



## Mortality for oral Cancer in Minas Gerais, Brazil, from 1996 to 2012

Mortalidade por Câncer de boca em Minas Gerais, Brazil, de 1996 a 2012

La mortalidad en Cáncer de boca en Minas Gerais, Brasil, 1996 a 2012

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### ABSTRACT

**Keywords:** Mortality;  
Neoplasms; Trends

**Aim:** To investigate the spatial-temporal distribution of mortality from oral cancer in Minas Gerais between 1996 and 2012. **Methods:** The analysis of the growth trend rates of the series was made by Moving Average. **Results:** In the period there were 8.675 deaths from mouth cancer and these were identified in all the regions of the state. Being, 6,974 (80,4%) men and 1,701 (19,6%) women. Regarding the crude rate, we observed a tendency of growing of mortality from this cancer type. This phenomenon was also observed when executed the weighting by sex, especially for males and over 60 years old. Was rejected the null hypothesis of stationary of mortality series for oral cancer in Minas Gerais during the period. **Conclusion:** Moving Average weighted by age and gender allowed to observe an increase in the mortality rate in all age groups and for both sexes especially men and older than 60 years.

### RESUMO

**Descritores:**  
Mortalidade; Neoplasias;  
Tendências

**Objetivo:** Investigar a distribuição espaço-temporal da taxa de mortalidade por câncer de boca do estado de Minas Gerais entre 1996 e 2012. **Métodos:** A Média Móvel foi utilizada para analisar a tendência de crescimento da taxa. **Resultados:** No período estudado ocorreram 8.675 óbitos por câncer de boca e estes foram identificados em todas as microrregiões do estado. Sendo, 6.974 (80,4%) homens e 1.701 (19,6%) mulheres. Houve tendência de crescimento da taxa bruta de mortalidade por este tipo de câncer. Este fenômeno também foi observado quando executado a ponderação por sexo, principalmente para o sexo masculino e indivíduos acima dos 60 anos. Foi rejeitada hipótese de nulidade de estacionariedade da mortalidade por câncer de boca em Minas Gerais no período estudado com elevação da taxa de 2,22 em 1996 para 3,87 em 2012. **Conclusão:** Observou-se o crescimento da taxa nas faixas etárias estudadas, em homens e acima de 60 anos.

### RESUMEN

**Descriptores:**  
Mortalidad; Neoplasias;  
Tendencias

**Objetivo:** Investigar la distribución espacial y temporal de la mortalidad por cáncer oral en el estado de Minas Gerais entre 1996 y 2012. **Métodos:** El promedio móvil se utilizó para analizar la tendencia de la tasa de crecimiento. **Resultados:** En el período hubo 8.675 muertes por cáncer de boca y éstos fueron identificados en todas las regiones del estado. Y, 6.974 (80,6%) eran hombres y 1.701 (19,6%) mujeres. Con respecto a la tasa bruta, se observa una tendencia creciente en la mortalidad por este tipo de cáncer y cuando se ejecuta la ponderación por sexo, especialmente para los varones y más de 60. Rechazó la hipótesis nula de estacionariedad de la mortalidad por cáncer oral en Minas Gerais durante el período. **Conclusión:** Promedio ponderado por edad y sexo Mobile ha observado tasa de crecimiento en los grupos de edad y en los hombres y por encima de 60 años.

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## INTRODUCTION

In Brazil and in the world, epidemiological studies indicate that the cancer of the mouth and pharynx as one of the main causes of death from cancer, especially in males<sup>(1-3)</sup>.

Regional differences in the distribution of mortality have been attributed to consumption of cigarettes smoking and alcohol consumption, socioeconomic conditions, type of diet or directly related to genetic characteristics of the population<sup>(3-5)</sup>. In Brazil, study showed that there is a regional variations of the incidence rate of cancer have also been shown, with being the South and Southeast regions presenting that showed the highest rates<sup>(5)</sup>.

