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Spatial analysis of fetal mortality from congenital syphilis in the municipality of Recife-PE-Brazil between 2007 and 2016

Análise espacial da mortalidade fetal por sífilis congênita no Município do Recife-PE-Brasil entre 2007 e 2016

Análisis espacial de la mortalidad fetal por sífilis congénita en el municipio de Recife-PE-Brasil entre 2007 y 2016

Roberta de Souza Pereira da Silva Ramos[1]
Gledsângela Ribeiro Carneiro[1]
André Luiz Sá de Oliveira[2]
Tarcisio Neves da Cunha[3]
Vânia Pinheiro Ramos[1]

1. Universidade Federal de Pernambuco, Programa de Pós-Graduação em Enfermagem. Recife, PE, Brasil.

2. Instituto Aggeu Magalhães, Fundação Instituto Oswaldo Cruz. Recife, PE, Brasil.

3. Fundação Instituto Oswaldo Cruz. Rio de Janeiro, RJ, Brasil.

Corresponding author:
Roberta de Souza Pereira da Silva Ramos.
E-mail: roberta_sps@hotmail.com

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Abstract

Objective: To analyze the spatial distribution of fetal mortality due to congenital syphilis among the neighborhoods of the city of Recife-PE. **Method**: Ecological study, based on the epidemiological indicator fetal mortality rate due to congenital syphilis, aggregated at the neighborhood level, in two five-year periods: 2007 to 2011 and 2012 to 2016. The pattern of spatial autocorrelation was determined by the Moran Global and Local Indexes, with statistical significance lower than 5% and represented in BoxMap and MoranMap maps that indicated areas with high, low and epidemiological transition rates and clusters of greater epidemiological interest. **Results**: It was reported 208 fetal deaths. The Moran Global Index showed a reasonable degree of positive spatial autocorrelation in the first five-year period (I = 0.351 and p-value = 0.01) and a weak degree in the second five-year period (I = 0.189 and p-value = 0.02). Sanitary Districts I and VII had the highest percentages of neighborhoods that formed the cluster of high rates of the indicator with 63.3% and 38.4% in the first and second five-year periods, respectively. **Conclusions and Implications for Practice:** The spatial analysis pointed out the critical areas for the occurrence of the indicator, which could contribute to investment in priority areas for the prevention of vertical transmission of syphilis.

Keywords: Spatial analysis; Congenital syphilis; Fetal mortality; Incidence; Vertical transmission.

Resumo

Objetivo: analisar a distribuição espacial da mortalidade fetal por sífilis congênita entre os bairros do Município do Recife-PE. **Método**: estudo ecológico, realizado a partir do indicador epidemiológico taxa de mortalidade fetal por sífilis congênita, agregado ao nível dos bairros, em dois quinquênios: 2007 a 2011 e 2012 a 2016. O padrão de autocorrelação espacial foi determinado pelos Índices de Moran Global e Local, com significância estatística inferior a 5% e representado em mapas BoxMap e MoranMap que apontaram as áreas com taxas altas, baixas e em transição epidemiológica e os clusters de maior interesse epidemiológico. **Resultados**: foram notificados 208 óbitos fetais. O Índice Global de Moran evidenciou autocorrelação espacial positiva em grau razoável, no primeiro quinquênio (I = 0,351 e *p-valor* = 0,01) e, em grau fraco, no segundo quinquênio (I = 0,189 e *p-valor* = 0,02). Os Distritos Sanitários I e VII obtiveram os maiores percentuais de bairros que formaram o cluster de altas taxas do indicador com 63,3% e 38,4% no primeiro e segundo quinquênios, respectivamente. **Conclusões e implicações para a Prática:** a análise espacial apontou as áreas críticas para ocorrência do indicador, podendo contribuir para o investimento nas áreas prioritárias de prevenção da transmissão vertical da sífilis.

Palavras-chave: Análise espacial; Sífilis congênita; Mortalidade fetal; Incidência; Transmissão vertical.

Resumen

Objetivo: Analizar la distribución espacial de la mortalidad fetal por sífilis congénita entre los barrios de Recife-PE. **Método**: Estudio ecológico, basado en el indicador epidemiológico tasa de mortalidad fetal por sífilis congénita, agregada a nivel de barrio, en dos quinquenios: 2007 a 2011 y 2012 a 2016. El patrón de autocorrelación espacial fue determinado por los Índices Moran Global y Local, con significancia estadística menor al 5% y representados en mapas de BoxMap y MoranMap, que indicaron áreas con tasas de transición alta, baja y epidemiológica y conglomerados de mayor interés epidemiológico. **Resultados**: Notificadas 208 muertes fetales. El Índice Global de Moran mostró un grado razonable de autocorrelación espacial positiva en el primer quinquenio (I = 0,351 y *p-valor*=0,01) y un grado débil en el segundo quinquenio (I = 0,189 y *p-valor*=0,02). Los Distritos Sanitarios I y VII presentaron los mayores porcentajes de barrios que formaron el cluster de tasas altas del indicador con 63,3% y 38,4% en el primer y segundo quinquenio, respectivamente. **Conclusión e Implicación para la Práctica**: El análisis espacial señaló las áreas críticas para la ocurrencia del indicador, que podrían contribuir a la inversión en áreas prioritarias para la prevención de la transmisión vertical de sífilis.

Palabras clave: Análisis espacial; Sífilis congénita; Mortalidad fetal; Incidencia; Transmisión vertical.

INTRODUCTION

The global scale of sexually transmitted infections demonstrates that this is a public health problem, in addition to representing a warning to governments around the world. The WHO bulletin points to the countries' lack of progress on the problem and highlights the profound impact on the health of adolescents, adults, and children due to the debilitating factors associated with these infections[1]. Among the infections, syphilis is noteworthy for affecting more than 12 million people worldwide, with 1 million cases per year only in pregnant women[2].

As for the negative effects of syphilis, neurological and cardiovascular diseases, infertility, pregnancy complications, stillbirths, and an increased risk of HIV can be mentioned. Results of a systematic review and meta-analysis estimated that 25.6% (CI 95%: 18.5-34.2%) of untreated cases of syphilis in pregnancy resulted in early fetal deaths (fetus weighing 500 g or more, or 22 completed weeks of gestation or more) or late fetal deaths (fetus weighing 1,000 g or more, or 28 weeks or more). In that same study, it was shown that fetal loss and stillbirths were 21% more frequent than such events in women without syphilis[3]. Another study conducted at a global level highlighted syphilis as responsible for more than 300,000 fetal and neonatal deaths worldwide[4].

