Original article

Associated factors with spatial variation of adolescent pregnancy in Brazil, 2014: an ecological study of spatial clusters*

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Thiago Luis Cardoso Nascimento[1] - orcid.org/0000-0001-8850-0250
Camila Silveira Silva Teixeira[2] - orcid.org/0000-0001-6340-7957
Marília Santos dos Anjos[2] - orcid.org/0000-0002-9942-7869
Greice Maria de Souza Menezes[2] - orcid.org/0000-0002-8393-2545
Maria da Conceição Nascimento Costa[2] - orcid.org/0000-0001-7275-4280
Marcio Santos da Natividade[2] - orcid.org/0000-0002-3986-5656

[1]Universidade Federal da Bahia, Maternidade Climério de Oliveira, Salvador, BA, Brazil
[2]Universidade Federal da Bahia, Instituto de Saúde Coletiva, Salvador, BA, Brazil

Abstract

Objective: To identify socioeconomic and health care determinants of spatial variation in adolescent pregnancy in Brazil in 2014. **Methods:** This was a spatial ecological study having municipalities as units of analysis. Spatial linear regression was used to verify association between the fertility rate in 15-19 year-old women and socioeconomic and health variables. **Results:** The adolescent fertility rate was negatively associated with higher Family Health Strategy coverage (β = -0.011 – 95%CI -0.017;-0.005), an adequate number of prenatal consultations (β = -0.122 – 95%CI -0.132;-0.224) and low average family income *per capita* (β = -0.104 – 95%CI -0.105;-0.103). Association was positive in relation to the Gini index (β = 7.031 – 95%CI 4.793;9.269), low income (β = 0.127 – 95%CI 0.108;0.145), higher household density (β = 6.292 – 95%CI 5.062;7.522) and less schooling (β = 0.260 – 95%CI 0.224;0.295). **Conclusion:** Reduced access to primary care and lower income are associated with higher adolescent fertility rates. Poorer socioeconomic and health care indicators are associated with higher adolescent fertility rates.

Keywords: Pregnancy in Adolescence; Spatial Analysis; Socioeconomic Factors; Primary Health Care.

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Correspondence:
Thiago Luis Cardoso Nascimento – Rua Quintino de Carvalho, No. 230, Ed. Pontevedra, apt. 501, Jardim Apipema, Salvador, BA, Brazil. Postcode: 40155-280
E-mail: thiagocard27@hotmail.com

Introduction

Adolescent pregnancy is a complex phenomenon. It involves biological, social, economic and cultural aspects and therefore takes on different meanings depending on the context in which it occurs.[1] Every year more than 16 million 15-19 year-old female adolescents become mothers in low- and middle-income countries. Among such countries located in Latin America and the Caribbean and Africa (2005-2010), rates of 72 and 108 births/1,000 women in this age range were estimated, respectively.[2]

> *Every year more than 16 million 15-19 year-old female adolescents become mothers in low- and middle-income countries.*

In Brazil, adolescent pregnancy became a noticeable Public Health problem as the relative increase in the fertility rate among women up to 19 years old took place, rising from 7.1% in 1970 to 23% in 2006.[3] The fertility rate varied considerably over the period between 1990 and 2009, with the country's overall average national fertility rate falling as much as 30.6%, while it fell by 36.4% in the Southern region and 12.0% in the Northern region.[2] Data from the Brazilian National School Health Survey conducted in 2015 provided evidence that over 23,000 adolescents from all five Brazilian macro-regions reported having become pregnant at least once.[4]

Adolescent pregnancy should not be classified as a risk solely in view of the biomedical parameter. Other factors should also be taken into consideration, such as lifestyle (use of alcohol and other drugs), availability and use of health services, as well as socioeconomic aspects.[5,6] A survey conducted in Brazilian state capitals (Rio de Janeiro, Porto Alegre and Salvador) found inverse association between adolescent pregnancy, level of schooling and family income.[7] Barriers to accessing health, among other public services, were also found to be factors related to adolescent pregnancy.[8,9]

