

# Oral Cancer: Socio-Spatial Analysis of a Brazilian Sample

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*Câncer Bucal: Análise Socioespacial de uma Amostra Brasileira*

*Cáncer Oral: Análisis Socioespacial de una Muestra Brasileña*

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## ABSTRACT

**Introduction:** Socio-spatial measures are largely used in health research, but it is still unusual in oral cancer investigation. **Objective:** This study aims to describe the sociodemographic and clinical features of oral cancer and analyze the spatial distribution of the disease in relation to the neighborhood socioeconomic status including availability of health care centers. **Method:** Sociodemographic, clinical and histopathologic data were collected from patients treated from 2005 to 2015. Descriptive data analyses of all variables were performed. The spatial analysis was carried out through the program R. Geographic distribution of patients' home addresses was analyzed using Ripley's K function and Kernel maps. The socio-spatial vulnerability was defined by household income and home adequacy. **Results:** Of the 127 patients included, the majority were males (76.4%), Caucasian or Brown (82.7%), married (35.4%), with low educational level (71.6%) and mean age of 59.5 years. Cases were distributed in clusters characterized by lower median income and inadequate sanitary conditions. Primary health care centers were homogeneously distributed throughout the city. **Conclusion:** These oral cancer cases are concentrated in regions under relatively low socioeconomic conditions, and despite the homogeneous distribution of primary health care centers, it is not enough to promote access for patients and oral cancer remains being diagnosed late.

**Key words:** Mouth Neoplasms; Oropharyngeal Neoplasms; Epidemiology; Spatial Analysis; Socioeconomic Factors.

## Resumo

**Introdução:** Medidas socioespaciais são amplamente utilizadas na pesquisa em saúde, mas ainda pouco exploradas em relação ao câncer de boca. **Objetivo:** Descrever as características sociodemográficas e clínicas do câncer de boca e analisar a distribuição espacial da doença em relação ao status socioeconômico do bairro, incluindo a disponibilidade de centros de saúde. **Método:** Foram coletados dados sociodemográficos, clínicos e histopatológicos dos pacientes atendidos no período de 2005 a 2015. Foram realizadas análises descritivas dos dados de todas as variáveis. A análise espacial foi realizada por meio do programa R. A distribuição geográfica dos endereços residenciais dos pacientes foi analisada usando a função K de Ripley e mapas de Kernel. A vulnerabilidade socioespacial foi definida pela renda familiar e adequação do domicílio. **Resultados:** Dos 127 pacientes incluídos, a maioria era do sexo masculino (76,4%), branca ou parda (82,7%), casada (35,4%), com baixa escolaridade (71,6%) e idade média de 59,5 anos. Os casos foram distribuídos em grupos caracterizados por menor renda mediana e condições sanitárias inadequadas. **Conclusão:** Os casos de câncer oral estão concentrados em regiões de baixa condição econômica. Embora os centros de atenção primária à saúde tenham sido homogeneamente distribuídos por toda a cidade, isso não é suficiente para promover o acesso dos pacientes e o câncer de boca continua sendo diagnosticado tardiamente.

**Palavras-chave:** Neoplasias Bucais; Neoplasias Orofaringeas; Epidemiologia; Análise Espacial; Fatores Socioeconômicos.

## Resumen

**Introducción:** Las medidas socioespaciales son ampliamente utilizadas en las investigaciones relacionadas con la salud, sin embargo, existen pocos estudios en relación con el cáncer oral. **Objetivo:** Describir las características sociodemográficas y clínicas del cáncer oral y analizar la distribución espacial de la enfermedad en relación con el estado socioeconómico del vecindario, la disponibilidad de centros de salud. **Método:** Se recogieron datos sociodemográficos, clínicos e histopatológicos de pacientes tratados entre 2005 y 2015. Se realizaron análisis descriptivos de los datos para todas las variables. El análisis espacial se realizó utilizando el programa R. La distribución geográfica de las direcciones de los hogares de los pacientes se analizó utilizando la función K de Ripley y los mapas de Kernel. La vulnerabilidad socioespacial se definió por el ingreso familiar y la adecuación del hogar. **Resultados:** De los 127 pacientes incluidos, la mayoría eran hombres (76.4%), blancos o morenos (82.7%), casados (35.4%), con baja educación (71.6%) y edad promedio 59,5 años. Los casos se distribuyeron en grupos caracterizados por ingresos medios más bajos y condiciones sanitarias inadecuadas. Los centros de atención primaria de salud se distribuyeron de manera homogénea en toda la ciudad. **Conclusión:** Estos casos de cáncer están concentrados en regiones con condiciones socioeconómicas relativamente más bajas. A pesar de la distribución de la atención primaria, esta no es suficiente para promover el acceso de los pacientes a ella y su diagnóstico continúa siendo tardío.

