

Spatial distribution of C-sections within the state of São Paulo

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SUMMARY

Objective: to identify spacial patterns for cesarean deliveries per microregion in the state of São Paulo.

Methods: this is an ecological and exploratory study with data on live births occurred between 2003 and 2007 in 63 microregions in the state of São Paulo. Variables analyzed included cesarean delivery rates, teenage mothers, mothers with high levels of education and who had at least seven prenatal consultations. Moran's index (I), a measure of spatial autocorrelation of rates related to the variables described above and which identifies the presence of spatial clusters, was calculated. The distributions of the variables' rates in this study were visualized using thematic maps. The Moran map was used to identify microregions with high priority need for attention. Pearson correlation coefficients among the variables were also obtained.

Results: there were 3,045,293 births, being 1,636,009 (53.7 %) cesarean deliveries. It was possible to identify spatial clusters of C-sections ($I = 0.58$ and $p < 0.01$) in the microregions located on the north and northwest of the state of São Paulo, as well as in Guaratinguetá; the values found for Moran index were, $I = 0.32$, $I = 0.30$ and $I = 0.24$, for the rates of teenage mothers, schooling and number of consultations, respectively, being all significant results ($p < 0.01$). Micro-regions with high-priority need for attention were identified. Cesarean rates were significantly correlated with high rates of maternal education and number of prenatal consultations.

Conclusion: the identification of these microregion clusters with high rates of cesarean delivery allows health managers to implement policies in order to minimize these rates.

Keywords: spatial distribution of the population, public health, C-section, maternal age, maternal education, geographic information systems.

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INTRODUCTION

Currently, Brazil has an overall C-section rate of 32%, reaching 90% in some private clinics.¹ In the state of São Paulo, the rate of C-sections amounts to 32.9% in the public setting and 80.4% in private setting.² Compared to spontaneous vaginal delivery, cesarean section is associated with an increased risk of infections, occasional need for blood transfusion, pneumonia, cardiopulmonary complications, thromboembolism and gastrointestinal disorders in women giving birth.^{1, 3-6} In addition, the risk of hospital readmission within sixty days after surgery is higher than that seen after spontaneous vaginal delivery.⁵

A recent review showed that the rates of cesarean delivery have increased in recent years in European countries, and the rates around the world have been between 13.5% and 39.2% of births.⁷

Geoprocessing is becoming an important tool in the field of Public Health, as it allows an overview of a particular problem. This technique was used in determining areas for malaria control,⁸ in the spread of the AIDS epidemic,⁹ and in the study of birth profiles in Vale do Paraíba.¹⁰

One of its applications encompasses the identification of spatial clusters defined as any cluster of events

that is not merely casual and whose identification is the focus of research in spatial statistics.

With the development of these maps, we seek to examine whether the distribution of these events actually follows a pattern in terms of space or if it is a random event.

The objective of this study was to identify spatial clusters of cesarean section rates in microregions of the state of São Paulo.

METHODS

This is a study of ecological and exploratory design, in which secondary data from live births were used; the information was gathered from the Datasus portal and refers to microregions within the state of São Paulo in the period from January 1, 2003 to December 31, 2007. Data were georeferenced according to the place of residence of the mother. These data were analyzed using TerraView 4.0.0. software program, made available by the National Institute for Space Research - INPE (www.dpi.inpe.br/terraview/). The proportions of cesarean deliveries were calculated according to the following groups: mothers aged below 20 years, mothers with formal education above eight years (high school and above), and mothers who had seven or more prenatal consultations. These proportions were obtained in percentages and compared to the total number of live births.

63 microregions that make up the state of São Paulo and have an approximate population of 41 million inhabitants were analyzed.

The spatial statistics used a georeferenced database of the microregions, and a data analysis technique divided by area in order to obtain the Global Moran's index (I). The equation that expresses this index takes into account the number of areas (microregions), the weights of the neighborhoods, the average incidence rate of cesarean section for each microregion in the periods studied and the mean values for the entire study area.

The Moran's index is a global measure of spatial autocorrelation; spatial autocorrelation measures the association of values of a single variable Y within any specific area i with the values of the same variable Y , however measured for an area neighboring i . That is, the index measures the extent to which the value of a variable in an area is associated with the same variable in neighboring areas. We can say that autocorrelation measures the level of spatial interdependence between the variables and the strength of the relation determining whether that is a random distribution or not. Its value is contained in the $[-1; 1]$ interval. The closer to 1, the more similar the areas compared to each other, whereas the closer to -1 , the least similar these areas would be from each other.