Evolution of adolescent pregnancy can be associated with different contexts, which could make adolescent females vulnerable to health risks.[10] Negative psychological conditions experienced during pregnancy, and problems arising therefrom, can directly affect their health and that of their babies, such as gestational diabetes and pre-eclampsia, with the latter being related to fetal suffering and prematurity.[11] Moreover, when they become mothers, adolescents can experience intense mental suffering, negative self-worth and few or no expectations for the future. These circumstances may represent greater risk of school grade repetition, difficulty in limiting fertility, and economic dependence.[12] In Brazil there are few spatial cluster studies of adolescent pregnancy and all of them have demonstrated its relationship with diverse socioeconomic determinants.[3,5,13-15]

This study intends to broaden understanding and produce information, not investigated on the individual level, capable of informing decision making regarding addressing this Public Health problem from a collective perspective. To identify socioeconomic and health care determinants of spatial variation in adolescent pregnancy in Brazil in 2014.

Methods

An ecological study was conducted, having all the Brazilian municipalities as its units of analysis. The study population was comprised of 15-19 year-old women, resident in the country's municipalities in 2014. The outcome of interest was spatial variation in the adolescent fertility rate. Health care and socioeconomic indicators of the municipalities were taken as independent variables: number of prenatal care sessions attended; proportion of Family Health Strategy (FHS) coverage; average family income per capita; proportion of low-income population (up to half a minimum wage – BRL R$ 724 in 2014); dweller density per household; and the Gini index, an instrument capable of measuring the degree of income concentration in a given group. The Gini index rating varies from 0 to 1, where 0 is representative of a situation of equality, and 1 is representative of wealth concentration.[16] The number of live births and information on pregnant adolescents were retrieved from the Health Ministry's Live Birth Information System (SINASC). Primary Health Care electronic medical records (e-SUS APS) were used to collect information on FHS coverage. Population and socioeconomic indicator projections for each municipality were provided by the Brazilian Institute of Geography and Statistics (IBGE).

Adolescent fertility rates were estimated according to the ratio between the number of live births born to 15-19 year-old puerperal women resident in each municipality in 2014, and the number of women in the

same age group living in the same municipality in the same year. The rates were presented per 1,000 women in that age group. In this study, the adolescent fertility rate was interpreted as being 'risk of adolescent pregnancy'. The proportion of adequate number of prenatal care sessions was estimated based on information available on the SINASC system, with an adequate number being considered to be serven sessions or more.[17] The proportion of adolescents with low schooling levels was also calculated, based on the proportion of 15-19 year-old puerperal women with less than eight years of schooling. This proportion was used as a proxy for individual socioeconomic status. Crude adolescent fertility rates were calculated for Brazil as a whole and for each municipality. These rates were smoothed in order to minimize random fluctuations caused by low numbers, by applying the global empirical Bayesian method.[18] This method also uses data from neighboring areas in order to estimate risk of occurrence of an event in each area. In this way estimates are obtained for a local average – rather than the global average –, and are therefore less unstable.[19,20] Descriptive analysis was performed on the distribution of all the indicators used in the study, based on the respective medians for Brazil as a whole and for its geographic regions. Thematic maps were produced in order to identify patterns in the spatial distribution of the smoothed fertility rates; analysis of the rates adjusted for the variables investigated was based on the spatial regression model, using the Qgis 2.18 program.

In order to perform the spatial analysis, a neighborhood matrix or weighted adjacency matrix was built using the GeoDa 1.8 program. Existence of spatial autocorrelation between the smoothed adolescent fertility rates was assessed by calculating the Global Moran's index. Risk areas were identified by calculating the Local Moran's index (LISA: local indicator of spatial association), which enable assessment of the existence of clusters with similar values (high or low), assuming a p-value <0.05. Following identification of spatial autocorrelation in the smoothed adolescent fertility rates in the municipalities, existence of association between these rates and the respective independent variables (socioeconomic and health care) was then assessed. Bivariate and multivariate linear spatial autoregressive (SAR) models were built and the respective 95% confidence intervals (95%CI) were calculated.

All the statistical analyses were performed using Stata version 13 and GeoDa 1.8. The study was based on secondary public domain data and, therefore, it was not necessary to submit the project to a Research Ethics Committee, in accordance with National Health Council Resolution No. 466, dated December 12th 2012.