**Palabras clave:** Neoplasias de la Boca; Neoplasias Orofaringeas; Epidemiología; Análisis Espacial; Factores Socioeconómicos.

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Part of this study was presented in the 31st. Brazilian Congress of Pathology (Belo Horizonte, 2017) and in the 44th. Brazilian Congress of Pathology and Oral Stomatology (Rio de Janeiro, 2018).



## INTRODUCTION

Cancer is one of the leading causes of death in the world; and, in Brazil, oral cancer is a high-incidence malignancy. The Brazilian National Institute of Cancer (INCA, acronym in Portuguese) estimates 15,190 new cases in 2020<sup>1</sup>. This type of cancer has a varied global distribution, and independent of place, more than 90% of the cases are diagnosed as squamous cell carcinoma (SCC)<sup>2</sup>. SCC etiology is due to a combination of numerous risk factors that include personal habits, occupation and genetic factors<sup>3</sup>.

Individuals diagnosed with oral cancer are influenced by environmental, social, economic, geographic and demographic factors. Socioeconomic inequities are also determinant in the development of oral cancer<sup>4-6</sup> since individuals residing in underserved neighborhoods are more exposed to risk factors and allegedly have less access to health services<sup>7</sup>.

Geographical information systems (GIS) and spatial analysis can be useful tools for understanding the distribution and factors related to diseases and also, for the implementation of health policies, however, the incorporation of these techniques varies among fields<sup>8</sup>. There are few studies using geospatial methods to analyze these trends in oral cancer and the majority were conducted in developed countries<sup>9-12</sup>. In Latin America, and specifically in Brazil, there are scarce studies investigating the association of geographic and socioeconomic aspects with oral cancer.

Therefore, the objectives of this study were to describe the sociodemographic and clinical features of oral cancer and analyze the spatial distribution of the disease in relation to the neighborhood socioeconomic status (household income and sanitary conditions) and the distribution of public primary health care providers. These patients resided in Belo Horizonte, Brazil and were referred to the Department of Head and Neck Surgery in a public hospital of this city from 2005 to 2015.

## METHOD

### STUDY AREA

The study was conducted in the capital of the state of Minas Gerais, Belo Horizonte, located in the southeast of Brazil, with an extension of 331,401 km<sup>2</sup> of territorial area. This city is divided into nine administrative units or regions, has 487 neighborhoods and 2,523,794 inhabitants<sup>13</sup>.

### DATA COLLECTION

This study was approved by the Institutional Review Board (protocol 1,682,525). A cross-sectional study was

conducted in the Head and Neck Surgery Department (HNSD) of the Alpha Institute of Gastroenterology at the Hospital of Clinics of the Federal University of Minas Gerais (HC-UFMG), one of the eight public and private reference centers for head and neck cancer treatment in Belo Horizonte.

Medical records from the HNSD were identified for the period from January 2005 to December 2015. Data were reviewed and analyzed by a single trained researcher. The study only included records of patients with primary, histologically confirmed, and previously untreated oral cavity cancer (OCC) or oropharyngeal cancer (OPC). The data collected included sociodemographic, clinical, and histopathologic characteristics, and the variables studied were age, gender (female/male), skin color as declared by the patient (Caucasian/brown/black), years of education (no education/up to 8 years/from 9 to 11 years/more than 11 years), marital status (married/unmarried), self-reported home address, smoking status and alcohol use (yes/no), histopathologic diagnostic, the primary tumor location (categories C00-C10; International Classification of Diseases ICD-10). The data were transferred to a standardized spreadsheet in a secure format.

Records were excluded when diagnosis confirmation, type of treatment, and home address were missing.

Descriptive data analyses of all variables with the calculation of proportions, measures of central tendency, and variability were performed. A binary logistic regression model was constructed, and the values for unadjusted and adjusted odds ratios (OR) (CI 95%) were estimated. The latter was calculated using the Enter method, and only variables with a *p*-value of less than 0.05 were maintained in the final logistic regression model. The Hosmer and Lemeshow test was employed to evaluate the goodness of fit. All analyses were developed in an SPSS version 19.0 program (SPSS Inc., Chicago, IL, USA).