These indices were calculated for all areas. Thematic maps that allow visual identification of the distribution of these events in the microregions were prepared.

A Moran map of C-section rates was created; the map shows areas of high priority for possible intervention. The Moran map is a two-dimensional representation of the Moran scatterplot where each polygon is displayed, indicating its quadrant in the scattering diagram. In this map, the microregions located in Q1 require special attention in order to reduce the rates of the studied outcome, which in our case is the rate of cesarean deliveries.

The Pearson correlation coefficients between C-section rates and other variables were estimated.

Tables with the coefficients of global Moran and Pearson correlation were built. The variables were expressed as percentages in the tables, with mean, minimum and maximum values.

As this is an ecological study using secondary data obtained from the network, identifying the subject is not possible, and thus approval by the Research Ethics Committee was not required.

RESULTS

During the study period, there were 3,045,293 live births, of which 1,636,009 (53.7%) were delivered by cesarean section. The percentages of other variables, along with their mean, minimum and maximum values are shown in Table 1. The high mean value of the proportion of cesarean deliveries is clearly observed.

TABLE 1 Mean, minimum and maximum (Min - Max) values, and respective standard deviations (SD) of rates per 100 live births, delivered by C-section; mothers with high level of education; mothers aged less than 20 years (adolescents); and mothers who had seven or more prenatal consultations, by microregion in the state of São Paulo, from 2003 to 2007

	Mean (SD)	Min- Max
Cesarean delivery	57.0 (10.8)	31.7 - 76.8
Adolescent mothers	19.5 (2.3)	14.6 - 25.0
Mothers with high level of education	70.8 (7.5)	42.4 - 72.8
Mothers who had seven or more prenatal consultations	74.1 (10.2)	39.4 - 93.7

The Moran index (I) was positive and significant for all variables studied, demonstrating the presence of spatial clusters for all determinants.

The spatial distribution of cesarean deliveries, represented here by rates per 100 live births, by microregion in the state of São Paulo, from 2003 to 2007, is shown in Figure 1. The presence of high rates of cesarean sections in the north and northwest part of the state is evident, with spatial clusters toward the border of the states of Minas Gerais, Mato Grosso do Sul and northern Paraná, as well as in the microregion of Guaratinguetá, within Vale do Paraíba. Lower rates were found to the south of the state near the border of Paraná and in the microregions of Avaré, Franco da Rocha, and Campos do Jordão. Moran's index was $I = 0.58$ ($p < 0.01$).

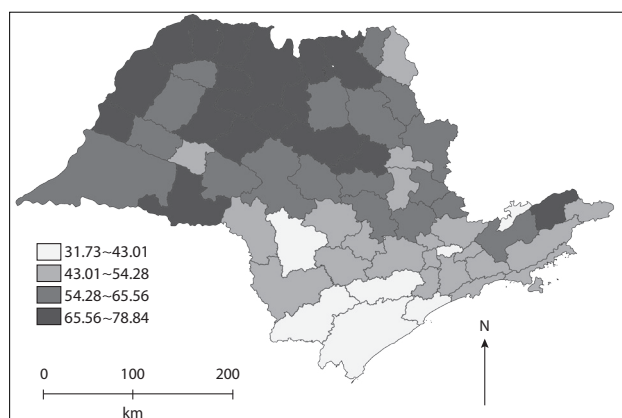


FIGURE 1 Spatial distribution of rates of cesarean delivery, in percentages, by microregion in the state of São Paulo, 2003-2007.

The spatial distribution of the proportion of teenage mothers, by microregion, identified larger proportions in the southern part of the state, in the microregions of Avaré, Itapeva, Capão Bonito, and Registro, close to the border of Paraná, in addition to Ituverava, which is located upstate. Lower rates are located east of the state, in the microregions of Amparo, Campinas, Jundiaí, Osasco, São Paulo, Guarulhos, and São José dos Campos, as well as in Franca and Ribeirão Preto, upstate. Moran's index was $I = 0.32$ ($p < 0.01$). The distribution of these microregions is similar to that observed for cesarean rates.

The spatial distribution for maternal schooling above eight years of formal education by microregion found higher proportions in the west of the state, bordering the north of the state of Paraná, and in Vale do Paraíba. Moran's index for this variable was $I = 0.30$ ($p < 0.01$). The spatial distribution of this variable's proportions in the microregions is similar to that of the proportions of cesarean sections.