Between 2017 and 2018, the incidence rate of congenital syphilis in Brazil more than quadrupled, going from 2.0 to 9.0 cases/1000 live births. Among the Brazilian states, Pernambuco had a disease detection coefficient of 14.3 cases/1000 live births, higher than the national rate, and among the capitals, Recife had the highest incidence rate (29.3 cases/1000 live births), also surpassing the Brazilian average[5]. Such data, in addition to reaffirming the disease epidemic in the country, converge to the need to expand interventions and services aimed at preventing vertical transmission of the disease with a view to achieving the goal of eliminating the disease[6], thus minimizing its impact as a problem of public health.

Research that aimed to describe the evidence produced by studies that used spatial analysis to identify priority areas of intervention for syphilis elimination concluded that this is an effective tool capable of directing the planning of strategies and avoiding investment in geographically non-priority areas for infection control[7].

In this sense, the aim of this study was to analyze the spatial distribution of fetal mortality from congenital syphilis between the neighborhoods of Recife / PE, with a view to supporting the planning of prevention and control actions in the municipality through spatial analysis and indicating priority areas for investments in the qualification of prenatal care.

METHOD

This is an epidemiological, analytical, transversal, and ecological study carried out in the municipality of Recife, capital of the State of Pernambuco, Northeast region of Brazil, whose census population is 1,537,704 inhabitants, being the ninth most populous city in Brazil. The city has a territorial area of approximately 218,843 km^{2}[2,8] divided by the Municipal Health Department into eight Sanitary Districts: District I, comprising 11 neighborhoods; District II, consisting of 16 neighborhoods; District III, consisting of 16 neighborhoods; District IV, consisting of 12 neighborhoods; District V, consisting of 16 neighborhoods; District VI, consisting of 5 neighborhoods; District VII, made up of 13 neighborhoods and District VIII, made up of three neighborhoods, totaling 94 neighborhoods (Figure 1).

Data on the study population were provided by the Executive Secretariat for Sanitary Surveillance and corresponded to all cases of fetal deaths due to congenital syphilis as the underlying cause, in the period from January 2007 to December 2016. Deaths whose addresses in the notifications did not allow framing the occurrence in any of the 94 neighborhoods of the municipality were excluded. In situations where the notifications had the variable referring to the name of the neighborhood not filled in, the Google Earth tool was used to locate the address and include cases that occurred in the studied municipality in the survey.

The epidemiological indicator used in the study was the fetal mortality rate due to congenital syphilis as an underlying cause, aggregated at the level of the Recife's neighborhoods. The calculation of the indicator was made by applying the formula[9]: Number of fetal deaths due to congenital syphilis x 1000 / Number of live births added to fetal deaths due to congenital syphilis in the municipality of Recife, during the study period. The data source used to obtain the numerator was the Mortality Information System (MIS), fed from the data contained in the death certificate. And, to obtain the denominator, in addition to the MIS, data were extracted from the Information System on Live Births (ISLB), fed from the data contained in the live birth certificate.

The use of the number of live births provided by ISLB to compose the denominator was a methodological strategy to represent the total population of pregnant women in the city since the electronic system for collecting information on prenatal care of pregnant women attended by the Unified System Health – SISPRENATAL does not represent a secure source of information about pregnant women due to poor records[10]. The addition of fetal deaths from congenital syphilis to the number of live births was made to ensure that the denominator was contained in the universe of the numerator.

The extraction of cases from the MIS was performed using the variables "weeks of pregnancy" (deaths occurring from the 22nd week of pregnancy were considered) and "base cause of death" (those whose underlying cause was the diagnosis of congenital syphilis were considered). From these variables, 241 cases were identified, among which 33 were excluded due to inconsistency in the addresses that did not allow the allocation of cases in one of the Recife's neighborhoods. Thus, the final sample corresponded to 208 fetal deaths. The temporal aggregation in quinquenniums was made to allow a comparative analysis between the periods.

Due to the great instability associated with the use of crude rates to express the risk of occurrence of a certain event, when it is rare and susceptible to substantial variations and calculated

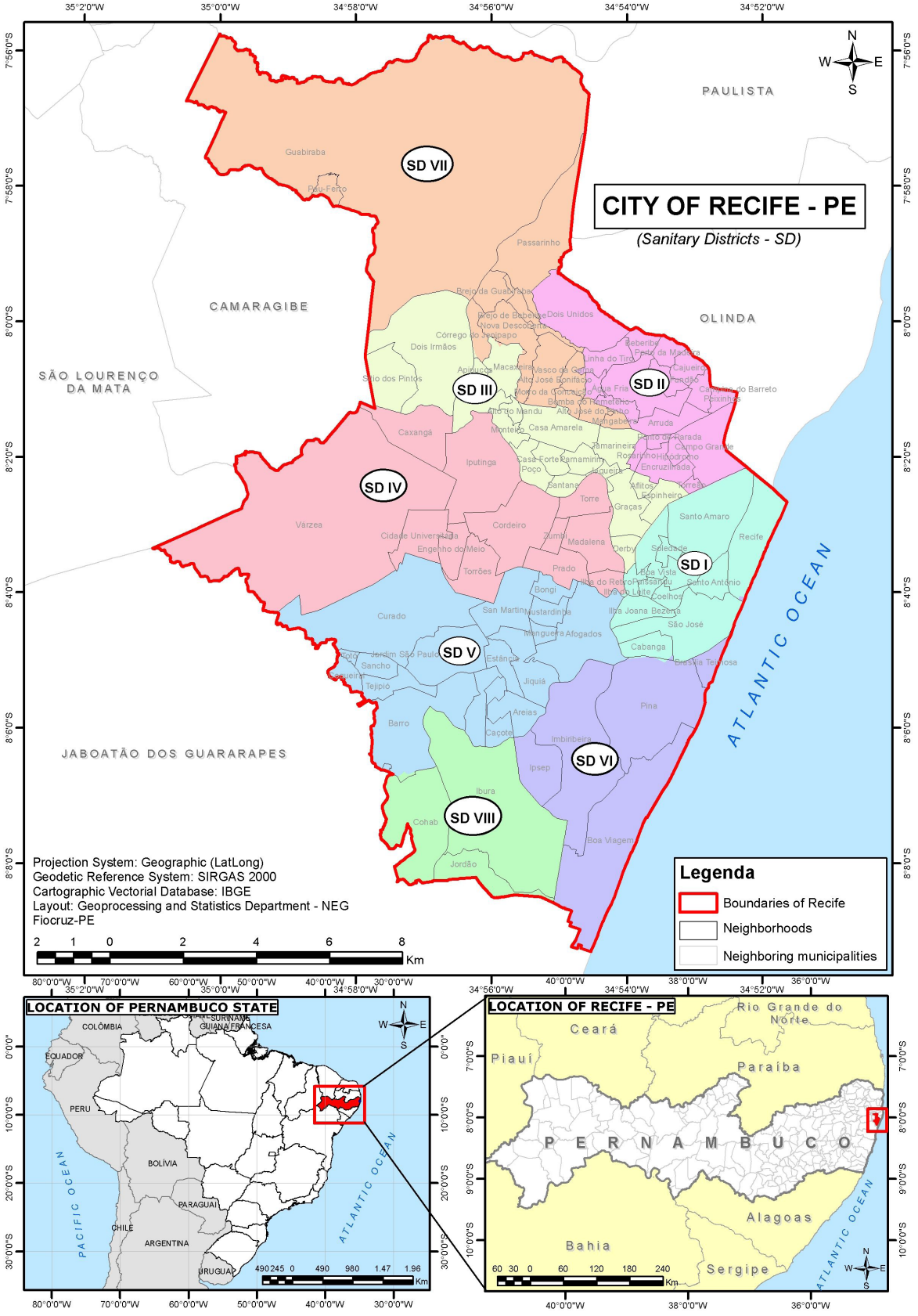

Figure 1. Map of the municipality of Recife-PE with identification of the eight Sanitary Districts. Recife-PE, Brasil, 2020.
Source: Statistics and Geoprocessing Nucleus of Fiocruz/PE