In 2013, it was estimated that the incidence rate of all neoplasms in the state of Minas Gerais, for all neoplasms, the incidence was of 284 new cases per 100,000 men and 232 new cases per 100,000 women. The crude mortality rates were 90.5 deaths per 100,000 men and 72.6 deaths per 100,000 women. For oral cancer, which is common in both sexes, the incidence rates were higher in men than in women<sup>(6)</sup>.

The time-space analysis and the mapping of mortality from oral cancer makes it possible to know the variation in mortality rates and identify who they are, how many there are, and how the deaths are distributed. In addition it also to allowing the planning of actions that provide the development of necessary measures to cope with and to control of the mortality of the population studied. In the present study, the null hypothesis is that there is a trend toward the stationary of the average rates and a standard space-temporal distribution of oral cancer mortality rates in Minas Gerais, Brazil, between 1996 and 2012.

The aim of this study is to identify a non-random standard of the mortality rate for oral and oropharynx cancer according to the geographical location of deaths and identify any a cluster formation in the distribution of deaths in Minas Gerais, Brazil, between 1996 and 2012.

## METHODOLOGY

The State of Minas Gerais is located in the Southeast region of Brazil, comprises of. Account with 853 municipalities, 66 microregions and a total population of 19,597,330 people (10% of the population of the country). Minas Gerais has a Medium Human Development Index (IDHM) of 0.731 and Gini Index of 0.46. The urbanization is 85.3% of state and the economically active population is 9.94 million people. The state has tropical climate, with average annual temperatures exceeding 18 °C<sup>(7-8)</sup>.

This is an ecological study with secondary data. For analysis of oral cancer mortality in Minas Gerais state were used data provided by Mortality Information System (SIM)<sup>(9)</sup>. The data collection was standardized by the selection of deaths by place of residence. To see the consistency of information we opted to collect data from access to data by two sites: Secretaria de Estado de Saúde de Minas Gerais (SES/MG) containing updated data up to 2013 and Tabnet/DataSUS in which data are available until December 2012<sup>(10-11)</sup>. This procedure was carried out at different times

to ensure that there was no double inclusions or any exclusion of records and ensures the quality of the data as the two databases systems are fed constantly and continuously. Subsequently, the data extracted from the system was tabulated in computational program Excel ®. For this study, the data of the year 2013 and 2014 were excluded because they are subject to changes in the SIM. Due to the use of it is public data the study was not submitted to the research ethics committee.

The selection of anatomical regions of origin of the tumors was based on Chapter 2 (neoplasms) of International Classification of Diseases (ICD-10)<sup>(12)</sup>. For this study were selected categories: C00 to C14<sup>(12)</sup>. The validity and reliability use of data extracted from the SIM have been shown conducted in previous studies<sup>(13-14)</sup>.

From the absolute frequency of oral cancer deaths in the period of 1996 to 2012 the crude mortality rates were calculated and weighted by age and sex<sup>(15-16)</sup>. The rates weighted by age were standardized by the direct method and in two age groups: up to 59 years old and over 60 years old<sup>(17)</sup>. This study was based on epidemiological studies that investigated the space- time patterns of this oral cancer mortality type of death in Sao Paulo and between the Brazilian regions for the analysis of the evolution of oral mortality from this type of cancer<sup>(3,5-6,15)</sup>.

A time series is a set of observations on a variable (mortality rate) at a regular interval (year) in a specified period<sup>(16)</sup>. For this study, the time series of seventeen years of crude mortality rates and microregions were partitioned in cycles of 4 years: 1996-1999, 2000-2003, 2005-2008 and 2009-2012<sup>(16-17)</sup>. The year 2004 was considered a middle point of the series<sup>(16-17)</sup>. This procedure is to verify that the rates are increasing, static, or regressing in relation to a reference point of the series. Usually the middle point is the value of the rate of the central year (in this case 2004) or calculates the average of the whole period (1996 to 2012)<sup>(16-17)</sup>. Admits that the data set of rates has a behavior of discrete type to styling the phenomenon, describe the behavior of the series and to make estimates<sup>(16)</sup>.