Regarding the number of medical consultations, the Moran index was positive and significant ($I = 0.24$; $p < 0.01$),

with higher proportions of mothers who had at least 7 consultations in the microregions located in the central, northern and northwestern parts of the state. The lowest proportions are seen in a strip of 12 microregions stretching from east, in the border of the state of Rio de Janeiro, all the way to the state of Paraná, including the Greater São Paulo metropolitan area.

The Moran map for C-section rates is shown in Figure 2 and indicates an area of high priority for intervention in 13 microregions located in the north and northwest of the state, close to the border of the states of Minas Gerais and Mato Grosso do Sul.

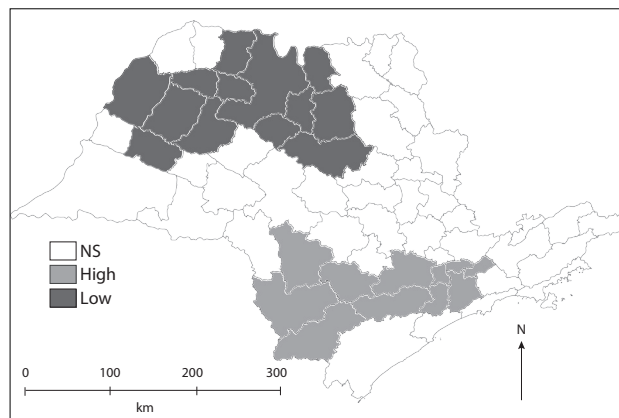


FIGURE 2 Microregions of the state of São Paulo according to priority – high, low and non-significant (NS) – for intervention in rates of cesarean delivery. Microregions in the state of São Paulo, 2003-2007.

cesarean rates were negatively correlated, although not significantly, with the rates of teenage mothers ($r = -0.14$); in contrast, the correlations with educational level ($r = 0.50$) and number of consultations ($r = 0.60$) were statistically significant.

DISCUSSION

The importance of this study is to identify spatial clusters of microregions with high rates of cesarean delivery. These clusters of micro-regions with high rates of cesarean sections are located in the north and northwest of the state of São Paulo. This is, to our knowledge, the first study using this type of approach.

The data obtained from Datasus refer to all deliveries including those conducted by the Federal Unified Health System (SUS) or private institutions (covered by health plans and pregnant women who receive care in private clinics).

According to the Ministry of Health, C-sections already represent 43% of the deliveries carried out in Brazil both in public and private settings, while the World Health Organization recommends that C-sections are performed in no more than 15% of births, always in situations that involve risks for both mother and child.¹¹ A study by Barros et al.,¹¹ conducted in the city of Pelotas (state of Rio Grande do Sul) in 2004 showed an overall cesarean rate of 45%, being 36% performed in patients assisted by the SUS and 81% in the private setting, where 35% of C-sections performed electively. When taking into account private health plans, it appears that this percentage is even higher, reaching 80%.¹²

In the public SUS setting, however, C-sections account for 26% of all births. According to the Interagency Health Information Network (RIPSA, in Portuguese) report in Brazil, from 2008, cesarean deliveries are more common among women with higher levels of education, reaching almost 70% among those with 12 years or more of schooling and being less 20% among women with less formal education. The mother's education variable can be treated as an approximation of maternal social class and remains as the most important factor associated with birth weight and neonatal mortality. A study by Freitas et al.¹³ showed that women over age 30 have a higher probability of cesarean delivery than women below 20 years.

Comparing the spatial distribution of cesarean births and mothers under age 20, a higher rate of teenage mothers was observed in areas to the south of the state, where fewer cesarean deliveries are performed, suggesting that microregions with lower socioeconomic development are those with the highest rates of teenage mothers and lower rates of cesarean section. Likewise, Simões et al.¹⁴ analyzed characteristics of adolescent pregnancy in São Luís, Maranhão, and observed that the general characteristics of adolescent mothers differed from older women. In the study presented here, the highest rates of adolescent mothers are concentrated in rural areas with possible compromised infrastructure.