under small populations, these crude incidence rates of congenital syphilis were smoothed by the local empirical Bayesian method. The Bayesian rates have less variability and are better suited to the real risks of the event occurring in each geographic area of the study. The local empirical Bayes estimator calculates a weighted average of the rates presented by the geographic neighbors of the area in which the rate is to be estimated, converging towards a local average, with reduced random variability and with better quality of the worked indicators[11].

The distribution of spatial patterns and identification of the trend of formation of homogeneous areas (Q1 and Q2) and transition areas for the studied indicator (Q3 and Q4), in both quinquenniums, were evidenced through the Box Map, using graduated color symbology, where the darkest were used for the strata of neighborhoods with the highest incidence rates of fetal death due to congenital syphilis, while the lighter ones for the strata of neighborhoods with the lowest incidence of the adverse event[12]. The ranges of rates used in the Box Map were identified by the quartile method, where the number of four classes and the number of observations in each were defined.

Neighborhoods located in the Q1 quadrant (High-high) were those that presented high rates (above the mean) of the variable of interest and were surrounded by neighborhoods that also presented high rates; neighborhoods located in quadrant Q2 (Low-low) were those that presented low rates (below the average) of the variable of interest and were surrounded by neighborhoods that also presented low rates; neighborhoods located in quadrant Q3 (High-low) were those that presented high rates of the variable of interest and were surrounded by neighborhoods that presented low rates; and, finally, neighborhoods located in quadrant Q4 (Low-high) were those that presented low rates of the variable of interest and were surrounded by neighborhoods that had high rates of the same variable. Neighborhoods located in quadrants Q3 and Q4 are considered to be in epidemiological transition in relation to the studied indicator.

The existence of spatial autocorrelation of the rate of fetal deaths from congenital syphilis, at the neighborhoods level, in each quinquennium of the study, was determined by calculating the Global Moran Index (I), which indicates how much the analyzed area is similar to its immediate neighbor, evidencing the occurrence of clusters in the study area. Index values close to +1 indicate positive spatial autocorrelation (data tend to be similar to the values of its neighbors); values close to -1 indicate negative spatial autocorrelation (data tend to be different from the values of its neighbors); values equal to zero indicate the absence of spatial correlation and values close to zero indicate very low spatial autocorrelation[13].

To interpret the degree of spatial autocorrelation of the indicator, this study used the following categorization of the Kappa coefficient, proposed by Jacob Cohen in 1960, in order to measure the degree of agreement between proportions derived from dependent samples: less than 0 (insignificant); between 0 and 0.2 (weak); between 0.21 and 0.4 (reasonable); between 0.41 and 0.6 (moderate) and between 0.61 and 0.8 (strong)[14].

The existence of a global pattern of positive spatial association may hide the existence of negative local autocorrelation patterns in some geographic units[15]. Furthermore, when using many areas, it is likely that different regimes of the spatial association will occur and that local maximums of autocorrelation will appear, where the spatial dependence is even more pronounced. Thus, it is important to examine patterns on a smaller scale through the use of local indices of spatial autocorrelation, also known as LISA (Local Indicator for Spatial Autocorrelation).

In addition to indicating the occurrence of clusters, the LISA is able to report their approximate location[16,17], identifying the regions that presented local correlation significantly different from that observed in the rest of the data[13,18]. The LISA used in this study was the Moran's Local Index, proposed by Luc Anselin[19]. The identified clusters were categorized into four quadrants: Q1 (High-high), Q2 (Low-low), Q3 (High-low), and Q4 (Low-high) and displayed in the Moran Map. The quadrants were differentiated by color, according to the autocorrelation pattern found. Neighborhoods classified in quadrant Q1 corresponded to the highest risk areas for the occurrence of the investigated epidemiological indicator. In the Moran Map, only neighborhoods whose Moran's Local Index values were statistically significant (p-value < 0.05) were considered.

The cartographic base of digital grids used is on the Recife City Hall website, available in the Universal Transverse Mercator (UTM) SAD-69 projection system, zone 25 south. In order to meet the standardized norms of the current Brazilian geodetic system, the projection system was converted to SIRGAS 2000. The production of maps was carried out by the Statistics and Geoprocessing Nucleus of Fiocruz-PE. The Excel spreadsheet program was used to clean and organize the database with double verification and indicator calculations. Spatial analysis and calculation of smoothed rates by the empirical Bayes method were performed using TerraView software version 4.2.2. The maps were made using the QGIS® version 2.14 software.

This study is part of a doctoral thesis approved by the Research Ethics Committee of the Health Sciences Center of Universidade Federal de Pernambuco according to opinion number 2,449,817.

RESULTS

During the study period, 208 cases of fetal deaths due to congenital syphilis were reported in Recife, being 54 in the first quinquennium and 154 in the second one, which represented 4.9% and 7.2% of the cases of the disease, respectively. Between 2007 and 2011, the highest average fetal mortality rate was found in the neighborhood of Hipódromo (2.7 cases for every 1000 total births) while between 2012 and 2016, the neighborhoods of Prado obtained the highest average rate (6.5 cases for every 1000 total births). Figure 2 illustrates the spatial analysis of the smoothed and average rates of fetal mortality due to congenital syphilis during the studied period.