### ORGANIZATION OF SPATIAL DATABASES

The cases were registered on maps by georeferencing. The home address of the patients was the reference and it was converted into points of latitude and longitude, using an Internet-based mapping engine that relies on commercial mapping data sources<sup>14</sup>. The information in the Brazilian Demographic Census 2010<sup>13</sup> was used to obtain the sociodemographic characterization and variables. The cartographic bases and tables with the variables of interest of the census sectors of the city were grouped per neighborhoods for the comparisons. The addresses of the public primary health care providers were obtained from the official website of the local government and they were converted into points of latitude and longitude in the same way as the patient's

addresses. The system of projections and coordinates UTM was used, and the Datum 69 of South America for the 23S time zone.

#### ANALYSIS OF THE RANDOMNESS AND THE DENSITY OF POINTS

The spatial analysis was carried out through the program R<sup>15</sup>, using the *rgdal*<sup>16</sup>, *plyr*<sup>17</sup>, *rgeos*<sup>18</sup> and *maptools*<sup>19</sup>.

Ripley's K function was used for the analyses of level of aggregation and determined whether cases were randomly distributed or tend to be more concentrated in certain regions<sup>20</sup>. Monte Carlo simulations were performed to construct the confidence intervals, with a confidence level of 99%. The area of influence of 5,000 meters was adopted. The hypothesis of complete randomness in the spatial distribution of points is accepted if the curve is inside the envelope. If it is above the upper limit of the envelope, there are indications that the cases are in aggregate manner.

The Kernel density estimation was performed to produce a map of intensity, providing better observation of the spatial distribution pattern of the cases in Belo Horizonte. The Kernel function is a spatial interpolation method; it determines the intensity of occurrences of an event in a region. This function studies the regions where the process occurs and those where there was no real occurrence, in order to establish the spatial density and to identify surfaces with higher aggregation<sup>21</sup>. The Gaussian Kernel function with sigma parameter defined as 0.013 was used, and the Kernel map resolution is 128x128 pixels.

#### VARIABLES

Oral Cancer patients are influenced by socioeconomic, environmental and geographic factors<sup>4</sup>, and for this reason, socio-spatial vulnerability conditions not obtained from medical records were explored. The variables used were defined by the Brazilian Demographic Census<sup>13</sup>: low socioeconomic conditions (number of heads of household with no monthly income or a minimum monthly salary of US\$290 per number of heads in households) and residential adequacy characteristics (referring to households with no water supply, or sewage collecting system or garbage pickup, or more than 2 residents per bedroom).

To analyze the relationship between cancer and geographic access to the health services, the public primary health care providers of each regional were also included in the analysis, independent of the type of health care, since patients with oral cancer can look for either physicians or dentists for attention<sup>22</sup>.

## RESULTS

In total, 300 medical records were evaluated and 127 cases of OPC and OCC were included in this study. Patients that did not reside in Belo Horizonte (n=153), and cases without diagnosis of SCC or confirmation (n=20) were excluded. Males were greatly prevalent (76.4%), and the average age was 59.5 years old (range: 25–91 years old). Most of the patients were Caucasian or brown (105/127, 82.7%) and married (45/127, 35.4%). Low educational level was frequent among the subjects, as 71.6% of the patients had only up to eight years of formal education. Tobacco smoking and alcohol use were identified in 89.0% and 80.3% of the patients, respectively.

OCC accounted for 53.5% of the cases, and the remaining 46.5% were OPC. Lesions on three or more anatomic sites were found in 50 (39.4%) patients. The majority of the subjects presented in the late stage of the disease, 64.5% were diagnosed with stage III or IV, and only 8.7% of the patients were classified in stage I. More than half of the patients (55.1%) received surgical treatment.

When OPC and OCC were compared, none of the variables in the adjusted model presented a statistically significant difference (Table 1).

In the absence of difference, spatial analysis did not consider OPC and OCC separately. Northwest, Northeast and Venda Nova were the administrative areas of the city with higher prevalence of patients (Figure 1).

Ripley's K function showed that there was an aggregate spatial pattern throughout the city. However, cluster formation occurs in only a few places. Clusters can be observed on Kernel maps, where they appear in denser colors in gray (Figure 2).

