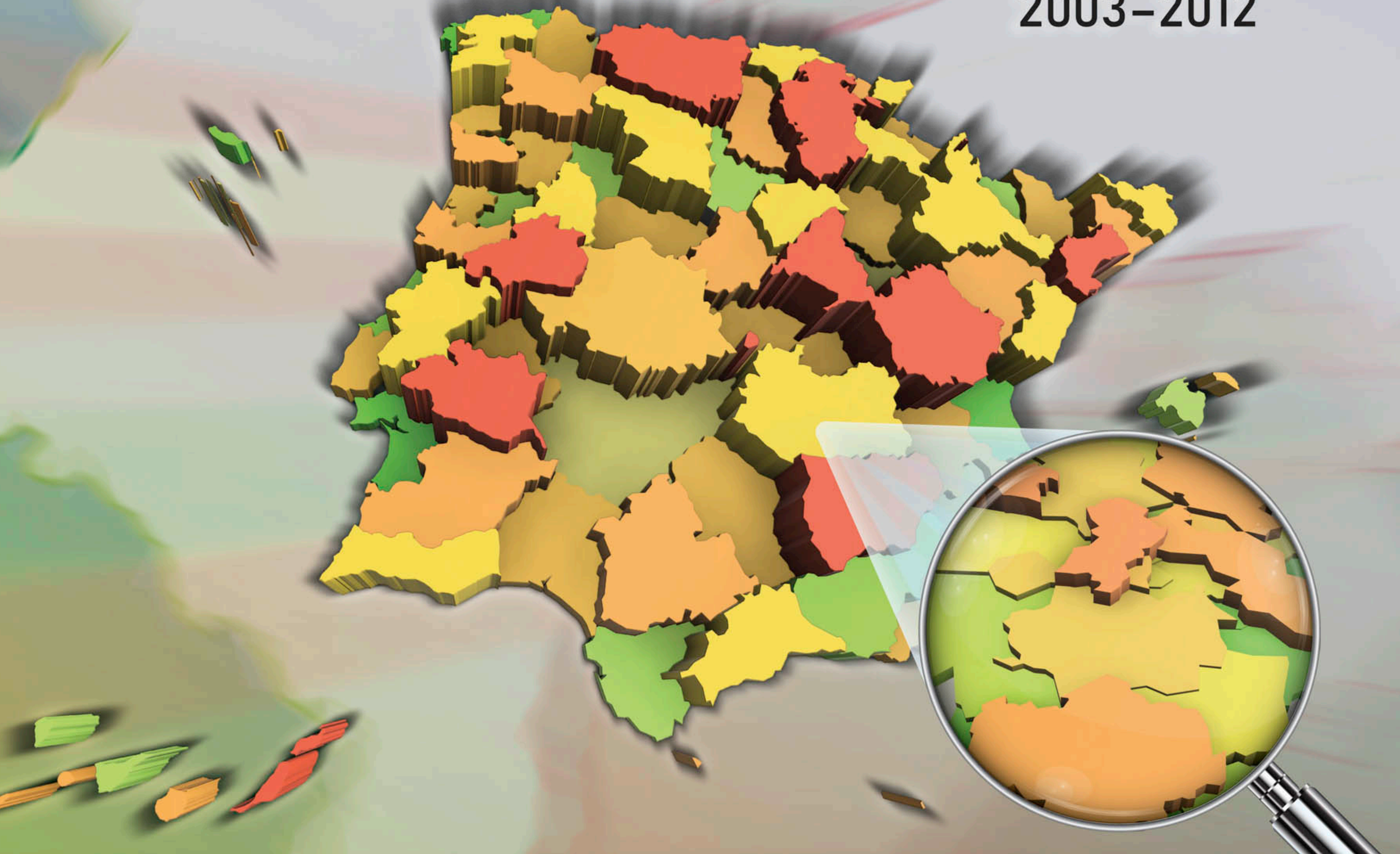
Atlas of Cancer Mortality in Portugal and Spain
2003–2012



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Atlas of Cancer Mortality in Portugal and Spain 2003–2012

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December 2021

Project “Atlas of Cancer Mortality in Portugal and Spain (2003–2012)”

Proyecto “Atlas de mortalidad municipal por cáncer en Portugal y España (2003–2012), AMOCAPE”
Projeto “Atlas municipal de mortalidade por cancro em Portugal e Espanha (2003–2012), AMOCAPE”

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FOREWORD, NATIONAL INSTITUTE OF HEALTH CARLOS III

Cancer is a major public health concern in Europe; it represents a tremendous burden not only for patients and families, but for the whole society. And scientific research is the only way forward. Promoting research offers a unique opportunity to understand the biology of cancer, optimize diagnosis and treatment, and support all patients' quality-of-life. Moreover, scientific research provides crucial information regarding risk factors and environmental exposure that allows many types of cancer to be prevented.

This scientific project, which represents the combined endeavor of research teams from Portugal and Spain, is focused on the geographical distribution of different cancer types across these two countries and will provide useful information for both understanding and preventing cancer.

Dr. Raquel Yotti
General Secretary for Research of Spain

National Institute of Health Carlos III (*Instituto de Salud Carlos III, ISCIII*) is focused in improving the health of citizens through science. As cancer is a major concern for people, families and society, our organization is commited to promote research and innovation on this topic. In this regard, at the European level, fighting cancer has been recognized as a critical challenge that needs to be approached through well-designed multidisciplinary collaborative actions. This project represents a joint effort between two National Institutes of Health that will add high-level value to build broader collaborative initiatives in Europe in futures years.

Working together, we will ensure that more people will live after being diagnosed with a cancer, that more patients are going to be diagnosed earlier, and that they will have a better quality of-life after treatment. We are deeply commited to making advances to cope with this major public challenge.

Dr. Cristóbal Belda
Director of National Institute of Health Carlos III, Spain

Cancer is one of the main causes of morbidity and mortality worldwide and its monitoring is essential for both control and prevention. Mortality is a key indicator to monitor and assess the burden of cancer, and studying the spatial distribution of cancer-associated mortality is a fundamental part of cancer surveillance. Geographical patterns help generate new hypotheses about both cancer aetiology and its clinical management. Previous atlases of cancer mortality using large geographical units have confirmed that cancer risk does not respect regional or national frontiers. This emphasizes the value of exploring patterns linked to environmental and lifestyle factors shared by communities – irrespective of national boundaries – ideally using small geographical units that would help to identify these underlying factors. The Spanish National Centre for Epidemiology, has published several cancer mortality atlases and has developed an interactive web server that analyses this information at the provincial and municipal level. All this experience is the basis of the international project "Atlas of cancer mortality in Portugal and Spain" (*"Atlas de MOrtalidad por CÁncer en Portugal y España"* – AMOCAPE), a collaboration between two research groups from two national public institutions of great prestige. To our knowledge, this is the first international atlas using municipalities as the basic unit of analysis, probably due to the difficulties involved in processing information at these levels of spatial aggregation. However, spatial patterns that extend over different countries can help to generate or reinforce etiological hypotheses that are linked to environmental exposures – and these are difficult to assess in classical epidemiological studies. This atlas is an important collaboration that will undoubtably generate many new scientific questions. There is no doubt that this approach can be useful in other contexts and I am sure that the present work will foster new research projects and international collaborations.

Prof. Marina Pollán
Director of National Centre for Epidemiology
Scientific Director CIBERESP
National Institute of Health Carlos III, Madrid, Spain

FOREWORD, NATIONAL INSTITUTE OF HEALTH DOUTOR RICARDO JORGE

The National Institute of Health Doutor Ricardo Jorge (INSA) is the Portuguese Reference Laboratory and Health Observatory. Its mission is to contribute to public health gains. It does this through research and technological development activities, health observation and epidemiological surveillance, reference laboratory activity, as well as coordinating the external evaluation of laboratory quality, dissemination of scientific culture, and capacity building and training.

This Atlas of Cancer Mortality in Portugal and Spain 2003–2012 is a good example of virtually combining scientific research activities and observation of health status activities. The atlas also illustrates the benefits of partnerships between INSA's Department of Epidemiology (DEP) and the National Centre for Epidemiology of the National Institute of Health Carlos III (ISCIII), in Spain. Such activities are fundamental for supporting public health decision-making and the design of intervention strategies aimed at producing health gains.

This is not the first work that brings together the INSA and ISCIII Institutes, as the collaboration between these similar institutes from countries with shared borders has been going on for several years – as is the case with influenza – and is expected to continue for a long time to come. A significant benefit of this atlas is the fact that it deals with a wide group of types of cancer, and that it covers the entire border between Portugal and Spain; this consequently allows a combined cross-border analysis of the reality of cancer mortality in both countries.

The Directive Council of the INSA congratulates the whole research team and would like to express their will to further deepen the collaboration with the ISCIII.

Fernando Almeida
Chairman of the Executive Board

Cristina Abreu dos Santos
Member of the Executive Board

This cancer mortality atlas of the Iberian Peninsula is a product of epidemiological research activities and observation of health status and determinants by the DEP of the INSA, in partnership with the ISCIII, in Spain. Such activities are fundamental to support decision-making and planning in public health, as well as to monitor public health interventions and their impact at the population level.

Describing the spatial patterns of a health event like cancer with such a high frequency is useful for the planning and evaluation of health care and health services according to local needs. It also aids in designing, implementing and evaluating specific health programs at regional and local levels.

The present atlas is one of the results of the AMOCAPE project, and its greatest asset is the fact that it covers the entire border between Portugal and Spain, allowing a combined cross-border analysis of the reality of cancer mortality for both countries. This cross-border view makes sense as health determinants frequently do not stop at borders and their effects are felt on both sides of any given frontier. To our knowledge, this is the first cancer mortality atlas that presents data from more than one country analysed together using municipality as the geographic unit of analysis. The first coordinator of the DEP at INSA, my predecessor the late Dr. José Marinho Falcão, was involved in two cancer mortality atlases in Portugal published previously, in the late 1980s and 1990s, which used geographical aggregation data by district.

In addition, the atlas may contribute to generate new research hypotheses on possible aetiological factors for cancer – through the analysis of continuous geographic patterns between countries, in geographical areas that share similar risk factors, in particular, environmental factors. I consider it very important to maintain this collaboration with the ISCIII in order to continue this work, eventually addressing other diseases and health determinants, as well as involving other countries in addition to Portugal and Spain.

Prof. Dr. Carlos Matias Dias
Public Health Medical consultant, Coordinator of the Department of Epidemiology
National Institute of Health Ricardo Jorge, Lisbon, Portugal

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The monitoring of cancer – one of the main causes of morbidity and mortality worldwide [Bray et al., 2018] – is essential for its prevention and control. This monitoring can be carried out in different ways, but geographical representation on maps is of great interest for various objectives, such as identifying areas that require more detailed study and, above all, the formulation of aetiological hypotheses to account for the differences observed.

There are maps with a long tradition, such as the mortality atlases published in many countries [Cayolla da Mota and Marinho Falçao, 1987; Cayolla da Mota and Marinho Falçao, 1997; López-Abente et al., 1984; López-Abente et al., 2006; IARC, 2008; Pickle et al., 1996], whose data source – death certificates – is of sufficient quality to be able to carry out reliable studies both of a geographical type and analyses of temporal development.

Until a few years ago, these geographic studies were limited to thematic maps in which large areas were used as the basic units of study. However, although this type of representation is useful for documenting spatial patterns in broad strokes, when it is necessary to go deeper into the study of any pathology it is useful to go to a smaller geographical scale: the most used are health areas, municipalities and census tracts [Baltrus et al., 2019; López-Abente et al., 2014a; Marí-Dell'Olmo et al., 2016].

Working with geographic areas, such as municipalities and census tracts, requires the problem derived from the 'analysis of small areas' to be taken into account. This is faced through the use of smoothing techniques that allow extraction of the spatial patterns contained in the data while using generalized linear mixed regression models [Fong et al., 2010]. These spatial models constitute a specific class of hierarchical models and are also an ideal instrument to be able to analyse spatial patterns' explanatory variables, in addition to having many other advantages for controlling the spatial effects present in this type of study.

Maps of cancer mortality distribution that include several countries have been produced previously [IARC, 2008; Jemal et al., 2020; Pickle et al., 1996], and one message emerges clearly from all of these atlases: cancer risk does not respect national frontiers. However, to date, there has not been an international approach that uses small units for these maps – possibly due to the difficulties involved in processing information at these levels of spatial aggregation. But, given that aetiology hypotheses can be reinforced by the identification of spatial patterns which extend over a number of territories belonging to different countries, any effort in this regard is essential.

Portugal and Spain are countries in the southern region of the European continent that share a border throughout much of their territory. Given that the geographic patterns of mortality are not isolated facts and can extend beyond the borders of the countries, the possibility of preparing maps for both countries together would allow a new (more realistic) vision of the cancer situation, and provide information for two neighbouring countries in order to identify possible areas which could benefit from joint research or prevention policies.

The objectives of this atlas were:

1) To study the existence of spatial patterns for the most frequent tumours in Portugal and Spain jointly, taking municipalities as the unit of analysis and using spatial smoothing techniques.
2) To explore the feasibility of analysing the mortality of the two countries jointly in a single model to minimize border effects.
3) To explore the usefulness of the information referring to municipalities in the elaboration of joint country maps as an instrument of surveillance and for the generation of hypotheses on aetiological factors.
4) To provide high-resolution images showing the spatial distribution of cancer mortality in Portugal and Spain (including islands).

In this atlas, we mapped the municipal relative risks (RRs) of cancer mortality (smoothed standardized mortality ratios (SMRs)) in Portugal and Spain for the period 2003–2012 and the distributions of the posterior probabilities (PPs) of having a RR>1 – for both sexes together, and also for men and women separately. The RRs were calculated using spatial models that include observed and expected deaths from cancer at a municipal level.

DATA SOURCES

We used individual death entries for the period 2003–2012 provided by the national statistics institutes of Spain and Portugal for the types of cancers included in Table 1.

The observed deaths were broken down by municipality (8,097 municipalities in Spain and 308 in Portugal), age group (18 groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85+) and sex.

The population by municipality, age group and sex corresponding to 2005 and 2010 (the midpoints of the two five-year intervals covered by the study period) were also provided by the national statistics institutes of Spain and Portugal.

ANALYSIS

Expected deaths

The numbers of expected deaths were calculated by multiplying the overall age-specific mortality rates – considering Portugal and Spain together for the two five-year study periods – by the person-years of each town, broken down by the same strata. The municipal populations by age group and sex of the central years were multiplied by five to obtain the person-years in each stratum. Subsequently, SMRs were computed as the ratios of observed to expected deaths.

Municipal relative risks (RRs) and Posterior probabilities (PPs)

Municipal smoothed SMRs, i.e., RRs, were calculated using the conditional autoregressive model proposed by Besag, York and Mollié [Besag et al., 1991] based on fitting a spatial Poisson model with observed cases as the dependent variable, expected cases as an offset, and two types of random effect terms: a) municipal contiguity and b) municipal heterogeneity. PPs were calculated as the probability that RR>1.

Table 1. Cancer types analysed in the AMOCAPE project and their International Classification of Diseases 10th revision (ICD-10) codes.

NAME	ICD-10
LIP, ORAL CAVITY AND PHARYNX	C00–C14
OESOPHAGUS	C15
STOMACH	C16
SMALL INTESTINE	C17
COLORECTAL	C18–C21
LIVER	C22.0
GALLBLADDER	C23–C24
PANCREAS	C25
NASAL	C30–C31
LARYNX	C32
LUNG	C33–C34
PLEURA	C38.4, C45.0
BONES	C40–C41
MELANOMA	C43
SKIN	C44
PERITONEUM	C45.1, C48
CONNECTIVE AND SOFT TISSUE	C49
BREAST	C50
VULVA AND VAGINA	C51–C52
UTERUS	C53–C55
OVARY	C56–C57
PROSTATE	C61
TESTIS	C62
KIDNEY	C64–C66, C68
BLADDER	C67
OTHER CENTRAL NERVOUS SYSTEM	C70, C72
BRAIN	C71
THYROID GLAND	C73
OTHER AND ILL-DEFINED SITES	C76–C80
HODGKIN LYMPHOMA	C81
NON-HODGKIN LYMPHOMA	C82–C86, C96
MULTIPLE MYELOMA	C90
LEUKAEMIA	C91–C95

The models were fitted with "Integrated nested Laplace approximations" [Rue et al., 2009] (INLAs) as the tool for Bayesian inference, using the R-INLA package with the option of a simplified Laplace estimation of the parameters and the default specification for the distribution of the hyper-parameters in all the models. The spatial term was modelled using a conditional autoregressive structure and the heterogeneity term, which corresponds to the unstructured residual, was modelled using an exchangeable prior. The contiguity criterion was the adjacency of municipal boundaries according to official maps.

PRESENTATION OF THE RESULTS

Of the tumours included in the whole AMOCAPE project, this atlas only shows those whose spatial patterns transcend the borders between Spain and Portugal, therefore suggesting the presence of common risk factors; and, those with a number of deaths high enough to avoid convergence problems in the statistical models and oversmoothed estimators (see Table 2).

Table 2. Cancer types selected to be shown in the atlas, their ICD-10 codes and joint numbers of cancer deaths in Spain and Portugal, by sex (2003–2012).

NAME (ICD-10)	DEATHS in men	DEATHS in women
OESOPHAGUS (C15)	19,957	3,447
STOMACH (C16)	49,706	31,498
COLORECTAL (C18–C21)	101,211	72,941
PANCREAS (C25)	33,114	29,501
LARYNX (C32)	18,372	939
LUNG (C33–C34)	197,798	36,525
FEMALE BREAST (C50)	-	76,219
PROSTATE (C61)	74,023	-
BLADDER (C67)	44,337	10,402
LEUKAEMIA (C91–C95)	21,898	17,303

For each cancer death cause listed in Table 2, a general comment about the tumour is presented, together with the municipal RR maps and the distribution of PPs with an RR>1 for both sexes, and for men and women separately.

The map in Annex I shows the location of Portugal and Spain in the European continent.

The map in Annex II shows the Spanish and Portuguese regional (for both countries) and provincial (only for Spain) administrative distributions to help the reader better understand the description of the results.

OESOPHAGUS (ICD-10 C15)

Globally, oesophageal was the 7^{th} most diagnosed cancer in 2018 (572,034 new cases) and was 6^{th} for mortality (508,505 deaths), corresponding to 3.4% of total cases and 5.4% of deaths from all cancers except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. Approximately 70% of cases and deaths occur in men [Bray et al., 2018]. Asia is the continent with the highest share of incidence (77.0%) and mortality (78.2%) due to oesophageal cancer, followed by Europe (9.3% incidence and 8.9% mortality) [IARC, 2021a].

At the European level in 2018, oesophageal was the 19^{th} most diagnosed cancer (52,964 new cases) and 13^{th} for cancer mortality (45,061 deaths), accounting for 1.4% of new cases and 2.3% of all-site deaths except NMSC [European Commission, 2020]. The age-standardized rate (ASR) of incidence per 100,000 was 8.7 in men and 1.9 in women, with a mortality ASR of 7.3 in men and 1.4 in women [Ferlay et al., 2018]. The estimated 5-year relative survival for the period 2000–2007 for adults >15 years was 11.9% in men and 13.4% in women [Istituto Superiore di Sanità, 2019].

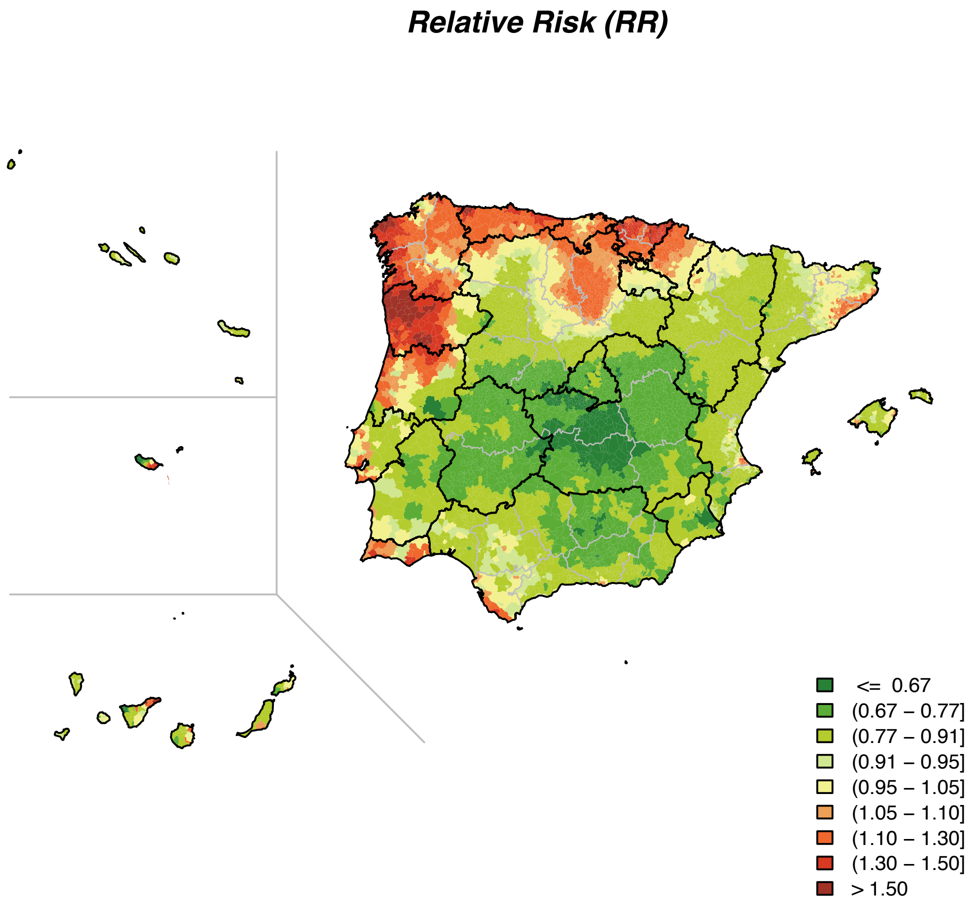
In Spain, oesophageal cancer was the 21^{st} most diagnosed cancer in 2018 (2,311 new cases, 1,909 in men and 402 in women) and 15^{th} for mortality (2,026 deaths, 1,696 in men and 330 in women), excluding NMSC [European Commission, 2020]. Thus, oesophageal cancer accounted for 0.9% of new cases and 1.8% of all-site deaths excluding NMSC [European Commission, 2020]. The incidence ASR was 6.0 in men, and 1.0 in women; the mortality ASR, 5.2 in men and 0.7 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for oesophageal cancer incidence, it decreased in men (from 8.9 in the period 1993–1997 to 6.7 in 2015) and slightly increased in women (from 0.9 in the period 1993–1997 to 1.0 in 2015) [Galceran et al., 2017]. For spatial patterns, in 2015 the estimated oesophageal cancer mortality ASR per 100,000 in men varied from 11.3 in Avila to 2.8 in Palencia, while in women it varied from 4.3 in Ceuta to 0.0 in Avila, Lugo and Teruel [National Centre for Epidemiology - ISCIII, 2021]. The 5-year relative survival estimated for adults >15 years for 2000–2007 was 9.3% for men and 12.2% for women [Istituto Superiore di Sanità, 2019].