The spatial distribution revealed that, in the first quinquennium, the areas with the highest rates were formed mainly by the neighborhoods of the Sanitary District I (81.8%); followed by

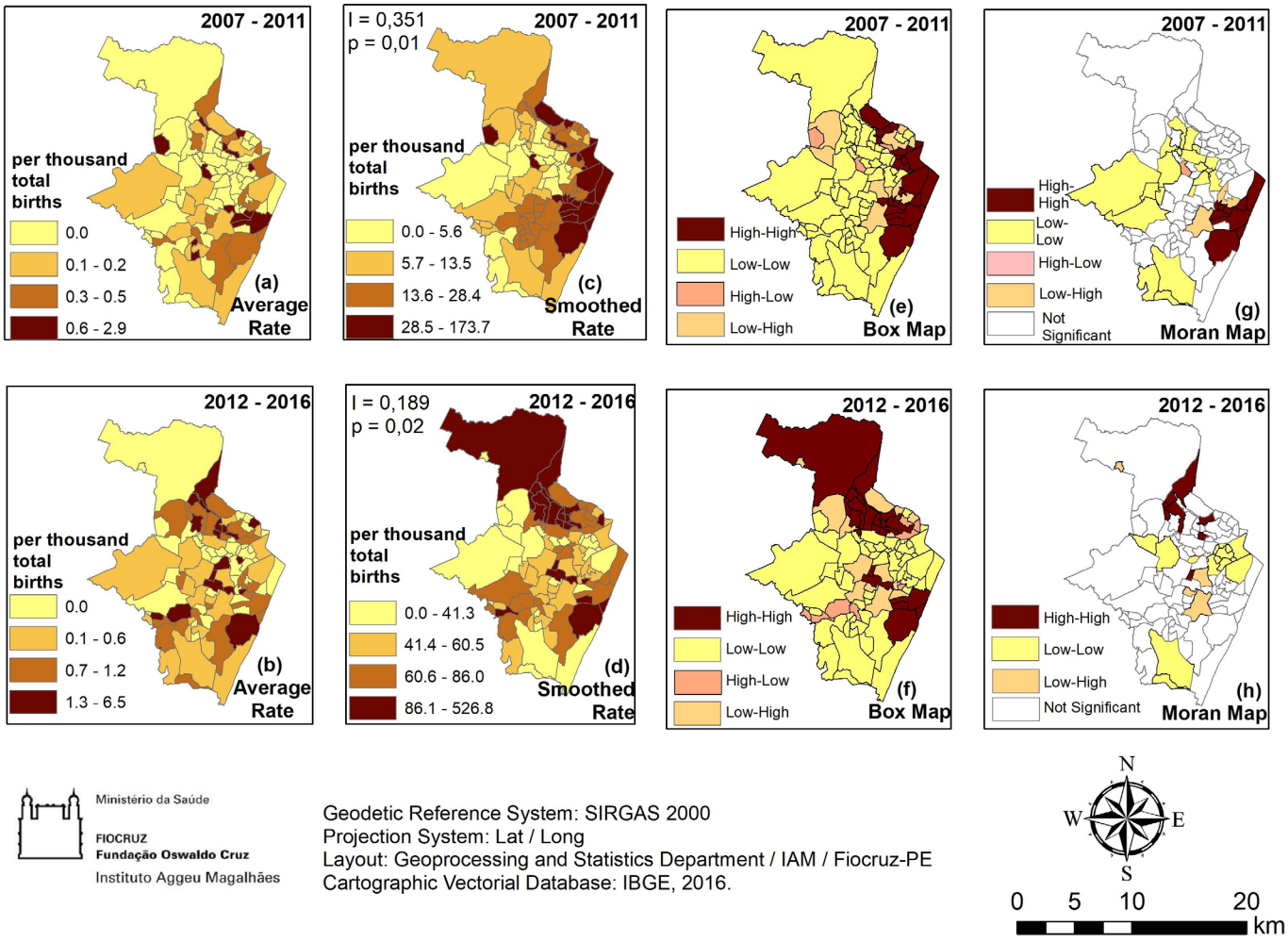

Figure 2. Spatial distribution of the mean (a and b) and smoothed (c and d) rates of fetal deaths from congenital syphilis (per 1000 total births), identification of homogeneous and epidemiological transition areas in Box Map (e and f), and statistically significant clusters in Moran Map (g and h), in the municipality of Recife-PE, Brazil, in the five-year period 2007 to 2011 and 2012 to 2016.
Source: Prepared by the authors

Districts II (44.4%), VI (40%) IV (33.3%) and, finally, III (12.5%). Sanitary District V had no cases of fetal death from the disease. In the second quinquennium, the areas that concentrated the highest rates were formed by 76.9% of the neighborhoods in the Sanitary District VII; 40% of District VI neighborhoods; 25% of neighborhoods in District IV; 18.8% of the neighborhoods in District I; 16.6% of the neighborhoods in District II and, finally, 6.2% in District V.

The Moran Global Index showed a reasonable degree of positive spatial autocorrelation in the first quinquennium (I = 0.351 and p-value = 0.01) (Figure 2c) and a weak degree in the second quinquennium (I = 0.189 and p-value = 0.02) (Figure 2d). Table 1 illustrates the number and percentage of neighborhoods, according to the Sanitary Districts, located in each quadrant of the Box Map, in each quinquennium of the study. In the first quinquennium, clusters with high fetal mortality rates and neighbors with similar values (High-high) were noticed, mainly in Sanitary Districts I (Soledade, Santo Amaro, Recife, São José, Cabanga, Joana Bezerra Island, Paissandu, Ilha do Leite, Coelhos and Santo Antônio) and II (Peixinhos, Campo Grande, Torreão, Encruzilhada, Ponto de Parada, Hipódromo, Arruda, Alto Santa Terezinha, Linha do Tiro, Dois Unidos and Beberibe) (Figure 2e). In District IV, only one borough obtained a High-high standard (Ilha do Retiro) and, in District VI, two neighborhoods (Pina and Brasília Teimosa).

Between 2007 and 2011, the areas classified as of epidemiological transition with a High-low pattern (Q3) were located in Districts III (Poço da Panela and Sítio dos Pintos) and II (Bomba do Hemetério) and with a low-high pattern (Q4) in the Districts II (Campina do Barreto, Água Fria and Campina do

Table 1. Distribution of the number and percentage of neighborhoods according to High-high, Low-low, and of epidemiological transition patterns of fetal deaths due to congenital syphilis, identified by Box Map, according to the Sanitary Districts of Recife-PE, Brazil between 2007 and 2011 and 2012 and 2016.

Sanitary Districts	Box Map quadrants							
	Q1 (High-High)		Q2 (Low-Low)		Q3 (High-Low)		Q4 (Low-High)	
	2007-11	2012-16	2007-11	2012-16	2007-11	2012-16	2007-11	2012-16
District I	10 (90%)	2 (18.1%)	0	6 (54.5%)	0	1 (9%)	1 (9%)	2 (18.1%)
District II	11(61.1)	4 (22.2%)	3 (16.6%)	8 (44.4%)	1(5.5%)	2 (11.1%)	3 (16.6%)	3 (16.6%)
District III	0	1 (6.2%)	12 (75%)	13 (81.2)	2 (12.5%)	0	2 (12.5%)	2 (12.5%)
District IV	1 (8.3%)	3 (25%)	9 (75%)	7 (58.3%)	0	0	2 (16.6%)	2 (16.6%)
District V	0	0	15 (93.7)	9 (56.2%)	0	3 (18.7%)	1 (6.2%)	3 (18.7%)
District VI	2 (40%)	2 (40%)	3 (60%)	2 (40%)	0	0	0	0
District VII	0	11 (84.6)	13 (92.3)	0	0	0	0	2 (15.3%)
District VIII	0	0	3 (100%)	2 (66.6%)	0	0	0	0
**Total	24 (25%)	23 (24.4)	58 (61.7)	47 (50%)	3 (3.1%)	6 (6.3%)	9 (9.5%)	14 (14.8)

Barreto); IV (Madalena and Caxangá); III (Dois Irmãos); I (Boa Vista) and V (Afogados).