Income distribution was heterogeneous. Most of the cases of patients with oral cancer were located in areas with a higher number of residents with no monthly income or minimum monthly salary (72.4% poor, less than 5 minimum monthly salary; 15% medium-class, 5 to 8.5, minimum wage and 12.4% high-income neighborhoods, 8.6 minimum wage - deep gray areas, Figure 3). The distribution in relation to residential adequacy characteristics is similar to the household income. Oral cancer cases were concentrated in neighborhoods with a higher number of households with underserved sanitary conditions.

Finally, a homogeneous distribution of public primary health care providers and cancer cases are observed in Figure 4. The red asterisks represent the primary health care clinics and the black asterisks are the cases of OCC and OPC. These health care centers are evenly distributed

**Table 1.** Factors associated with oropharyngeal cancer, HC-UFMG, 2005-2015

Variables <sup>a</sup>	Oral cavity cancer	Oropharyngeal cancer	Unadjusted odds ratio		Adjusted odds ratio*	
	N= (%)	N= (%)	(95% CI)	(p-value)	(95% CI)	(p-value)
<b>Gender</b>						
Female	21 (70.0)	9 (30.0)	1			
Male	47 (48.5)	50 (51.5)	2.482 (1.033-5.964)	0.042	1.466 (0.557-3.860)	0.438
<b>Age</b>						
≥ 55 years	46 (54.1)	36 (45.9)	1			
< 55 years	22 (48.9)	23 (51.1)	1.336 (0.644-2.770)	0.436		
<b>Skin color</b>						
Caucasian	32 (59.3)	22 (40.7)	1			
Brown	26 (50.9)	25 (49.1)	1.399 (0.646-3.027)	0.394		
Black	8 (47.0)	9 (53.0)	1.636 (0.547-4.987)	0.379		
<b>Years of education</b>						
No education	10 (71.4)	4 (28.6)	1			
Up to 8 years	40 (51.9)	37 (48.1)	2.312 (0.667-8.013)	0.186		
From 9 to 11 years	12 (46.2)	14 (53.8)	2.917 (0.725-11.739)	0.132		
More than 11 years	4 (66.7)	2 (33.3)	1.250 (0.667-8.013)	0.832		
<b>Marital status</b>						
Married	27 (60.0)	18 (40.0)	1			
Unmarried	38 (50.0)	38 (50.0)	1.500 (0.711-3.166)	0.287		
<b>Tobacco use</b>						
No	13 (92.8)	1 (7.2)	1			
Yes	55 (48.7)	58 (51.3)	13.709 (1.735-108.331)	0.013	8.009 (0.909-70.594)	0.061
<b>Alcohol use</b>						
No	19 (76.0)	6 (24.0)	1			
Yes	49 (48.0)	53 (52.0)	3.425 (1.264-9.279)	0.015	1.921 (0.640-5.764)	0.244

**Captions:** <sup>a</sup>Data for some variables are missing; \*Hosmer-Lemeshow test  $p=0.780$ .

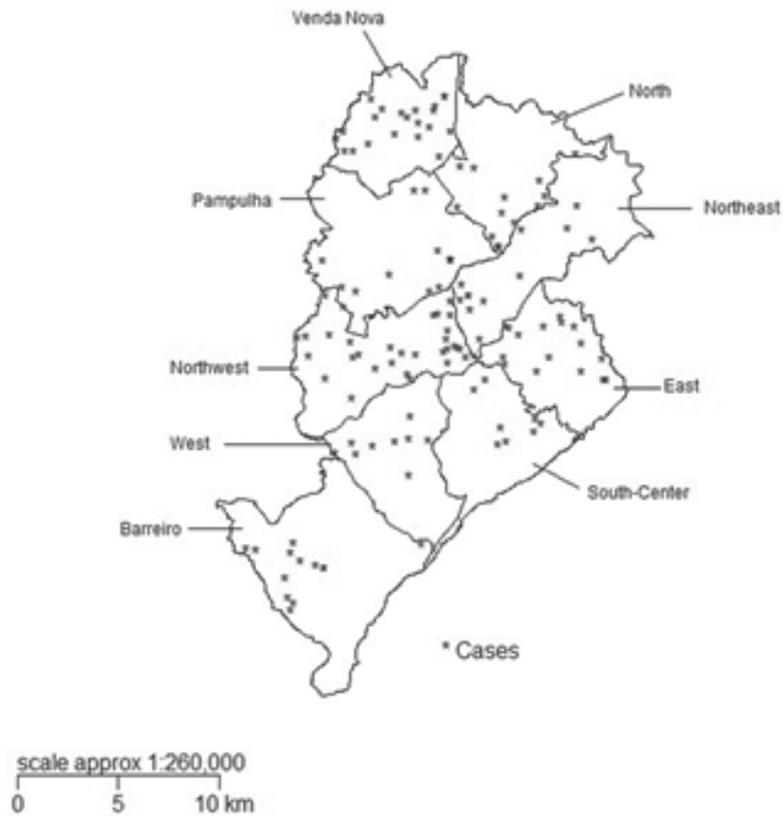
throughout the city offering options of services to the patients.

