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EXTENDED ABSTRACT

# Thyroid Cancer Incidence in North Region of Portugal: A Spatial Analysis using Moran's Index

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## Introduction:

Cancer incidence has been increasing worldwide and is one of the most important causes of morbidity and mortality [1]. In 2020, approximately 19 million new cases of cancer and almost 10 million deaths due to cancer were estimated [2]. Consistently, there is a growing trend in cancer incidence in the North Region of Portugal, highly supported by the rising number of cases of thyroid cancer, particularly among women [3]. Regional differences were found in the incidence of thyroid cancer, which is higher in the North of Portugal compared to other regions [3,4]. The regional and sex differences reported in Portugal seem to line up with what is happening in other countries [5].

Monitoring the trends and patterns in cancer incidence is relevant at regional and national levels for cancer prevention and control [2,3,6,7]. In this context, spatial data analysis is especially useful when the geographic location can play an important role in the development of the phenomenon under study [8]. The study of spatial patterns of thyroid cancer incidence has been carried out in different countries, allowing the identification of regional differences [9,10,11]. Disease mapping is a popular tool in cancer's spatial epidemiology. Spatial distribution patterns have been studied using distinct methods (e.g. Moran's I, Bayesian models) [7].

Our main goal is to map thyroid cancer incidence and investigate the existence of spatial distribution patterns in the North Region of Portugal.

## Methods:

We analyzed thyroid cancer cases, diagnosed between 2001 e 2015, in the North Region of Portugal. Thyroid cancer was classified according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (C73). The study area comprised the following five districts: Braga, Bragança, Porto, Viana do Castelo, and Vila Real. The municipality was considered the geographical unit of analysis. The number of cancer cases was retrieved from the North Region Cancer Registry (RORENO), by sex, age (5-year age-groups), municipality, and year of diagnosis. Population estimates were acquired from Statistics Portugal (INE).

Age-standardized incidence rates (ASIR), for each municipality were calculated by the direct method using the European standard population, adjusted by age-group and sex. The administrative boundary of the municipalities was obtained from the Portuguese Public Administration's open data portal.

R software version 4.0.2 was used for geospatial analyses and map visualization [12]. The ASIR of thyroid cancer mapping was performed at a municipality level, for men and women. We computed a spatial neighborhood matrix of the municipalities, using the queen criterion of contiguity. Spatial distribution patterns were studied using Moran's I method, which estimates spatial autocorrelation based on data by area and the location of the study units.

## Results:

Between 2001 and 2015, there were 9,726 cases of thyroid cancer in the North Region, 82% of them in women. The median age was 50 (IQR = 22). The ASIR at a municipality level was presented in choropleth maps, for women, for men, and for both sexes (Figures 1-3). The ASIR varies across municipalities, with the highest rate of 55.63/100000 in women (Vila do Conde), and of 15.74/100000 in men (Póvoa do Varzim).

**Keywords:**
Disease mapping, Moran's I, North Region, Spatial Analysis, Thyroid Cancer Incidence

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**Conflict of interest:**
The authors declare no conflict of interests.

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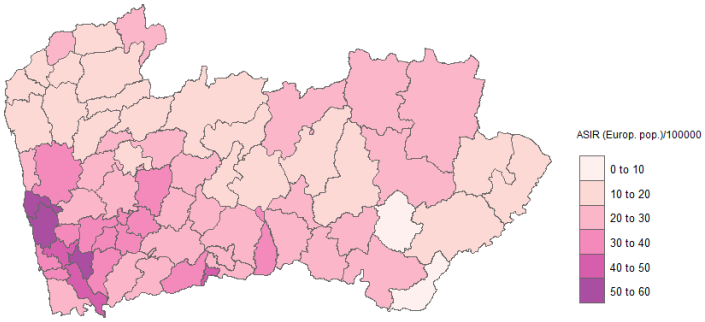


**Figure 1 -** North Region of Portugal map, representing women's Age-standardized incidence rates (ASIR), for each municipality, calculated by the direct method using European standard population, adjusted by age group and sex, per 100000.

