Racial Residential Segregation and Cervical Cancer Mortality in Health Regions of Brazil

Segregação Residencial Racial e Mortalidade por Câncer do Colo do Útero nas Regiões de Saúde do Brasil

Segregación Residencial Racial y Mortalidad por Cáncer del Cuello Uterino en las Regiones de Salud de Brasil

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ABSTRACT

Introduction: Cervical cancer (CC) is one of the most common cancers in women and has been associated with low levels of development. **Objective:** To investigate the association between standardized CC mortality rate and racial residential segregation. **Method:** An ecological study that had as unit of analysis the 438 Health Regions in Brazil in 2010. The outcome was the mortality rate by CC in women, standardized by age, per 100,000 women. The exposure of interest was the Racial Interaction Index (RII), a measure of residential segregation in the uniformity dimension, estimated from 2010 Census data aggregated by census tracts. The Human Development Index (HDI) was a control covariate. The association between variables was analyzed using a linear regression model. **Results:** The mortality rate due to CC had the highest values in the health regions of the North and Midwest and the lowest in the South and Southeast, a pattern different from the HDI and RII, with lower numbers in the North and Northeast and higher in the South and Southeast. The RII had a negative association with the mortality rate; in the model adjusted by the HDI, each increase of 0.1 in the RII was associated with a decrease of 0.6 deaths per 100,000 women. **Conclusion:** Residential racial segregation is associated with mortality by CC. Residential segregation indicators should be considered for inclusion in future epidemiological studies outcomes as important contextual determinants of the health-disease process.
Key words: social segregation; uterine cervical neoplasms; spatial analysis; health status disparities.

RESUMO

Introdução: O câncer do colo do útero (CCU) é um dos mais frequentes em mulheres e tem sido relacionado a baixos níveis de desenvolvimento. **Objetivo:** Investigar a associação entre a taxa de mortalidade padronizada por CCU e a segregação residencial racial. **Método:** Estudo ecológico que teve como unidade de análise as 438 Regiões de Saúde do Brasil em 2010. O desfecho foi a taxa de mortalidade por CCU em mulheres, padronizada por idade, por 100 mil mulheres. A exposição de interesse foi o Índice de Interação Racial (IIR), uma medida de segregação residencial da dimensão uniformidade, estimada a partir de dados do Censo Demográfico 2010 agregados por setores censitários. O Índice de Desenvolvimento Humano (IDH) foi covariável de controle. A associação entre as variáveis foi analisada por modelo de regressão linear. **Resultados:** A taxa de mortalidade por CCU teve os maiores valores nas Regiões de Saúde do Norte e do Centro-Oeste, e os menores no Sul e no Sudeste, padrão diferente do IDH e do IIR, com valores menores no Norte e no Nordeste e maiores no Sul e no Sudeste. O IIR teve associação negativa com a taxa de mortalidade; no modelo ajustado pelo IDH, cada aumento de 0,1 no IIR esteve associado à diminuição de 0,6 óbitos por 100 mil mulheres. **Conclusão:** A segregação residencial racial está associada à mortalidade por CCU. Os indicadores de segregação residencial deveriam ser considerados para inclusão em futuros estudos epidemiológicos como importantes determinantes contextuais do processo saúde-doença.
Palavras-chave: segregação social; neoplasias do colo do útero; análise espacial; disparidades nos níveis de saúde.