## DISCUSSION

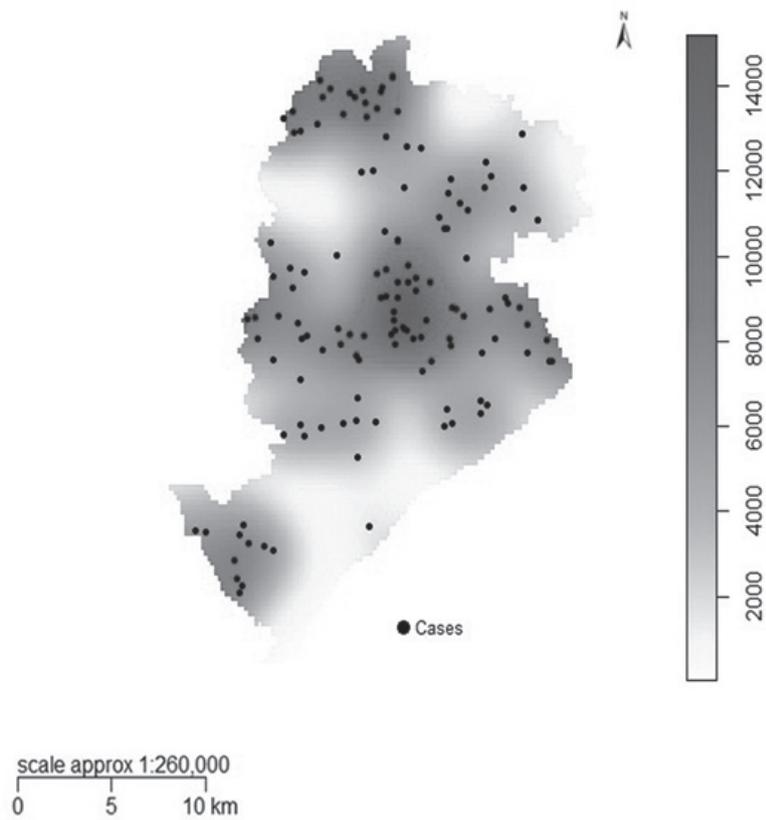
According to the present study, the profiles of patients with oral cancer were represented by a diagnostic of oral squamous cell carcinoma in Caucasian male patients, older than 59 years old, with low educational level, and intense use of tobacco and alcohol, with similar distribution

between OCC and OPC just like other Brazilian studies have described<sup>23,24</sup>.