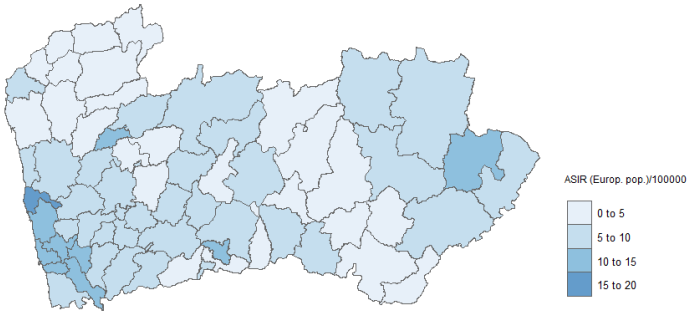


**Figure 2 -** North Region of Portugal map, representing men's Age-standardized incidence rates (ASIR), for each municipality, calculated by the direct method using European standard population, adjusted by age group and sex, per 100000.

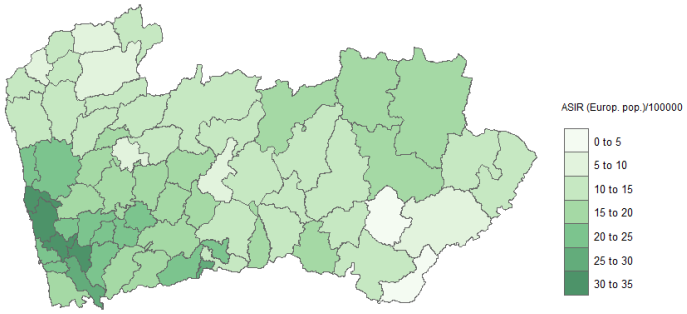


**Figure 3 -** North Region of Portugal map, representing Age-standardized incidence rates (ASIR), for each municipality, calculated by the direct method using European standard population, adjusted by age group and sex, per 100000.

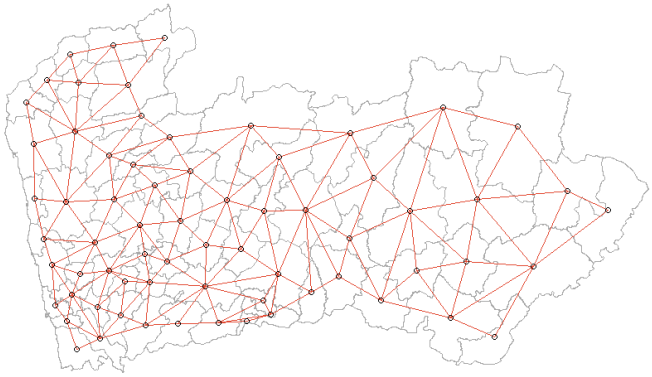

**Figure 4 -** North Region of Portugal map, representing the spatial neighborhood matrix based on the queen criterion of contiguity.

The spatial neighborhood matrix based on the queen criterion of contiguity can be visualized in Figure 4. A spatial distribution pattern was found for ASIR of cancer thyroid in the North Region. For ASIR in both sexes, we estimated a Moran's I of 0.59 ($p < 0.001$), for ASIR in women a Moran's I of 0.56 ($p < 0.001$), and in men 0.41 ($p < 0.001$).

## Discussion:

Portugal presents higher estimates of ASIR than Europe and world average, mainly because of the high incidence rates in the North Region [4]. In this region, the incidence of thyroid cancer is much higher in women, in line with European and world tendencies. We found patterns in incidence rates. Moran's I method revealed a significant spatial association of data. There were two spots of high incidence in the North Region, one of them at the central coast and the other located at the northeast area. In future studies, we aim to compare these findings with other methods used in spatial epidemiology, such as the Bayesian approach [7]. Regional differences found are line up with what is happening in other countries [5].

The identification of regional differences may be relevant for future investigation, cancer prevention, and control.

### Ethics committee and informed consent:

The study was approved by the Ethics Committee of the Portuguese Institute of Oncology of Porto (Ref. CES IPO: 69/022).

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