In the second quinquennium, there was a displacement of the neighborhoods with high rates, mainly to Sanitary District VII, which obtained 84.6% of its neighborhoods allocated in Q1 (Vasco da Gama, Alto José Bonifácio, Macaxeira, Nova Descoberta, Morro da Conceição, Alto José do Pinho, Córrego do Jenipapo, Brejo de Beberibe, Brejo da Guabiraba, Passarinho, and Guabiraba). The other neighborhoods with High-high standards were located in Districts VI (Pina and Brasília Teimosa), II (Bomba do Hemetério, Água Fria, Alto Santa Terezinha and Linha do Tiro); IV (Zumbi, Ilha do Retiro and Prado); I (São José and Cabanga) and III (Alto do Mandu) (Figure 2f).

During this period, the epidemiological transition areas with a High-low pattern (Q3) were located in Sanitary Districts V (Estância, Coqueiral and Jardim São Paulo); II (Fundão and Campina do Barreto) and I (Ilha do Leite) and those with Low-high pattern (Q4) in Districts V (San Martin, Bongi and Afogados); I (Joana Bezerra Island); IV (Lamb and Magdalene); II (Cajueiro, Dois Unidos and Beberibe); III (Apipucos and Dois Irmãos) and VII (Mangabeira and Pau-Ferro).

In the first quinquennium, the neighborhoods identified in Q1 (High-high) of the Box Map, which remained with the same pattern in the second quinquennium, were located in Sanitary Districts I (Ilha do Leite and Cabanga), II (Alto Santa Terezinha and Bomba do Hemetério), IV (Ilha do Retiro) and VI (Pina and Brasília Teimosa). Table 1 illustrates the number and percentage of neighborhoods, according to the Sanitary Districts of the municipality of Recife, located in each quadrant of the Box Map during the study period.

Table 2 illustrates the number and percentage of neighborhoods located in each cluster identified by the Moran Map, according to the Sanitary Districts of Recife, in the two quinquenniums of the study.

In the quinquennium of 2007 to 2011, four clusters were identified. The cluster with High-high pattern (Q1) was formed by nine neighborhoods, seven of them (Recife, São José, Ilha Joana Bezerra, Paissandu, Ilha do Leite, Coelhos, and Santo Antônio) located in the Sanitary District I and two (Pina and Brasília Teimosa) in Sanitary District VI. The cluster with Low-low pattern (Q2) was formed by twenty neighborhoods, six of them located in the Sanitary District IV (Torre, Zumbi, Engenho do Meio, Cidade Universitária, Iputinga and Várzea); nine, in District III (Tamarineira, Jaqueira, Graças, Nova Descoberta, Morro da Conceição, Casa Amarela, Parnamirim, Alto do Mandu and Apipucos); one in District VII (Vasco da Gama); one, in District V (Curado) and three neighborhoods detached from the main neighborhood located in District VIII (Ibura, Jordão and Cohab). Between clusters Q1 and Q2, there were the epidemiological transition clusters with a High-low pattern (Q3), formed by only one neighborhood (Poço da Panela), located in District III and Low-high (Q4) formed by two neighborhoods, one located in District I (Boa Vista) and another in District V (Afogados) (Figure 2g).

In the quinquennium of 2012 to 2016, three clusters were identified. The cluster with a High-high pattern (Q1) was formed by seven neighborhoods, five of them located in the Sanitary District VII (Nova Descoberta, Alto José do Pinho, Córrego do Jenipapo, Brejo da Guabiraba, and Passarinho); one in District II (Linha do Tiro) and one in District IV (Zumbi). The cluster with Low-low pattern was formed by fifteen neighborhoods, one located in the Sanitary District I (Santo Amaro); six in District II (Campo Grande, Torreão, Encruzilhada, Rosarinho, Ponto de Parada and Hipódromo); four in District III (Dois Irmãos, Graças, Aflitos and Espinheiro), two in District IV (Iputinga and Caxangá) and two in District VIII (Ibura and Jordão). The Low-high pattern cluster

Table 2. Distribution of the number and percentage of neighborhoods that formed the High-high, Low-low, High-low, and Low-high clusters of incidence of fetal deaths from congenital syphilis identified in the Moran Map, according to the Sanitary Districts of Recife-PE, Brazil in quinquenniums 2007 to 2011 and 2012 to 2016.

Sanitary Districts	Moran Map Clusters							
	Q1 (High-High)		Q2 (Low-Low)		Q3 (High-Low)		Q4 (Low-High)	
	2007-11	2012-16	2007-11	2012-16	2007-11	2012-16	2007-11	2012-16
District I	7 (63.6%)	0	0	1 (9%)	0	0	1 (9%)	0
District II	0	1 (5.5%)	0	6 (33.3%)	0	0	0	0
District III	0	0	7 (43.7%)	4 (25%)	1 (6.2%)	0	0	0
District IV	0	1 (8.3%)	6 (50%)	2 (16.6%)	0	0	0	1 (8.3%)
District V	0	0	1 (6.2%)	0	0	0	1 (6.2%)	2 (12.5%)
District VI	2 (40%)	0	0	0	0	0	0	0
District VII	0	5 (38.4%)	3 (23%)	0	0	0	0	1 (7.6%)
District VIII	0	0	3 (100%)	2 (66.6%)	0	0	0	0
**Total	9 (9.5%)	7 (7.4%)	20 (21.2%)	15 (15.9%)	1 (1%)	0	2 (2.1%)	4 (4.2%)

was formed by four neighborhoods, one in Sanitary District IV (Madalena); two in District V (Afogados and Bongi), and one in District VII (Pau-Ferro). There was no stationary character between neighborhoods with high rates (Q1) or low rates (Q2) (Figure 2h).

DISCUSSION

The average percentage of fetal deaths associated with congenital syphilis evidenced in the municipality of Recife, in the two quinquenniums investigated (6.05%), was higher than that found in other studies in the cities of Belo Horizonte (3.4%)[20], Palmas (5 .9%)[21], Caxias (5.6%)[22], and Maringá (3.4%)[23], all performed from SINAN's data. The incidence of congenital syphilis evidenced by a survey conducted in Recife[24] was higher than the regional and national[4] coefficients, as well as those found in other Brazilian capitals in the Northeast[25], North[21], and South[23], which may explain the higher percentage of fetal deaths presented by the municipality in relation to other locations in the country.