RESUMEN

Introducción: El cáncer de cuello uterino (CCU) es uno de los más frecuentes en las mujeres y se ha relacionado con bajos niveles de desarrollo. **Objetivo:** Investigar la asociación entre la tasa de mortalidad estandarizada de CCU y la segregación racial residencial. **Método:** Estudio ecológico que tuvo como unidad de análisis las 438 Regiones de Salud de Brasil en 2010. El resultado fue la tasa de mortalidad por CCU en mujeres, estandarizada por edad, por 100.000 mujeres. La exposición de interés fue el Índice de Interacción Racial (IIR), una medida de segregación residencial en la dimensión de uniformidad, estimada a partir de los datos del censo de 2010 agregados por secciones censales. El Índice de Desarrollo Humano (IDH) fue una covariable de control. La asociación entre variables se analizó mediante un modelo de regresión lineal. **Resultados:** La tasa de mortalidad por CCU tuvo los valores más altos en las Regiones de Salud del Norte y el Medio Oeste y los más bajos en el Sur y el Sudeste, un patrón diferente al del IDH y el IIR, con valores más bajos en el Norte y el Noreste y más altos en el Sur y el Sudeste. El IIR se asoció negativamente con la tasa de mortalidad; en el modelo ajustado por el IDH, cada aumento de 0,1 en el IIR se asoció con una disminución de 0,6 muertes por cada 100.000 mujeres. **Conclusión:** La segregación racial residencial está asociada con la mortalidad por CCU. Los indicadores de segregación residencial deberían considerarse para su inclusión en futuros estudios epidemiológicos como importantes determinantes contextuales del proceso salud-enfermedad.
Palabras clave: segregación social; neoplasias del cuello uterino; análisis espacial; disparidades en el estado de salud.

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INTRODUCTION

Cervical cancer (CC) is ranked fourth in incidence and mortality by disease in women worldwide[1]. In the last years, the incidence and mortality dropped in Brazil, but important regional inequalities remain at the North and Northeast States with values well higher than in the South and Southeast's[2,3]. It is already known the relation among low Human Development Index and worst epidemiological indicators of the disease[4].

Residential segregation is a social determinant of health increasingly valued in international epidemiological studies but still little investigated in Brazil[5]. Segregation measures show to what extent two or more groups are separated in a space. Among its various dimensions, the exposure represents the level of potential contacts among social groups in the residence and the degree of interaction is one of the most utilized indicators in this dimension[6]. A systematic review about the relation among residential segregation and incidence and mortality by cancer concluded that segregation was associated with cancer indicators in 70% of the studies although articles about CC have not been found[5].

There are no studies in Brazil yet investigating the association among residential segregation and mortality by CC. The objective of this study was to investigate the association between standardized mortality rate by CC and racial residential segregation in Brazil's health regions.

METHOD

Ecological study with 438 Brazilian health regions referenced to 2010; the regions were defined by Regionalization Master Plans of every State, gathering groups of contiguous municipalities with similar socioeconomic characteristics with joint plans and offer of health services[7].

The outcome was the age-standardized rate of mortality by CC per 100 thousand women. The exposure of interest was the Racial Interaction Index (RII), a measure of residential segregation of the domain exposure[6]. The Human Development Index (HDI) was utilized as covariable of exposure. The mortality rate by CC and HDI were obtained from the Evaluation of the Performance of the Health System (PROADESS)[8].

The RII varies from 0 (lower interaction) to 1 (higher interaction) and was estimated by the authors based in the Demographic Census of 2010[9] (Results of the Universe/Aggregate by Census sectors) downloaded from IBGE website, item Statistics, utilizing the scripts created by Sparks[10]. The file "Pessoa03_MG.csv" was utilized to get the number of total residents by race/color (variables v001

to v006) and created the category "Black" race/color as the sum of "Black" and "Brown", to compare with the category "White". The data of 2010 were utilized because this was the most recent Demographic Census of Brazil. The equation below calculates the RII:

$$RII = \frac{\sum_i^n \left| \frac{b_i}{B} \times \frac{a_i}{t_i} \right|}{2}$$

Where:
RII = Racial Interaction Index;
a_i = population of group A (white) in subarea i;
b_i = population of group B (black) in subarea i;
B = population of group B in the larger area ;
t_i = total population in subarea i;
subarea = census sectors;
larger area = Health Region.

The statistical distribution of the variables was presented in tables (measures of central tendency and dispersion) and thematic maps (in quintiles).

The association among the variables was evaluated by linear regression models and the multiple model with HDI, RII and a variable representing the great region (to adjust by non-measured characteristics). The residues of the multiple model were evaluated by normal distribution, homoscedasticity, and absence of spatial correlation. When spatial correlation exists, the Lagrange multiplying test was applied, which indicates Spatial Autoregressive (SAR) as the best spatial model, including a spatial lag of the outcome as a covariable of the model or Spatial Error Model (SEM), encompassing a spatial dependence in the error. The queen spatial weight matrix was utilized where all the contiguous regions are neighbors. The multiple models were compared by the Akaike –Akaike Information Criterion (AIC), which indicates the best adjustment when the value is lower. The software R version 3.6.1[11] was utilized for all the analyzes.