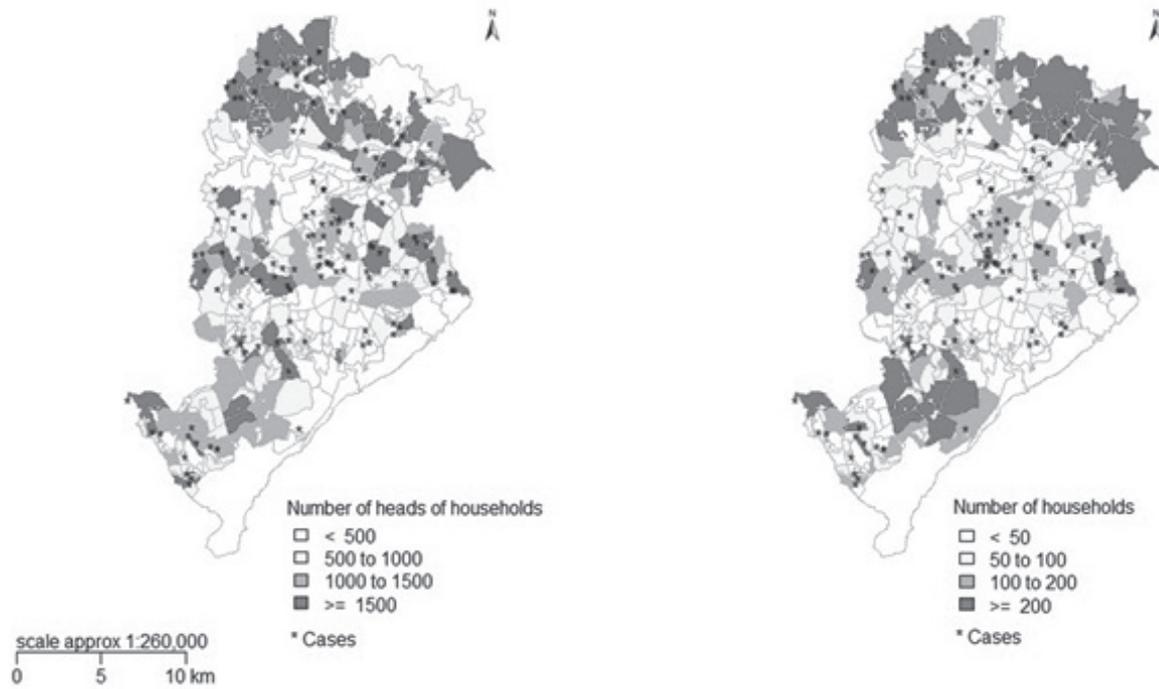
The results provide a visual representation of patients with oral cancer in Belo Horizonte, showing a cluster pattern of distribution in the city. Also, after analyzing the distribution of socioeconomic variables – low income and home adequacy – it was possible to observe that the majority of the cases occurred in poor neighborhoods, although these cannot be pointed out as the unique determining factors for the occurrence of the cases. Regions with highest prevalence



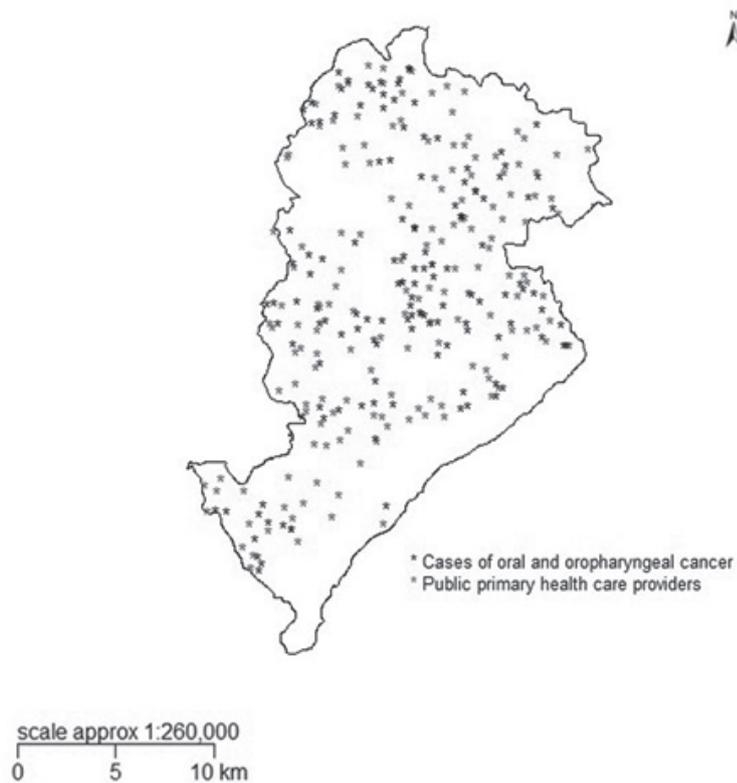
**Figure 1.** Distribution of cases of oral and oropharyngeal cancer. Belo Horizonte, Brazil, January 2005 to December 2015



**Figure 2.** Kernel density estimation of cases of oral and oropharyngeal cancer according to the location of the residence. Belo Horizonte, Brazil, January 2005 to December 2015



**Figure 3.** Concentration of oral and oropharyngeal cancer weighted for socioeconomic conditions and the infrastructure of the residences. Belo Horizonte, Brazil, January 2005 to December 2015



**Figure 4.** Distribution of public primary health care providers and oral and oropharyngeal cancer cases. Belo Horizonte, Brazil

were also the administrative units with the lowest average per capita income<sup>25</sup>.