The quality of prenatal care is a factor that must be mentioned when talking about the adverse effects on pregnancy. Congenital syphilis is an event which sentinels the quality of prenatal care provided[26]. Brazil, despite having increased its prenatal coverage, has low quality and a high percentage of inadequacy[27]. Corroborating the national data, a study carried out in Recife showed that, although most pregnant women attend seven prenatal consultations, they show great dissatisfaction with the quality of the service offered[28], which can contribute to their non-adherence to the practices recommended by health professionals and, thus, have an impact on the increased risk of vertical transmission of syphilis during pregnancy, in addition to the fetal death outcome due to infection secondary to failure to perform the appropriate treatment.

Other important factors that deserve mention for influencing the occurrence of stillbirths due to congenital syphilis, was the lack of penicillin in the market, which affected practically all Brazilian states[29,30], as well as the resistance of some professionals to use the drug indicated due to the risk of anaphylactic reaction[31] which highlights difficulties in managing cases of syphilis during pregnancy[32], and converges to the need to reorganize obstetric care in the municipality[28] in order to prevent the vertical transmission of the disease and, consequently, the negative outcomes related to it.

The factors that determine the vertical transmission of syphilis are not restricted to aspects related to individual maternal and child characteristics and prenatal care. Such factors are also related to the characteristics of the space organization and living conditions[33]. The results of the spatial analysis revealed that the distribution of smoothed average rates of fetal mortality due to congenital syphilis in the municipality did not follow a random pattern. In the two quinquenniums investigated, the Moran Global Index was significant, which showed a positive spatial autocorrelation, indicating that nearby neighborhoods are similar to each other and the existence of clusters.

Obtaining the average rates estimated the risk of fetal deaths due to congenital syphilis at zero for several neighborhoods, in both quinquenniums, something considered unreal when referring to data related to diseases. Event maps based directly on these estimates are difficult to interpret and often lead to false conclusions, as the calculation of rates in small populations makes them high, which can generate a false idea of a high-risk area for the disease. In this study, this variability associated with observations and not with the phenomenon itself was stabilized by applying the Bayesian estimator[34].

Between 2007 and 2011, District I was the main high-risk area for the occurrence of the fetal death outcome due to congenital

syphilis, with most of its neighborhoods with high-high cluster areas. Research that investigated the association of morbidity from congenital syphilis and socioeconomic factors, classified the neighborhoods in the center of Recife in the strata of best, regular and worst Living Condition Index (LCI). In this study, 63.6% of the central neighborhoods of the municipality were located in the strata with worse or regular LCI[32]. In this quinquennium, District VI of Recife showed two neighborhoods with critical areas for stillbirths due to congenital syphilis, both in the worst range of the LCI[34].

Between 2012 and 2016, the highest risk areas were identified, mainly in District VII, where five neighborhoods had high-high cluster areas; followed by Districts II and IV, each with a neighborhood considered as a critical area. In this quinquennium, with the exception of the Zumbi neighborhood, in District IV, the others are located in the worst LCI range.

This work does not have a methodological framework to explain the migration of the high-risk areas from Sanitary District I (in the first quinquennium) to Sanitary District VII (in the second quinquennium), however, it assumes that this change in profile is due to the process of epidemiological transition, in which some neighborhoods of District I improved their health promotion and care processes. In addition, the neighborhoods in District I, as they represent the center of the municipality, had an older urbanization process, compared to neighborhoods in District VII, where the urban expansion process was more recent and where irregular settlements are observed in the periphery of the municipality.

Although this research did not aim to analyze the association between fetal mortality due to congenital syphilis and socioeconomic variables, its results suggested that the critical areas identified for the occurrence of fetal death may have some relationship with the areas of less favored socioeconomic conditions and greater social vulnerability, corroborating with a nationwide study[35]. The social vulnerability has territorial reproduction and can be understood as a set of factors of the most varied dimensions that do not act on an individual alone but on an entire community or territory. The sum or interpolation of these factors generates a more or less excluding social reality depending on the intensity that affects individuals and populations[36].

In this context, the risk of fetal death due to congenital syphilis can be higher or lower according to the profile of living conditions expressed by social vulnerability factors. Importantly, of the 16 neighborhoods classified as high risk for the outcome in both quinquenniums, 62.5% had high illiteracy rates; 68.75% were in the highest poverty range and 56.5% were classified in the strata of highest proportion of pregnant women without prenatal care[37].

The data evidenced by this research also corroborates a study that identified Districts I, VII, and VI as priority care areas to avoid perinatal mortality. In addition, it is pertinent to highlight that the neighborhoods of District I (Recife, Ilha Joana Bezerra, and Santo Antônio); II (Linha do Tiro), and VII (Alto José do Pinho, Nova Descoberta and Brejo da Guabiraba) which showed high-high clusters in this research coincide with areas classified as of high social need[38].

Another study carried out in Recife cited District I, mainly, and VII as regions that present centers of concentration of poverty and important social inequalities[39], corroborating what was pointed out by this study, which evidenced these two Districts as representatives of great vulnerability to the occurrence of fetal mortality due to congenital syphilis. As for areas classified as undergoing an epidemiological transition, the neighborhood of Poço da Panela stood out for having presented high incidence rates and neighbors with opposite rates, characterizing itself as an important area for implementation and/or intensification of actions to control congenital syphilis with a view to reducing preventable cases. District V did not present critical areas in any of the quinquenniums, demonstrating that it is not a priority area for interventions.

Despite having limitations regarding data quality, typical of studies with databases, and the possibility that the calculation of the indicator was overestimated due to the absence of data on abortions due to congenital syphilis to be added to total births, the results were able to highlight the coincidence between the areas of greatest risk for the occurrence of the outcome with the areas of greatest social vulnerability in the municipality and to point out the priority areas for structuring the health care network for prevention and control interventions in the population of pregnant women.

The territorial analysis is a powerful tool to contribute to the planning and execution of promotion, prevention, and comprehensive health care actions[40]. The territorialization of health is a social process of change in sanitary practices, being, therefore, a fundamental policy to give effect to the principles of the SUS (*Sistema Único de Saúde*, in free translation Unified Health System) in Brazil[41].

Therefore, to ensure effective intervention actions in the areas of evidenced clusters, further studies are needed to identify the risks, vulnerabilities, and potential of these areas in the perspective of articulating and dialoguing with the population and analyzing the health situation and living conditions for the recognition of the social determinants of community health.

CONCLUSION

The study showed that the priority neighborhoods for interventions aimed at preventing the occurrence of fetal deaths from congenital syphilis are mainly located in the Sanitary District I, followed by Districts VII and VI. Districts II and IV presented only one neighborhood each with critical areas located in its geographic space and V did not show priority neighborhoods. The results can support political decisions regarding the allocation of resources destined for the most vulnerable areas in relation to the studied indicator. The results suggest a possible relationship between fetal death and neighborhoods with greater social deprivation and poorer living conditions, but it emphasizes the importance of further publications to investigate the association between the incidence rates of fetal mortality due to the disease between neighborhoods and indicators of social vulnerability.

