas Espaciais*- INPE (Brazilian Institute for Space Research), São José dos Campos, SP, Brazil.), GeoDa 1.10 (Center for Spatial Data Science, Computation Institute, The University of Chicago, IL. USA) and QGis 2.14.11 (Open Source Geospatial Foundation- OSGeo, Beaverton, OR. USA) were used. The territorial meshes necessary for making the maps came from *Instituto Brasileiro de Geografia e Estatística* (IBGE) (Brazilian Institute on Geography and Statistic).

In this study, only secondary data from public domain information systems were used, in which it is impossible to identify individuals. For this reason, authorization from the Research Ethics Committee was waived.

Results

In the period of 1996 to 2016, 586 maternal deaths were registered in Alagoas, resulting in a mortality rate of 47.63 deaths for every 100 thousand LB. The regression model showed a linear growth trend over the temporal series (APC 2.8%; CI95%= 0.9 - 4.7; p<0.001). The first macro-region concentrated 62.42% (n=366) deaths and demonstrated a tendency for mortality to increase (APC 3.1%; CI95%= 1.4 - 4.8; p<0.001), while the second presented the highest MMR (52.27 / 100 thousand LB), but with a stationary trend. The 3rd and 4th micro-regions were the only ones with an increasing trend (APC 25.0% and 22.7%, respectively). In contrast, the highest MMR were observed in the 9th (56.74 / 100 thousand LB) and the 10th (59.57 / 100 thousand LB) micro-regions, located in the Outback lands in the State (Figure 1).

Of the registered deaths, 36.35% (n=213) correspond to the age group of 20 to 29 years old (32.44/100 thousand LB), although the highest MMR was registered in the range of 40 to 49 years old (206.52/100 thousand). Mortality in the 15 to 19 age group was the only one with a growing trend (APC 5.4; CI95%= 2.6 - 8.2; p<0.001). The black and mixed skin color women had the highest mortality rates (158.21/100 thousand LB and 40.77/100 thousand LB, respectively), with an upward trend in both (APC 21.0% and 40.6%, respectively). Low schooling was another characteristic that stood out, with MMR being higher in the population with no schooling (37.84/100 thousand). Additionally, the highest mortality was observed in widowed women (333.89/100 thousand LB) (Table 1).

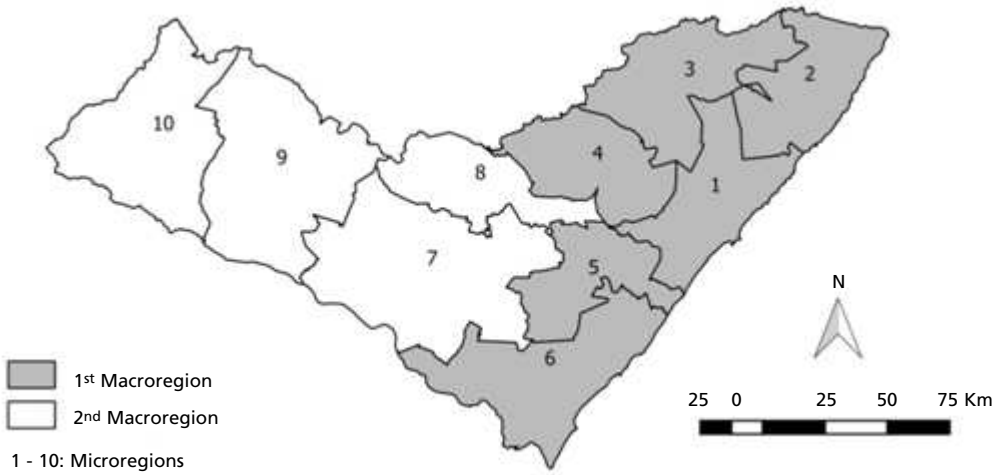
As for the causes of deaths, the groups "edema, proteinuria and hypertensive disorders in pregnancy, childbirth and puerperium" (26.28%; n=154 cases; MMR 12.52/100 thousand LB) and "complications at labor and childbirth" stood out (24.06%; n=141 cases; MMR 11.46/100 thousand LB). The categories "eclampsia" (12.97%; n = 76 cases; MMR 6.18 / 100 thousand LB) and "other diseases of the mother, classified elsewhere, but which complicate with pregnancy, childbirth and puerperium" (9.22%; n = 54 cases; MMR 4.39 / 100 thousand) occupied the first positions. Additionally, 87.71% (n = 514 cases) were classified as direct maternal obstetric death (Table 2).