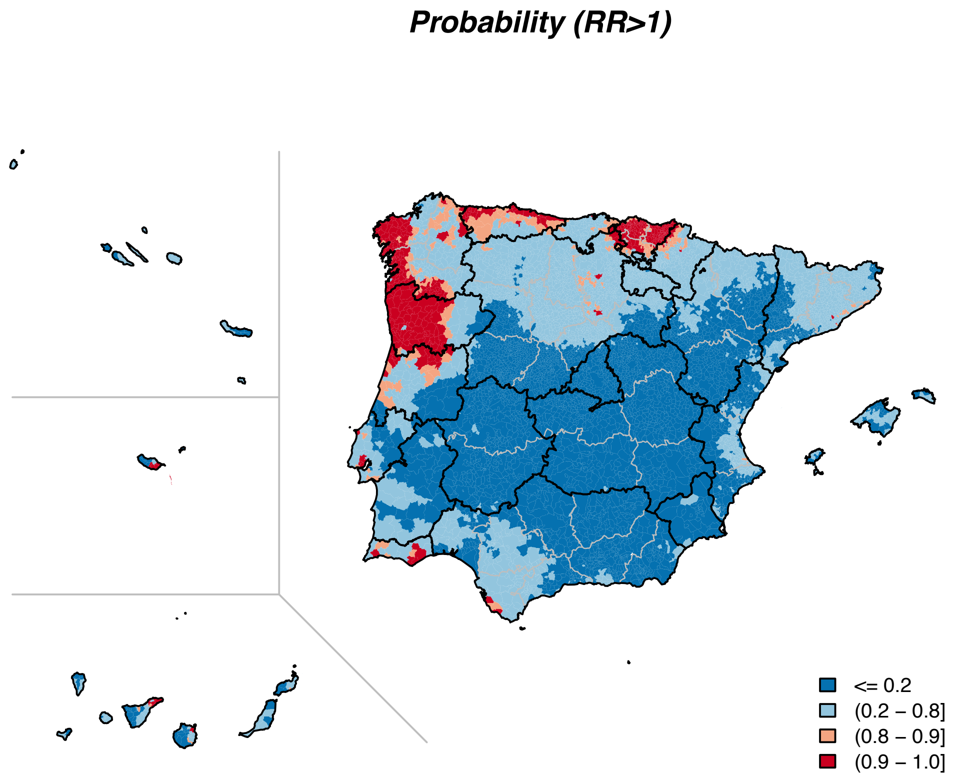
In Portugal, oesophageal was the 19^{th} most diagnosed cancer in 2018 (706 new cases, 638 in men and 68 in women) and 13^{th} for mortality (599 deaths, 540 in men and 59 in women) [European Commission, 2020]. Thus, oesophageal cancer contributed 1.3% of all new cases and 2.1% of all-site deaths except NMSC. The estimated incidence ASR per 100,000 was 9.6 in men and 0.6 in women; the mortality ASR, 7.9 in men and 0.5 in women [Ferlay et al., 2018]. Incidence in Portugal increased slightly between 2001 and 2010 in both sexes. 478 new cases were registered in 2001 (389 in men and 89 in women) [IPO-Porto, 2008] and in 2010, 559 (469 in men 90 in women) [IPO-Porto, 2016]. In turn, the number of deaths slightly decreased between 2002 (542) and 2010 (528) in both sexes [INE-Portugal, 2019]. This decrease was due to the number of deaths in women, as the number of deaths in men remained similar (448 in 2002 and 446 in 2010) [INE-Portugal, 2020]. Finally, estimated 5-year relative survival for adults >15 years for 2000–2007 was 9.7% for men and 13.3% for women [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that during the period 2003–2012 there were 23,404 deaths due to oesophageal cancer (17,982 in Spain and 5,422 in Portugal), accounting for 1.9% of all cancer deaths except NMSC on the Iberian Peninsula, of which 19,957 were men and 3,447 women.

The present atlas found an excess of risk of death in men from oesophageal cancer in the north of the Iberian Peninsula. This area of risk extends along the Cantabrian and Atlantic coasts in Spain, also including the regions of Navarre and northern Castile & Leon. In Portugal, it extends through the northwest and centre of the country, and some municipalities on the south coast of LVT and in most municipalities in the Algarve. In women, there was not an excess of risk in the central part of the Cantabrian coast in Spain and the north of Castile & Leon, but an excess mortality risk in the south, specifically in the province of Cadiz. In Portugal, there was a lower risk in the Algarve and the south of the LVT region and a higher risk in the west of the Norte and Centro regions and some municipalities on LVT's west coast.

These results suggest the existence of differences (both geographically and by sex) in the distribution of the main risk factors for oesophageal cancer, and probably in the distribution of the most frequent histological types. Given the spatial differences found between sexes, lifestyle and behaviour seem to be the main factors involved in the risk patterns for this tumour. Higher alcohol and tobacco consumption in some regions could partly explain these results [IARC, 2021c]. The fact that men drink and smoke more than women [Drope et al., 2018; WHO, 2018] would also partly explain the differences, with the pattern in women apparently more linked to the distribution of other risk factors, such as excess body weight and obesity, and lower fruit and vegetable consumption [Abnet et al., 2018]. Finally, the fact that there are areas that present an excess risk of mortality in both men and women suggests the involvement of common environmental or sociocultural factors.


Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1)
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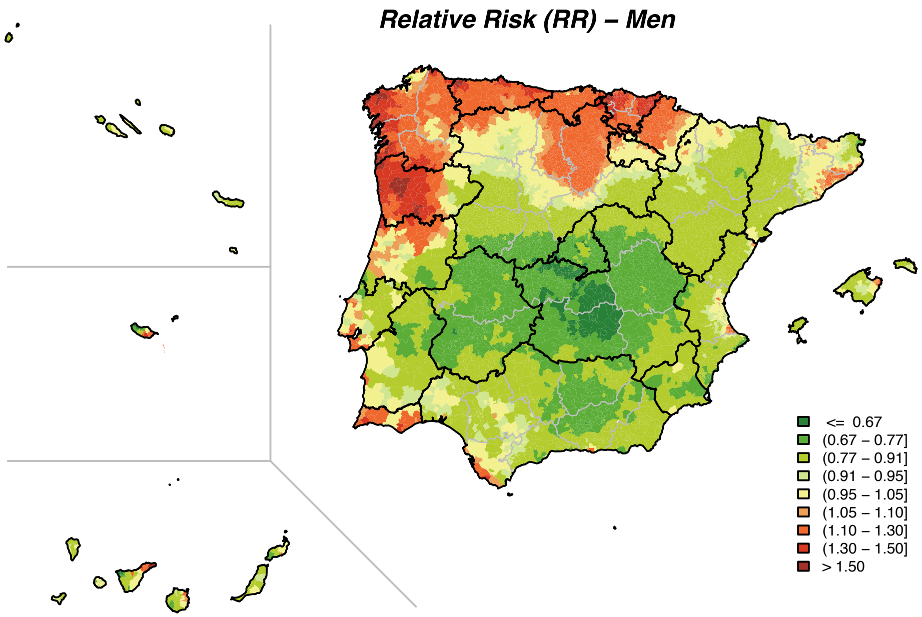
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Men
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(0.77 – 0.91]
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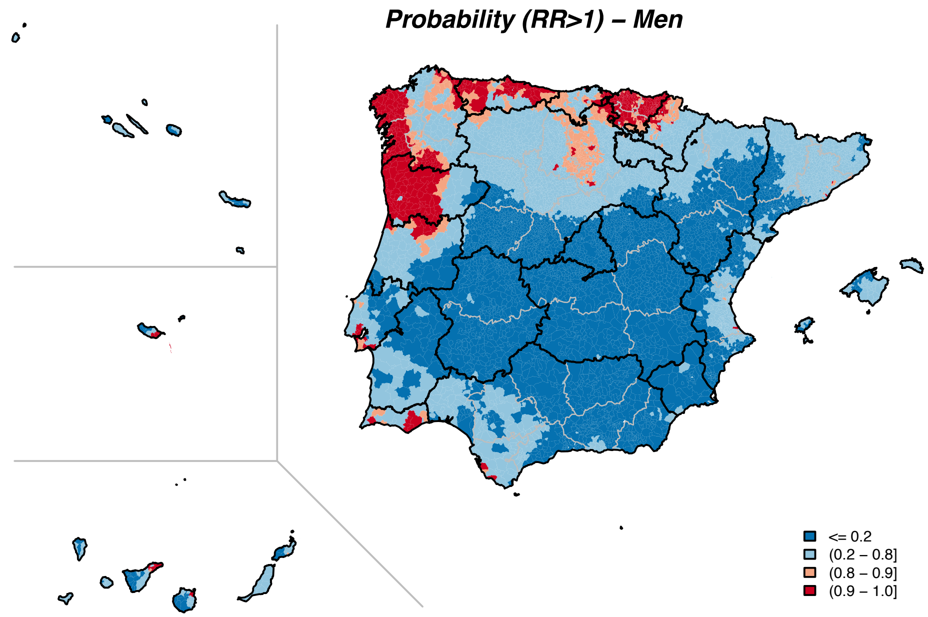
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1) – Men
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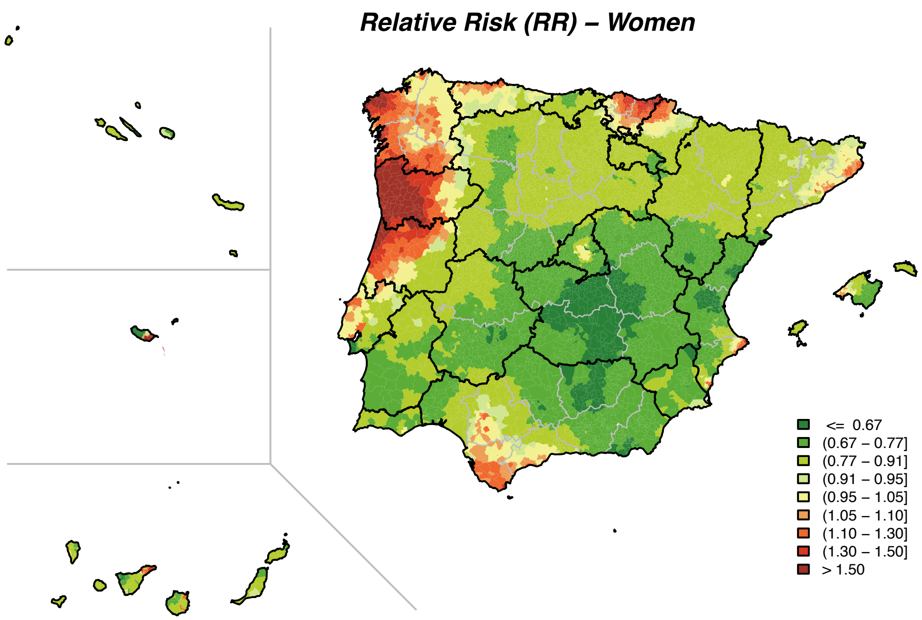
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Women
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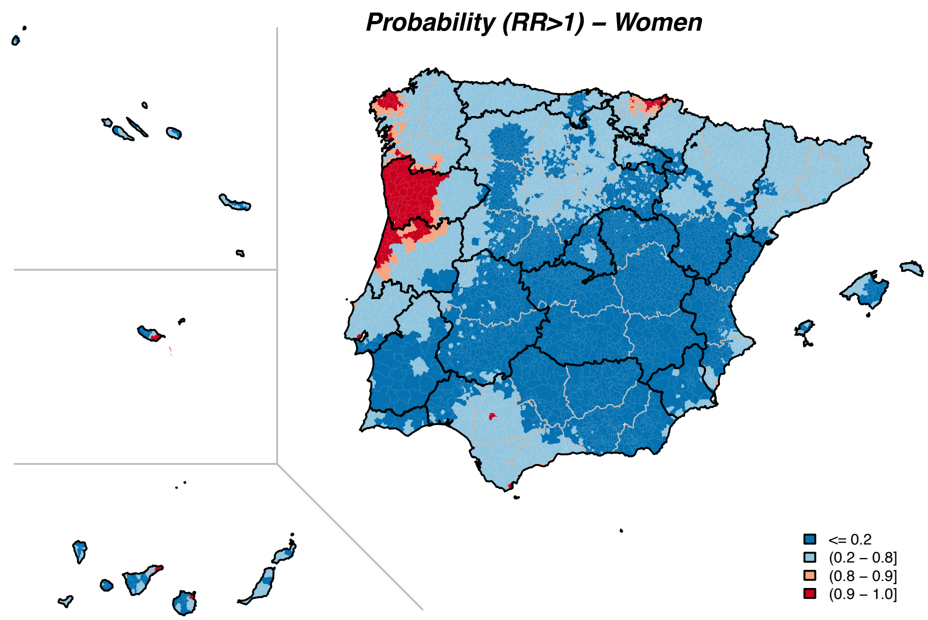
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1) – Women
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

STOMACH (ICD-10 C16)

In 2018, stomach was the 5^{th} most diagnosed cancer worldwide (1,033,701 new cases) and 3^{th} for mortality (782,685 deaths), corresponding to 6.1% of total cases and 8.2% of deaths for all types of cancer except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. Approximately two-thirds of new cases and deaths occur in men [Bray et al., 2018]. The continents with the highest incidence and mortality of stomach cancer are Asia (74.5% and 74.7%, respectively) and Europe (12.9% and 13.1%) [IARC, 2021a].

At the European level, stomach cancer was the 8^{th} most diagnosed cancer (133,133 new cases) and 6^{th} for mortality (102,167 deaths), accounting for 3.4% of new cases and 5.3% of all-site deaths except NMSC [Ferlay et al., 2018]. Both incidence and mortality were higher in men. The incidence age-standardized rate (ASR) per 100,000 was 17.0 for men and 8.0 for women, with the mortality ASR 12.6 in men and 5.8 in women [Ferlay et al., 2018]. The estimated 5-year relative survival for the period 2000–2007 for adults >15 years was 22.8% in men and 25.1% in women [Istituto Superiore di Sanità, 2019].

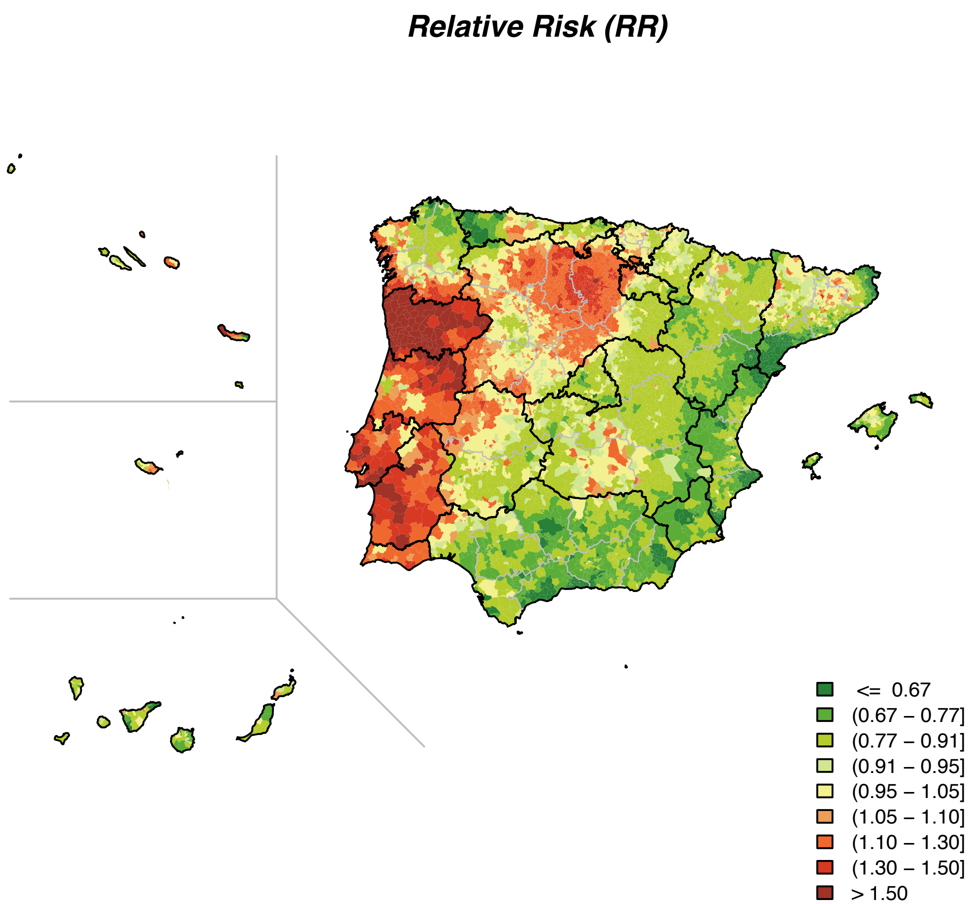
In Spain, stomach cancer was 9^{th} for new cases in 2018 (4,761 in men and 2,923 in women) and 7^{th} in mortality (3,413 deaths in men and 2,196 in women), excluding NMSC [Ferlay et al., 2018]. Thus, stomach cancer accounted for 3.1% of new cases and 5.0% of deaths of all sites except NMSC. The estimated incidence ASR per 100,000 was 13.9 in men, and 6.5 in women; the mortality ASR, 9.5 in men and 4.4 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for stomach cancer incidence per 100,000 a decrease in men was observed (from 25.7 in the period 1993–1997 to 16.2 in 2015) as well as in women (from 11.1 in the period 1993–1997 to 8.0 in 2015) [Galceran et al., 2017]. Concerning spatial patterns in 2015, the estimated mortality ASR per 100,000 for stomach cancer in men varied from 19.1 (Palencia) to 5.4 (Santa Cruz de Tenerife), while in women it varied from 7.8 (Palencia) to 2.7 (Melilla) [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for adults >15 years in 2000–2007 was 23.1% for men and 25.4% for women [Istituto Superiore di Sanità, 2019].

In Portugal, stomach cancer was the 5^{th} most diagnosed cancer in 2018 (2,885 new cases, 1,717 in men and 1,168 in women) and 3^{rd} for mortality (2,275 deaths, 1,382 in men and 893 in women) [Ferlay et al., 2018]. Thus, stomach cancer contributed to 5.2% of new cases and 7.9% of all-site deaths except NMSC. The estimated ASR incidence per 100,000 was 22.8 in men and 11.0 in women, and mortality ASR was 17.4 in men and 7.7 in women [Ferlay et al., 2018]. The incidence of stomach cancer in Portugal slightly increased from 2001 to 2010 in both sexes. In 2001 2,692 new cases were registered (1,659 in men and 1,033 in women) [IPOPorto, 2008] and in 2010, 2,934 (1,760 in men and 1,174 in women) [IPO-Porto, 2016]. Nevertheless, stomach cancer's position in the rank of all-cancer incidence in Portugal is going down. The number of deaths decreased between 2002 and 2010 for both sexes (from 2,523 to 2,318). This decrease was due to the deaths in men, as the number of deaths in women remained similar [INE-Portugal, 2019]. Finally, the estimated 5-year relative survival for adults between 2000 and 2007 was 29.1% for men and 34.8% for women [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that during the period 2003–2012 there were 81,204 deaths due to stomach cancer (57,280 in Spain and 23,924 in Portugal), accounting for 6.6% of all deaths from cancer, except NMSC, on the Iberian Peninsula, of which 49,706 were in men and 31,498 in women.

The clusters with high relative risk (RR) of stomach cancer mortality are larger in Portugal than in Spain. In Portugal, the highest values occur throughout the mainland, with particular emphasis in the Norte region, the northern part of the Centro region, LVT, and the central and coastal part of the Alentejo region. In Spain, the high values are located on the west coast and in the south of Galicia, the centre of Asturias, an extensive central section of Castile & Leon, a small part of La Rioja, in the centre of Castile-La Mancha and the west of Castile & Leon and Extremadura. The cross-border area of high values is more widespread in women than in men. Moreover, on the women's map, there is a zone with high values in northern Catalonia (on the border with France), not present on the men's map. The lowest RR values (in both sexes) tend to form a band running through the regions of Andalusia, Murcia, the Valencian Region, and southern Aragon and Catalonia. There is also an area of low values in the western part of Asturias.

The observed pattern suggests a possible role played by environmental exposure which is shared by both sexes. The best-established risk factors for stomach cancer are *Helicobacter pylori* infection, considered the most important; tobacco smoking; occupations in rubber production; and exposure to asbestos and ionizing radiation [IARC, 2021b]. Other factors related to this tumour include some dietary habits, partial gastrectomy and aspirin intake, with this last having a possible protective role [Ye et al., 2018]. The marked differences observed in the patterns of distribution of stomach cancer mortality between Portugal and Spain may be due, on the one hand, to the presence of different risk factors in each country or, on the other, to the variations in the distribution of these risk factors in each country.