Results

We assessed 5,157 (92.6%) of Brazil's 5,570 municipalities. The majority of the 413 excluded municipalities were located in the South and Southeast regions, and their exclusion was due to the inexistence of information needed for the study.

In 2014, the crude adolescent fertility rate in Brazil was 65.1/1,000 women in the 15-19 age group. In the North, Midwest and Northeast regions, particularly in municipalities with more than 50,000 inhabitants, the rates varied between 73/1,000 and 103/1,000 women aged 15-19. In the South and Southeast regions, the rates were estimated as being 55/1,000 and 56/1,000 women aged 15-19, respectively.

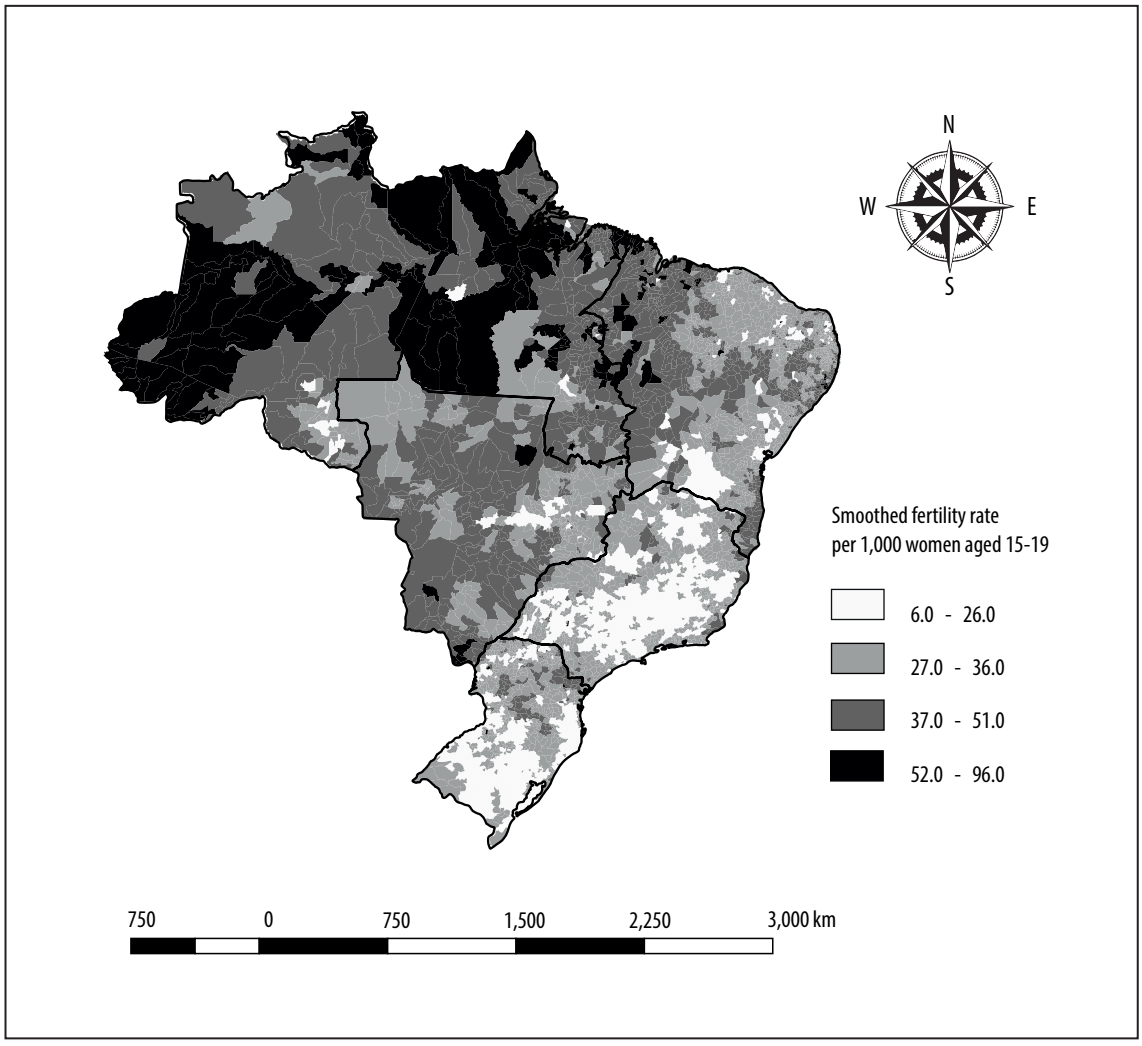
The median smoothed adolescent fertility rate for Brazil as a whole was 65.6/1,000 women aged 15-19 (interquartile range: 48.56-49.1) (Table 1). The North, Midwest and Northeast regions had higher medians: 93.5/1,000, 73.1/1,000 and 69.3/1,000 women aged 15-19, respectively. The highest median proportions of people with low income (up to half a minimum wage) were found in the North (30.2%) and Northeast (32.6%) regions, as were higher proportions of dweller density per household and adolescent mothers with less than eight years of schooling; lower proportions of adequate numbers of prenatal care sessions were also found in those regions. The Northern region had the lowest proportion of FHS coverage (80.0% – 95%CI 55.1;93.4) in relation to the other regions (Table 1).