To investigate the existence of trend (growth, stationary or decrease) in a series of rates an analysis was carried out using Moving Average method (MA)<sup>(16-17)</sup>. The MA is calculated by averaging the values closest to the years of a series<sup>(16)</sup>. In this study the MA was centered on 4 terms (years). In this procedure the smoothed coefficient of each cycle corresponds to the arithmetic mean of the rates of years of each cycle<sup>(16)</sup>. The MA allows the smoothing of the rate and filtering the noise that can interfere with the amplitude of the data series, oscillation of rates over the years and reading trends successfully<sup>(16)</sup>.

For the analysis of the trend in this series, in the crude mortality rates series were standardized by sex and age in two groups: up to 59 years old and over 60 years old. This option modeling facilitate the elaboration, interpretation and statistical power<sup>(16-17)</sup>. Simple linear regression was used to confirm or reject the null hypothesis or stationary of the series<sup>(16-17)</sup>. The oral cancer mortality rate was considered as a dependent variable (y) the mortality rate for oral cancer having as basis the Brazilian population census of 2010 and the independent variable (x) the average rates in cycles of

4 years<sup>(17)</sup>. To avoid auto-correlation between the terms of the regression equation, fireworks were used to centralize the variable year transforming it into calendar year less the middle point (2004)<sup>(16)</sup>. Was admitted statistically linear trend significant equal to or less than 0.05 ( $p < 5 \%$ )<sup>(16-17)</sup>.

### Spatial Analysis

Because of aggregated data, we constructed a matrix of proximity (neighborhood) to estimate the variability and explore the data. The strategy of construction was by contiguity, where an object is near only those who share border and without weight<sup>(18)</sup>.

In order to describe the geographic pattern of the occurrence of oral cancer were constructed thematic maps of the four groups formed and by microregion<sup>(18)</sup>. The Spatial Dependence (SD) is a characteristic related to the representation of data through subdivisions territoriais<sup>(18)</sup>. It represents a variable associated with an area resembles more to its neighbors than the rest of the locations of the sample set<sup>(18-19)</sup>. The SD is important to investigate, statistically, the existence of spatial patterns between places and values<sup>(18-19)</sup>. The method of spatial analysis used was the Spatial Moving Average (SMA). Is a technique to evaluate the variations and trends, the rates in relation to the area, through the estimation of the amount of the fee by a weighted average of the rates of neighboring areas<sup>(18-19)</sup>. The average value of the attribute in the region of study makes it possible to lower the impact of random fluctuation of data<sup>(18-19)</sup>. The SMA was calculated by cycles, in the case presented, cycles of 4 and 5 years, following the same pattern for the crude rates. This procedure also makes it possible to check the existence of clusters of deaths and increasing growth trend of deaths during the period studied<sup>(16-17)</sup>. The subtitles of the maps were standardized in four extracts for ease of viewing and understanding the results. For the construction of the maps were used a digital cartographic base released by the

Brazilian Institute for Geography and Statistics (IBGE) and the computer program of geoprocessing TerraView® version 4.2.2<sup>(20-21)</sup>.

## RESULTS

During the period studied there were 8.686 deaths from oral and cancer in Minas Gerais. Eleven subjects were excluded from the analysis due to lack of information on the geographical location. Therefore, the total number of cases considered in this study was of for this study were considered 8.675, of these 6.974 (80,4%) males and 1.701(19,6%) females.

The relation to the crude mortality rate revealed a tendency of increase in mortality for oral cancer. This phenomenon was also observed when the deaths were weighted by sex, especially for males. For females there was a fluctuation of the rate until the year 2005. From 2006, there was a progressive increase in the mortality rate. The Prevalence Ratio (PR) average for the rate indicates that, during the study period, the rate of male deaths was 4.28 higher than the female rate. (Table 1).