Relative Risk (RR)
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(0.67 – 0.77]
(0.77 – 0.91]
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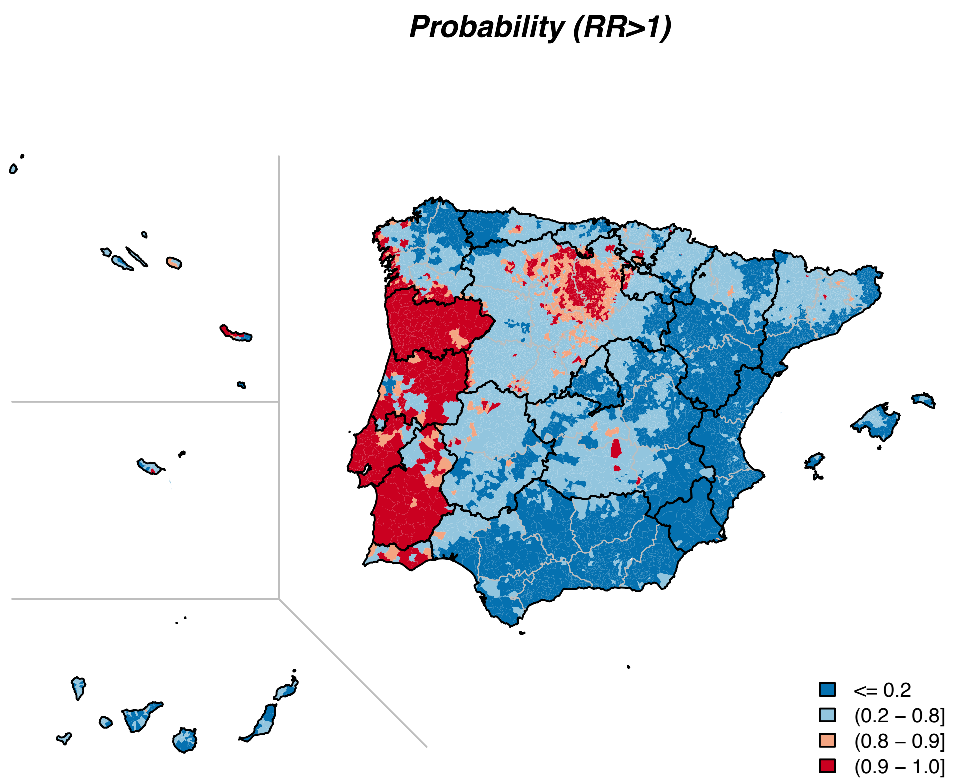
Probability (RR>1)
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(0.8 – 0.9]
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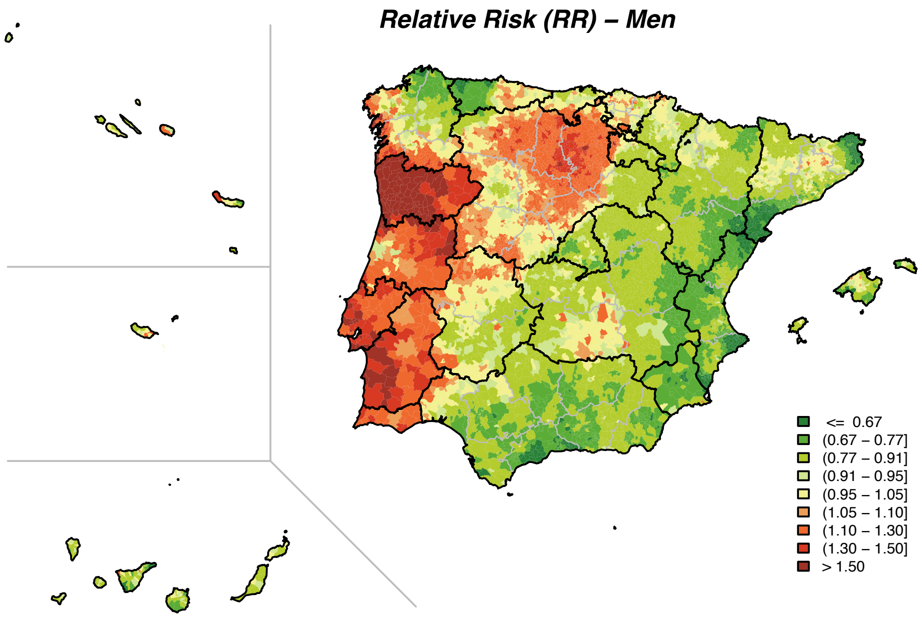
Relative Risk (RR) – Men
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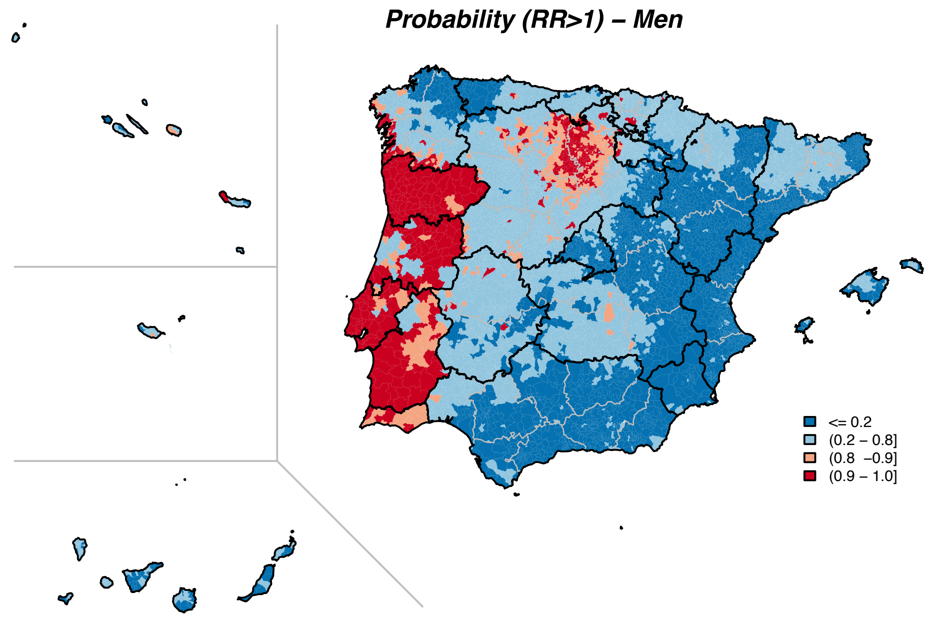
Probability (RR>1) – Men
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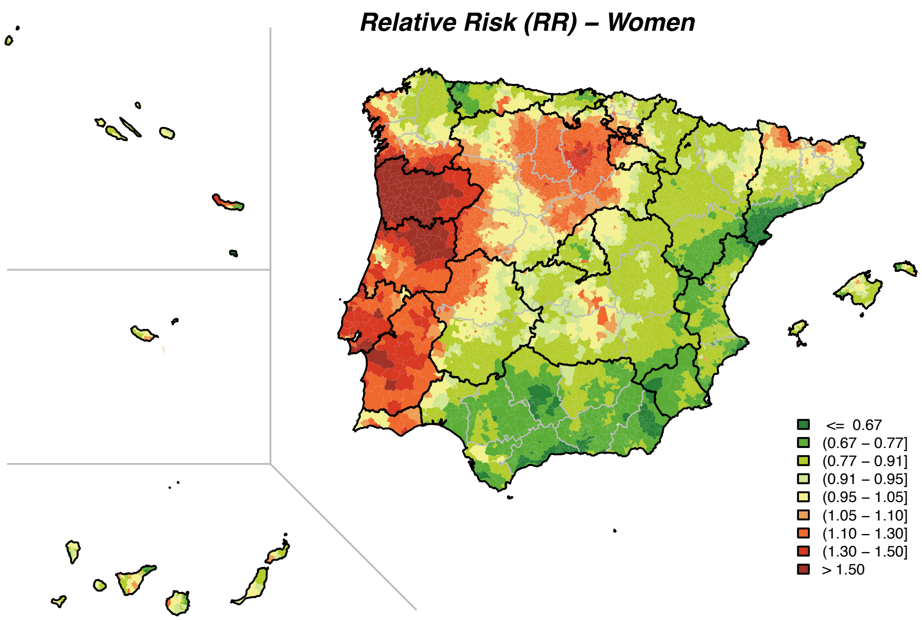
Relative Risk (RR) – Women
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(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
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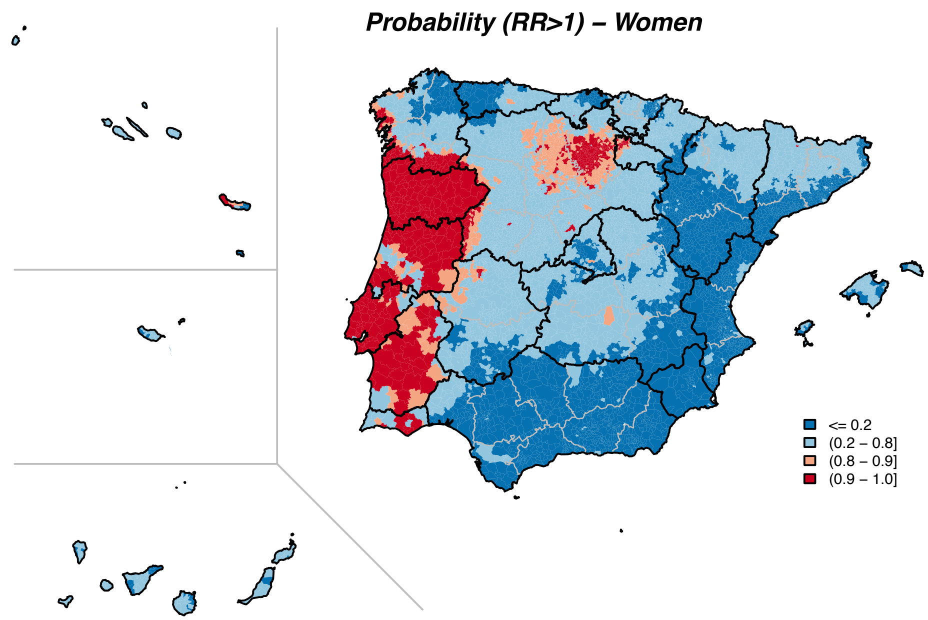
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1) – Women
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

COLORECTAL (ICD-10 C18–C21)

Globally, colorectal cancer was the 3^{rd} most diagnosed in 2018 (1,849,518 new cases) and was 2^{nd} for mortality (880,792 deaths), corresponding to 10.9% of total cases and 9.3% of deaths from all cancers except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. The proportions of new cases and deaths were approximately the same in males and females [Bray et al., 2018]. Asia was the continent with the largest share of incidence (51.8%) and mortality (52.4%) followed by Europe (27.0% and 27.5%, respectively) [IARC, 2021a].

At the European level, colorectal cancer was 2^{nd} for both number of diagnoses (511,620 new cases) and cancer mortality (246,214 deaths) in 2018, accounting for 12.8% of new cases and 12.6% of all-site deaths except NMSC [Ferlay et al., 2018]. Both incidence (67.7%) and mortality (67.2%) were higher in men. The age-standardized rate (ASR) of incidence per 100,000 was 55.9 for men and 35.6 for women, with a mortality ASR of 25.4 in men and 15.3 in women [Ferlay et al., 2018]. The estimated 5-year relative survival for the period 2000–2007 for adults >15 years was 55.1% in men and 55.4% in women [Istituto Superiore di Sanità, 2019].

In Spain, colorectal was the most diagnosed cancer in 2018 (22,744 new cases in men and 14,428 in women) and 2^{nd} for mortality (10,038 deaths in men and 6,645 in women) [Ferlay et al., 2018]. Thus, colorectal cancer accounted for 15.1% new cases and 14.9% deaths of all sites except NMSC. The incidence ASR was 67.7 in men and 34.4 in women, and the mortality ASR was 26.8 in men and 12.7 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for cancer incidence, an increase in men was observed: from 31.3 in 1993–1997 to 49.0 in 2015 for colon; and from 20.4 to 28.8 for rectum – as well as in women: from 22.6 in 1993–1997 to 29.7 in 2015 for colon; and from 10.7 to 12.4 for rectum [Galceran et al., 2017]. Concerning spatial patterns in 2015, the mortality ASR for colon cancer in men varied from 26.6 in Teruel to 11.4 in Alava, while in women it varied from 14.9 in Soria to 4.9 in Guadalajara. The mortality ASR for rectum cancer ranged from 11.2 (Zamora) to 2.2 (Ceuta) in men, and 6.7 (Avila) to 0.0 (Melilla) in women [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for adults (>15 years) 2000–2007 was 55.3% in men and 55.0% in women [Istituto Superiore di Sanità, 2019].

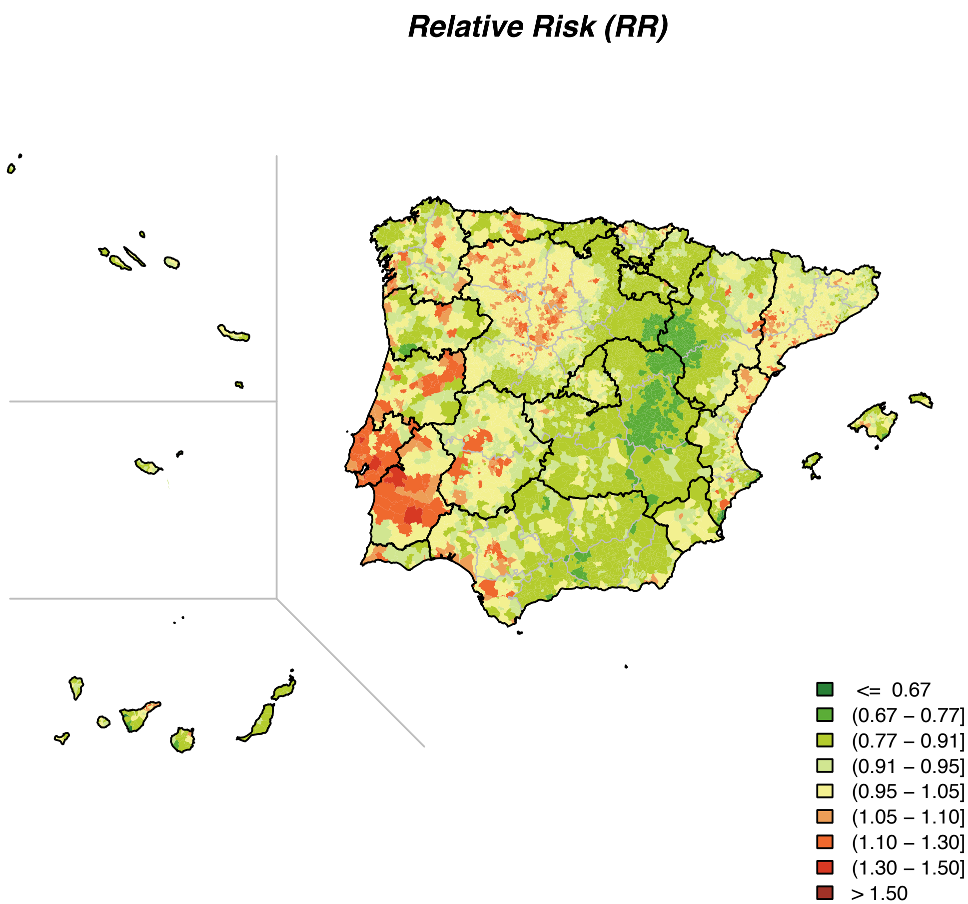
In Portugal, colorectal cancer was also the most common cancer by incidence (6,104 new cases in men and 4,166 in women) and 2^{nd} by mortality (2,497 deaths in men and 1,764 in women) [Ferlay et al., 2018]. Thus, colorectal cancer contributed to 18.4% of new cases and 14.8% of all-site deaths except NMSC. The incidence ASRs were 80.2 in men and 42.1 in women, and the ASR of mortality was 29.5 in men and 14.9 in women [Ferlay et al., 2018]. Colorectal cancer incidence has increased since 2001 in both sexes; 5,317 new cases were registered in 2001 (3,040 in men and 2,277 in women) [IPO-Porto, 2008] and 7,539 in 2010 (4,435 men and 3,104 women) [IPO-Porto, 2016]. The number of deaths also increased between 2002 (3,129) and 2010 (3,759) in both sexes. This increase was higher in men [INE-Portugal, 2019]. Finally, the estimated 5-year relative survival for adults (>15 years) 2000–2007 was 56.2% for men and 57.6% for women [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that for the period 2003–2012 there were 174,152 deaths due to colorectal cancer (138,926 in Spain and 35,226 in Portugal), accounting for 14.1% of all cancer deaths, except NMSC, on the Iberian Peninsula – 101,211 men and 72,941 women.

This atlas shows clear geographical patterns on the Iberian Peninsula for both sexes. An excess of mortality risk is shown in the western and coastal areas of the peninsula. In Spain, the risk tends to be higher in some municipalities of Castile & Leon, Asturias, Extremadura, western Andalusia, and the Valencian Region. In Portugal, the largest cluster of high relative risk (RR) values includes much of the LVT region (notably the south), extends through the centre of the Alentejo region to the Spanish border. Another cluster of high values in Portugal appears in the northeast of the Centro region. In contrast, the areas with lower risk extend in a north-south strip that goes through Navarre, La Rioja, eastern Castile & Leon, western Aragon, Castile-La Mancha, and eastern Andalusia.

The comparison of RR maps by sex shows that the aforementioned strip-shaped cluster is much broader in men than in women, although the Basque Country shows medium to high values in men and low in women. In turn, the larger cluster located in Portugal does not extend so sharply towards the Spanish border on the women's map. Additionally, on this map, the high-value cluster in the region of Castile & Leon is much larger than on the men's map, and some high-value clusters are located on the coast of the Valencian Region.

The results presented suggest the existence of geographical differences in the distribution of the main established risk factors. The observed pattern could be explained, in part, by the increased consumption of tobacco, alcoholic drinks or red/processed meat (known risk factors for colorectal cancer [Marley and Nan, 2016]) in certain regions. The role of diet in colorectal cancer is partially confirmed by similarities with the spatial patterns found for stomach cancer – which shares some risk factors with colorectal.


Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
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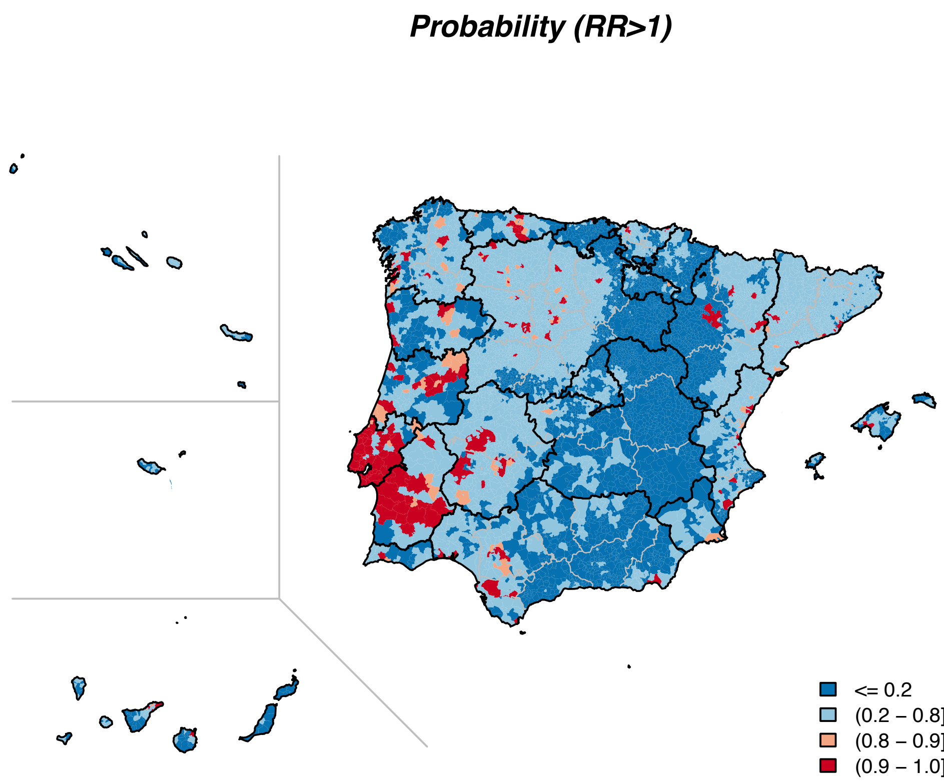
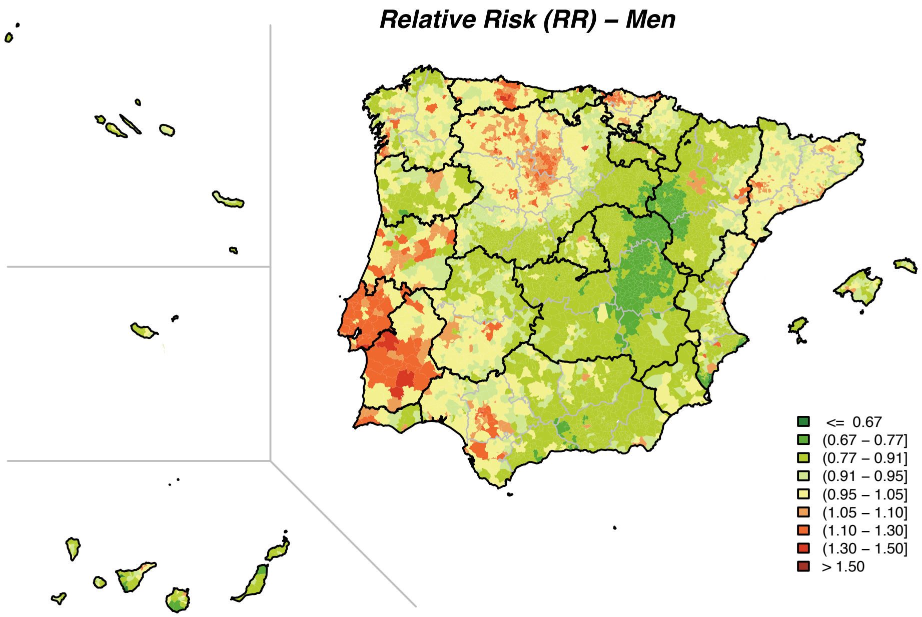

Probability (RR>1)
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Men
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
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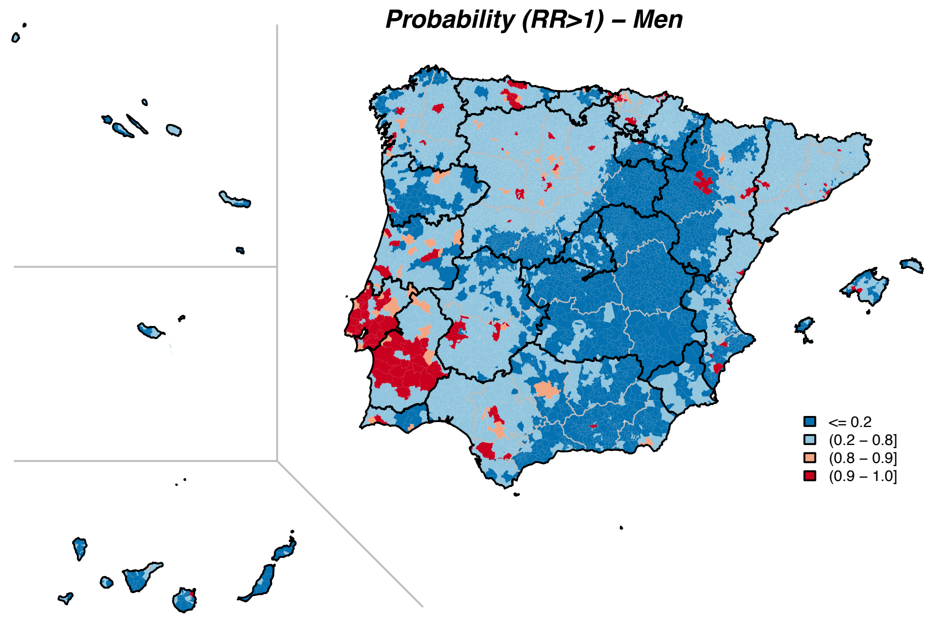
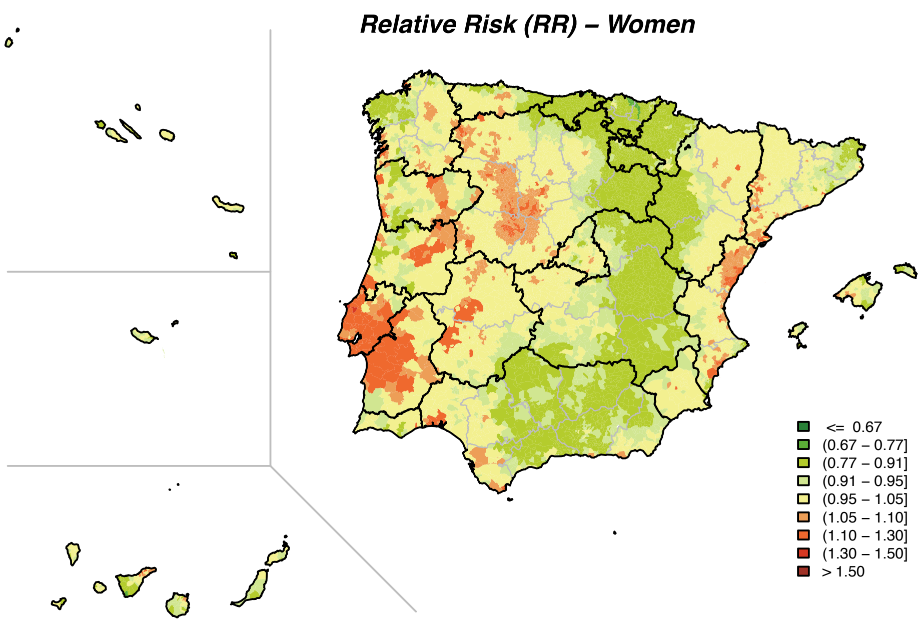

Probability (RR>1) – Men
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Women
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
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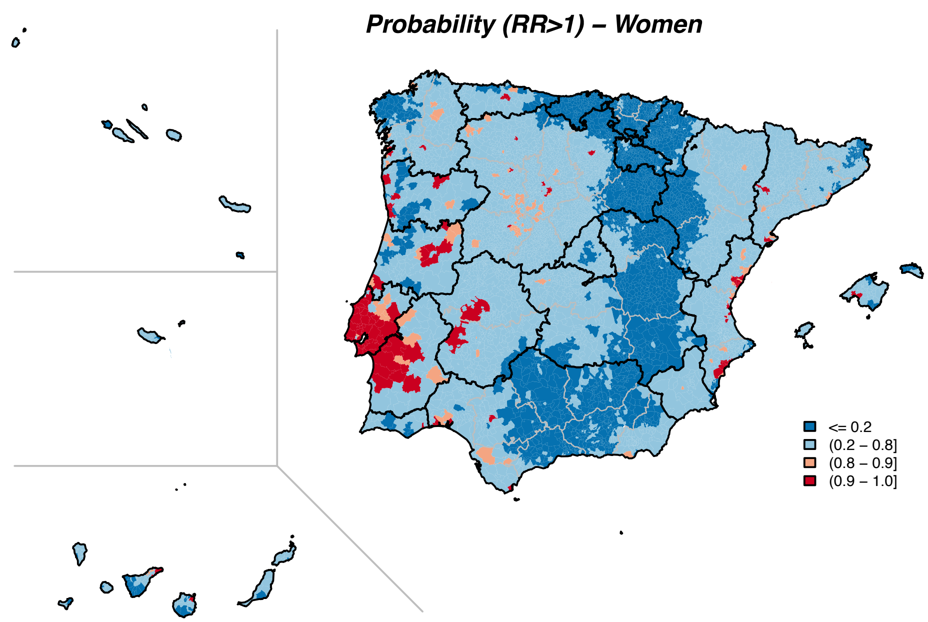
> 1.50


Probability (RR>1) – Women
<= 0.2
(0.2 – 0.8]
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PANCREAS (ICD-10 C25)

Globally, pancreatic cancer was 12^{th} for new cases (458,918) and 7^{th} for mortality (432,242 deaths) among all types of cancer in 2018, excluding non-melanoma skin cancer (NMSC) – corresponding to 2.7% of total cases and 4.7% of deaths for all cancers except NMSC [Bray et al., 2018]. The incidence and mortality rates in men and women were very similar (53.0% of cases and 52.5% of deaths occurred in men) [Bray et al., 2018]. Asia is the continent with the highest incidence (46.7%) and mortality (46.4%) from pancreatic cancer followed by Europe (28.9% and 29.6%, respectively) [IARC, 2021a].