The majority of the North and Midwest region municipalities had higher smoothed adolescent fertility rates, ranging between 37/1,000 and 96/1,000 women aged 15-19 (Figure 1). Analysis of the rates adjusted by the variables investigated highlighted that the North and Northeast regions had a larger number of municipalities with higher smoothed adolescent pregnancy rates. The intensity of this indicator was heterogeneous in some areas: lower in South and Midwest region municipalities, and higher in some North and Southeast region municipalities. The Global

Table 1 – Median (Md) and interquartile range (IQR) of demographic, socioeconomic and health care indicators for municipalities grouped according to geographic macro-regions, Brazil, 2014

Indicators	North (n=442)	Northeast (n=1,768)	Southeast (n=1,512)	South (n=1,019)	Midwest (n=416)	Brazil (n=5,157)
Adolescent fertility rate[a]	93.5 (74.2;113.6)	69.3 (56.1;84.1)	53.3 (43.5;64.8)	54.2 (39.9;68.2)	73.1 (59.1;87.7)	65.6 (48.56;49.1)
Gini index	0.6 (0.5;0.6)	0.5 (0.5;0.6)	0.4 (04;0.5)	0.4 (0.4;0.5)	0.5 (0.4;0.5)	0.5 (0.42;0.53)
Average family income *per capita* (in minimum wages)	314.5 (229.0;406.0)	253.1 (218.0;295.0)	572.5 (443.0;701.0)	658.3 (305.0;799.0)	559.3 (472.0;645.0)	440.5 (268.0;631.0)
Proportion (%) of low-income population[b]	30,2 (17,0;44,0)	32.6 (24.0;40.0)	3.7 (1.1;9.5)	1.3 (0.1;5.3)	3.6 (0.5;9.6)	11.5 (2.1;31.0)
Dweller density per household	3.6 (3.2;4.4)	3.3 (3.2;3.5)	3.0 (2.9;3.1)	2.9 (2.8;3.0)	2.9 (2.8;3.0)	3.1 (2.9;3.3)
Family Health Strategy coverage (%)	80.0 (55.1;93.4)	93.4 (85.2;100.0)	92.8 (65.8;100.0)	95.6 (73.4;100.0)	89.0 (74.2;100.0)	93.3 (74.8;100.0)
Proportion (%) of adequate number of prenatal care sessions[c]	47.8 (36.0;60.6)	59.1 (47.0;70.4)	76.8 (69.4;83.0)	78.9 (69.5;85.4)	68.5 (59.1;76.3)	69.6 (56.4;79.5)
Schooling rate[d] (%)	3.4 (2.0;5.3)	2.9 (2.0;3.8)	1.4 (0.8;2.0)	1.6 (1.0;2.2)	1.8 (1.1;2.7)	2.0 (1.2;4.4)

a) Fertility rate among women 15-19 years old (per 1,000 women) smoothed using the empirical Bayesian method – proxy for pregnancy in adolescence.
b) Up to half a minimum wage.
c) Had seven or more prenatal care sessions.
d) Schooling rate as a proxy for socioeconomic status.