AUTHOR'S CONTRIBUTIONS

Study design. Roberta de Souza Pereira da Silva Ramos.

Data collection. Roberta de Souza Pereira da Silva Ramos. Gledsângela Ribeiro Carneiro.

Data analysis. Roberta de Souza Pereira da Silva Ramos. Gledsângela Ribeiro Carneiro. André Luiz Sá de Oliveira. Tarcisio Neves da Cunha. Vânia Pinheiro Ramos.

Interpretation of results. Roberta de Souza Pereira da Silva Ramos. Gledsângela Ribeiro Carneiro. Tarcisio Neves da Cunha.

Writing and critical review of the manuscript. Roberta de Souza Pereira da Silva Ramos. Gledsângela Ribeiro Carneiro. André Luiz Sá de Oliveira. Tarcisio Neves da Cunha. Vânia Pinheiro Ramos.

Approval of the final version of the article. Roberta de Souza Pereira da Silva Ramos. Gledsângela Ribeiro Carneiro. André Luiz Sá de Oliveira. Tarcisio Neves da Cunha. Vânia Pinheiro Ramos.

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ASSOCIATED EDITOR

Gerson Luiz Marinho

SCIENTIFIC EDITOR

Ivone Evangelista Cabral

REFERENCES

1. WHO: World Health Organization. Chlamydia, gonorrhoea, trichomoniasis and syphilis: global prevalence and incidence estimates, 2016 [Internet]. WHO; 2016 [citado 2017 abr 2]. Disponível em: https://apps.who.int/iris/handle/10665/246296
2. Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Departamento de DST, Aids e Hepatites Virais. Boletim Epidemiológico Sífilis. Vol. 49. Brasília: Ministério da Saúde; 2018.
3. Gomez GB, Kamb ML, Newman LM, Mark J, Broutet N, Hawkes SJ. Untreated maternal syphilis and adverse outcomes of pregnancy: a systematic review and meta-analysis. Bull World Health Organ. 2013 mar 1;91(3):217-26. http://dx.doi.org/10.2471/BLT.12.107623. PMid:23476094.
4. Unemo M, Bradshaw CS, Hocking JS, de Vries HJC, Francis SC, Mabey D et al. Sexually transmitted infections: challenges ahead. Lancet Infect Dis. 2017 ago;17(8):e235-79. http://dx.doi.org/10.1016/S1473-3099(17)30310-9. PMid:28701272.
5. Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Departamento de DST, Aids e Hepatites Virais. Boletim Epidemiológico Sífilis. Vol. 49. Brasília: Ministério da Saúde; 2019.
6. Organização Pan-Americana da Saúde. Organização Mundial da Saúde. 50° Conselho Diretor. 62a Sessão do Comitê Regional. Resolução CD50.R12. Estratégia e plano de ação para a eliminação transmissão materno-infantil do HIV e da sífilis congênita [Internet]. Washington (DC): OPAS/OMS; 2010 [citado 2013 mar 14]. Disponível em: https://www.paho.org/hq/dmdocuments/2010/CD50.R12-p.pdf
7. Ramos RSPS, Ramos VP. Análise espacial como ferramenta de identificação de áreas prioritárias de intervenção para prevenção da sífilis. Cien Saude Colet [Internet]. 2020; [citado 2020 mar 5]. Disponível em: http://www.cienciaesaudecoletiva.com.br/artigos/analise-espacial-como-ferramenta-de-identificacao-de-areas-prioritarias-de-intervencao-para-prevencao-da-sifilis/17500?id=17500
8. IBGE: Instituto Brasileiro de Geografia e Estatística. Diretoria de Pesquisas, Coordenação de População e Indicadores Sociais. IBGE Cidades. IBGE; 2021 [citado 2021 jan 10]. Disponível em: https://cidades.ibge.gov.br/brasil/pe/recife/panorama
9. Ministério da Saúde (BR). Secretaria de Vigilância em Saúde. Secretaria de Atenção à Saúde. Manual de vigilância do óbito infantil e fetal e do Comitê de Prevenção do Óbito Infantil e Fetal. 2ª ed. Brasília: Ministério da Saúde; 2009.
10. Andreucci CB, Cecatti JG. Desempenho de indicadores de processo do Programa de Humanização no Pré-Natal e Nascimento no Brasil: uma revisão sistemática. Cad Saude Publica. 2011;27(6):1053-64. http://dx.doi.org/10.1590/S0102-311X2011000600003. PMid:21710003.
11. Dos Santos AE, Rodrigues AL, Lopes DL. Aplicações de Estimadores Bayesianos Empíricos para Análise Espacial de Taxas de Mortalidade. Anais do VII Simpósio Brasileiro de Geoinformática; 2005; Campos do Jordão (SP), Brasil. São José dos Campos: INPE; 2005. p. 300-9.
12. Santos L, Raia AA Jr. Análise espacial de dados geográficos: a utilização da Exploratory Spatial Data Analysis - ESDA para identificação de áreas críticas de acidentes de trânsito no município de São Carlos (SP). Soc Natur. [Internet]. 2006; [citado 2020 dez 14];18(35):97-107. Disponível em: http://www.seer.ufu.br/index.php/sociedadenatureza/article/view/9251
13. Ministério da Saúde (MS). Fundação Oswaldo Cruz (Fiocruz). Introdução a Estatística Espacial para Saúde Pública. Brasília: MS; 2007. (Série B. Textos Básicos de Saúde). (Série Capacitação e Atualização em Geoprocessamento em Saúde; 3).
14. Fleiss JL. Statistical methods for rates and proportions. New York: John Wiley; 1981. p. 212-36.
15. Almeida ES. Econometria espacial aplicada. Campinas: Alínea Editora, 2012.
16. Jacquez GM. Spatial cluster analysis. In: Fotheringham S, Wilson J, editors. The handbook of geographic information science. Hoboken: Blackwell Publishing; 2008. p. 395-416.
17. Pfeiffer DU, Robinson TP, Stevenson M, Stevens KB, Rogers DJ, Clements ACA. Spatial analysis in epidemiology. Oxford University Press New York; 2008. http://dx.doi.org/10.1093/acprof:oso/9780198509882.001.0001.
18. Duarte-Cunha M, Souza-Santos R, Matos HJD, Oliveira MLWD. Epidemiological aspects of leprosy: a spatial approach. Cad Saude Publica. 2012;28(6):1143-55. http://dx.doi.org/10.1590/S0102-311X2012000600013. PMid:22666818.
19. Anselin L. The Moran scatterplot as an ESDA tool to assess local instability in spatial association. In: Fisher M, Scholten HJ, Unwin, D, editors. Spatial analytical perspectives on GIS. London: Taylor & Francis; 1996. p. 111-26
20. Nonato SM, Melo APS, Guimarães MDC. Sífilis na gestação e fatores associados à sífilis congênita em Belo Horizonte-MG, 2010-2013. Epidemiol Serv Saude. 2015 dez;24(4):681-94. http://dx.doi.org/10.5123/S1679-49742015000400010.
21. Cavalcante PAM, Pereira RBL, Castro JGD. Sífilis gestacional e congênita em Palmas, Tocantins, 2007-2014. Epidemiol Serv Saúde. 2017;26(2):255-64. http://dx.doi.org/10.5123/s1679-49742017000200003.
22. Conceição HN, Câmara JT, Pereira BM. Análise epidemiológica e espacial dos casos de sífilis gestacional e congênita. Saúde Debate. 2019 out;43(123):1145-58. http://dx.doi.org/10.1590/0103-1104201912313.
23. Padovani C, Oliveira RR, Pelloso SM. Syphilis in during pregnancy: association of maternal and perinatal characteristics in a region of southern Brazil. Rev Lat Am Enfermagem. 2018;26(0):e3019. http://dx.doi.org/10.1590/1518-8345.2305.3019. PMid:30110097.
24. Silva IMD, Leal EMM, Pacheco HF, Souza JG Jr, Silva FS. Perfil epidemiológico da sífilis congênita. Rev Enferm UFPE on line. 2019;13(3):604-13. http://dx.doi.org/10.5205/1981-8963-v13i3a236252p604-613-2019;
25. Holanda MTCG, Barreto MA, Machado KMM, Pereira RC. Perfil epidemiológico da sífilis congênita no Município do Natal, Rio Grande do Norte - 2004 a 2007. Epidemiol Serv Saude. 2011 jun 20;20(2):203-12. http://dx.doi.org/10.5123/S1679-49742011000200009.