In the spatial modeling in Alagoas, 12 cities did not register any maternal deaths in the studied period. On the other hand, 14 registered ten or more deaths, with a total of 340 cases. Among these, the State capital, Maceió, registered 142 deaths. As for MMR, 11 cities presented rates higher than 100 deaths/100 thousand LB, with emphasis on Maragogi (476.19/100 thousand), Marechal Deodoro (239.18/100 thousand) and Jundiá (200.49/100 thousand). After the correction on the rates performed by the Bayesian model, no city was registered as silent and only one had a rate higher than 100/100 thousand (Jacuípe, 106.60 / 100 thousand LB). In Moran Map, only eight cities were considered priorities: five in the North Coast (Porto Calvo, Maragogi, Jacuípe, Campestre and Jundiá), one in the Scrubland (Arapiraca) and two in the Outback lands (Águabranca and Pariconha) (Figure 2).

In the analysis of bivariate autocorrelation, a spatial relation was observed between MMR and all the analyzed social indicators. As in the univariate analysis, the priority cities were concentrated mainly in the Northeast and in the Outback lands in the State: Two cities for the General *Índice de Vulnerabilidade Social* (IVS) (Social Vulnerability Index) (in the Northeast of the State), five for the Urban Infrastructure of the IVS (in the Northeast), seven for the Human Capital of the IVS (five in the Northeast and two in the Outback lands), 12 for the Income and Work of the IVS (one in the Scrubland and 11 in the Outback lands) and ten for the Gini Index (three in the Scrubland and seven in the Outback lands) (Figure 3).

Figure 1

Maternal Mortality Ratio by health macro-region and health micro-region in Alagoas, Brazil, 1996 to 2016.



	Maternal deaths		MMR	*Jointpoint regression* model 1996-2016			
Territorial Unit	**n**	**%**		**APC**	**CI95%**	***p***	**Classification**
Health Macroregion							
1st	366	62.46	45.22	3.1	1.4 – 4.8	<0.001	Increasing
2nd	220	37.54	52.27	2.7	-0.7 – 6.1	0.1	Stationary
Health Region							
1st	183	31.23	42.84	1.8	-0.7 – 4.4	0.2	Stationary
2nd	32	5.46	49.06	18.3	-8.6 – 53.3	0.2	Stationary
3rd	50	8.53	54.25	25.0	0.5 – 55.5	<0.001	Increasing
4th	30	5.12	53.73	22.7	2.8 – 46.5	<0.001	Increasing
5th	44	7.51	49.71	12.8	-1.6 – 29.2	0.1	Stationary
6th	27	4.61	33.58	12.3	-17.9 – 53.5	0.4	Stationary
7th	106	18.09	53.05	2.8	-0.5 – 6.3	0.1	Stationary
8th	21	3.58	34.83	6.5	-23.3 – 47.9	0.7	Stationary
9th	56	9.56	56.74	8.4	-11.4 – 32.6	0.4	Stationary
10th	37	6.31	59.57	-0.6	-27.8 – 37.0	1.0	Stationary
State	586	100.0	47.63	2.8	0.9 – 4.7	<0.001	Increasing

Table 1

Sociodemographic characterization of maternal deaths and Maternal Mortality Ratio (MMR), Alagoas, Brazil, 1996 to 2016.

	Maternal deaths		Live births		MMR	*Jointpoint regression* model 1996-2016			
	n	%	n	%		APC	CI95%	*p*	Classification
Age group (years)									
10 - 14	5	0.85	16389	1.33	30.51	-	-	-	-
15 - 19	111	18.94	302631	24.60	36.68	5.4	2.6 to 8.2	<0.001	Increasing
20 - 29	213	36.35	656651	53.37	32.44	3.4	-0.4 to 7.3	0.1	Stationary
30 - 39	207	35.32	230492	18.73	89.81	0.1	-2.3 to 2.5	0.9	Stationary
40 - 49	50	8.53	24211	1.97	206.52	2.3	-19.1 to 29.3	0.8	Stationary
Skin Color/race									
White	75	12.80	187336	15.23	40.04	21.4	-15.3 to 73.4	0.3	Stationary
Black	19	3.24	12009	0.98	158.21	21.0	1.1 to 44.8	<0.001	Increasing
Yellow	1	0.17	4843	0.39	20.65	-3.5	-10.6 to 4.1	0.3	Stationary
Mixed	334	57.00	819274	66.59	40.77	40.6	29 to 53.3	<0.001	Increasing
Indigenous	0	0.00	2949	0.24	0.00	-	-	-	-
Ignored	157	26.79	203963	16.58	-				
Schooling									
None	58	9.90	153282	12.46	37.84			-[a]	
1 to <8 years	160	27.30	628088	51.05	25.47				
8 or more	68	11.60	414068	33.65	16.42				
Ignored	300	51.19	34936	2.84	-				
Marital status									
Single	264	45.05	499781	40.62	52.82			-[a]	
Married	184	31.40	350712	28.50	52.46				
Widow	8	1.37	2396	0.19	333.89				
Legally Separated	2	0.34	3201	0.26	62.48				
Consensual union	0	0.00	151452	12.31	0.00				
Other	19	3.24	0	0.00	0.00				
Ignored	109	18.60	222832	18.11	48.92				
Total	586	100	1230374	100	47.63				