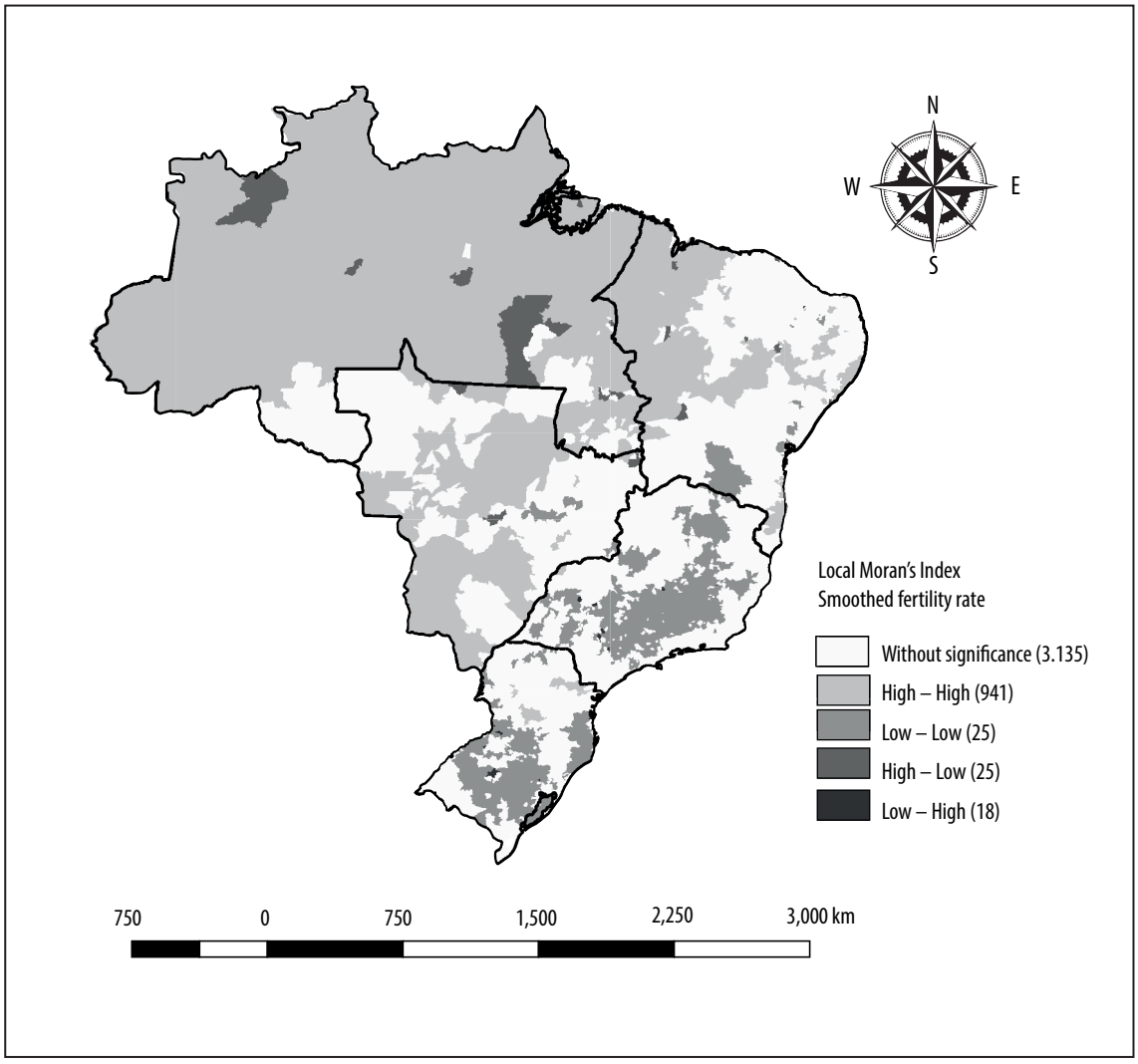
a) Assessed using Local Moran's index, by assessing existence of clusters of similar values (high or low), assuming a p-value <0.05.
b) Rate transformed using the empirical Bayesian method.

Figure 1 – Spatial distribution of fertility rates[a] (smoothed[b]) among 15-19 year-old adolescents, per municipality, Brazil, 2014

Moran's index showed statistically significant spatial autocorrelation (I = 0.790; p<0.001) for adolescent fertility rates, indicating spatial dependency.