The greatest variations between cycles occurred for male and over 60 years, respectively. The MA weighted by age and sex showed an increase in the allowed mortality observe the rate growing of the age groups studied and for both sexes. The values of the middle point of the series came from the mean values of the rates. Regarding the weighting by sex, men had higher rates and float when compared with the female and the crude rates. The cycle of 2009-2012 (end series) weighted rates by age indicated an increased trend. (Table 2).

The MA has allowed the rate smoothing, especially in microregions with larger swings. The tendency of increase in mortality rates is illustrated in Graphic 1 by the behavior of MA and linear trend lines. The MA smoothed the average rate in four cycles. A succession of irregular peaks and depressions was observed between the microregions

**Table 1** - Oral cancer mortality, Minas Gerais, Brazil, 1996-2012.

Year	Deaths	Rate*	Male (R)	Female (R)	PR**	Mean	SD	Variance
1996	367	2.22	282(3.41)	84(1.00)	3.41	0.43	2.47	6.13
1997	333	1.97	261(3.11)	73(0.85)	3.65	0.39	2.32	5.42
1998	367	2.14	299(3.53)	68(0.78)	4.52	0.43	2.75	7.58
1999	356	2.05	296(3.45)	60(0.68)	5.07	0.41	2.74	7.55
2000	356	2.03	286(3.23)	70(0.77)	4.19	0.41	2.42	5.86
2001	407	2.24	328(3.65)	79(0.86)	4.24	0.47	2.93	8.6
2002	424	2.31	328(3.61)	96(1.03)	3.50	0.49	2.92	8.52
2003	445	2.40	381(4.15)	64(0.68)	6.10	0.52	2.73	7.47
2004	487	2.56	389(4.20)	98(1.03)	4.07	0.57	2.93	8.6
2005	561	2.91	467(4.90)	94(0.96)	5.10	0.65	3.02	9.17
2006	520	2.67	418(4.33)	102(1.03)	4.20	0.6	3.16	10.04
2007	606	3.14	489(5.01)	117(1.17)	4.28	0.71	3.9	15.22
2008	603	3.03	480(4.89)	123(1.22)	4.00	0.7	3.3	10.89
2009	661	3.30	532(5.37)	129(1.27)	4.22	0.77	3.43	11.79
2010	690	3.52	549(5.70)	141(1.41)	4.04	0.8	3.96	15.69
2011	723	3.66	582(6.00)	141(1.40)	4.28	0.84	4.33	18.77
2012	769	3.87	607(6.21)	162(1.60)	3.88	0.9	4.65	21.64
<b>Total</b>	8.675	-	6.974	1.701	-	10.09	-	178.94

(Rate\*): Rate per 100 thousand

(PR\*\*): Prevalence Ratio: male deaths rate divided by female deaths rate

Supply: Data SUS

**Table 2 - Oral cancer mortality standardized trends for age and sex, Minas Gerais, Brazil, 1996-2012.**

Death rate	Moving Average							Trend
	1996-1999	2000-2003	2005-2008	2009-2012	MP*	M*	V*	
≥ 59 years old	1.03	1.18	1.57	1.98	1.39	1.4	0.95	increase
≤ 60 years old	13.53	12.75	15.46	15.81	14.7	14	2.28	increase
Crude	2.09	2.24	2.93	3.58	2.56	2.7	1.49	increase
Male	3.37	3.66	4.78	5.82	4.2	4.4	2.45	increase
Female	0.82	0.83	1.09	1.42	1.03	1	0.6	increase

MP\*= Midpoint for the year 2004  
 M\* = Average for 1996 to 2012  
 V\* = range (cycle 4 value minus the value of cycle 1)