The review and approval by the Institutional Review Board was waived because only secondary public data were utilized according to Ordinance 510/2016[12] of the National Health Council.

RESULTS

North and Midwest health regions presented the highest rates and the lowest at the South and Southeast regions, different from HDI and RII, with lower values at North and Northeast and higher at South and Southeast (Table 1; Figure 1).

Table 1. Statistic distribution of the variables per great Brazilian regions, 2010

Variable/Region	Mean	SD	Min.	Q1	Q2	Q3	Max.
Rate							
Brazil	4.85	3.30	0.00	2.60	4.40	6.10	22.30
North	7.65	4.67	0.00	4.20	7.40	10.60	22.30
Northeast	5.57	3.29	0.00	3.50	5.20	7.00	15.00
Southeast	3.48	2.19	0.00	2.10	3.30	4.60	13.60
South	4.06	1.97	0.00	2.45	4.15	5.20	9.90
Midwest	5.98	3.90	0.00	3.75	5.70	8.20	18.80
HDI							
Brazil	0.66	0.07	0.48	0.60	0.66	0.71	0.82
North	0.60	0.04	0.48	0.58	0.61	0.64	0.69
Northeast	0.59	0.03	0.53	0.57	0.59	0.61	0.70
Southeast	0.70	0.05	0.56	0.68	0.71	0.74	0.81
South	0.71	0.03	0.65	0.70	0.71	0.73	0.77
Midwest	0.69	0.03	0.64	0.68	0.69	0.70	0.82
RII							
Brazil	0.42	0.20	0.11	0.25	0.38	0.60	0.87
North	0.23	0.07	0.11	0.18	0.22	0.25	0.41
Northeast	0.27	0.08	0.12	0.22	0.27	0.33	0.49
Southeast	0.49	0.16	0.18	0.36	0.51	0.62	0.75
South	0.72	0.09	0.50	0.64	0.73	0.79	0.87
Midwest	0.37	0.08	0.16	0.32	0.38	0.42	0.50

Captions: SD = standard deviation; Min. = minimal; Q1 = first quartile (percentile 25); Q2 = second quartile (median); Q3 = third quartile (percentile 75); Max. = maximal; Rate = mortality rate standardized per cervical cancer (per 100 thousand women); HDI = Human Development Index; RII = Racial Interaction Index.
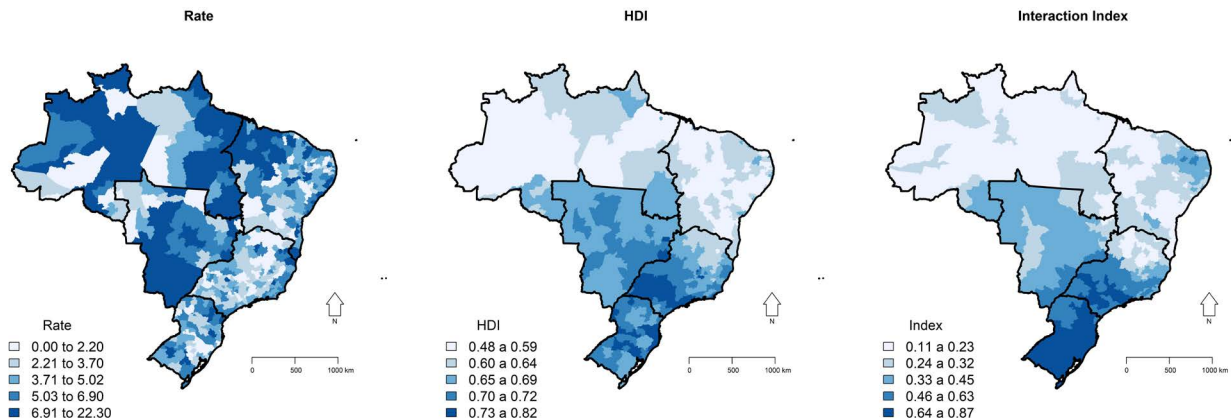
Figure 1. Spatial distribution of the variables standardized mortality rate per CC, HDI and RII at Brazilian Health Regions, 2010

HDI and RII according to simple linear regression models were negatively associated with rate of mortality by CC and significant difference between the mean of the rate of the Southeast region (reference) and the means of the North, Northeast and Midwest regions with higher rates. After adjusted to HDI and RII, the South region had higher mean mortality rate than the Southeast's (Table 2).