MMR = Maternal Mortality Ratio; APC = Annual Percentage Change (annual percentage change for Portuguese); CI95% = 95% confidence interval; *p* = Probability of significance; [a] without enough data to calculate.

Table 2

Maternal Mortality Ratio by groups, categories and causes of deaths in Alagoas, Brazil, 1996 to 2016.

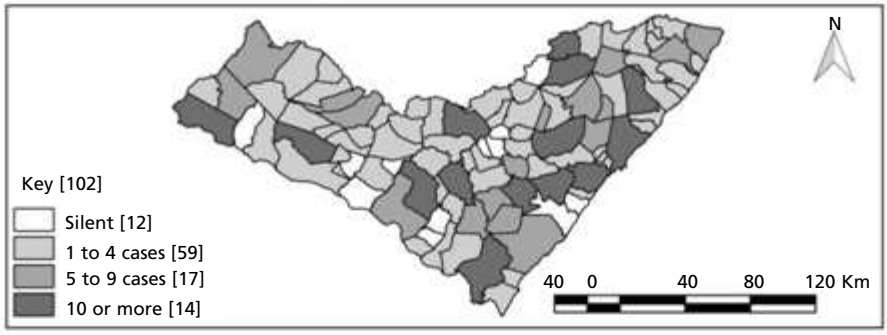
Variable	N	%	MMR
ICD Group			
Human Immunodeficiency Virus [HIV] disease.	6	1.02	0.49
Pregnancyending in abortion.	44	7.51	3.58
Edema, proteinuria and hypertensive disorders in pregnancy, childbirth and puerperium.	154	26.28	12.52
Other maternal disorders predominantly related to pregnancy.	19	3.24	1.54
Care provided to the mother for reasons related to the fetus and amniotic cavity and for possible problems related to childbirth.	40	6.83	3.25
Complications on labor and childbirth.	141	24.06	11.46
Complications predominantly related to puerperium.	123	20.99	10.00
Other obstetric conditions, not classified elsewhere.	59	10.07	4.80
Categories with at least ten maternal deaths			
Eclampsia	76	12.97	6.18
Other diseases of the mother, classified elsewhere, but which complicate with pregnancy, childbirth and puerperium.	54	9.22	4.39
Abnormalities of uterine contraction.	39	6.66	3.17
Postpartum hemorrhage.	39	6.66	3.17
Other puerperal infections.	35	5.97	2.84
Puerperal infection.	30	5.12	2.44
Other complications on labor and childbirth, not classified elsewhere.	29	4.95	2.36
Premature detachment of the placenta.	28	4.78	2.28
Embolism of obstetric origin.	27	4.61	2.19
Other complications of puerperium, not classified elsewhere.	25	4.27	2.03
Gestational hypertension without any significant proteinuria.	24	4.10	1.95
Unspecified maternal hypertension.	22	3.75	1.79
Gestational hypertension with significant proteinuria.	19	3.24	1.54
Otherobstetric traumas.	16	2.73	1.30
Ectopicpregnancy.	14	2.39	1.14
Unspecified abortion.	10	1.71	0.81
Complicated labor and childbirth by intrapartum hemorrhage, not classified elsewhere.	10	1.71	0.81
Other observed categories (n=31)	89	15.19	7.23
Obstetric cause			
Direct obstetric maternal death			
Indirectobstetric maternal death			
Unspecified obstetric maternal death			

MMR = Maternal Mortality Ratio.