At the European level, pancreatic was the 9^{th} most diagnosed cancer in 2018 (132,559 new cases) and 4^{th} for deaths (128,045), accounting for 3.4% of new cases and 6.6% of all-site deaths except NMSC [Ferlay et al., 2018]. Both incidence, 50.7%, and mortality, 50.8%, were higher in men. The age-standardized rate (ASR) of incidence per 100,000 was 13.9 in men and 9.5 in women, with a mortality ASR of 13.3 in men and 8.9 in women [Ferlay et al., 2018]. The estimated adult 5-year relative survival for the period 2000–2007 was 5.8% in men and 5.9% in women [Istituto Superiore di Sanità, 2019].

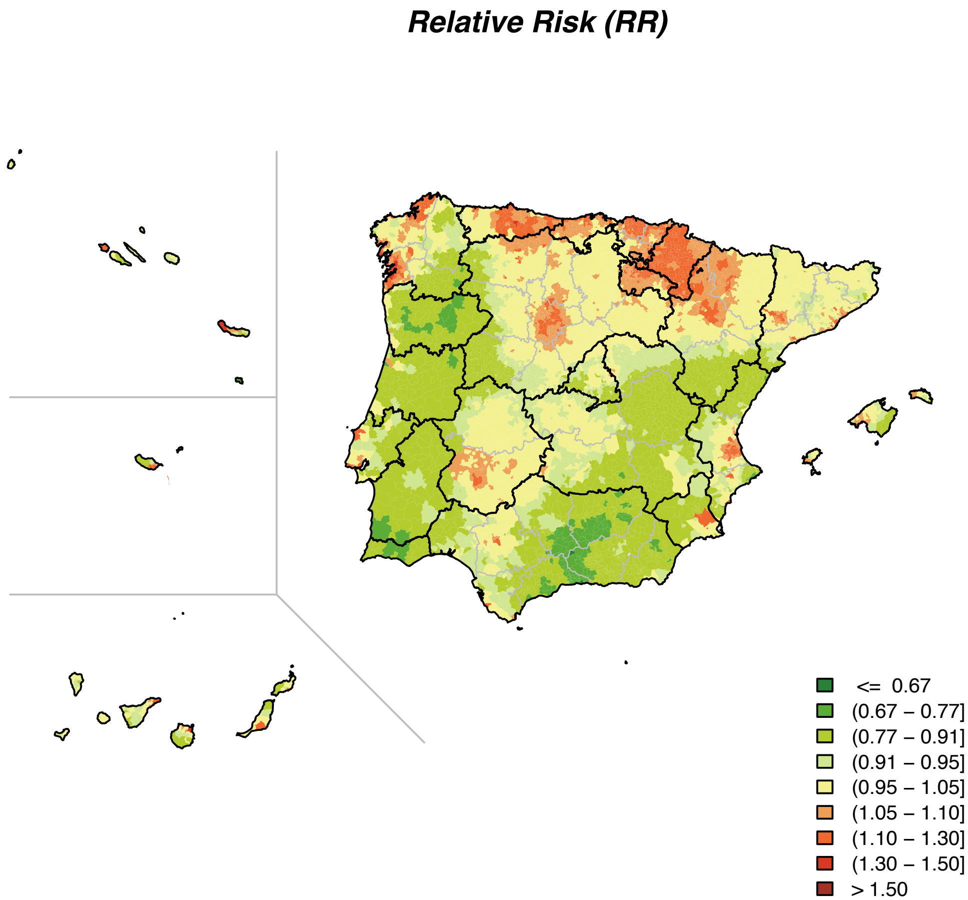
In Spain, pancreatic was the 8^{th} most diagnosed cancer in 2018 (3,988 new cases in men and 3,777 in women) and was 3^{rd} for mortality (3,708 deaths in men and 3,571 in women) [Ferlay et al., 2018]. Thus, pancreatic cancer accounted for 3.1% of new cases and 6.5% of all-site deaths except NMSC. The incidence ASR was 11.9 in men and 8.3 in women; mortality ASRs were 10.8 in men and 7.5 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for pancreatic cancer incidence, there was an increase in both men (from 9.1 in 1993–1997 to 11.3 in 2015) and in women (from 5.5 in 1993–1997 to 7.9 in 2015) [Galceran et al., 2017]. For spatial patterns in 2015, the estimated mortality ASR per 100,000 for pancreatic cancer in men varied from 17.2 (Teruel) to 5.6 (Zamora), while in women it varied from 11.0 (Ceuta) to 4.1 (Albacete) [National Centre for Epidemiology - ISCIII, 2021]. The estimated adult 5-year relative survival for 2000–2007 was 4.6% in men and 5.4% in women [Istituto Superiore di Sanità, 2019].

In Portugal, pancreatic was the 9^{th} most diagnosed cancer in 2018 (894 new cases in men and 725 in women) and was 6^{th} for mortality (877 deaths in men and 717 in women) [Ferlay et al., 2018]. Thus, pancreatic cancer accounted for 2.9% of new cases and 5.6% of all-site deaths except NMSC. The incidence ASRs were 11.5 in men and 6.1 in women; the mortality ASRs were 11.2 in men and 6.0 in women [Ferlay et al., 2018]. The incidence of pancreatic cancer in Portugal increased from 2001 in both sexes; 475 new cases were registered in 2001 (248 in men and 227 in women) [IPO-Porto, 2008] and 773 in 2010 (459 in men and 314 in women) [IPO-Porto, 2016]. The number of deaths also increased between 2002 (948) and 2010 (1,244) in both sexes. This increase was higher in men [INE-Portugal, 2019]. Finally, estimated adult 5-year relative survival for 2000–2007 was 6.8% in men and 9.2% in women [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that, during the period 2003–2012, there were 62,615 deaths due to pancreatic cancer (51,387 in Spain and 11,228 in Portugal). This accounted for 5.1% of all cancer deaths, excluding NMSC, on the Iberian Peninsula, of which 33,114 were men and 29,501 women.

In this atlas, the relative risk (RR) of pancreatic cancer mortality is low in Portugal and in the south and east of Spain, except for two small high-value clusters in Murcia and the Valencian Region. The regions with excess risk are mainly distributed along the Cantabrian coast, from the eastern part of Asturias to Cantabria and the Basque Country, and extending into Navarre, La Rioja, and northwestern Aragon for both sexes. There are also areas of higher mortality (more extensive in men) in the central area of Castile & Leon (mainly Valladolid), the coast of Pontevedra, the north of Corunna, in Ribera Alta and Baja in Valencia, in the La Huerta region of Murcia and in Badajoz. In Portugal, excess of risk is concentrated in particular municipalities in the LVT region (Cascais and Lisbon) in both men and women. Comparing the Iberian Peninsula RR maps for men and women, the distribution patterns are relatively similar, but with larger high-value clusters for men, and broader average-value clusters for women.

The most established risk factor for pancreatic cancer is tobacco smoking [IARC, 2021c]. However, the similarity in the geographic patterns for men and women mentioned above suggests that this spatial distribution is due to risk factors with similar distribution in both sexes, which is not the case with smoking. Furthermore, the spatial patterns for this tumour do not resemble that observed for lung cancer, a disease strongly associated with tobacco, suggesting the existence of other factors that could explain pancreatic cancer distribution in Spain and Portugal. Other risk factors with consistent evidence of a relation with pancreatic cancer are hereditary and chronic pancreatitis, and several rare, high-penetrance genetic disorders [Antwi et al., 2018; Benetou et al., 2018]. Obesity and diabetes have emerged as important risk factors for the disease [IARC, 2021b]; other suggested risk factors include *Helicobacter pylori* infection, excessive alcohol consumption, high intakes of red and processed meat, and food and beverages containing fructose and saturated fats.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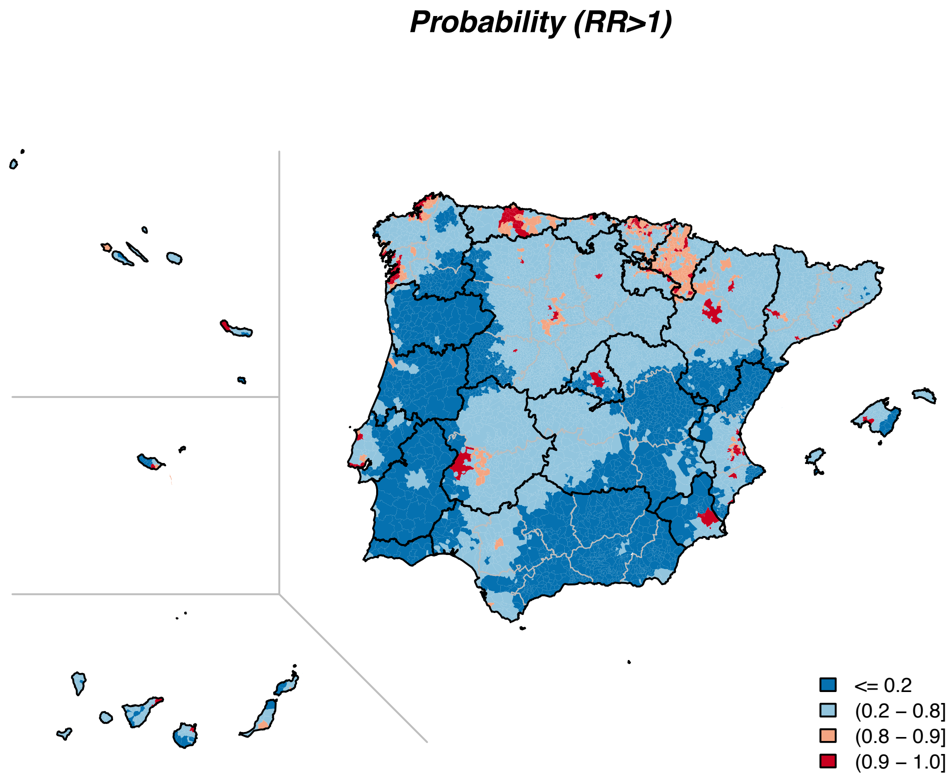
Probability (RR>1)
<= 0.2
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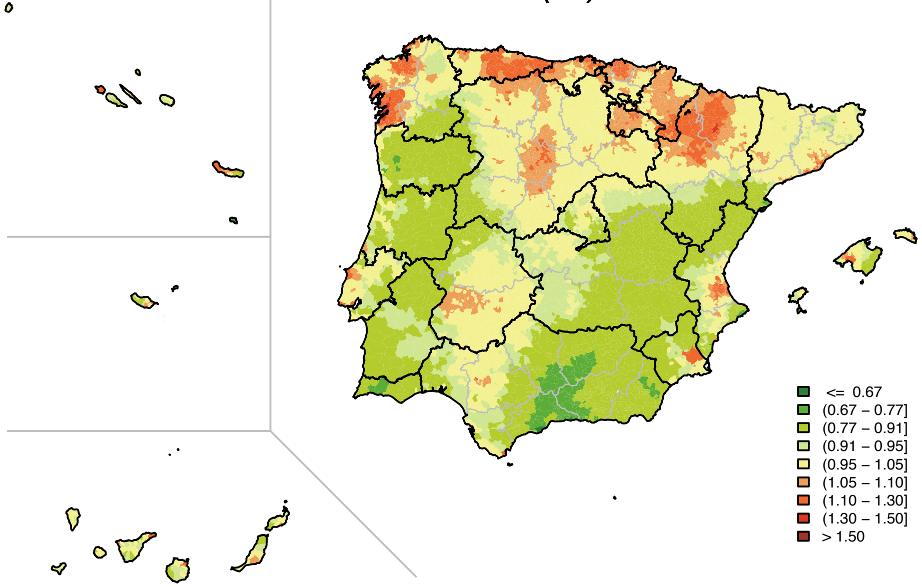
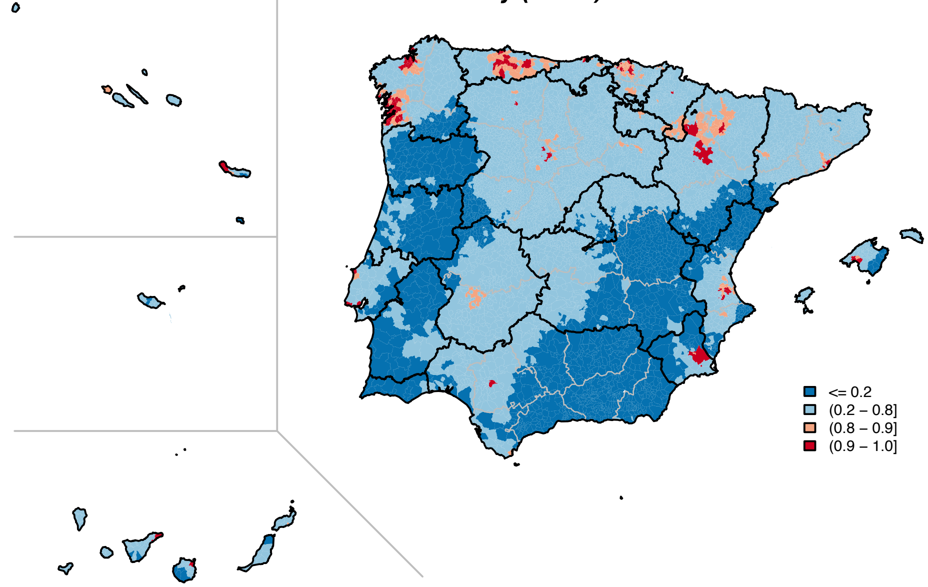
(0.8 – 0.9]
(0.9 – 1.0]

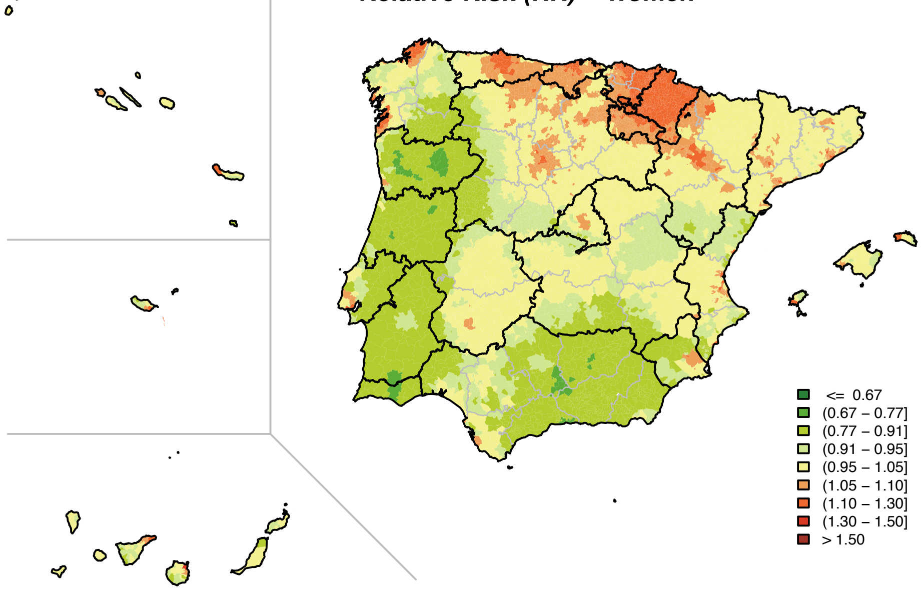
Relative Risk (RR) – Men



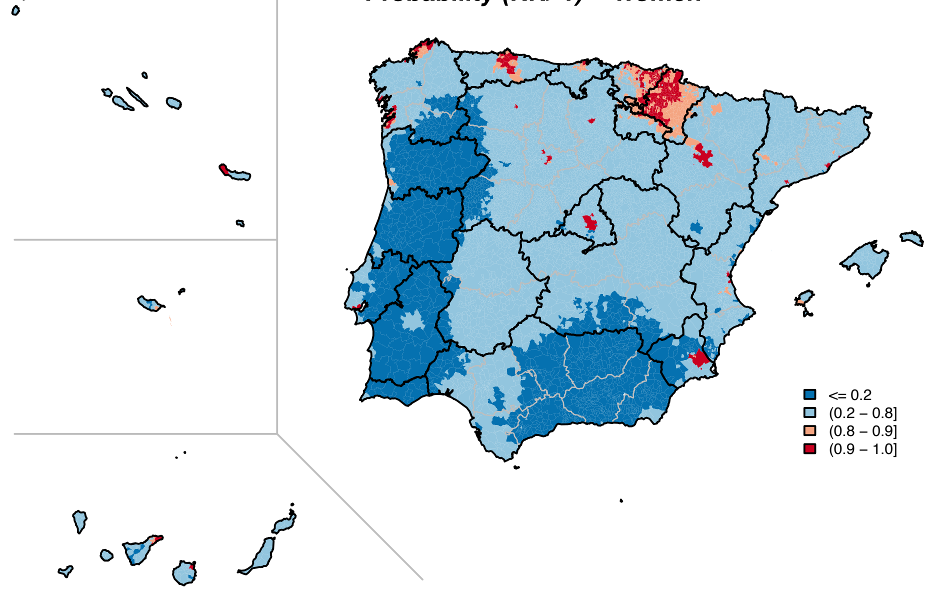
Probability (RR>1) – Men



Relative Risk (RR) – Women



Probability (RR>1) – Women



LARYNX (ICD-10 C32)

Globally, laryngeal was the 21st most diagnosed cancer (177,422 new cases) and was 19th for cancer mortality (94,771 deaths) in 2018, corresponding to 1.0% of both total cases and deaths from all types of cancer except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. Approximately 87% of new cases and 86% of deaths occur in men [Bray et al., 2018]. Asia is the continent with both, the highest share of incidence (52.6%) and mortality (54.9%) from laryngeal cancer, followed by Europe (22.5% cases and 20.7% deaths) [IARC, 2021a].

At the European level, laryngeal was the 21st most diagnosed cancer (39,875 new cases) and also 21st for mortality (19,577 deaths) in 2018, accounting for 1.0% of new cases and 1.0% of deaths of all-site cancer deaths except NMSC [Ferlay et al., 2018]. Both incidence (88.4%) and mortality (90.0%) were higher in men. The incidence ASR per 100,000 was 7.8 in men and 0.9 in women, and the mortality ASR, 3.8 in men and 0.3 in women [Ferlay et al., 2018]. The estimated 5-year relative survival for 2000–2007 for adults >15 years was 60.0% in men and 61.0% in women [Istituto Superiore di Sanità, 2019].

In Spain, laryngeal cancer was the 20th most diagnosed cancer (2,689 new cases, 2,416 in men and 273 in women) in 2018, and 18th for mortality (1,273 deaths, 1,176 in men and 97 in women) from all sites except NMSC [Ferlay et al., 2018]. Thus, in Spain, laryngeal cancer accounted for 1.1% both of new cancer cases and all-site deaths, excluding NMSC. The estimated incidence ASR per 100,000 was 7.8 in men and 0.9 in women; the mortality ASR, 3.4 in men and 0.3 in women [Ferlay et al., 2018]. The annual trend for laryngeal cancer incidence ASR per 100,000 was to decrease in men (from 20.3 in the period 1993-1997 to 12.1 in 2015) and to increase in women (from 0.6 in the period 1993-1997 to 1.0 in 2015) [Galceran et al., 2017]. For spatial patterns in 2015, the estimated mortality ASR per 100,000 from laryngeal cancer in men varied from 10.0 in Soria to 1.9 in Ceuta, while in women it varied from 2.5 in Melilla to 0.0 in Zamora, Valladolid, Teruel, Tarragona, Soria, Palencia, Lugo, Jaen, Cuenca, Ciudad Real, Ceuta, Avila, Albacete and Corunna [National Centre for Epidemiology - ISCIII, 2021]. Estimated 5-year relative survival for adults >15 years old for 2000–2007 was 61.5% for men and 71.8 for women [Istituto Superiore di Sanità, 2019].

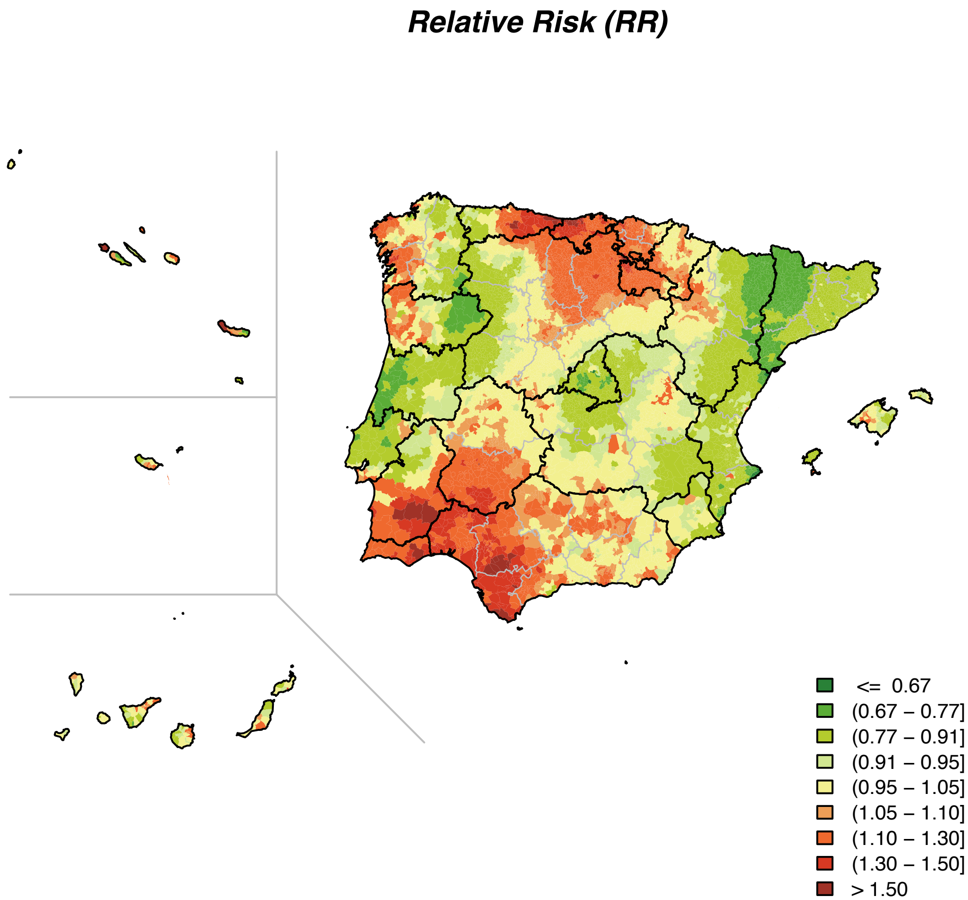
In Portugal, laryngeal cancer was 20th for incidence in 2018 (586 new cases, 543 in men and 43 in women) and 18th for mortality (340 deaths, 319 in men and 21 in women) [Ferlay et al., 2018]. Thus, laryngeal cancer contributed 1.1% of new cases and 1.2% of all-site deaths except NMSC. The estimated incidence ASR per 100,000 was 8.7 in men, and 0.4 in women; the mortality ASR, 4.8 in men and 0.2 in women [Ferlay et al., 2018]. Laryngeal cancer incidence in Portugal slightly increased from 2001 in both sexes. In 2001, 530 new cases were registered (513 in men and 17 in women) [IPO-Porto, 2008] and, in 2010, 626 (591 men and 35 women) [IPO-Porto, 2016]. In turn, the number of deaths was similar in 2002 (382) and 2010 (387) in both sexes. This similarity reflected a slight increase in men's deaths, and a slight decrease in women's deaths [INE-Portugal, 2019]. Finally, the estimated 5-year relative adult survival (>15 years) 2000–2007 was 47.1% in men and 59.2% in women [Istituto Superiore di Sanità, 2019].