When assessing areas considered to be risk areas for this outcome, the Local Moran's index also revealed statistically significant dependence (Figure 2). Clusters of neighboring municipalities with high rates (high/high) were located in the Midwest, the Northeast and in the Northern region in particular, with rates equal to or greater than 37/1,000 women aged 15-19. Clusters of neighboring municipalities with lower rates (low/low) were located in the Southeast and Southern regions, with rates varying between 27/1,000 and 36/1,000 women aged 15-19. Municipalities with transition areas, i.e. municipalities with low rates next to municipalities with high rates (low/high), were concentrated in the Northern region. Municipalities with high rates next to municipalities with low rates (high/low) were dispersed over the South and Southeast regions (Figure 2).

Global Moran's index bivariate values for each indicator assessed were: FHS coverage (I = 0.145; p<0.001); Gini index (I = 0.278; p<0.001); dweller density per household (I = 0.342; p<0.001); average



a) Assessed using Local Moran's index, by assessing existence of clusters of similar values (high or low), assuming a p-value <0.05.
b) Rate transformed using the empirical Bayesian method.

Figure 2 – Spatial autocorrelation patterns[a] of smoothed[b] fertility rates among 15-19 year-old adolescents, per municipality, Brazil, 2014

family income per capita (I = 0.477; p<0.001); proportion of adolescent mothers with less than eight years of schooling (I = 0.517; p<0.001); proportion of adequate number of prenatal care sessions (I = 0.662; p<0.001); and proportion of low-income population (I = 0.807; p<0.001) (Table 2). In the multivariate spatial linear regression analysis, inverse association was found between spatial variation of the smoothed adolescent fertility rates and the following factors: (i) low average family income *per capita* (β = -0.104 – 95%CI -0.105;-0.103); (ii) proportion of women aged 15-19 with an adequate number of prenatal care sessions (β = -0.122 – 95%CI -0.224;-0.132); and (iii) FHS coverage (β = -0.011 – 95%CI -0.017;-0.005) (Table 3). However, these associations were positive when the following municipal indicators were assessed: Gini index (β = 7.031 – 95%CI 4.793;9.269), dweller density per household (β = 6.292 – 95%CI 5.062;7.522), proportion of low-income population (β = 0.127 – 95%CI 0.108;0.145) and proportion of mothers aged 15-19 with less than eight years of schooling (β = 0.260 – 95%CI 0.224;0.295) (Table 3).

Table 2 – Bivariate Moran's index for the relationship between adolescent fertility rate[a] and demographic, socioeconomic and health care indicators, Brazil, 2014

Indicators	Moran's index	p-value
Gini indexi	0.278	<0.001
Average family income *per capita* (in minimum wages)	0.477	<0.001
Proportion (%) of low-income population[b]	0.807	<0.001
Dweller density per household	0.342	<0.001
Family Health Strategy coverage (%)	0.145	<0.001
Proportion (%) of adequate number of prenatal care sessionsc[c]	0.662	<0.001
Puerperal women (%) aged 15-19 with less than eight years of schooling	0.517	<0.001

a) Fertility rate among women 15-19 years old (per 1000 women) smoothed using the empirical Bayesian method – proxy for pregnancy in adolescence.
b) Up to half a minimum wage.
c) Had seven or more prenatal care sessions.

Table 3 – Coefficients of bivariate and multivariate spatial linear regression[a] (β) and confidence intervals for association between adolescent fertility rate[b] and demographic, socioeconomic and health care indicators, Brazil, 2014

Indicators	Bivariate spatial linear regression β (95%CI)[c]	Multivariate spatial linear regression β (95%CI)[c]
Índice de Gini	5.433 (3.196;7.671)	7.031 (4.793;9.269)
Average family income *per capita* (in minimum wages)	-0.099 (-0.100;-0.098)	-0.104 (-0.105;-0.103)
Proportion (%) of low-income population[d]	0.095 (0.076;0.113)	0.127 (0.108;0.145)
Dweller density per household	1.760 (1.637;1.88)	6.292 (5.062;7.522)
Family Health Strategy coverage (%)	-0.003 (-0.004;-0.003)	-0.011 (-0.017;-0.005)
Proportion (%) of adequate number of prenatal care sessions[e]	-0.054 (-0.064;-0.044)	-0.122 (-0.224;-0.132)
Proportion (%) of 15-19 year-old puerperal women with less than eight years of schooling	0.295 (0.331;0.260)	0.260 (0.224;0.295)