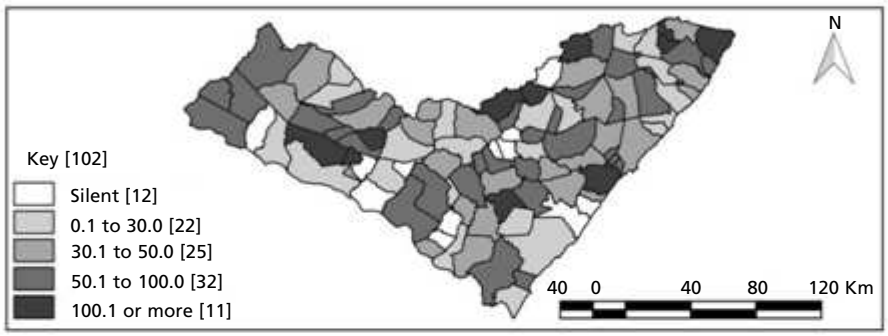
Figure 2

Spatial modeling of maternal deaths in Alagoas, Brazil, 1996 to 2016.

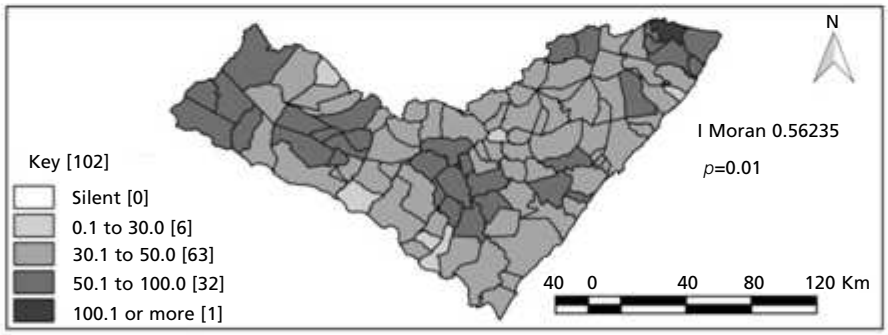
a) Classification of the cities according to the number of maternal deaths