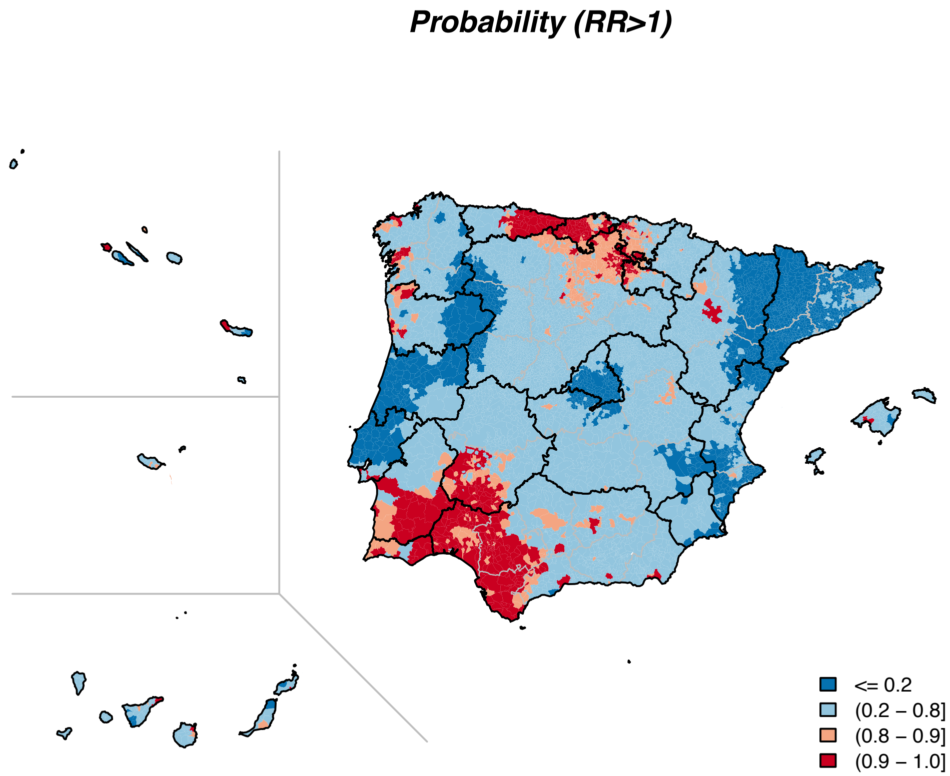
The results reported in this atlas show that during the period 2003-2012 there were 19,311 deaths due to laryngeal cancer (15,508 in Spain and 3,803 in Portugal), accounting for 1.6% of all cancer deaths except NMSC on the Iberian Peninsula, of which 18,372 were men and 939 women.

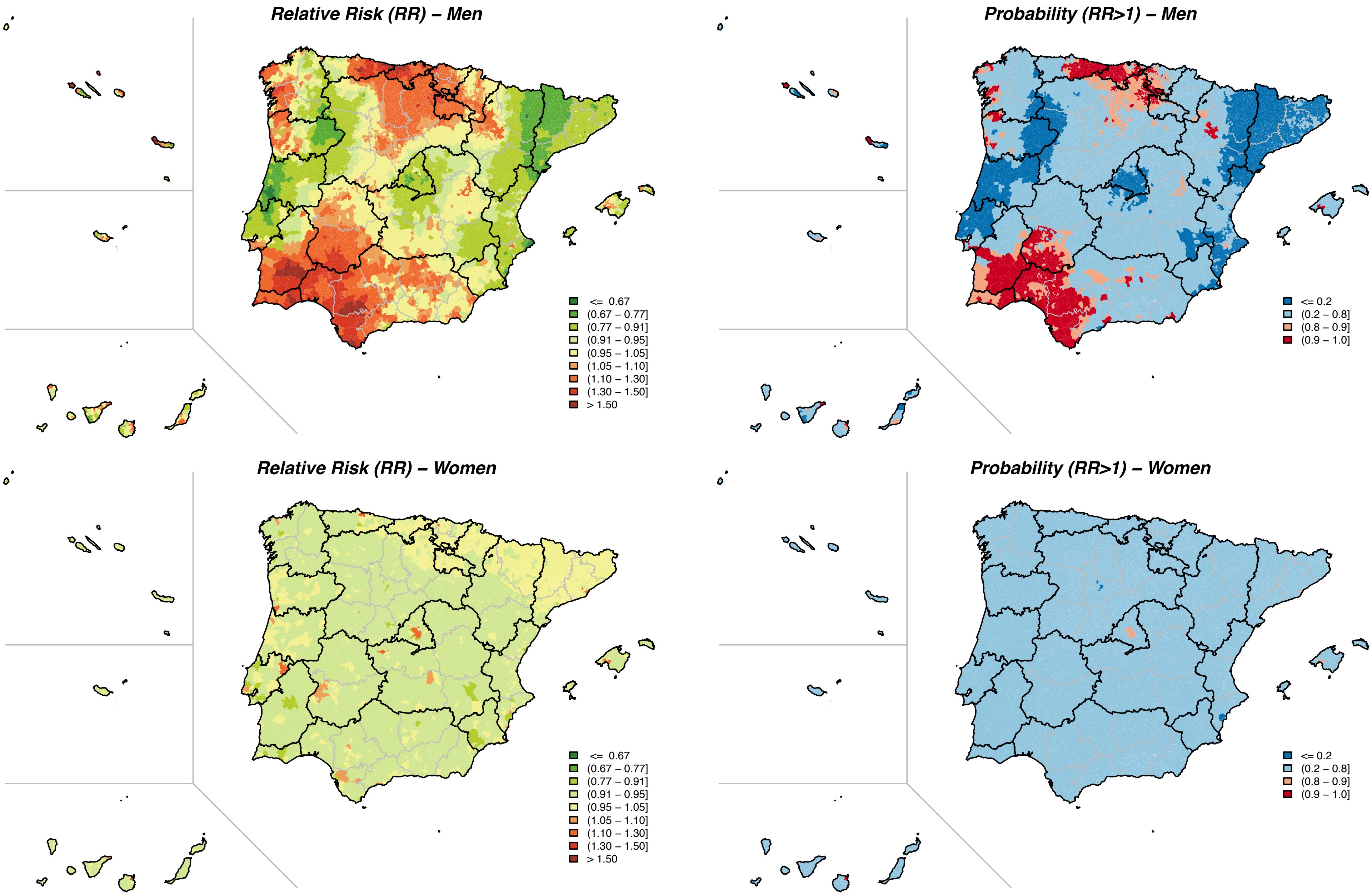
In the present atlas, in men, there are three areas with an excess of mortality risk: a) an area in the north of Spain, which includes eastern Asturias, Cantabria, the western parts of the Basque Country and La Rioja, the north of Castile & Leon, and some municipalities of Navarre and Aragon; b) a second located in western areas of Galicia and northwest of Portugal; and c) the most significant, an area in the southwest of the Iberian Peninsula, which includes the south of Extremadura, western Andalusia, and the south of Portugal, including the Algarve region and part of the Alentejo. In women, no pattern was observed, except an excess of risk in the municipality of Madrid, which may reflect an oversmoothing of the model as a consequence of the low number of deaths from this tumour in women.

Lower relative risk values (RR) also tend to cluster. The map highlights three areas in particular: a) a strip in Portugal that extends through LVT, Centro and the east of the Norte region, and continues into Spain – partially covering the provinces of Castile & Leon, Galicia and Asturias; b) a second cluster located in Madrid and part of Castile-La Mancha; and, c) a third area on the east coast of the peninsula, which covers Catalonia and the Valencian Region, and parts of Aragon and Castile-La Mancha.

The general pattern observed could be partly explained by tobacco and alcohol consumption, the main risk factors for laryngeal cancer [Olshan and Hashibe, 2018], as men smoke and drink more than women [Drope et al., 2018; WHO, 2018]. This would also explain the differences found between the sexes. Moreover, the existence of high RR-value clusters, specifically in the southwest of the Peninsula, points to the presence of environmental and/or occupational risk factors [Malhotra et al., 2018].


Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1)
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Men
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50
Probability (RR>1) – Men
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]
Relative Risk (RR) – Women
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50
Probability (RR>1) – Women
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

LUNG (ICD-10 C33–C34)

In 2018, lung cancer was the leading cause of cancer incidence and mortality worldwide, with 2,093,876 new cases and 1,761,007 deaths, corresponding to a 11.6% share of total cases and 18.4% of deaths from all cancers except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. Approximately 65% of new cases and 67% of deaths occur in men [Bray et al., 2018]. Asia is the continent with the highest share of lung cancer incidence (58.5%) and mortality (60.7%), followed by Europe (22.4% and 22.0%) [IARC, 2021a].

At the European level, lung cancer was the 3^{rd} most diagnosed cancer in 2018 (470,039 new cases) and was 1^{st} for mortality (387,913 deaths), accounting for 12.0% of new cases and 20.1% of all-site deaths except NMSC [Ferlay et al., 2018]. Both incidence (66.3%) and mortality (68.9%) were higher in men. The age-standardized rate (ASR) of incidence per 100,000 was 65.2 in men and 26.4 in women, with mortality ASRs of 55.0 in men and 19.1 in women [Ferlay et al., 2018]. The estimated 5-year relative survival for the period 2000–2007 was 11.7% in men and 15.6% in women [Istituto Superiore di Sanità, 2019].

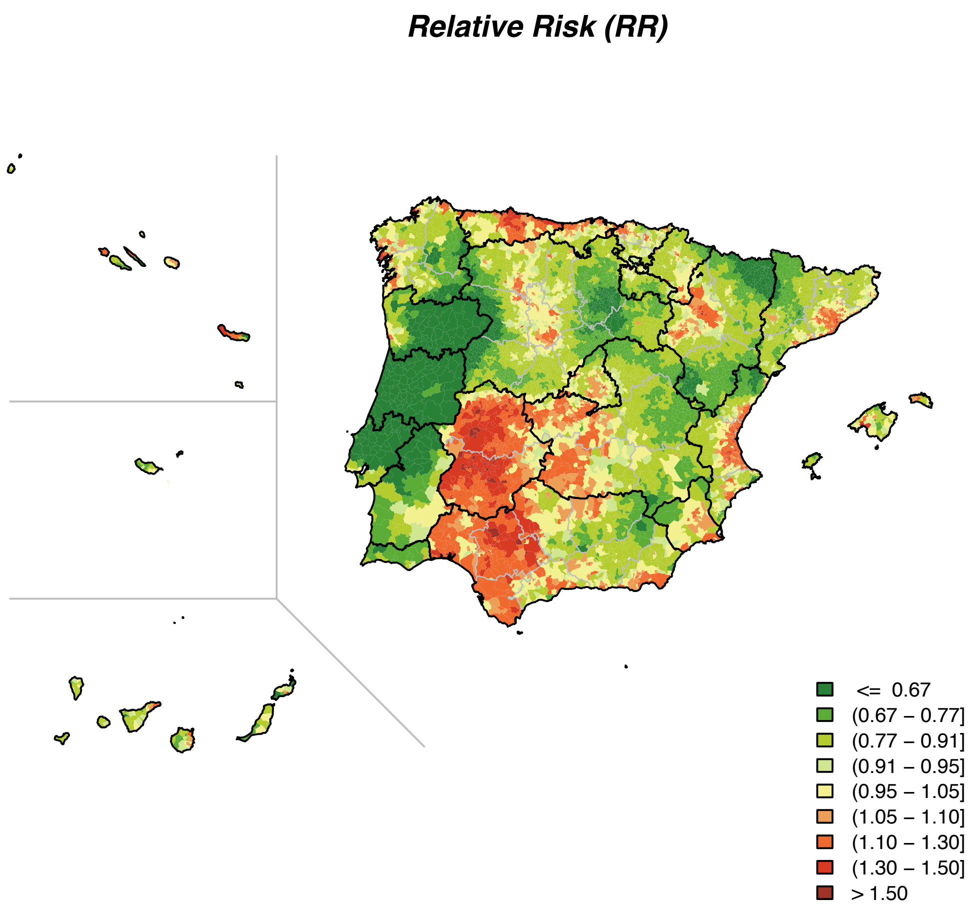
In Spain, lung cancer was the 4^{th} most diagnosed cancer in 2018 (20,437 new cases in men and 6,914 in women) and was responsible for more deaths than any other cancer (17,559 in men and 5,337 in women) [Ferlay et al., 2018]. Thus, lung cancer accounted for 11.0% new cases and 20.3% of all-site deaths except NMSC. The incidence ASR was 62.3 in men and 19.7 in women; the mortality ASR, 51.9 in men and 14.4 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for lung cancer incidence, a decrease in men was observed (from 81.5 in 1993-1997 to 74.1 in 2015) but with an increase in women (from 7.0 in 1993-1997 to 17.9 in 2015) [Galceran et al., 2017]. For the spatial patterns in 2015, the mortality ASR in men varied from 72.4 (Caceres) to 42.1 (Avila), while in women it varied from 20.8 (Guipuzcoa) to 6.4 (Avila) [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for 2000–2007 was 10.0% in men and 15.3% in women [Istituto Superiore di Sanità, 2019].

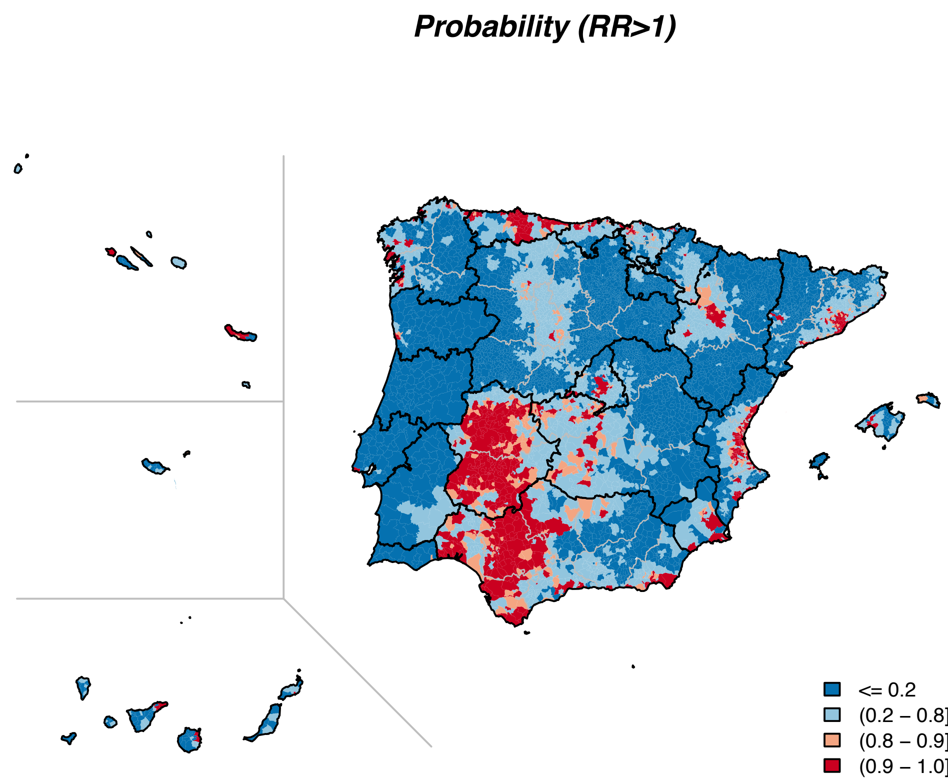
In Portugal, lung was the 4^{th} most diagnosed cancer in 2018 (3,998 new cases in men and 1,286 in women) and was 1^{st} for mortality (3,654 deaths in men and 1,017 in women) [Ferlay et al., 2018]. Thus, lung cancer contributed 9.5% of all new cases and 16.3% of all-sites deaths except NMSC. The incidence ASR was 55.2 in men and 13.8 in women; the mortality ASR, 49.1 in men and 10.4 in women [Ferlay et al., 2018]. Lung cancer incidence in Portugal has been increasing since 2001 for both sexes. In 2001, 2,385 new cases were registered (1,964 in men and 421 in women) [IPO-Porto, 2008] and, in 2010, 3,787 (2,915 men and 872 women) [IPO-Porto, 2016]. Deaths increased from 2002 (3,027) to 2010 (3,652) in both sexes. This increase was greater in women than in men [INE-Portugal, 2019]. Finally, the estimated 5-year relative survival for 2000–2007 was 9.9% in men and 18.1% in women [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that for the period 2003-2012 there were 234,323 deaths due to lung cancer (200,536 in Spain and 33,787 in Portugal), accounting for 18.9% of all cancer deaths except NMSC on the Iberian Peninsula – of which 197,798 were men and 36,525 women.

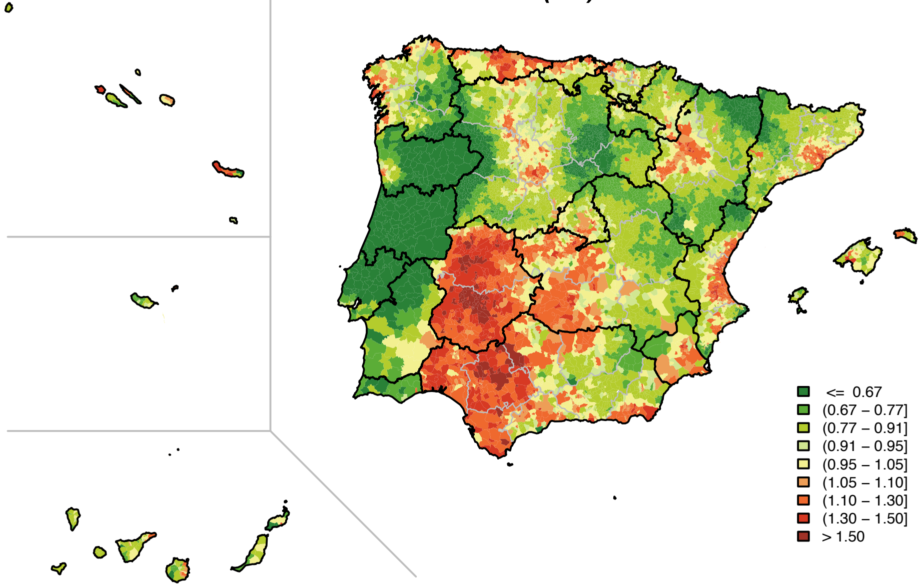
In this atlas, the highest relative risks (RRs) for lung cancer mortality tend to cluster in Spain, particularly in the region of Extremadura and in the western parts of Andalusia and Castile-La Mancha. Other smaller clusters were also identified in Asturias, Madrid, Aragon and along the Mediterranean coast. In contrast, in Portugal, large clusters of low RRs were found in the interior of the Norte region, in Centro and LVT, and in the north of Alentejo, extending into adjacent areas in eastern Galicia and the west of Castile & Leon. It should be noted that there was a very small cluster of high RRs in Porto (on the coast of the Norte region). RR distribution patterns were quite different in males and females; in men, they were very similar to the patterns described previously for both sexes; in women, in turn, they were characterized by a much lower occurrence of municipalities classified with extreme RRs (high or low), notably shown by a significant decrease in the low-RR cluster in Portugal, and the disappearance of the high-RR cluster in southwest Spain.

Generally, lung cancer is mainly attributed to tobacco smoking [Malhotra et al., 2018]. Thus, the spatial differences found between sexes may be partially explained by tobacco smoking, as more men smoke than women [Drope et al., 2018]. While lung cancer mortality has decreased in males, it is still increasing among females in many European countries due to changes in tobacco use patterns during the last few decades. Other established environmental risk factors for lung cancer include: exposure to second-hand tobacco smoke; occupational exposure; exposure to radiation; and exposure to indoor and outdoor air pollution [López-Abente et al., 2014b; Vineis and Fecht, 2018]. Potential associations with lung cancer include improper diet, alcohol consumption, and oestrogens; as well as infection with human papillomavirus, Human Immunodeficiency Virus and the Epstein-Barr virus. However, clear evidence to ascertain these relations is not yet available [Akhtar and Bansal, 2017]. Future preventive efforts and research need to focus on non-cigarette tobacco products, as well as establishing a better understanding of risk factors for lung carcinogenesis in those who have never smoked [Malhotra et al., 2016].

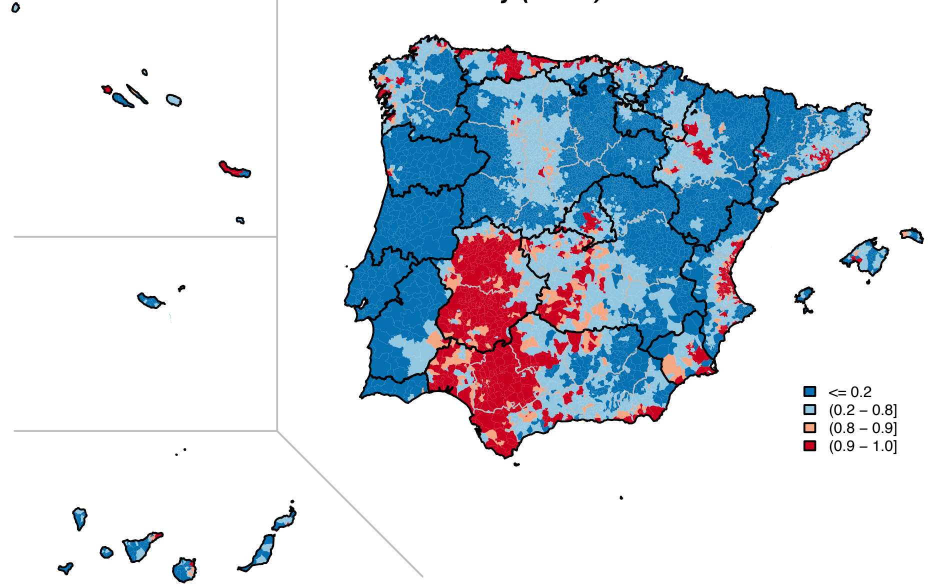

Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1)
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

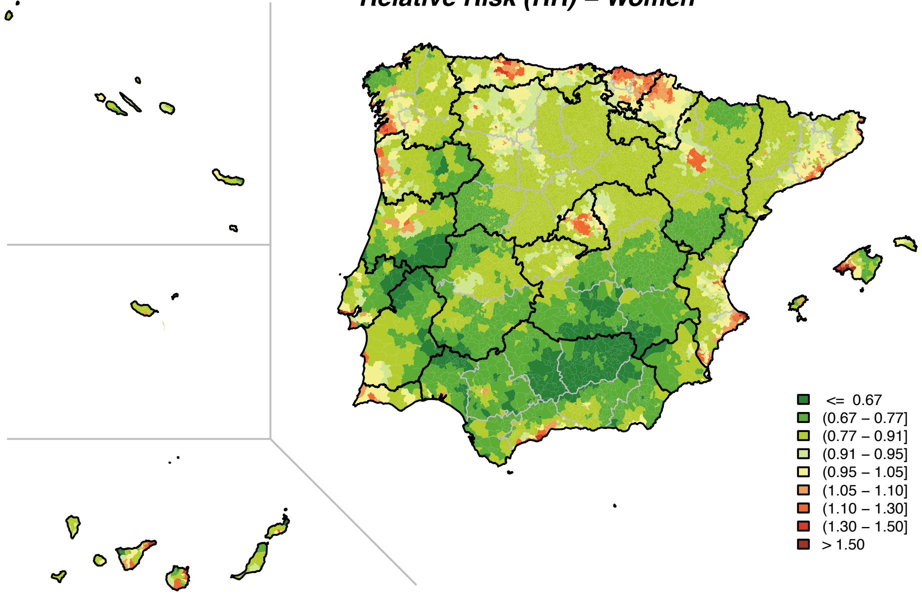
Relative Risk (RR) – Men



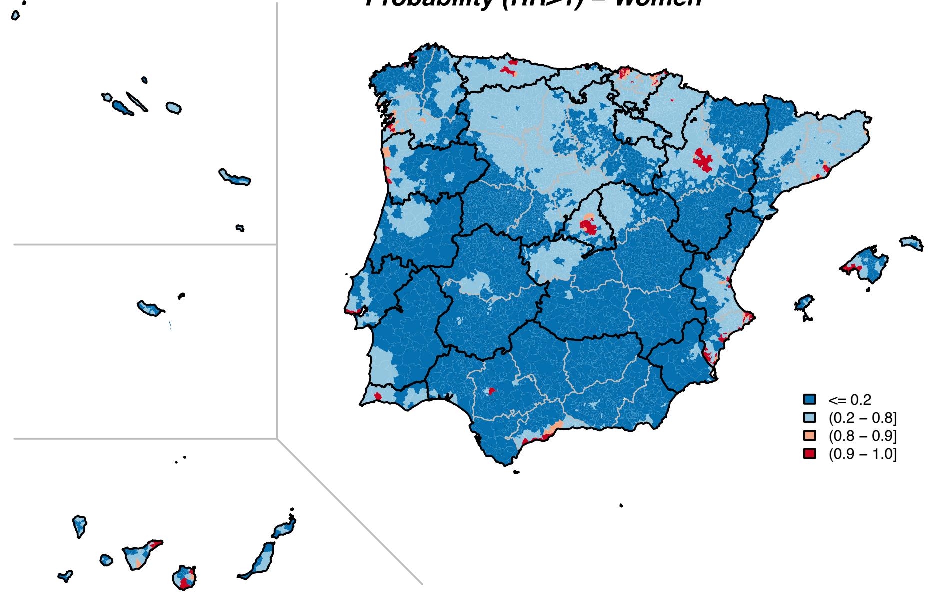
Probability (RR>1) – Men



Relative Risk (RR) – Women



Probability (RR>1) – Women



FEMALE BREAST (ICD-10 C50)

Worldwide, breast cancer was the most diagnosed cancer and largest contributor to cancer mortality in women (2,088,849 new cases and 626,679 deaths), corresponding to 25.4% of total cases and 15.1% of total deaths for all cancers except non-melanoma skin cancer (NMSC) in women [Bray et al., 2018]. Asia is the continent with the highest share of incidence (43.6%) and mortality (49.6%) for female breast cancer, followed by Europe (25.0% and 22.0%) [IARC, 2021a].