26. Domingues RM, Saracen V, Hartz ZM, Leal MC. Congenital syphilis: a sentinel event in antenatal care quality. Rev Saude Publica. 2013 fev;47(1):147-56, discussion 157. http://dx.doi.org/10.1590/S0034-89102013000100019. PMid:23703141.
27. Nunes JT, Gomes KRO, Rodrigues MTP, Mascarenhas MDM. Qualidade da assistência pré-natal no Brasil: revisão de artigos publicados de 2005 a 2015. Cad Saúde Colet. 2016;24(2):252-61. http://dx.doi.org 10.1590/1414-462X201600020171.
28. Silva ALA, Mendes ACG, Miranda GMD, Souza WV. A qualidade do atendimento ao parto na rede pública hospitalar em uma capital brasileira: a satisfação das gestantes. Cad Saude Publica. 2017;33(12):e00175116. http://dx.doi.org/10.1590/0102-311x00175116. PMid:29267694.
29. CDC: Centers for Disease Control and Prevention. Sexually transmitted diseases treatment guidelines. Syphilis during pregnancy [Internet]. CDC; 2021 [citado 2021 set 10]. Disponível em: https://www.cdc.gov/std/treatment-guidelines/syphilis-pregnancy.htm
30. Santos T. Desabastecimento de penicilina alerta para desafio global de combate à sífilis [Internet]. MEDSCAPE; 2016 [citado 2017 abr 2]. Disponível em: http://portugues.medscape.com/verartigo/6500488
31. Guanabara MAO, Leite-Araújo MA, Matsue RY, Barros VL, Oliveira FA. Acesso de gestantes às tecnologias para prevenção e controle da sífilis congênita em Fortaleza-Ceará, Brasil. Rev Salud Publica (Bogota). 2017 jan/fev;19(1):73-8. http://dx.doi.org/10.15446/rsap.v19n1.49295.
32. Domingues RMSM, Lauria LM, Saraceni V, Leal MC. Manejo da sífilis na gestação: conhecimentos, práticas e atitudes dos profissionais pré-natalistas da rede SUS do município do Rio de Janeiro. Ciênc Saúde Coletiva. 2013 maio;18(5):1341-51. http://dx.doi.org/10.1590/S1413-81232013000500019.
33. Melo NGDO, Melo DA Fo, Ferreira LOC. Diferenciais intraurbanos de sífilis congênita no Recife, Pernambuco, Brasil (2004-2006). Epidemiol Serv Saude. 2011 jun;20(2):213-22. http://dx.doi.org/10.5123/S1679-49742011000200010.
34. Dos Santos AE, Rodrigues AL, Lopes DL. Aplicações de estimadores bayesianos empíricos para análise espacial de taxas de mortalidade. Anais do VII Simpósio Brasileiro de Geoinformática; 2005; Campos do Jordão (SP), Brasil. São José dos Campos: INPE. p. 300-9.
35. Domingues RMSM, Leal MC. Incidência de sífilis congênita e fatores associados à transmissão vertical da sífilis: dados do estudo Nascer no Brasil. Cad Saude Publica. 2016;32(6):e00082415. http://dx.doi.org/10.1590/0102-311X00082415. PMid:27333146.
36. Ministério do Desenvolvimento Social e Combate à Fome (BR). Orientações Técnicas da Vigilância Socioassistencial. Brasília: Ministério do Desenvolvimento Social e Combate à Fome; 2013. 58 p.
37. de Holanda ER, Galvão MT, Pedrosa NL, Paiva SS, de Almeida RL. Spatial analysis of infection by the human immunodeficiency virus among pregnant women. Rev Lat Am Enfermagem. 2015 maio/jun;23(3):441-9. http://dx.doi.org/10.1590/0104-1169.0481.2574. PMid:26155005.
38. Canuto IMB, Alves FAP, Oliveira CM, Frias PG, Macêdo VC, Bonfim CV. Intraurban differentials of perinatal mortality: modeling for identifying priority areas. Esc Anna Nery. 2019;23(1):e20180166. http://dx.doi.org/10.1590/2177-9465-ean-2018-0166.
39. Oliveira TG, Silveira Neto RM. Segregação residencial na cidade do Recife: um estudo da sua configuração. Rev Bras Est Reg Urb [Internet]. 2015; [citado 2018 ago 16];9(1):71-92. Disponível em: https://www.revistaaber.org.br/rberu/article/view/115/151
40. Fonseca BMC, Braga AMCB, Dias EC. Planejamento de intervenções em Saúde do Trabalhador no território: uma experiência participativa. Rev Bras Saúde Ocup. 2019;44:e36. http://dx.doi.org/10.1590/2317-6369000015018.
41. Faria RM. A territorialização da Atenção Básica à Saúde do Sistema Único de Saúde do Brasil. Ciênc Saúde Coletiva. 2020;25(11):4521-30. http://dx.doi.org/10.1590/1413-812320202511.30662018.