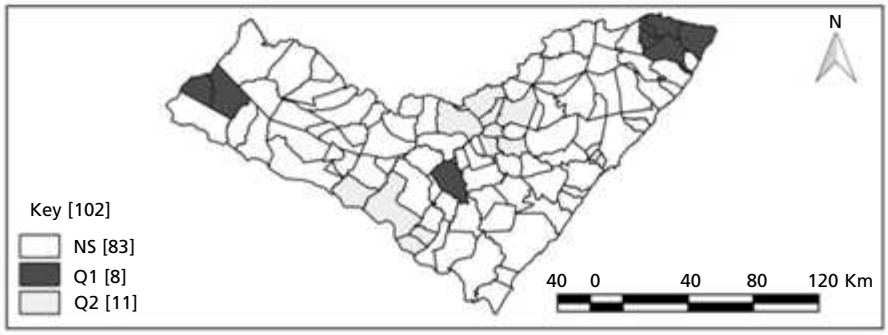
b) Gross maternal mortality ratio



c) Smooth maternal mortality ratio



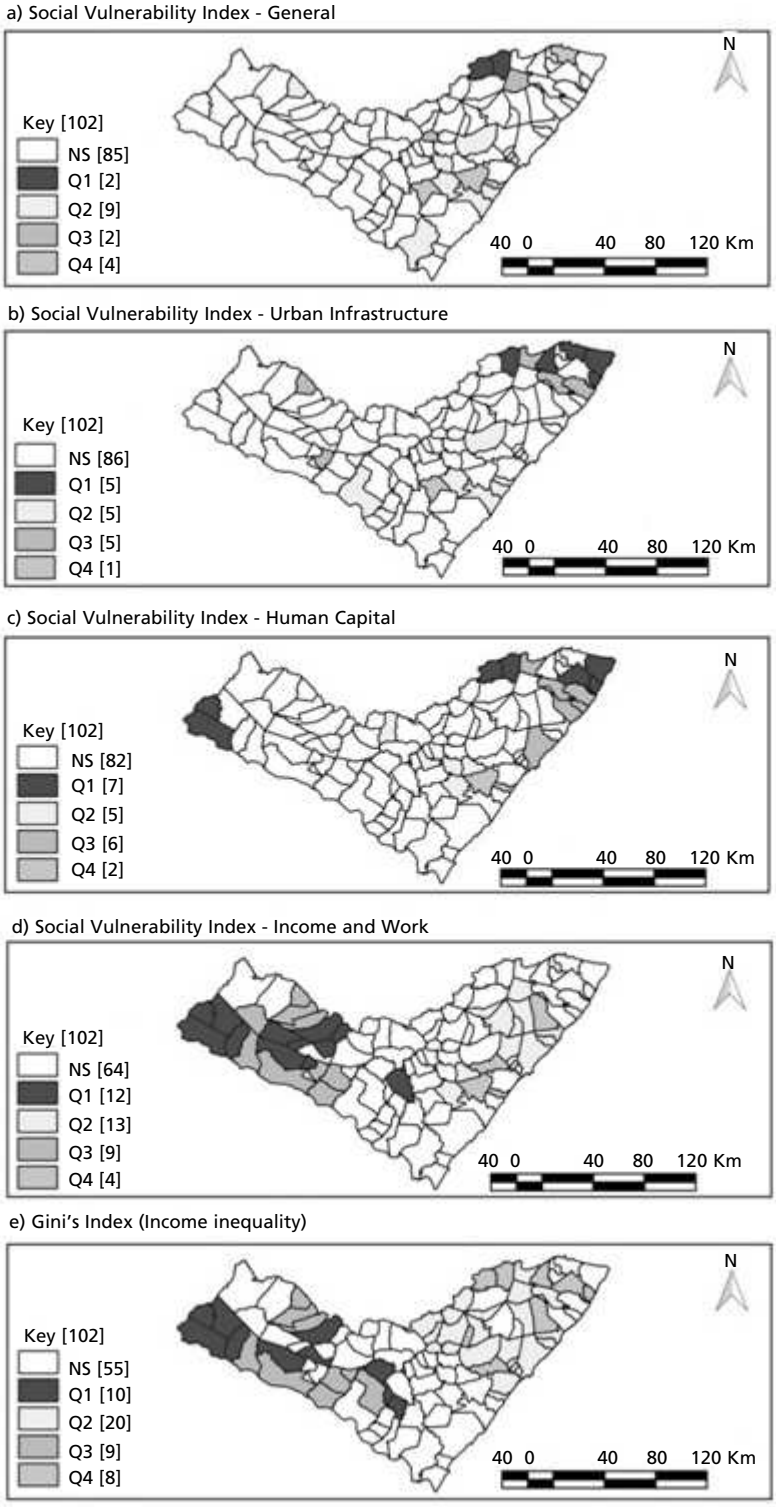
d) Moran map smooth maternal mortality



NS= Non significant.

Figure 3

Bivariable spatial autocorrelation between the maternal mortality ratio and social indicators, Alagoas, Brazil, 1996 to 2016.



NS= Non significant.

Discussion

This study analyzed the spatial-temporal dynamics on maternal mortality in the State of Alagoas (1996-2016) and the spatial relation with social vulnerability and income inequality. Maternal mortality is a public health problem that affects mainly underdeveloped and developing countries, such as Brazil, in which the sociodemographic characteristics reflect risk factors.[15] The profile observed in Alagoas is in line with the literature,[16] characterized by the predominance of the age group 20-29 years old (in numbers and percentages), race / black and mixed skin color and low schooling.

Black and mixed skin color women are the groups that are most vulnerable to maternal death. A study carried out in Mato Grosso, involving 219 deaths between 2000 and 2006, showed that the relative risk of women who died due to maternal causes was 7.4 times higher in black women when compared to ethnicity/white race.[16] In Minas Gerais, 59% of the maternal deaths between 1996 and 2008 were non-white women,[17] corroborating this present study. Ethnic differences are associated with social inequalities and adverse social insertion condition, characterized by little or no access to obstetric care services.[16]

In the context of social vulnerability, low schooling is another striking feature. In this study, considering only the registrations whose schooling level was concluded, 76.22% had less than eight years of schooling and the MMR decreased following the increase in education, similar to that observed in Paraná (64.3%).[17] The schooling level has a double effect on mortality: i) education determines the cultural profile and the behavior related to healthcare[16] and ii) and reduces the degree of social vulnerability, which is inversely proportional to access consumer goods and services, including health.[18]