At the European level, breast cancer was the 1^{st} for both cancer incidence and mortality in women in 2018 (522,513 new cases and 137,707 deaths), accounting for 28.2% of new cases and 16.2% of all-site deaths except NMSC in women [Ferlay et al., 2018]. The age-standardized rate (ASR) of incidence per 100,000 was 100.9, and the mortality ASR, 21.8 [Ferlay et al., 2018]. The estimated 5-year relative survival for 2000–2007 for adults >15 years was 83.8% (95% CI: 83.6-83.9) [Istituto Superiore di Sanità, 2019].

For women in Spain, breast cancer was the 1^{st} for new cases in 2018 (32,825) and 2^{nd} for mortality (6,421 deaths), excluding NMSC [Ferlay et al., 2018]. Thus, breast cancer accounted for 30.8% new cases and 14.5% all-site deaths except NMSC in women. Estimated incidence ASR per 100,000 was 101.2, and the mortality ASR, 15.4 [Ferlay et al., 2018]. Regarding the annual trends for female breast cancer incidence ASR per 100,000, there was an increase found (from 80.1 in the period 1993-1997 to 88.3 in 2015) [Galceran et al., 2017]. For spatial patterns in 2015, the estimated mortality ASR per 100,000 for female breast cancer varied from 34.2 in Melilla to 6.4 in Ceuta [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for adults >15 years for 2000–2007 was 85.2% (95% CI: 84.5-85.8) [Istituto Superiore di Sanità, 2019].

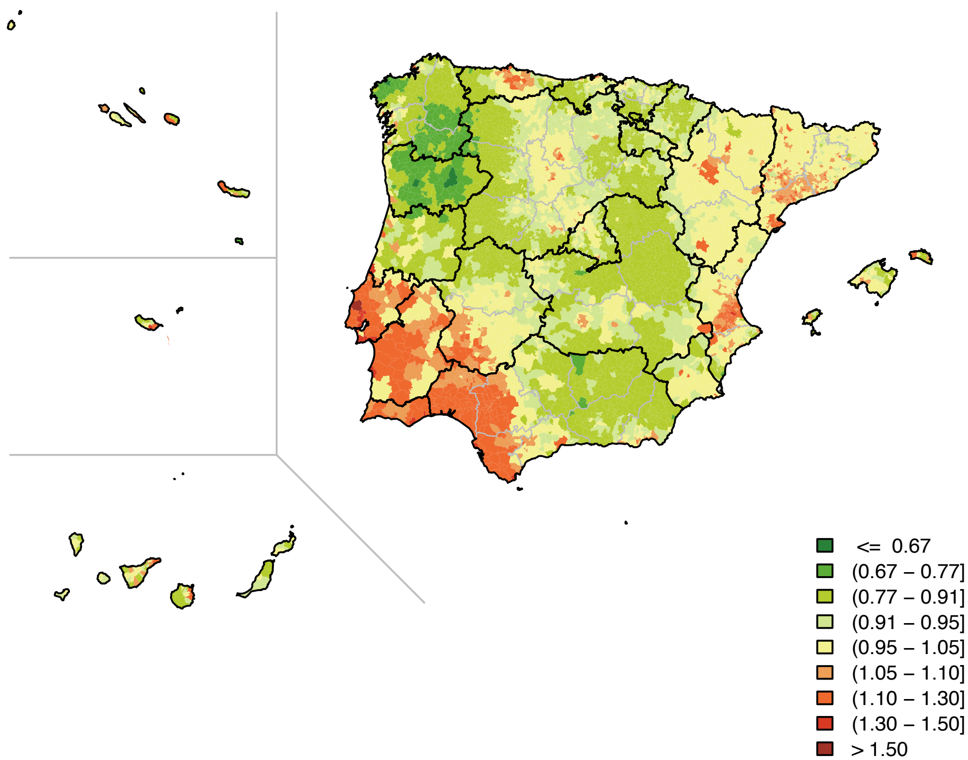
For women in Portugal, breast cancer was the most diagnosed cancer in 2018 (6,974 new cases) and was the 2^{nd} for mortality (1,748 deaths), for all sites except NMSC [Ferlay et al., 2018]. Thus, in women breast cancer contributed to 28.5% of new cases and 15.5% of all-site deaths except NMSC. Estimated incidence ASR per 100,000 was 94.0 and the mortality ASR, 16.6 [Ferlay et al., 2018]. Female breast cancer incidence in Portugal has been increasing since 2001. In 2001, 4,574 new cases were registered [IPO-Porto, 2008]; in 2010, 6,541 [IPO-Porto, 2016]. The number of deaths also increased between 2002 and 2010 (1,546 and 1,659, respectively) [INE-Portugal, 2019]. Finally, the estimated 5-year relative survival for adults >15 years for 2000–2007 was 84.4% (95% CI: 83.8-85.0) [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that there were 76,219 deaths due to female breast cancer in the period 2003-2012 (60,483 in Spain and 15,736 in Portugal), accounting for 6.2% of all cancer deaths except NMSC in the Iberian Peninsula.

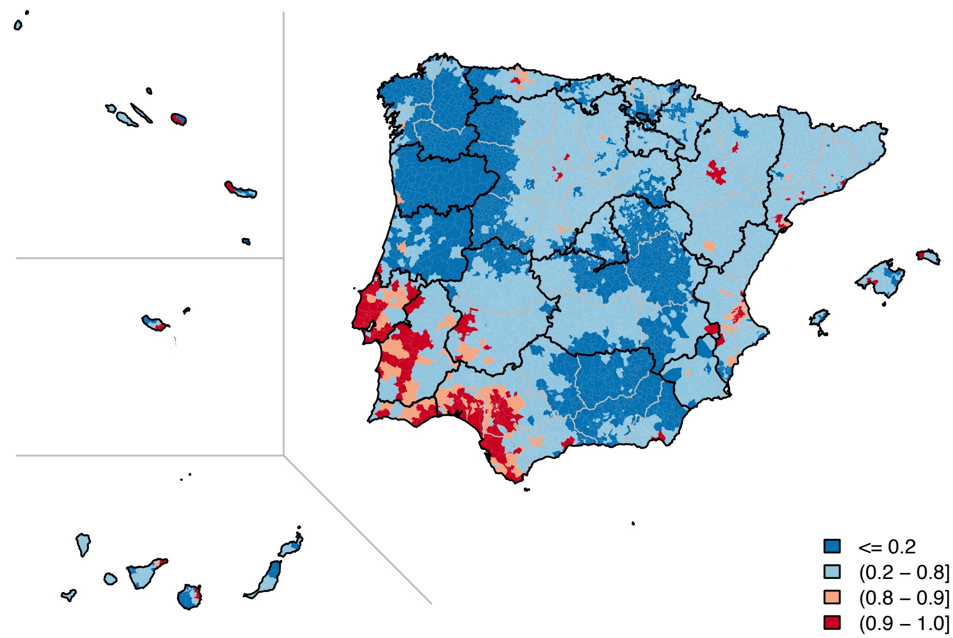
In this atlas, the clusters with high relative risk (RR) values for female breast cancer mortality tend to be located in the southwest of the peninsula, covering most of the LVT and Alentejo regions, and the Algarve in Portugal; and the west of Andalusia and the southwest part of Extremadura in Spain. In Spain, some smaller clusters of high RR values were identified, situated mainly in the regions of Asturias, Aragon, Catalonia and the Valencian Region. On the other hand, areas with lower RRs were found in the northwest of the Iberian Peninsula – the Norte region of Portugal and Galicia in Spain.

There are a variety of well-established risk factors for female breast cancer [Tamimi et al., 2018]. This cancer is associated with behavioural and genetic factors, such as age of menarche and menopause, age at first birth, hormonal contraceptives, and menopausal hormonal therapy. Other important factors include obesity, alcoholic beverage consumption and tobacco smoking [Brinton et al., 2018]. On the other hand, there is evidence for the protective role of physical activity and lactation. However, the patterns presented in this atlas seem to point to genetic or environmental risk factors rather than behavioural.

Relative Risk (RR)



Probability (RR>1)



PROSTATE (ICD-10 C61)

Globally, prostate was the 2^{nd} most commonly diagnosed cancer in men for 2018 (1,276,106 new cases) and the 5^{th} highest cause of cancer mortality (358,989 deaths) in men in 2018, which corresponds to 14.5% of total cases and 6.7% of all-site cancer deaths except non-melanoma skin cancer (NMSC) in men [Bray et al., 2018]. Europe is the continent with the highest share of global prostate cancer incidence (35.2%), followed by Asia (23.3%). For mortality, the order is inverted, with Asia having the highest share of mortality (33.0%), followed by Europe (29.9%) [IARC, 2021a].

At the European level, in 2018, prostate cancer was 1^{st} in incidence (449,761 new cases) and 3^{rd} mortality (107,315 deaths) in men, accounting for 21.8% of new cases and 10.0% of all-site deaths except NMSC in men [Ferlay et al., 2018]. The age-standardized rate (ASR) of incidence per 100,000 was 92.5, and the mortality ASR 19.4 [Ferlay et al., 2018]. The estimated 5-year relative survival for the period 2000–2007 for adults >15 years was 84.0% (95% CI: 83.8–84.2) [Istituto Superiore di Sanità, 2019].

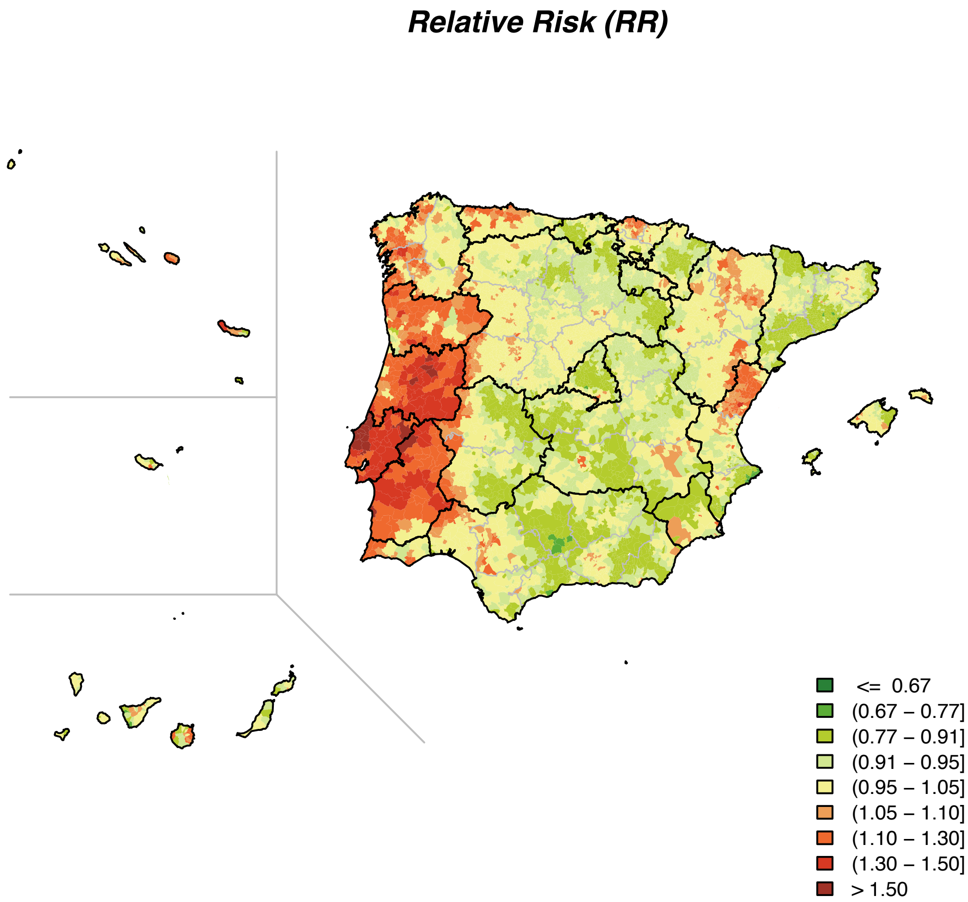
In Spain, prostate cancer was the most diagnosed cancer in men (31,728 new cases) during 2018 and was 3^{rd} for mortality (5,793 deaths), excluding NMSC [Ferlay et al., 2018]. Thus, in Spain, prostate cancer accounted for 22.3% of new cases and 8.5% of all-site deaths except NMSC in men. The estimated incidence ASR per 100,000 was 104.2, and the mortality ASR, 13.2 [Ferlay et al., 2018]. Regarding the annual trends for the prostate cancer incidence ASR per 100,000, this increased from 54.1 in the period 1993-1997 to 103.4 in 2015 [Galceran et al., 2017]. For the spatial patterns in 2015, estimated mortality ASR per 100,000 for prostate cancer varied from 21.5 in Badajoz to 8.9 in Teruel [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for adults >15 years for 2000–2007 was 84.4% (95% CI: 83.6-85.4) [Istituto Superiore di Sanità, 2019].

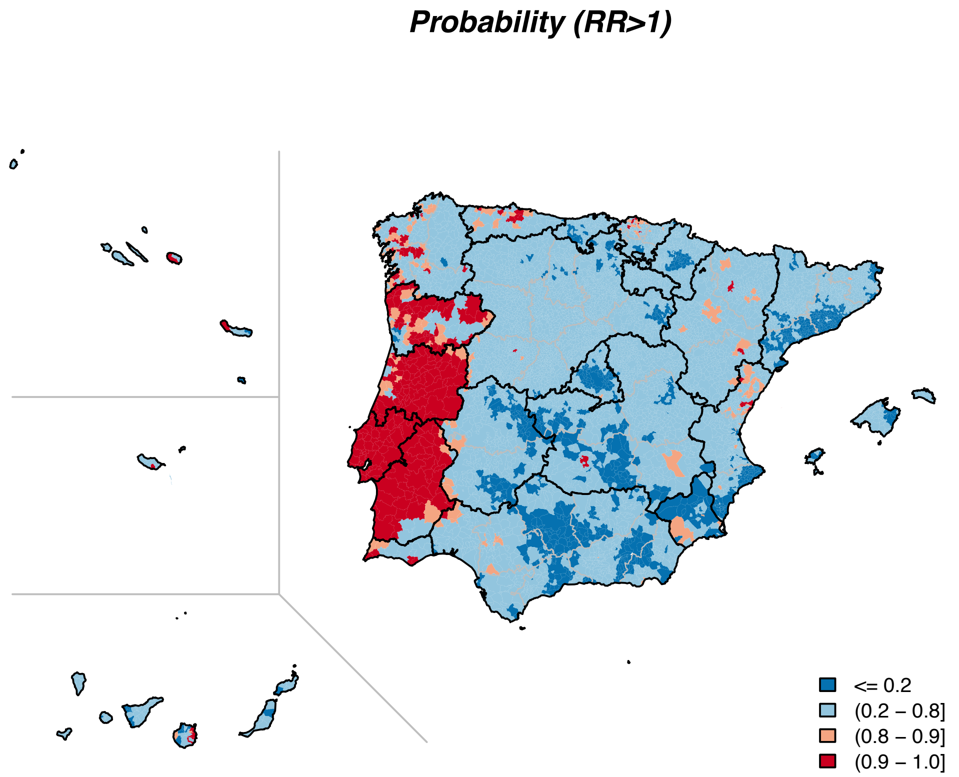
For men in Portugal, prostate was also the most diagnosed cancer (6,609 new cases) in 2018 and 3^{rd} for mortality (1,879 deaths) [Ferlay et al., 2018]. Thus, in men prostate cancer contributed 21.2% of new cases and 10.7% of all-site deaths except NMSC. Estimated incidence ASR per 100,000 was 87.7 and the mortality ASR, 18.9 [Ferlay et al., 2018]. Prostate cancer incidence in Portugal has been increasing since 2001. 3,895 new cases were registered in 2001 [IPO-Porto, 2008] and in 2010, 6,080 [IPO-Porto, 2016]. The number of deaths increased slightly between 2002 (1,701) and 2010 (1,783) [INE-Portugal, 2019]. Finally, the estimated 5-year relative survival for adults >15 years in 2000–2007 was 89.0% (95%CI: 88.3-89.8) [Istituto Superiore di Sanità, 2019].

The results reported in this atlas show that, during the period 2003–2012, there were 74,023 deaths due to prostate cancer (56,748 in Spain and 17,275 in Portugal), accounting for 6.0% of all cancer deaths on the Iberian Peninsula.

In the present atlas, there are clear differences in the distribution of the prostate cancer mortality relative risk (RR) values between Portugal and Spain. Portugal has high values across almost the entire territory. The exceptions are some municipalities in the Norte region and the coast of the Centro region, the south-eastern area of Alentejo, and most of the Algarve region. In contrast, there are few high-risk municipalities in Spain. The largest clusters are located in Galicia (showing some continuity with the areas of excess risk in Portugal), Asturias, Aragon, and the Valencian Region.

At present, the risk factors for prostate cancer are still not very well established. In fact, this is one of the few cancers for which the International Agency for Research on Cancer has not found evidence for a clear carcinogenic agent [IARC, 2021a]. However, family history and a number of genetic factors have been highlighted as well-evidenced risk factors for this cancer [Wilson and Mucci, 2018]. These could potentially explain the continuity of high RR values from Portugal through to Galicia. Other important risk factor is obesity, and some diet components have been suggested to be related to this tumour (mainly dairy products, calcium, meat and fat consumption) [Wilson and Mucci, 2018].


Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1)
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

BLADDER (ICD-10 C67)

Globally, bladder was the 10^{th} most diagnosed cancer in 2018 (549,393 new cases) and was 13^{th} for cancer mortality (199,922 deaths), corresponding to 3.2% of total cases and 2.1% of all-site cancer death except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. Approximately three-quarters of new cases and deaths occur in men [Bray et al., 2018]. Asia was the continent with the highest share of bladder cancer incidence (36.2%) and mortality (42.4%) followed by Europe (35.9% and 32.5%) [IARC, 2021a].

At the European level, bladder cancer ranked 5^{th} for new cases in 2018 (197,105) and 8^{th} for cancer deaths (64,966), accounting for 5.0% of new cases and 3.4% of all-site deaths [Ferlay et al., 2018]. Both incidence, 78.1%, and mortality, 75.9%, were higher in men. The age-standardized rate (ASR) of incidence per 100,000 was 30.9 in men and 6.5 in women; the mortality ASR, 9.2 in men and 1.9 in women [Ferlay et al., 2018]. 5-year relative survival for the period 2000–2007 for adults >15 years was 67.4% in men and 62.6% in women [Istituto Superiore di Sanità, 2019].

In Spain, bladder cancer was 5^{th} for new cases in 2018 (14,793 in men and 3,475 in women) and 6^{th} for cancer deaths (4,576 in men and 1,104 in women) [Ferlay et al., 2018]. Thus, bladder cancer accounted for 7.3% new cases and 5.0% all-site deaths. Incidence ASR was 42.2 in men and 8.3 in women; mortality ASR, 11.2 in men and 1.8 in women [Ferlay et al., 2018]. For the annual trends in incidence ASR, an increase in both men (from 50.3 in 1993-1997 to 55.7 in 2015) and women (from 5.5 in 1993-1997 to 9.0 in 2015) was observed [Galceran et al., 2017]. Focusing on spatial patterns in 2015, in men the estimated mortality ASR per 100,000 varied from 17.0 (Soria) to 7.4 (Avila), while in women it varied from 3.7 (Ceuta) to 0.0 (Melilla) [National Centre for Epidemiology - ISCIII, 2021]. The estimated 5-year relative survival for 2000–2007 was 68.5% in men and 66.8% in women [Istituto Superiore di Sanità, 2019].

In Portugal, bladder cancer had the 6^{th} highest incidence in 2018 (1,765 new cases in men and 575 in women) and was 8^{th} for mortality (819 deaths in men and 287 in women) [Ferlay et al., 2018]. Thus, bladder cancer contributed to 4.2% of all new cases and 3.9% of all-site deaths except NMSC. The incidence ASR was 22.2 in men and 4.9 in women; the mortality ASR, 9.1 in men and 1.9 in women [Ferlay et al., 2018]. The incidence in Portugal increased slightly from 2001 in both sexes. In 2001, 1,631 new cases were registered (1,254 in men and 377 in women) [IPO-Porto, 2008] and in 2010, 1,829 (1,412 men and 417 women) [IPO-Porto, 2016]. The number of deaths increased between 2002 and 2010 in both sexes (from 651 to 811). The percentage increment in number of deaths was similar for both men and women [INE-Portugal, 2019]. 5-year relative survival for 2000–2007 for adults >15 years was 71.6% in men and 72.2% in women [Istituto Superiore di Sanità, 2019].

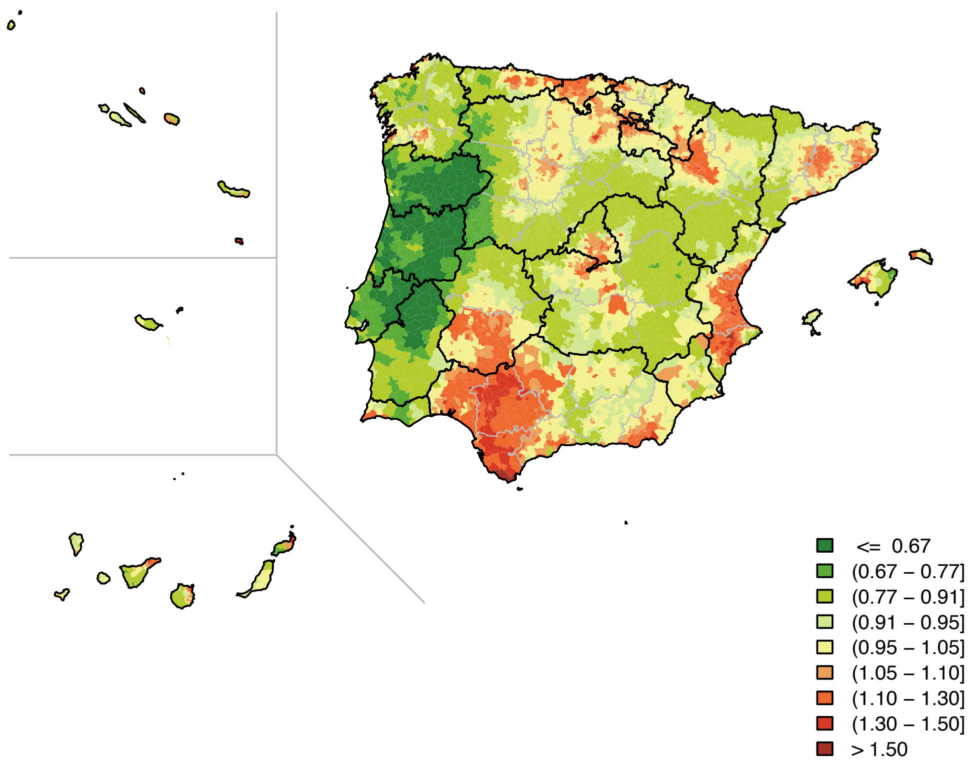
The results for the period 2003–2012 reported in this atlas show that there were 54,739 deaths due to bladder cancer (47,026 in Spain and 7,713 in Portugal), accounting for 4.4% of all cancer deaths except NMSC on the Iberian Peninsula, of which 44,337 were in men and 10,402 in women.