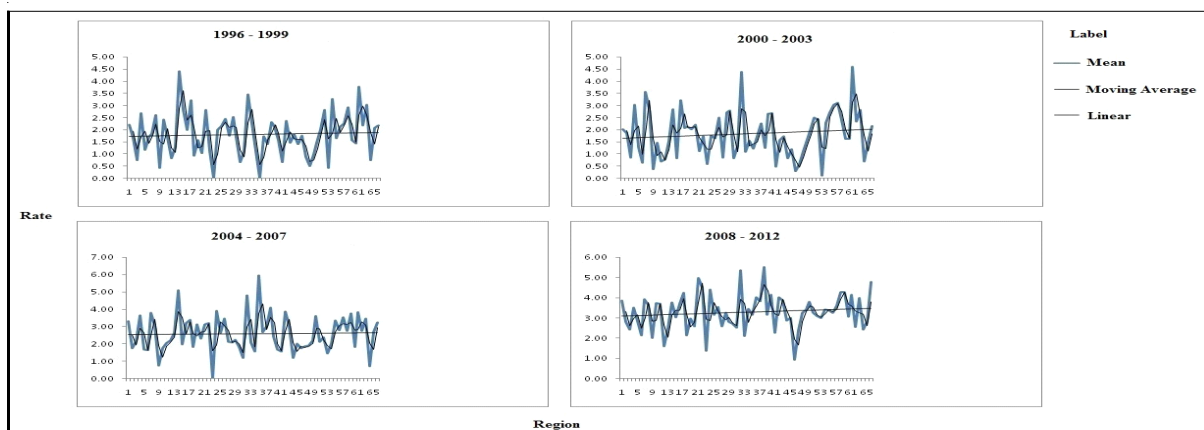
in four cycles and the same microregion between the four cycles. Also was observed an increase in rates according to the time. For the cycle four, no microregion presented rate equal or close to zero. So between 2008 and 2012, all the microregions notified cases of death from the types of cancer studied. (Graph 1).

It can be said that there were deaths from oral cancer in all microregions of the state and that the geographical distribution of these deaths occurred in a heterogeneous manner. The images produced by SMA were in mosaic form. In the analysis of SMA a trend toward an increase in mortality rates was observed with the evolution of years.

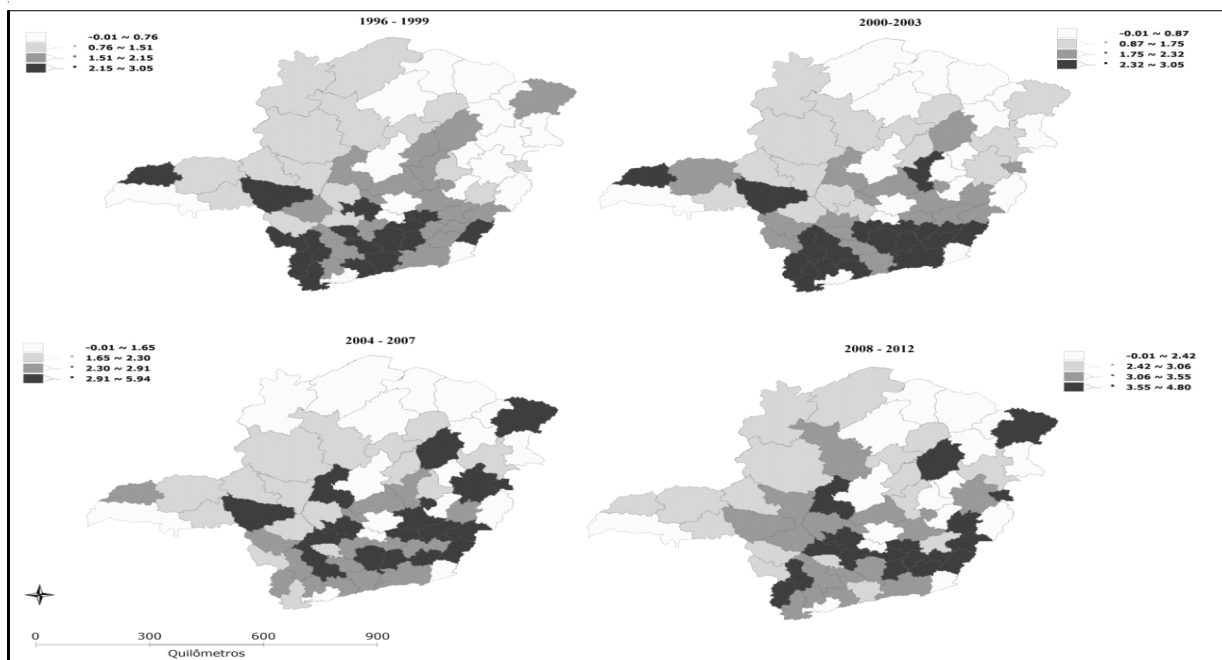
Being that the SMA periods of 2004 to 2012 showed higher increase than the period from 1996 to 2003. (Figure 1).