Therefore, these results suggest the presence of inequalities in individuals with oral cancer treated at HC-UFMG. In this scenario, economic factors may possibly be the cause in the randomly distribution of cancer cases in the city, with areas showing higher concentrations than others. As seen in this study, an investigation of socioeconomic inequities in patients with this type of cancer from 1975 to 2012 developed in Scotland, demonstrated that economically disadvantage areas of the country showed higher rates of incidence<sup>26</sup>.

These results strengthen the idea that individual economic position and geographical area of residence are important factors that influence the observed disparities in the prevalence of head and neck cancer, like the oral cancer<sup>9,27</sup>. As well as individual socioeconomic status, contextual effects of deprived areas help to increase the susceptibility of an individual to develop the disease<sup>10</sup>. For example, a systematic review demonstrated that health risk behaviors for oral cancer, as smoking, are more prevalent in adults who live in poor-resources neighborhoods<sup>28</sup>. Moreover, the present investigation reinforces the utility and importance of using geographic information system to elucidate the influence of these variables.

The results of this study showed homogeneity in the distribution of public primary health care providers in Belo Horizonte and therefore the areas with the highest number of cases had the same numbers of care centers as those with few cases. This result differs from a survey conducted in the city of Atlanta, Georgia, United States. It showed that in general, patients with head and neck cancer live in low socioeconomic neighborhoods with few available health services providers<sup>9</sup>.

This homogeneous distribution can be explained by the design of the basic health network in Belo Horizonte, the allocation of health care services is performed in accordance with the health vulnerability index (HVI)<sup>29</sup> and criteria such as population access to services and geographical barriers. The HVI shows the inequities of different social groups and identifies areas with an unfavorable socioeconomic condition to prioritize the allocation of resources<sup>30</sup>.

Despite the availability of public primary care centers in the regions of residence of the patients, the diagnosis remains late. This situation can be explained by the fact that geographical access is not the only factor that influences access to health services. Factors such as availability, acceptability, and quality of services are associated<sup>31,32</sup>. For example, an impediment to the use of public basic health services is the overlapping of appointments of clinical services and patients' working shift.

On the other hand, the simple existence of the service does not mean an effective diagnosis, for example, in this study the majority of the patients were diagnosed at stage III and IV. The lack of recognition of risk factors and initial symptoms by patients and professionals, the absence of effective preventive campaigns, and the professional's inability to detect potentially malignant lesions and cancer make difficult the early diagnosis<sup>33,34</sup>.

It is important to emphasize that the interpretation of the results of this study is complex since the socioeconomic data are aggregated, and there may be important differences between the individuals of the same neighborhood that couldn't be perceived, so the findings should be interpreted with caution<sup>35</sup>.

Studies using medical records have the advantage of providing information at a low cost; however, collected data are dependent of how complete the information is. Furthermore, this study represents the situation and the profile of patients that seek medical attention in a public hospital in Belo Horizonte, a city with eight other public and private reference hospitals. In despite of these limitations the results described in this paper are compatible with the literature. Nevertheless, conclusions should be drawn carefully.

Continuity of this study involving oral cancer patients treated in other public and private hospitals of Belo Horizonte, with the evaluation of individual economic situation associated with the socioeconomic characteristics of the neighborhoods is important for a better understanding of the socio-geographical circumstances that interfere in the disparities of patients with OCC and OPC<sup>35</sup>.

Also, the information from geospatial analysis could be useful for policymakers in the implementation of place-specific control and preventive policies focused in high risk populations<sup>36</sup>.

## CONCLUSION

The spatial distribution of oral cancer patients treated in the HC-UFMG is not random; cases are concentrated in regions with low socioeconomic conditions compared to others in the city. Although the patients have geographic accessibility to basic health services, cancer continues to be diagnosed late.

## CONTRIBUTIONS

Maria Cássia Ferreira de Aguiar, Letícia Cavalari Pinheiro, and Andrea López Soto participated in the conception and design of the study. Alexandre de Andrade Souza, Carlos José de Paula Silva, Patrícia Carlos Caldeira

and Mauro Henrique Nogueira Guimarães de Abreu also participated of the study planning. Maria Cássia Ferreira de Aguiar, Patrícia Carlos Caldeira, Letícia Cavaliari Pinheiro and Andrea López Soto drafted the article. All the authors assisted in the acquisition, analysis and interpretation of data, revised the article and approved the final version of the article to be published.

### CONFLICTS OF INTERESTS

The authors declare there is no conflict of interests of any kind.

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