Relative risk (RR) for bladder cancer mortality shows contrasts between Portugal and Spain. High-value clusters occur in Spain, but hardly at all in Portugal. The largest is located in Andalusia, extending into Extremadura. The clusters in the Valencian Region, Catalonia, Aragon, La Rioja, Cantabria and Asturias are also noteworthy. The clusters in the latter four regions, although not actually contiguous, convey an overall image of continuity in the RR distribution pattern. In Portugal the existence of low-RR clusters in most municipalities across the territory stands out. Only a small cluster of high values was identified on the west coast of the Algarve.

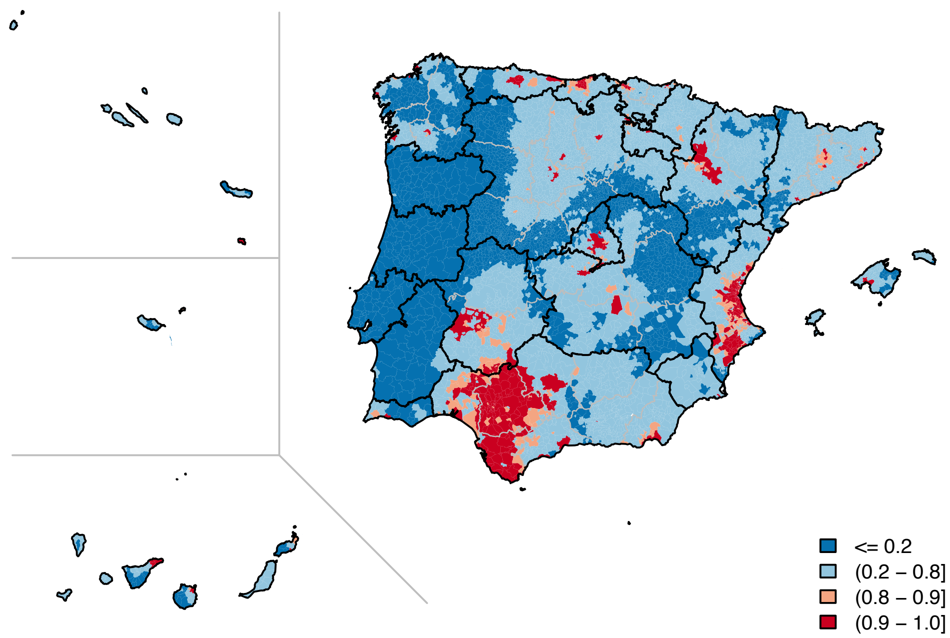
The most substantial differences in men – as compared to the results for the overall population – were the high-value clusters in Andalusia and Extremadura in Spain and, in Portugal, the low-value cluster in Alentejo which are larger on the men's map. In women, the geographic pattern was less marked, although as in men, an excess of risk was found in Cantabria and Asturias, as well as in some municipalities in the Valencian Region, southwest Andalusia, and the Balearic and Canary Islands. On the other hand, exclusively in women, there were regions with an excess of risk in certain coastal municipalities in Portugal, and the south and east of the Basque Country.

These results suggest the existence of differences (both geographically and by sex) in the distribution of the main risk factors for bladder cancer. The different patterns between women and men suggests that lifestyle and/or occupational factors may be found to be more significant than environmental exposure. Tobacco smoking is the most important known risk factor [Kogevinas et al., 2018]. When comparing the geographical pattern of bladder cancer with that of lung cancer, which is strongly linked to tobacco exposure, many similarities are evident, which is consistent with a critical role for tobacco smoking. However, there are also differences in the distribution of mortality risk between these two tumours, which may reflect the existence of occupational or environmental factors in certain regions that specifically affect lung and/or bladder cancer risk. Other potential risk factors that could be irregularly distributed among regions include occupational exposure, the ingestion of inorganic arsenic from drinking water or foods, and a diet low in fruit and vegetables.

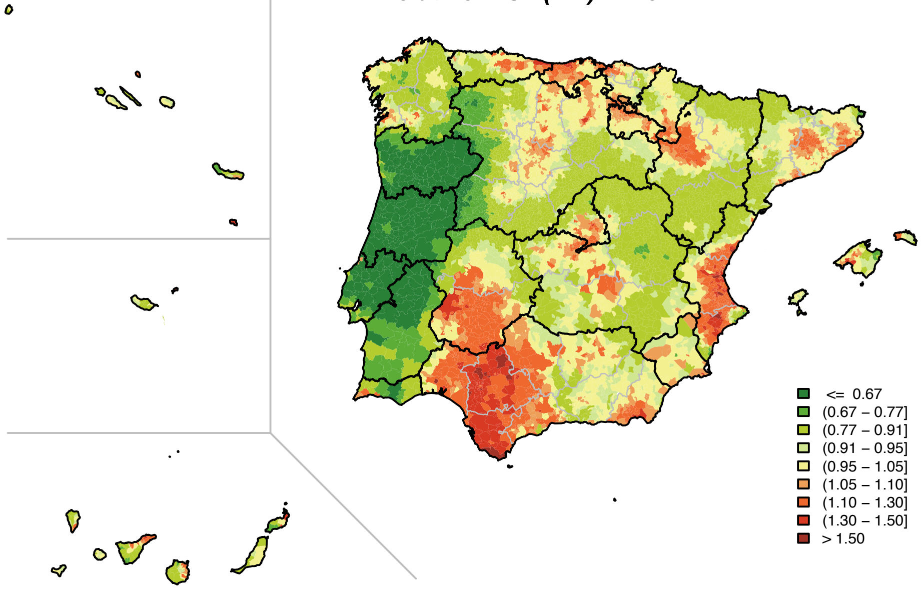
Relative Risk (RR)



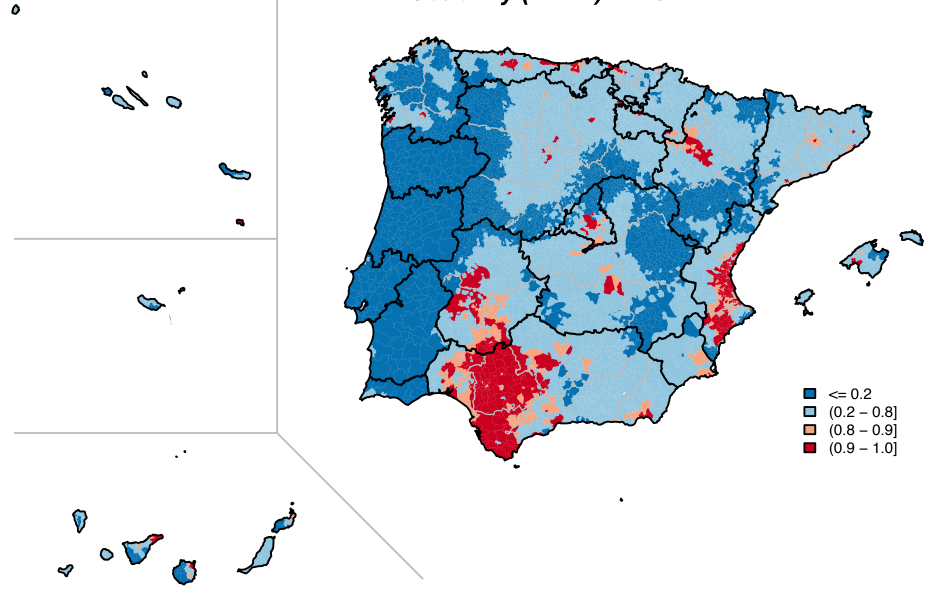
Probability (RR>1)



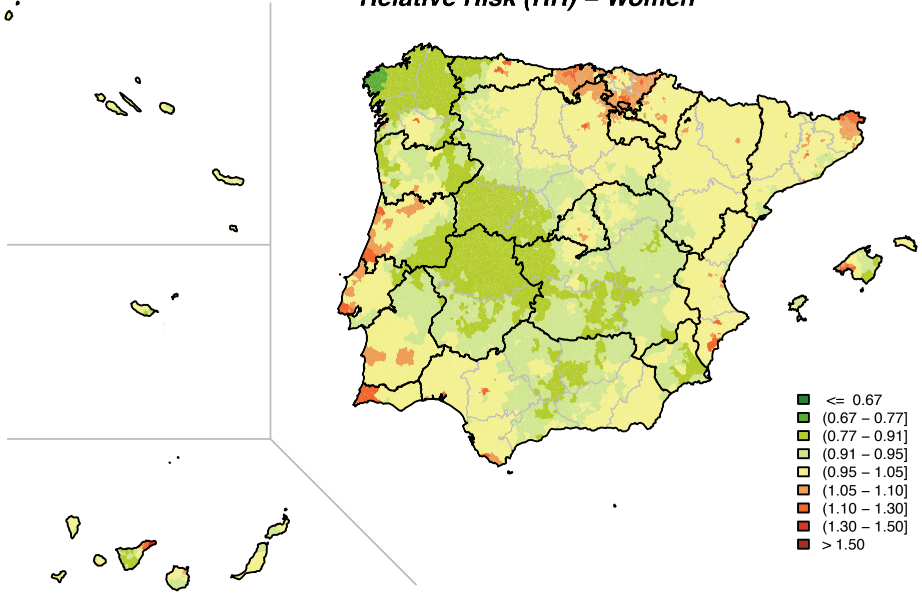
Relative Risk (RR) – Men



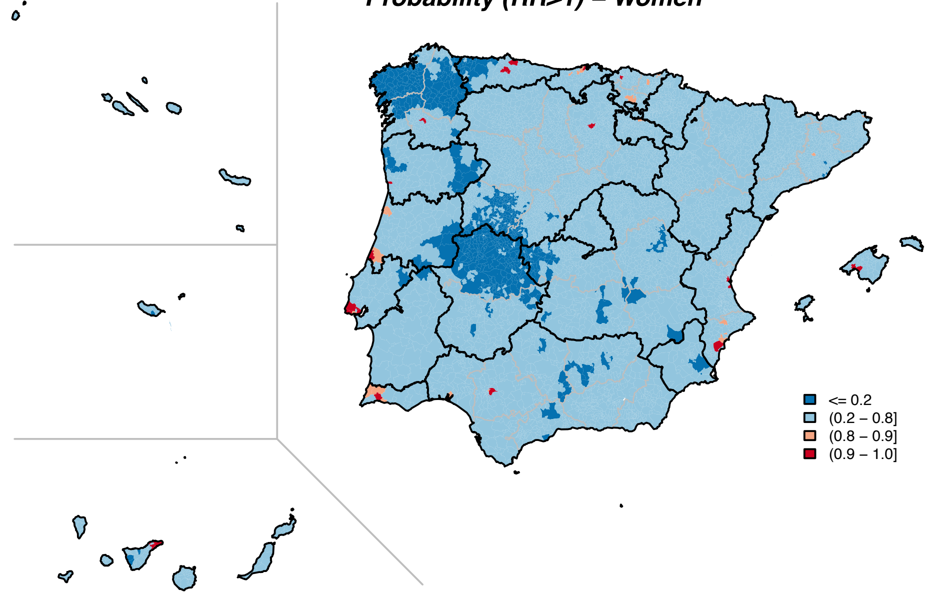
Probability (RR>1) – Men



Relative Risk (RR) – Women



Probability (RR>1) – Women



LEUKAEMIA (ICD-10 C91–C95)

LEUKAEMIA (ICD-10 C91–C95)

Globally, leukaemia was the 13^{th} most diagnosed cancer in 2018 (437,033 new cases) and was 10^{th} for mortality (309,006 deaths), corresponding to 2.6% of total cases and 3.3% of deaths from all cancers, except non-melanoma skin cancer (NMSC) [Bray et al., 2018]. A little more than half of the cases and deaths occur in men [Bray et al., 2018]. Again, Asia is the continent with the highest share of leukaemia incidence (48.7%) and mortality (53.7%), followed by Europe (21.7% and 19.9%) [IARC, 2021a].

At the European level, leukaemia was the 12^{th} most diagnosed cancer in 2018 (94,780 new cases) and was 9^{th} for mortality (61,476 deaths), accounting for 2.4% of new cases and 3.2% all-site deaths excluding NMSC [Ferlay et al., 2018]. Both incidence (56.2%) and mortality (55.4%) were higher in men. The incidence ASR per 100,000 was 11.7 in men and 7.4 in women, with a mortality ASR of 6.8 in men and 4.0 in women [Ferlay et al., 2018].

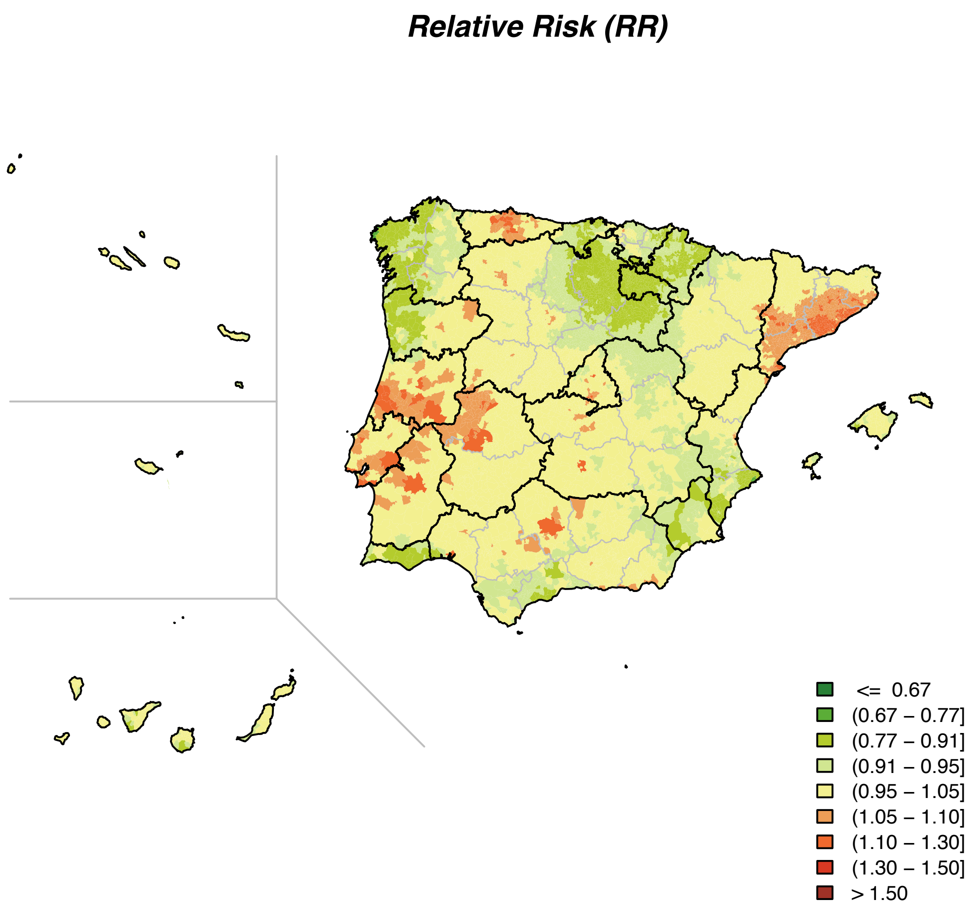
In Spain, leukaemia was the 12^{th} most diagnosed cancer in 2018 (5,839 new cases, 3,364 in men and 2,475 in women) and was 9^{th} for mortality (3,884 deaths, 2,199 in men and 1,685 in women), excluding NMSC [Ferlay et al., 2018]. Thus, leukaemia accounted for 2.3% of new cases and 3.4% of all-site deaths except NMSC. The estimated incidence ASR per 100,000 was 10.8 in men, and 6.8 in women; the mortality ASR, 6.1 in men and 3.5 in women [Ferlay et al., 2018]. Regarding the annual ASR trends for leukaemia incidence per 100,000, a slight decrease in men was found (from 13.1 in the period 1993-1997 to 12.6 in 2015) as well as in women (from 8.0 in the period 1993-1997 to 7.5 in 2015) [Galceran et al., 2017]. For spatial patterns in 2015, in men the estimated mortality ASR per 100,000 from leukaemia varied from 8.8 in Toledo to 1.6 in Soria, while in women it varied from 6.5 in Melilla to 0.0 in Ceuta [National Centre for Epidemiology - ISCIII, 2021].

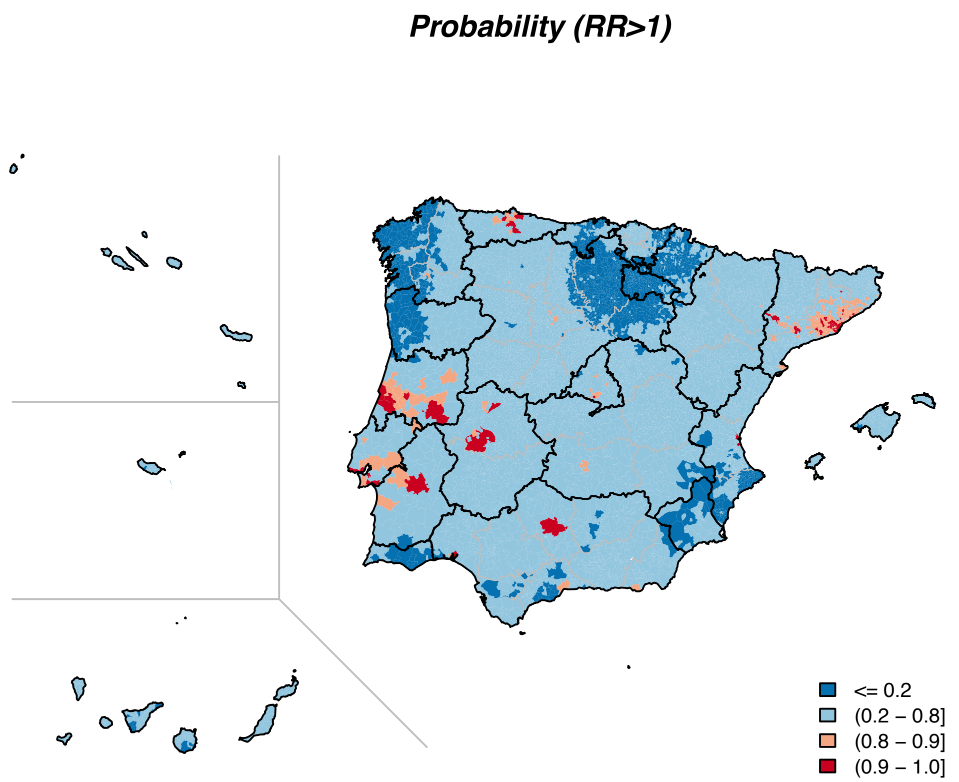
In Portugal, leukaemia was the 14^{th} most diagnosed cancer in 2018 (1,187 new cases, 706 in men and 481 in women) and was 11^{th} for mortality (955 deaths, 569 in men and 386 in women) [Ferlay et al., 2018]. Thus, leukaemia contributed to 2.1% of new cases and 3.3% of all-site deaths except NMSC. The estimated incidence ASR per 100,000 was 9.8 in men, and 5.5 in women; the mortality ASR, 7.0 in men and 3.5 in women [Ferlay et al., 2018]. The incidence of leukaemia in Portugal increased from 2001 on in both sexes – in 2001, 704 new cases were registered (402 in men and 302 in women) [IPOPorto, 2008] and in 2010, 785 were (447 men and 338 women) [IPO-Porto, 2016]. However, the number of deaths was similar in 2002 (762) and 2010 (793) for both sexes [INE-Portugal, 2019].

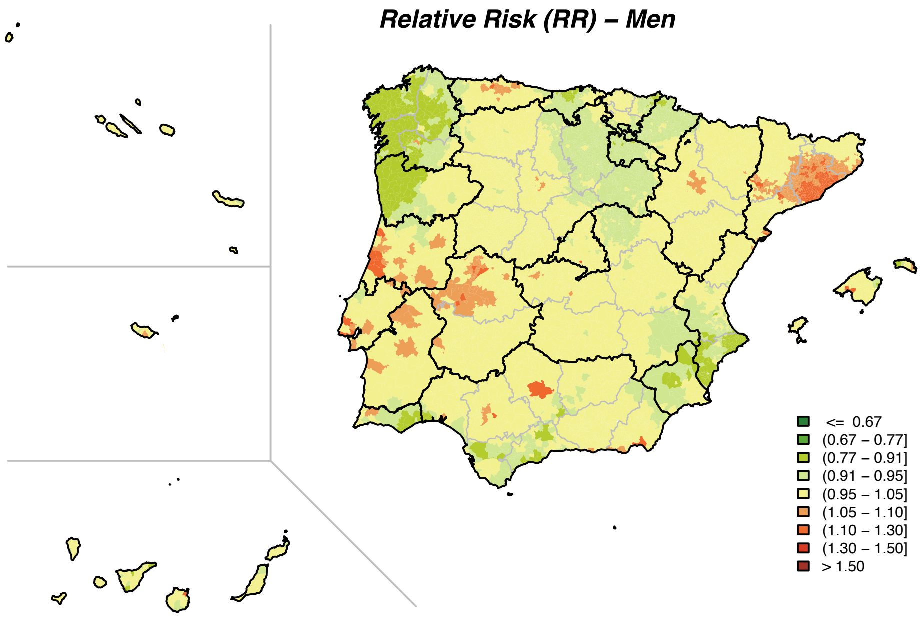
The results reported in this atlas show that there were 39,201 deaths due to leukaemia (31,643 in Spain and 7,558 in Portugal) in the period 2003-2012, accounting for 3.2% of all cancer deaths except NMSC on the Iberian Peninsula – of which 21,898 were in men and 17,303 in women.

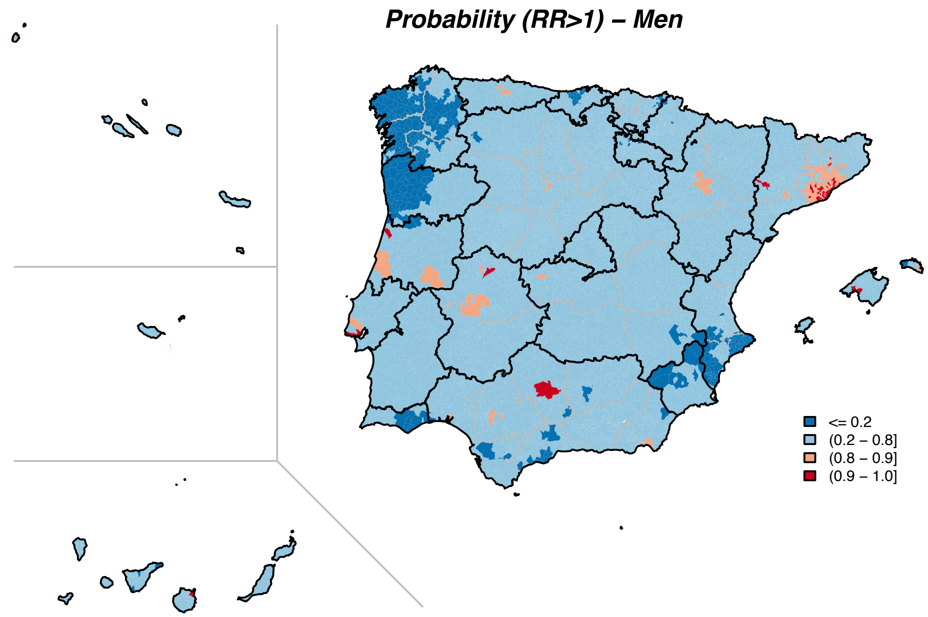
In this atlas, the relative risk of mortality due to leukaemia presents average values in most municipalities of the Iberian Peninsula. In Spain, clusters of high average values are observed in Catalonia, Asturias and Andalusia, although of reduced dimensions in the latter two regions. In Extremadura, there is also a cluster of high average values located in the northwest, extending into the Centro region of Portugal. In Portugal, there are a few more clusters with high average values, namely, in the LVT and Alentejo regions. These clusters are broader in women than in men.