a) Obtained using the empirical Bayesian method.
b) Fertility rate among women 15-19 years old (per 1,000 women) smoothed using the empirical bayesian method – proxy for pregnancy in adolescence.
c) 95%CI: 95% confidence interval.
d) Up to half a minimum wage.
e) Had seven or more prenatal care sessions.

Discussion

This study highlighted a considerably high fertility rate among adolescents (15-19 years old) in Brazil in 2014. Spatial distribution indicated higher rates in the Midwest, Northeast and Northern regions, with the latter region having the highest proportion of clustered municipalities in transition from low to high risk, i.e. municipalities with low rates influenced by neighboring areas with high rates. The Southeast region was found to have the largest number of high/low risk clusters, representing clusters of municipalities with high rates being influenced by neighboring areas with low rates, possibly leading to a fall in rates. Factors such as FHS coverage, proportion of adolescents having an adequate number of prenatal care sessions and low average family income *per capita* showed an inverse relationship with the adolescent fertility rate, demonstrating homogeneity between areas. The adolescent fertility rate was positively associated with municipal indicators, such as the Gini index, dweller density per household, proportion of low-income population and proportion of adolescent mothers with low levels of schooling.

The risk of pregnancy among adolescents found in Brazil was around four times greater than that estimated for European countries in 2010 (16.2/1,000 women aged 15-19 years old), and just over double the risk found in North American countries (28.3/1,000).[21] These facts highlight pronounced and already acknowledged social inequalities between high-, middle- and low-income countries.[22] Worldwide, greatest occurrence of pregnancy is associated with socially vulnerable groups, and within this reality 43.0% of pregnancies are unplanned.[10] In this study, the highest median adolescent fertility rates, along with the greatest proportion of low-income population, highest dweller density per household and lowest level of schooling, were found in the Midwest, North and Northeast regions, which historically have been associated with the poorest development and poverty indices in Brazil.

In Brazil, the trajectories of young people are considerably heterogeneous, depending on the social classes to which they belong, in particular with regard to the association between level of schooling and placement on the job market.[23] In the lower classes of the social pyramid, more frequently schooling is interrupted early and there is greater difficulty in finding work due to association with precarious living conditions. Among girls in settings strongly marked by social inequalities, not finishing school can precede occurrence of pregnancy or birth of a child.[24]

Pronounced differences were found in median adolescent fertility rates and in the proportion of municipalities in transition from low to high risk of this outcome, more so in the country's less developed regions. Brazil is among the countries with the world's highest indices of inequality[25] and, although the overall poverty rates have reduced over recent decades, internal disparities continue to be particularly significant.[26] The North and Northeast regions have the country's poorest socioeconomic indicators, widely made worse by conditions such as their vast territory, different population, economic and social characteristics,[27] as well as difficulties in accessing health services.

The relationship between social determination and maternal health care is well established.[6] This relationship reflects, to a certain extent, the scenario of health care coverage and access to health services. The low proportion of women with an adequate number of prenatal care sessions in the North and Northeast regions revealed here corroborate this evidence.[6] Previous SINASC data (2012) highlighted an insufficient proportion (73%) of women having six or more prenatal care sessions, although in lower percentages for women of lower economic levels, with less schooling and younger.[28]

Inverse association between the outcome investigated and health care indicators is a finding consistent with social, economic and health care reality in Brazil. Evaluation of the quality of prenatal monitoring in primary health care services in Brazil (2012-2013) demonstrated that just 15% of pregnant women received care characterized by adequate quality. It was also found that the poorest prenatal care was associated with younger age groups, lower family income, living in the North and Midwest regions, in smaller municipalities with lower human development indices (HDI).[6] Greater FHS coverage was also a factor associated with quality of antenatal care in municipalities with low HDI, i.e. socioeconomically more vulnerable.[6] Another study revealed that a low

number of prenatal care sessions can be attributed in part to difficulties in making appointments at health services and the peregrination undertaken by pregnant women in order to get access to childbirth facilities.[29]