The geographical distribution of the percentages of mothers with more than eight years of education shows a pattern with lower values in the microregions of Registro, Capão Bonito, Piedade, and Paraibuna/Paraitinga, indicating that areas with worst infrastructure are those with higher proportions of mothers with low education and lower rates of cesarean delivery. Similarly, a study by Haidar et al.,¹⁵ conducted in Vale do Paraíba, found that maternal education is strongly associated with type of delivery when mothers with higher levels of education have

a six times greater chance of having their children by cesarean section. This seems to be due to the mother's choice, as much as their physician's. Since cesarean sections are usually more expensive procedures, mothers with higher levels of education and consequently better economic conditions, may opt for it.

This statement must be viewed with caution because some microregions may present lower C-section rates due to areas with worst socioeconomic conditions, where birth care can be precarious to the point of compromising the outcomes of both mother and child.

The spatial patterns for cesarean section according to maternal age and education found in this study were similar to those found by D'Orsi and Carvalho.¹⁶

After spatial analysis of the distribution of mothers who had at least 7 prenatal consultations, it is clear that the microregions with the highest rates are concentrated in the central, northern and northwestern parts of the state, and these also have higher C-section rates; the Pearson correlation coefficient showed a strong correlation between this variable and cesarean deliveries; the spatial distribution of rates of mothers who had at least seven prenatal consultations reached a significant value for the Moran index. This spatial distribution is similar to that of mothers with high levels of education, suggesting that they initiate prenatal care earlier, possibly, and have more contact with the obstetrician, which facilitates the choice for cesarean delivery.¹³ We must remember that a greater number of prenatal consultations can be a sign of a risky pregnancy, which in turn may require cesarean delivery.

As seen in the Moran map, 13 microregions were found as high priority for intervention in order to reduce the rates of cesarean deliveries in northern and northwestern areas of the state, close to the border of Minas Gerais and Mato Grosso do Sul; it is noteworthy that these are microregions with the highest rates of highly educated mothers. Possibly, in regions where coverage of health plans is greater, cesarean rates also tend to be higher.

This study may have limitations, some related to the status of ecological study and other related to the data. The source of the research - Datasus - is widely used in ecological studies but may not have offered socioeconomic information, or information about the type of complications occurred in both vaginal and cesarean deliveries. The impact of cesarean section on the health of the newborn was not mentioned, either; causal relationships cannot be identified, but possible associations can be suggested. Furthermore, neonatal deaths that could be associated with type of delivery were not analyzed.

CONCLUSION

The identification of these microregion clusters with high rates of cesarean delivery, as well as the identification of microregions with high priority for intervention allows health managers to implement measures in order to minimize these rates.

RESUMO

Distribuição espacial das cesarianas no Estado de São Paulo.

Objetivo: identificar padrões espaciais para partos cesarianos por microrregião do Estado de São Paulo.

Métodos: estudo ecológico e exploratório com dados de nascidos vivos entre 2003 e 2007 de 63 microrregiões do Estado de São Paulo. As variáveis analisadas neste estudo foram, além de taxas de parto cesariano, taxas de mães adolescentes, de mães com alta escolaridade e de mães que realizaram pelo menos 7 consultas no pré-natal. Foram calculados os índices de Moran (I), que estimam autocorrelação espacial das taxas das variáveis acima descritas e identificam a presença de aglomerados espaciais. Essas taxas foram visualizadas pelos mapas temáticos; microrregiões com alta prioridade de atenção foram identificadas pelo mapa de Moran. Foram calculados os coeficientes de correlação de Pearson entre as variáveis.

Resultados: houve 3.045.293 partos, sendo 1.636.009 (53,72%) partos cesarianos. Foi possível identificar aglomerados espaciais de cesarianas ($I = 0,58$ e $p < 0,01$) nas microrregiões ao norte e noroeste do Estado, além de Guaraatinguetá. Os valores dos índices de Moran foram, para as taxas de mães adolescentes, $I = 0,32$; para as taxas de alta escolaridade, $I = 0,30$; e para as taxas do número de consultas, $I = 0,24$, todos significativos ($p < 0,01$). Foram identificadas microrregiões com alta prioridade de intervenção. As taxas de cesarianas estiveram correlacionadas significativamente com as taxas de alta escolaridade materna e com número de consultas.

Conclusão: a identificação desses aglomerados de microrregiões com altas taxas de cesarianas permite aos gestores de saúde implantar políticas para minimizar tais taxas.

Palavras-chave: distribuição espacial da população; saúde pública; cesariana; idade materna; escolaridade materna; sistemas de informação geográfica.

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