In the period from 1996 to 2003 a cluster formation with higher local mean was observed in South and East microregions. In the period of 2004 to 2012 a cluster formation in the Eastern region was observed with a tendency for the Central microregions. (Figure 1).

The simple linear regression analysis rejected the null hypothesis of stationary series of mortality from oral cancer in Minas Gerais in the period studied. The p-values were statistically significant and the Coefficient of Correlation increases as the temporal series evolves. (Table 3).



**Graphic 1 - Mortality rate trend measures comparison for oral cancer, Minas Gerais, Brazil, 1996- 2012.**



**Figure 1 - Space Moving Average by mortality rate for oral cancer, Minas Gerais, Brazil, 1996-2012.**



**Table 3** - Mortality trends analysis by crude rate cycles, Minas Gerais, Brazil, 1996-2012.

Cycle	R <sup>2</sup> *	CC**	F	p-value
1996-1999	0.9817	0.99	161.7	0.0043
2000-2003	0.9913	0.9971	341.7	0.0020
2005-2008	0.9931	0.9977	430.2	0.0016
2009-2012	0.9998	0.999	18521	0.0002

R2\*adjusted

CC \*\*Correlation Coefficient

## DISCUSSION

The study period was selected to a continuous series of data in a revision of the ICD and the standardization of rates<sup>(17)</sup>. Throughout the period there were more male deaths. However, looking at the Prevalence Ratio (PR) of 2012 there was a decrease from 1998 to 2011. This may mean a relative increase of female deaths in relation to male deaths by oral cancer in Minas Gerais. (Table 1). The mortality fluctuations from specific diseases can be artificial due to the greater sensitivity of new diagnostic methods, discontinuity of statistical series from revisions to the ICD, changes the population age structure and increased demand for health services by women<sup>(17)</sup>. This phenomenon was also reported for other types of cancer in Rio Grande Sul state<sup>(17)</sup>. In the period studied both the crude rate and the age weighted mortality rates increased in Minas Gerais. Previous studies showed a stationary tendency of this type of death in other regions of Brazil<sup>(15,22-24)</sup>. The differences found may be explained by methodological differences between the studies or by random fluctuation of the data (white noise)<sup>(16)</sup>. In this study a historical series of seventeen years was used which may have influenced the determination of stationary or none of the series and say the increasing rates growth trend<sup>(16-17)</sup>. The problem of detecting if there is a progressive increase in the rate of mortality is to evaluate stationarity of temporal series<sup>(16)</sup>. This type of problem is particularly complex in mortality series due to the rates showed significant rate fluctuations over time and between the microregions<sup>(16)</sup>.

The breakdown of the period of study in cycles made it possible to identify the variations in the behavior of mortality rates from oral cancer in Minas Gerais. One way to reduce the impact of random fluctuation of the rate was through the Moving Average. This procedure was showed in Graphic and maps. It may be indicated in future studies for mortality from oral cancer.

The age-adjusted mortality rate adjusted for age allows you to removes the effects of the changes in age composition of the population, especially in more advanced age groups<sup>(17)</sup>. In studies on the mortality rates for oral cancer, the frequency, crude rate or weighted were the measures most used<sup>(2,15,22-24)</sup>. However, there is a great variation in the type of weighting made according to age group used. These different classifications of age make the difficult the comparison between studies and undertakes the analysis of mortality by this type of weighting<sup>(2,22-23)</sup>. Previous studies have found higher prevalence rates for this type of death in men aged over 50 years old<sup>(2-3,15,22-24)</sup>. The present study obtained similar

results, however, the weighting was done with the cut-off point at the age of 60 years old<sup>(24)</sup>. This fact may occur depending on the slow progression of the disease, late diagnosis and less demand for dental services by men<sup>(2,24-25)</sup>. The fact that of higher prevalence rates are found in older individuals does not discard the need for studies in younger age groups<sup>(2,26)</sup>.