The multiple model had significant spatial correlation of the residues and for this, it was adjusted with the SEM spatial model which includes a structure of spatial dependence on error according to Lagrange's multiplier test. RII kept negative association and similar magnitude of the simple model, but the HDI lost the association; the means of the rates of the North, Northeast and Midwest

Table 2. Results of the models of linear regression for the association between the rate of mortality by CC and the variables regions of Brazil, HDI and RII

Variable	Simple Coef. (value of p)	Multiple Coef. (value of p)	Spatial multiple Coef. (value of p)
Region			
Southeast	Reference	Reference	Reference
North	**4.175 (<0.001)**	**3.321 (<0.001)**	**3.552 (<0.001)**
Northeast	**2.091 (<0.001)**	**1.595 (0.003)**	**1.497 (0.037)**
South	0.585 (0.185)	**1.900 (0.001)**	**1.807 (0.019)**
Midwest	**2.503 (<0.001)**	**1.892 (0.001)**	**2.127 (0.006)**
HDI	**-13.876 (<0.001)**	7.412 (0.112)	6.302 (0.214)
RII	**-5.668 (<0.001)**	**-6.053 (<0.001)**	**-5.839 (0.003)**
AIC multiple models		2.207,8	2.163,6

Caption: Coef. = Coefficient of the variable in the model; HDI = Human Development Index; RII = Racial Interaction Index; AIC = Akaike Information Criterion (as low, better is the model).

regions continued higher than the Southeast's. Each 0.1 rise of RII was associated with less 0.6 deaths per 100 thousand women (Table 2).

DISCUSSION

The present study showed that residential racial segregation is associated with mortality by CC even after adjustment by HDI at Brazil's health regions with highest rates at the regions with less racial interaction.

No articles investigating the relation among indexes of residential segregation and mortality by CC were encountered. For another types of cancer, residential economic and racial segregation was listed as one of the impact factors on survivorship of epithelial ovary cancer[13]. The relation between segregation and lung cancer was associated with higher mortality for Blacks living in more segregated regions, even after adjusted to tobacco burden and socioeconomic variables[14,15]. The staging of this cancer at the diagnosis and the likelihood of surgical treatment have also been influenced by segregation[16]. Living in a racially segregated neighborhood was significantly associated with high mortality[17,18]. Either White or Black women living in more segregated regions had less odds of being treated correctly[14]. The quality-of-life after cancer was significantly worse in survivors living in racially segregated areas, regardless of race or socioeconomic indicators[19].

The association of highest levels of HDI and lower mortality rates by CC has already been proven in Brazil[4]. Nevertheless, the health disparities are often kept even after the control for socioeconomic variables that can be explained in part by residential racial segregation[5].

The measurement of residential segregation can be one of the tools to help to understand the regional disparities of mortality by CC. The socioeconomic and demographic indicators typically utilized are important tools to analyze the process health-disease and the study of valid measures of residential segregation can reveal new aspects and inconspicuous complexities, which makes possible the identification of regions with high regional disparity in health and favor the choice of public policies targeted to minimize the inequities.

The main limitation of this study is the cross-sectional design which is not the most suitable for causal inferences in epidemiology. On the other hand, the benefits are the scope with information of the entire Brazilian population to calculate the indicators analyzed and a methodology easily reproducible by other investigators who wish to investigate the relation between residential segregation and health outcomes.

CONCLUSION

Racial residential segregation is associated with mortality by CC and its indicators should be included in future epidemiological studies as important contextual determinants of the health-disease process.

CONTRIBUTIONS

All the authors contributed substantially to the study design, acquisition, analysis and interpretation of the data, wording and critical review. They approved the final version to be published.

DECLARATION OF CONFLICT OF INTERESTS

There is no conflict of interests to declare.

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