Alagoas is the State with the lowest Índice de Desenvolvimento Humano (IDH) (Human Development Index) in Brazil (IDH=0.631) and has about 96.10% of the cities in high or extremely high social vulnerability.[10,11] The bivariable spatial correlation identified common priority areas related to urban infrastructure, human capital and income and work (including income inequality expressed by the Gini Index). In Brazil and Colombia, income inequality contributed to 23.40% in the difficulty of accessing specialized services and 37.20% to postnatal care, increasing the risk of maternal deaths.[19]

Even with the implementation of the *Rede Cegonha* (Stork Network) (2011/2012), which represents one of the most important public policies for the qualification of maternal and child care in Brazil, is responsible for the decline in maternal deaths,[20] Alagoas did not show a temporal change in the mortality, although the rate decreased from 59.09/100 thousand LB (2010) to 51.90/100 thousand LB (2016). This is to show that in vulnerable areas, the implementation of isolated health policies is not enough, but broader ones are needed that can impact on social determinants, by reducing existing pragmatic inequalities.

In 2014, about 99% of the women had at least one prenatal visit, in 76% of the first visit occurred before 16 weeks and 73% had six or more visits.[21] Even so, the quality of the program or the lack of adherence to the actions undermines its effectiveness. In 2018, in Brazil, in the North Region obtained the "worst adjustment" in the provision of services for prenatal care (51%) in the country (i.e., organizational analysis on services, quality of care and clinical care offered), followed by the Midwest (48%), the Northeast (44%) and the Southeast (43%), indicating that the country needs to expand its investments in maternal care.[21]

In Maceió, the capital of the State, an investigation carried out in 2016 showed that 74% of the pregnant women had difficulties in performing prenatal exams, with the scheduling and receiving the results were the main difficulties reported.[22] This fact indicates that the capital faces systematic difficulties in guaranteeing the quality of care offered to the maternal and child population, especially in the primary health care component.[23] In the countryside of the State, where the context of vulnerability is more intense and the cities face more difficulties (scarcity of financial resources, lack of human capital and precarious health services), the situation can be even more severe, since mortality rates are higher. The 9th and 10th health regions, located in the Outback lands of the State, for example, had the highest mortality rates.

Maternal deaths in Alagoas resulted mainly from hypertensive disorders during pregnancy, with eclampsia as the main cause, similar to the pattern observed in the country.[24] In 2017, in Latin America, these disorders accounted for 41% of the maternal deaths.[25] The high occurrence of eclampsia is related to the poor quality of care, representing a potentially preventable cause.[10,26]

Direct obstetric causes accounted for 87.71% of maternal deaths in Alagoas, corroborating studies carried out in Bahia (62.8%)27and in the city of Barbacena, Minas Gerais (82.75%).[28] This group of causes is more prevalent in pregnant women with

greater social vulnerability and derives from complications related to the pregnancy-puerperal cycle, due to poor care during pregnancy, childbirth or puerperium.[27]

The women's healthcare network in Alagoas is structured so that in the ten health regions (HR) there are primary care services and the usual risk reference centers, except in the 4th and 9th HR. While the high-risk reference centers are located only on the 1st, 7th and 9th HR. In the Moran Map, it was observed that the cities located in the 2nd and 10th HR were a priority. However, in the region, there are basic care services for pregnant women, indicating that there are weaknesses in the network.[28] In an investigation carried out in Espírito Santo, it was shown that despite the good coverage of the *Rede Cegonha* (Stork Network) in one of the HR, its malfunction caused the loss in the quality of care, aggravating the risks mainly in low-income pregnant women.[29] Access to health services, quality of care and early identification of possible complications are related to increased risk during pregnancy and its unfavorable outcome.[28]

Even considering methodological care, this study has limitations, among which the use of secondary data stands out, whereas quality has been questioned. The operational capacity of the surveillance system is one of the most important determinants of the quality of registered in the health information systems. The Northeast is the region with the highest underreporting cases in the country, which can compromise the reliability of the analyses.

In this study, the demographic profile was characterized by the predominance of young women (although MMR increases with age), with mixed skin color and low schooling. Direct causes and eclampsia made up the clinical profile. The trend was increasing in the State, with spatial-temporal inequality and correlation with social vulnerability and income inequality. The identification of priority areas can contribute to the planning, monitoring and targeting of the interventions

Authors' contribution

Duarte SEM, Santos ET, Souza CDF were responsible for the study design, performed the data acquisition and analysis, participated in the writing, interpretation of the results and review of the article; Araújo MDP, Machado MF, Correia DS, Fonseca LGA, Silva SM participated in the writing, interpretation of the results and review of the article. All authors approved the final version of the manuscript.

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