The SIM allows an analysis by category and, therefore, identify the anatomic site of origin of the lesion and has validity and reliability for oral cancer mortality studies<sup>(13-14,16)</sup>. However, Boing *et al* found a higher prevalence in nonspecific parties, which suggests a limitation of SIM for related oral cancer mortality studies because it hampers anatomy knowledge and the possible etiology of the lesion<sup>(23)</sup>. Previous study of a low socioeconomic macroregion of the Minas Gerais state showed difficulties in the management of SIM in small municipalities and underreporting<sup>(27)</sup>. Other studies have identified higher prevalences for tongue<sup>(15,22,24)</sup>. This can be the explanatory hypothesis for the microregions located in the poorest region of the state have the lowest average rates for the period studied between 1996 and 2003. (Figure 1). A study for the evaluation of information systems in the 2000s shows improvements in SIM on the basis of adequacy proposals by Brazilian Ministry of Health that have increased the coverage of these information systems<sup>(28)</sup>. This improvement of the SIM improves could explain an increase in the number of reported deaths and, consequently, an increase in the rates in microregions of Northern and microregions with a large number of small municipalities. However, in microregions potentially better structured, as in the case of Belo Horizonte, there was an increase in rates. Despite the limitations of SIM in relation to the quality information, to allow the sub-recording, this fact does not invalidate the use of the database for time series studies<sup>(17)</sup>. However, secondary data analyzes should be careful as the researcher had little or no control of data collection.

The SIM data cover long periods of time and have geographic national scope, state, and municipal and allowing the performance of studies about the oral cancer mortality profile<sup>(17)</sup>. The fact that they have adopted the residence place as methodological criterion made it possible to identify which macroregion of health the individual belongs to and enables the planning of actions for the early detection of this type of cancer and, consequently, to increase survival rates and reduce the frequency of deaths even not reducing the incidence<sup>(17)</sup>.

Góis Santos *et al* identified a higher frequency of deaths from oral cancer in neighborhoods with low or very low socioeconomic status in Aracaju/SE (Brazil)<sup>(29)</sup>. Another

Brazilian capital study correlated socioeconomic indicators with the mortality rates for oral cancer<sup>(3)</sup>. The socially disadvantaged groups are exposed to a greater number of risk factors, have worse nutritional conditions, oral health and less access to dental assistance, therefore, less potential for early diagnosis of cancerous lesions<sup>(2-3)</sup>. Tobacco and alcohol are recognized worldwide as the most important risk factors associated with the development of squamous cell carcinoma of the oral cavity and pharynx<sup>(2,30)</sup>. In the other study it was observed a protective factor from the consumption of dairy products and significant reduction toward trend a reduction in the risk of oral cancer linked to the consumption of vegetables and fruit<sup>(31)</sup>. The association with contextual and individual variables was not analysed in this study, but it is possible to identify a change in the behavior of the phenomenon when comparing of regions with better socioeconomic conditions to regions with the worse social indicators.

The phenomena of migration from poorer regions to others with better living conditions, labor supply and specialized service may explain a higher occurrence of deaths in regions with better socioeconomic indicators<sup>(2,4,32)</sup>. The change in the behavior of mortality rates for oral cancer can be explained by population migration between the microregions of the state in search of better opportunities for employment and income (Figure 1). For Boyle the migratory phenomena affect especially the morbidity-mortality studies because it can occur under or over-reporting records of deaths by region can occur<sup>(32)</sup>. This is a hypothesis accepted by this study and that deserves investigation in further studies.

## CONCLUSION

The use of SIM data and spatial analysis allowed space-

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