Unequal distribution of socioeconomic, demographic and health care factors in determining spatial variation of the adolescent fertility rate was evident in its relationship with the Gini index, an indicator of social inequality, in keeping with results of studies covering smaller areas.[3,5,13,30] Positive association between the fertility rate and the proportion of adolescent mothers with low schooling reinforces the role of this indicator as a proxy for precarious socioeconomic conditions. Economic disparity is a barrier to this population moving upwards socially, and occurrence of adolescent pregnancy tends to create a vicious circle in this scenario. Many pregnant adolescents end up giving up school and enter the job market without the necessary qualifications, thus perpetuating their low socioeconomic condition.[10]

Adolescence is considered to be a complex phase of transition, marked by physical, emotional and social changes, which can lead to different manifestations of vulnerability, influencing group relationships and relationships with family and peers, as well as learning about sexuality. Among other aspects, sexuality involves exercising sexual freedom, autonomy in making decisions about one's own body, sexual behavior and its consequences. As such, high occurrence of adolescent pregnancy points to the issue of gender vulnerability and, therefore, ends up being an aggravating factor of the individual and programmatic vulnerabilities of these adolescents.[10]

Addressing adolescent pregnancy, when it is early or unplanned, is a challenge for health services, since it involves diverse individual aspects (behaviors and culture), social aspects (social organization and structuring of public policies) and, above all, it has implications for health.[6,10] Greater FHS coverage and scaling up the Program for Primary Health Care Access and Quality Improvement (PMAQ-AB) can ensure better access to services by the population, improved working conditions and, above all, improved health care quality.[17] Given that PMAQ-AB implementation and inclusion of FHS teams in this initiative depend on the demands of municipal health service management,[17] these managers need to prioritize this policy as a strategy for addressing problems related to maternal health and family planning, particularly among adolescent women.

Recognizing that schools are a learning environment, present in the lives of these adolescents, human reproduction and a sexuality are themes of interest and relevant to be approached in the school environment. In particular, participation of health workers in the development of this process is fundamental, through intersectoral actions between Health and Education. The School Health Program, for instance, can enable the Family Health team to have access to schools in order to develop health promotion actions with students, teachers and staff.

With regard to analysis of the findings of this study, it should be noted that it was conducted using secondary data, subject to underrecording and underreporting. In addition to this limitation, interpretation of the fertility rate as risk of pregnancy can lead to the fertility rate being underestimated, given that especially in adolescence pregnancy often does not result in live births. Moreover, as it is a study of spatial clusters, mean indicators were used and they reflect a mean level of exposure, suggestive of a certain degree of homogeneity in risk distribution. This condition may conceal, albeit partially, specificities that should not be ignored. Another limitation of the study refers to problems relating to SAR modeling,[18] especially because it results in higher values.

This study produced information about adolescent pregnancy that is relevant for Brazil, confirming the influence of socioeconomic, demographic and health care factors on determining this outcome, and reiterates that pregnancy in this phase of life is a phenomenon specific to each territory. It is important to consider Brazil's social inequalities as being a macrostructural factor, to be included as a premise when planning and defining actions strategies aimed at addressing this problem. In this sense, intersectoral action is needed between the areas of Health and Education.

The associations between spatial variation of the adolescent fertility rate and poorer socioeconomic

and health indicators found in this study, highlight a growing Public Health problem in Brazil. However, considering the heterogeneity of the country's municipalities, intervention strategies need to be multifaceted, seeking proposals that are effective for adolescent health and quality of life. Finally, it is important to pay special attention to maintaining/scaling up public policies on health and social protection, in more socially vulnerable regions, with a view to minimizing regional inequalities.

Authors' contributions

Nascimento TLC and Costa MCN contributed to the study concept and design, data analysis and interpretation and drafting the first version of the manuscript. Natividade MS, Teixeira CSS, Menezes GMS and Anjos MS contributed to data analysis and interpretation, drafting and critically reviewing the intellectual contents of the manuscript. All the authors have approved the final version of the article and are responsible for all aspects thereof, including the guarantee of its accuracy and integrity.

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