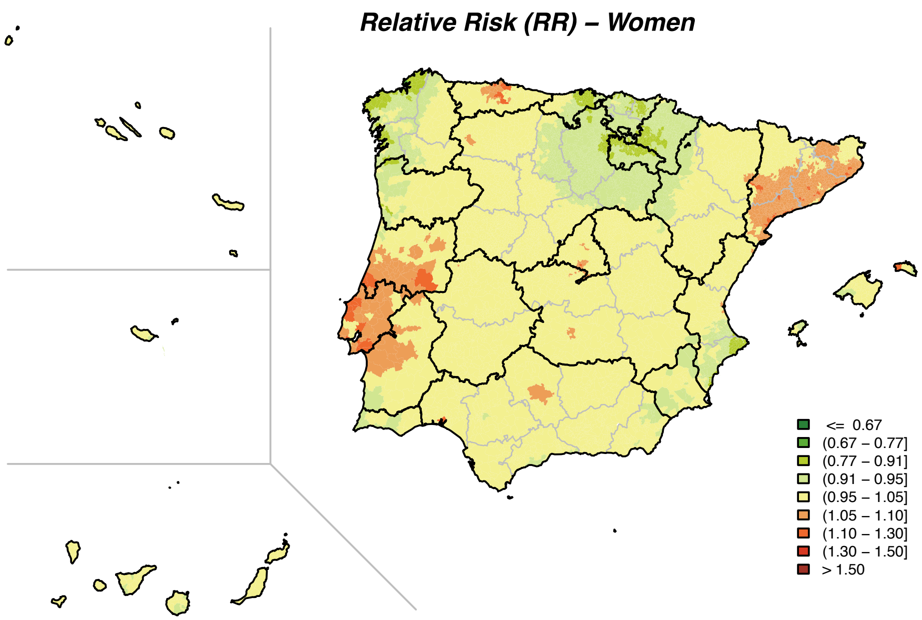
There is little and conflicting evidence for leukaemia risk factors. The primary reason for this is probably the variety of leukaemia subtypes. Nevertheless, genetics and environmental factors such as tobacco smoking, specific occupations and radiation are considered the most important [Roman et al., 2018]. Further research is needed to establish which of these might explain the patterns described in this atlas.

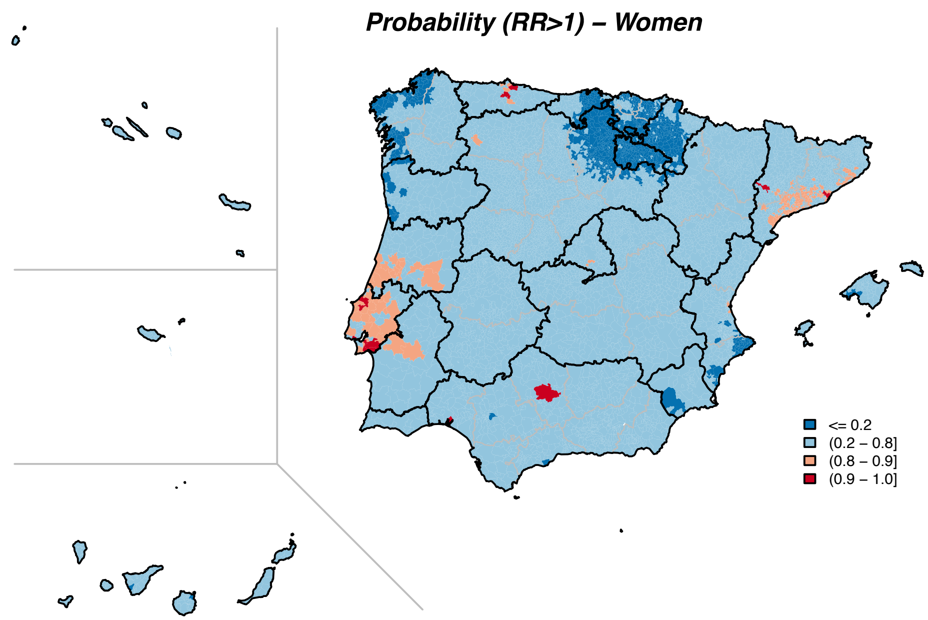

Relative Risk (RR)
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1)
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Men
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1) – Men
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]


Relative Risk (RR) – Women
<= 0.67
(0.67 – 0.77]
(0.77 – 0.91]
(0.91 – 0.95]
(0.95 – 1.05]
(1.05 – 1.10]
(1.10 – 1.30]
(1.30 – 1.50]
> 1.50


Probability (RR>1) – Women
<= 0.2
(0.2 – 0.8]
(0.8 – 0.9]
(0.9 – 1.0]

REFERENCES

REFERENCES

Abnet, C.C., Nyrén, O., Adami, H.-O., 2018. Esophageal cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 183–212.

Akhtar, N., Bansal, J.G., 2017. Risk factors of Lung Cancer in nonsmoker. Curr. Probl. Cancer 41, 328–339. https://doi.org/10.1016/j.currproblcancer.2017.07.002

Antwi, S.O., Jansen, R.J., Petersen, G.M., 2018. Cancer of the pancreas, in: Thun, M.J., Linet, M.S., Cerhan, J.R., Haiman, C.A., Schottenfeld, D. (Eds.), Schottenfeld and Fraumeni. Cancer Epidemiology and Prevention. Fourth Edition. Oxford University Press, Oxford, pp. 611–634.

Baltrus, P., Malhotra, K., Rust, G., Levine, R., Li, C., Gaglioti, A.H., 2019. Identifying County-Level All-Cause Mortality Rate Trajectories and Their Spatial Distribution Across the United States. Prev. Chronic. Dis. 16, 180486. https://doi.org/10.5888/pcd16.180486

Benetou, V., Ekbom, A., Mucci, L., 2018. Pancreatic cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 309–325.

Besag, J., York, J., Mollié, A., 1991. Bayesian image restoration, with two applications in spatial statistics. Ann. Inst. Stat. Math. 43, 1–20. https://doi.org/10.1007/BF00116466

Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R.L., Torre, L.A., Jemal, A., 2018. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA. Cancer J. Clin. 68, 394–424. https://doi.org/10.3322/caac.21492

Brinton, L.A., Gaudet, M.M., Gierach, G.L., 2018. Breast cancer, in: Thun, M.J., Linet, M.S., Cerhan, J.R., Haiman, C.A., Schotenfeld, D. (Eds.), Schottenfeld and Fraumeni. Cancer Epidemiology and Prevention. Fourth Edition. Oxford University Press, Oxford, pp. 861–888.

Cayolla da Mota, L., Marinho Falcão, J., 1987. Atlas do cancro em Portugal: 1980-1982. Lisboa: Ministério da Saúde.

Cayolla da Mota, L., Marinho Falcão, J., 1997. 2º Atlas da Mortalidade por Cancro em Portugal 1990-1992. Lisboa, Direcção Geral da Saúde e Escola Nacional de Saúde Pública (UNL).

Drope, J., Schluger, N., Cahn, Z., Drope, J., Hamill, S., Islami, F., Liber, A., Nargis, N., Stoklosa, M., 2018. The tobbaco atlas. Sixth edition. Atlanta: American Cancer Society and Vital Strategie. https://tobaccoatlas.org/wp-content/uploads/2018/03/TobaccoAtlas_6thEdition_LoRes_Rev0318.pdf

Ferlay, J., Colombet, M., Soerjomataram, I., Dyba, T., Randi, G., Bettio, M., Gavin, A., Visser, O., Bray, F., 2018. Cancer incidence and mortality patterns in Europe: Estimates for 40 countries and 25 major cancers in 2018. Eur. J. Cancer Oxf. Engl. 1990 103, 356–387. https://doi.org/10.1016/j.ejca.2018.07.005

Fong, Y., Rue, H., Wakefield, J., 2010. Bayesian inference for generalized linear mixed models. Biostatistics 11, 397–412. https://doi.org/10.1093/biostatistics/kxp053

Galceran, J., Ameijide, A., Carulla, M., Mateos, A., Quirós, J.R., Rojas, D., Alemán, A., Torrella, A., Chico, M., Vicente, M., Díaz, J.M., Larrañaga, N., Marcos-Gragera, R., Sánchez, M.J., Perucha, J., Franch, P., Navarro, C., Ardanaz, E., Bigorra, J., Rodrigo, P., Bonet, R.P., REDECAN Working Group, 2017. Cancer incidence in Spain, 2015. Clin. Transl. Oncol. Off. Publ. Fed. Span. Oncol. Soc. Natl. Cancer Inst. Mex. 19, 799–825. https://doi.org/10.1007/s12094-016-1607-9

IARC, 2008. Atlas of Cancer Mortality in the European Union and the European Economic Area, 1993-1997. Edited by Boyle P, Smans M. IARC Scientific Publication No. 159. https://publications.iarc.fr/Book-And-Report-Series/Iarc-Scientific-Publications/Atlas-Of-Cancer-Mortality-In-The-European-Union-And-The-European-Economic-Area-1993-1997-2008

IARC, 2021a. Global Cancer Observatory: Cancer Today. Lyon, France. http://gco.iarc.fr/

IARC, 2021b. Global Cancer Observatory: Cancer causes. Lyon, France: International Agency for Research on Cancer. http://gco.iarc.fr/

IARC, 2021c. List of Classifications by cancer site. https://monographs.iarc.fr/wp-content/uploads/2019/07/Classifications_by_cancer_site.pdf

INE-Portugal, 2019. Statistics Portugal. https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008461&contexto=bd&%20selTab=tab2,%20accessed%208/3/2019&xlang=en

IPO-Porto, 2016. Registo Oncológico Nacional 2010. https://ipoporto.pt/wpsite_2020/wp-content/uploads/2013/03/ro_nacional_2010.pdf

IPO-Porto, 2008. Registo Oncológico Nacional 2001. https://ipoporto.pt/wpsite_2020/wp-content/uploads/2013/03/roreno_nacional_2001.pdf

Istituto Superiore di Sanità, 2019. EUROCARE-5. https://w3.iss.it/site/EU5Results/forms/SA0007.aspx

Jemal, A., Torre, L., Soerjomataram, I., Bray, F., 2020. The Cancer Atlas, 3rd ed. American Cancer Society.

Kogevinas, M., Figueroa, J., Garcia-Closas, M., Mucci, L., 2018. Urinary bladder cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 543–569.

López-Abente, G., Escolar, A., Errezola, M., 1984. Atlas del cáncer en España. Gráficas Santamaría, S.A. I.S.B.N.: 84-398-2658-3.

López-Abente, G., Aragonés, N., García-Pérez, J., Fernández- Navarro, P., 2014a. Disease mapping and spatio-temporal analysis: importance of expected-case computation criteria. Geospatial Health 9, 27. https://doi.org/10.4081/gh.2014.3

López-Abente, G., Aragonés, N., Pérez-Gómez, B., Pollán, M., García-Pérez, J., Ramis, R., Fernández-Navarro, P., 2014b. Time trends in municipal distribution patterns of cancer mortality in Spain. BMC Cancer 14, 535. https://doi.org/10.1186/1471-2407-14-535

López-Abente, G., Ramis, R., Pollán, M., Aragonés, N., Pérez-Gómez, B., Gómez-Barroso, D., Carrasco, J.M., Lope, V., García-Pérez, J., Boldo, E., García-Mendizábal, M.J., 2006. Atlas municipal de mortalidad por cáncer en España, 1989-1998. Instituto de Salud Carlos III, Madrid.

Malhotra, J., Boffetta, P., Mucci, L., 2018. Cancer of the lung, larynx, and pleura, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 327–353.

Malhotra, J., Malvezzi, M., Negri, E., La Vecchia, C., Boffetta, P., 2016. Risk factors for lung cancer worldwide. Eur. Respir. J. 48, 889–902. https://doi.org/10.1183/13993003.00359-2016

Marí-Dell'Olmo, M., Gotsens, M., Palència, L., Rodríguez-Sanz, M., Martinez-Beneito, M.A., Ballesta, M., Calvo, M., Cirera, L., Daponte, A., Domínguez-Berjón, F., Gandarillas, A., Goñi, N.I., Martos, C., Moreno-Iribas, C., Nolasco, A., Salmerón, D., Taracido, M., Borrell, C., 2016. Trends in socioeconomic inequalities in mortality in small areas of 33 Spanish cities. BMC Public Health 16, 663. https://doi.org/10.1186/s12889-016-3190-y

Marley, A.R., Nan, H., 2016. Epidemiology of colorectal cancer. Int. J. Mol. Epidemiol. Genet. 7, 105–114.

National Centre for Epidemiology - ISCIII, 2021. Interactive Epidemiological Information System (ARIADNA). http://ariadna.cne.isciii.es/

Olshan AF, Hashibe M, 2018. Cancer of the larynx, in: Thun, M.J., Linet, M.S., Cerhan, J.R., Haiman, C.A., Schottenfeld, D. (Eds.), Schottenfeld and Fraumeni. Cancer Epidemiology and Prevention. Fourth Edition. Oxford University Press, Oxford, pp. 505–517.

Pickle, L.W., Mungiole, M., Jones, G.K., White, A.A., 1996. Atlas of United States mortality. U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICE. Public Health Service, Centers for Disease Control and Prevention, National Center for Health Statistics. https://www.cdc.gov/nchs/data/misc/atlasmet.pdf

Roman, E., Smith, A., Mucci, L., 2018. Leukemias, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 673–690.

Rue, H., Martino, S., Chopin, N., 2009. Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations. J. R. Stat. Soc. Ser. B Stat. Methodol. 71, 319–392. https://doi.org/10.1111/j.1467-9868.2008.00700.x

Tamimi, R., Hankinson, S., Lagiou, P., 2018. Breast cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 381–419.

Vineis, P., Fecht, D., 2018. Environment, cancer and inequalities—The urgent need for prevention. Eur. J. Cancer 103, 317–326. https://doi.org/10.1016/j.ejca.2018.04.018

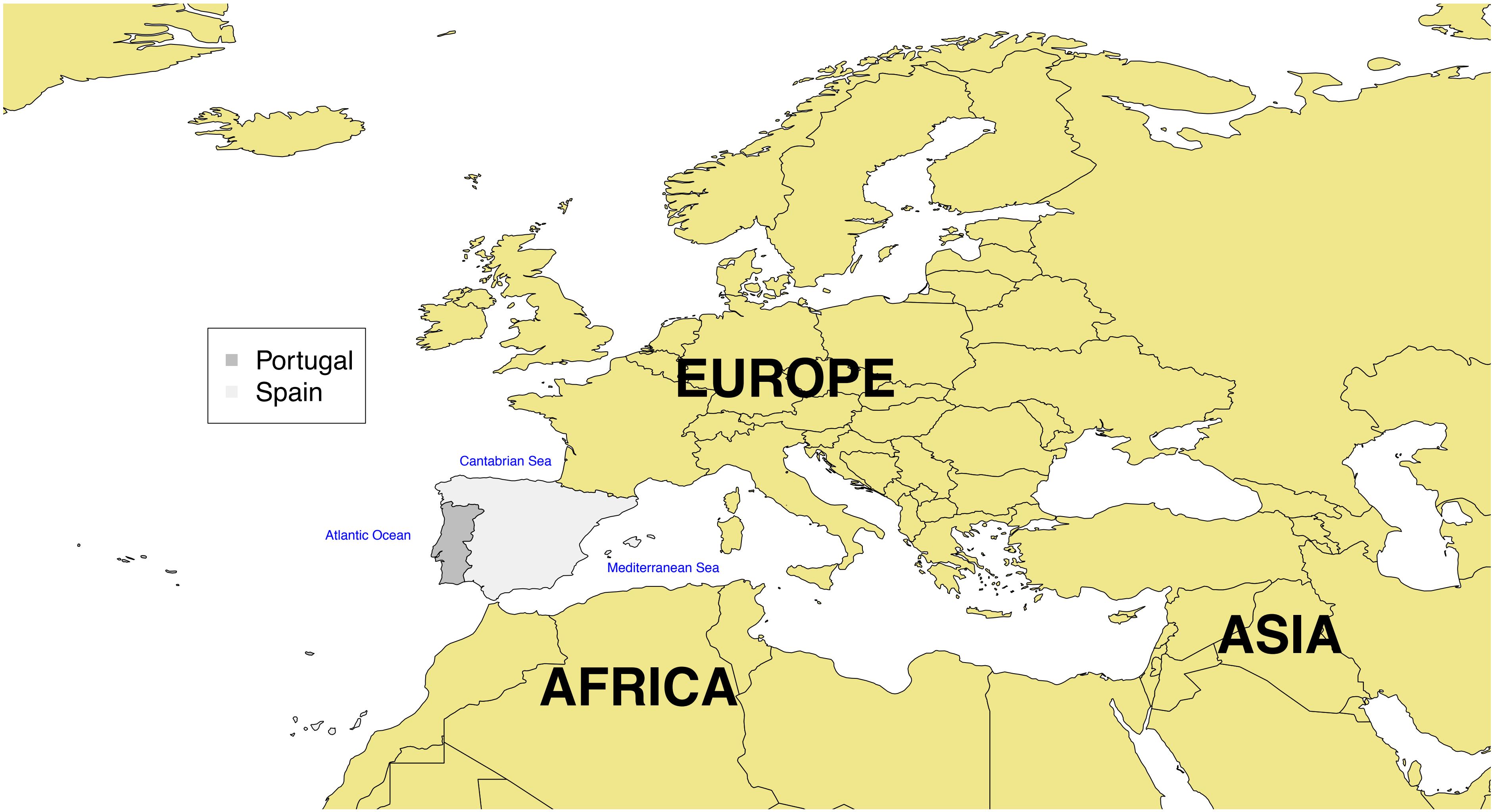
WHO, 2018. Global status report on alcohol and health 2018. https://www.who.int/publications/i/item/9789241565639

Wilson, K.M., Mucci, L., 2018. Prostate cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Third Edition. Oxford University Press, pp. 481–523.

Ye, W., Nyrén, O., Adami, H.-O., 2018. Stomach cancer, in: Adami, H.-O., Hunter, D.J., Lagiou, P., Mucci, L. (Eds.), Textbook of Cancer Epidemiology. Oxford University Press, pp. 213–242.

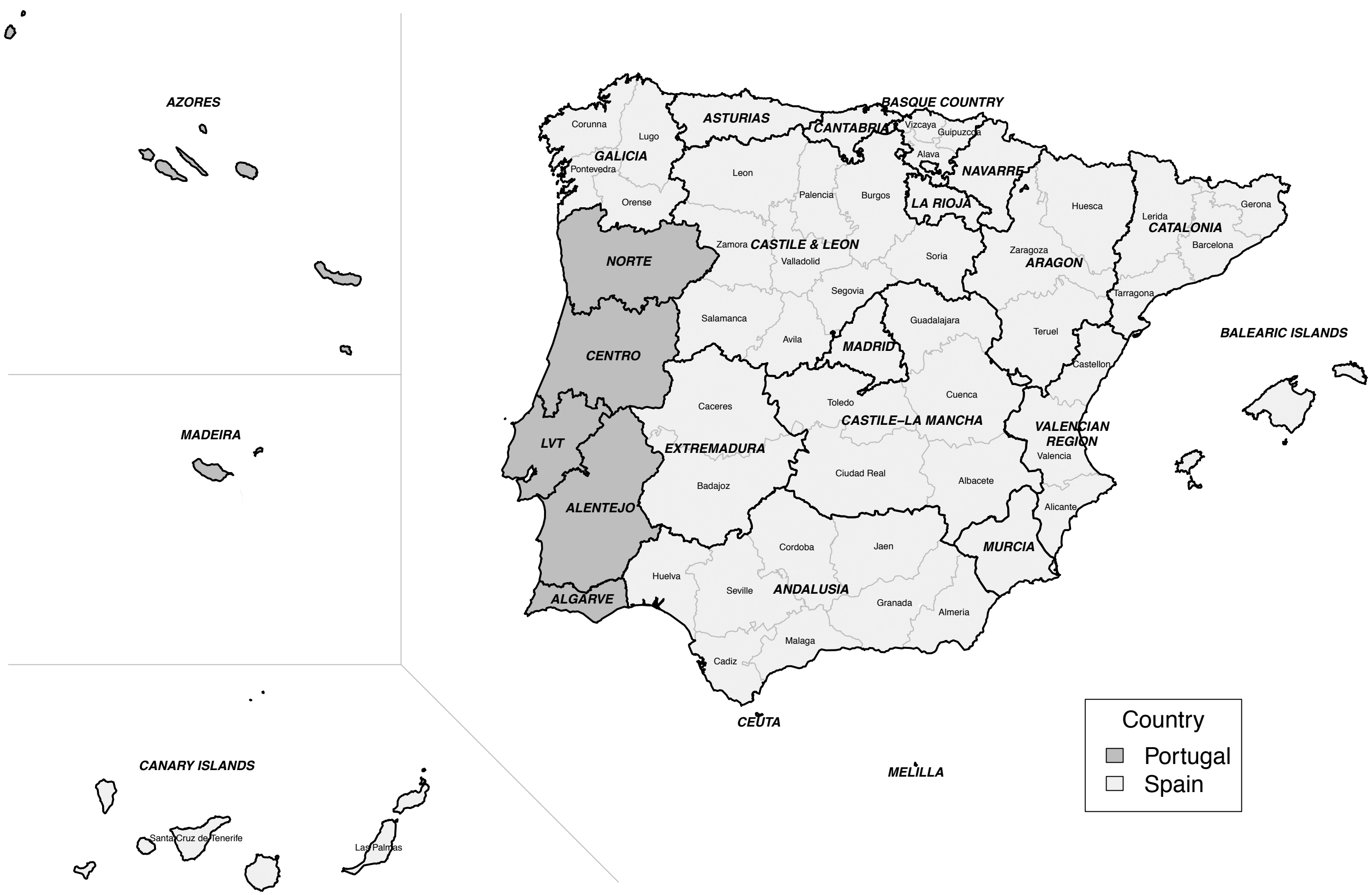
ANNEXES: ANNEX I AND ANNEX II

ANNEX I



Portugal
Spain
Cantabrian Sea
Atlantic Ocean
Mediterranean Sea
EUROPE
AFRICA
ASIA

ANNEX II


AZORES
MADEIRA
CANARY ISLANDS
Santa Cruz de Tenerife
Las Palmas
Corunna
Lugo
GALICIA
Pontevedra
Orense
ASTURIAS
CANTABRIA
BASQUE COUNTRY
Vizcaya
Guipuzcoa
Alava
NAVARRE
LA RIOJA
Leon
Palencia
Burgos
Zamora
CASTILE & LEON
Valladolid
Soria
Segovia
Salamanca
Avila
NORTE
CENTRO
LVT
ALENTEJO
ALGARVE
MADRID
Guadalajara
Huesca
Lerida
CATALONIA
Gerona
Barcelona
Zaragoza
ARAGON
Tarragona
Teruel
Castellon
BALEARIC ISLANDS
Caceres
EXTREMADURA
Badajoz
Toledo
Cuenca
CASTILE–LA MANCHA
Ciudad Real
Albacete
VALENCIAN REGION
Valencia
Alicante
MURCIA
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Almeria
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