

Cancer incidence predictions in the North of Portugal: keeping population-based cancer registration up to date

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Decision making towards cancer prevention and control requires monitoring of trends in cancer incidence and accurate estimation of its burden in different settings. We aimed to estimate the number of incident cases in northern Portugal for 2015 and 2020 (all cancers except nonmelanoma skin and for the 15 most frequent tumours). Cancer cases diagnosed in 1994–2009 were collected by the North Region Cancer Registry of Portugal (RORENO) and corresponding population figures were obtained from Statistics Portugal. JoinPoint regression was used to analyse incidence trends. Population projections until 2020 were derived by RORENO. Predictions were performed using the Poisson regression models proposed by Dyba and Hakulinen. The number of incident cases is expected to increase by 18.7% in 2015 and by 37.6% in 2020, with lower increments among men than among women. For most cancers considered, the number of cases will keep rising up to 2020, although decreasing trends of age-standardized rates are expected for some tumours. Cervix was the only cancer with a decreasing number of incident cases in the entire period. Thyroid and lung cancers were among those with the steepest increases in the number of incident cases

expected for 2020, especially among women. In 2020, the top five cancers are expected to account for 82 and 62% of all cases diagnosed in men and women, respectively. This study contributes to a broader understanding of cancer burden in the north of Portugal and provides the basis for keeping population-based incidence estimates up to date. *European Journal of Cancer Prevention* 25:472–480 Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.

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Introduction

Cancer is a leading cause of morbidity and mortality worldwide, with ~14 million new cases and 8.2 million cancer-related deaths estimated in 2012 (Ferlay *et al.*, 2013a). Moreover, by 2020, the number of incident cases is expected to increase by over 20%, with over 17 million people being diagnosed with cancer that year. In Portugal, as in Europe as a whole, this increase is expected to be more modest (~9–10%), although large differences are expected according to the cancer site and geographical region.

Decision making in the context of cancer prevention and control efforts requires monitoring of trends in cancer incidence and accurate estimation of its burden. Projections taking into account the expected demographic changes in the population provide up-to-date results that overcome the inherent delay between the moment events occur and the time data become available for annual reporting (Ferlay *et al.*, 2013b).

The International Agency for Research on Cancer has published incidence and mortality predictions for countries in Europe since the 1980s (Parkin *et al.*, 1993; Pisani *et al.*, 1993). However, given the heterogeneity between, as well as within, countries, it is useful to provide more detailed information on cancer for specific regions, because prevention and control efforts may have to reflect the differences between populations from specific geographical regions within nations. The North Region Cancer Registry of Portugal (RORENO) is a population-based cancer registry that covers ~3.2 million people who live in the five districts constituting northern Portugal (Braga, Bragança, Porto, Viana do Castelo and Vila Real). It was established in 1988 on a legal framework (government decree 35/88 of January 16th) and publishes annual reports on cancer incidence and mortality/incidence ratios in the region; survival data have also been published in local and international studies such as EURO CARE-5 and CONCORD-2. Apart from the initial years of operation, in which completeness of registration is expected to be lower, the functioning and resources involved in cancer registration in the region have been fairly stable. Currently, the last year of available data is 2009. That year, the 15 most frequent cancers

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in the north of Portugal comprised over 80% of the total number of diagnosed cases in the region (RORENO, 2015). This study aimed to analyse incidence trends and to estimate the number of cases in northern Portugal for 2015 and 2020, for all cancers except nonmelanoma skin and for the 15 most frequent tumours in the region.

Methods

We analysed data referring to the cancer cases diagnosed between 1994 and 2009 in the north of Portugal, for the 15 most frequent tumours in the region in 2009, considering the number of cases in both sexes together and all cancers except nonmelanoma skin. The cancers/groups of cancer [10th edition of the International Classification of Diseases (World Health Organization, 1992)] individually considered were oesophagus (C15), stomach (C16), colorectum (C18–C21), pancreas (C25), lung (C33–C34), melanoma of the skin (C43), female breast (C50), cervix uteri (C53), corpus uteri (C54), prostate (C61), kidney (C64), bladder (C67), brain and central nervous system (C70–C72), thyroid (C73) and non-Hodgkin lymphoma (C82–C85, C96).

Cancer data were retrieved from RORENO, by year of diagnosis, sex and 5-year age groups. Corresponding population figures were obtained from Statistics Portugal.

Sex-specific incidence rates were computed for each 5-year age group and calendar period, and age-standardized rates were calculated by the direct method, using the European standard population for all ages. Poisson regression analysis was performed using JoinPoint software (SEER, Bethesda, Maryland, USA) to identify significant changes in incidence trends (allowing up to two joinpoints and fixing four as the minimum number of observations from a joinpoint to either end of the data). For each of the segments obtained in the best model, the estimated annual percent change (APC) was computed by fitting a regression line to the natural logarithm of the rates using calendar year as a regressor variable.

We used 3-year moving averages to represent sex-specific incidence trends in the number of cases and age-standardized incidence rates (ASIR) for each cancer site.

Predicted numbers of cases for the years 2015 and 2020 were derived using the linear (for increasing or stabilizing trends) or log-linear (for decreasing trends) Poisson regression models proposed by Dyba and Hakulinen (2000) and Hakulinen and Dyba (1994). In these models, incidence data by age group (0–34, 35–44, 45–54, 55–64, 65–74, 75–84 and ≥ 85 years) over the most recent time period identified by sex-specific and site-specific joinpoint models were used.

For prostate cancer, an alternative scenario was considered (please see footnote of Supplemental Fig. 1, Supplemental digital content 1, <http://links.lww.com/EJCP/A24>), assuming a pattern of variation in incidence rates similar to the one that was observed in other settings

(Center *et al.*, 2012; Fontes *et al.*, 2013), where a steep increase due to prostate-specific antigen screening was followed by a decline and again a continued increase in rates in the most recent years.

Among women, an alternative scenario was considered for thyroid cancer (please see footnote of Supplemental Fig. 2, Supplemental digital content 2, <http://links.lww.com/EJCP/A25>), following the pattern observed in the USA (Li *et al.*, 2013; Davies and Welch, 2014), where rates are as high as in the north of Portugal, some of the highest in the world, and a marked but steady increase has been observed since the early/mid 1990s, with no steeper increase afterwards.

Age-specific numbers of cancer cases, ASIR and corresponding 95% prediction intervals were computed for 2015 and 2020 using the population predictions performed by RORENO; the latter were calculated assuming a constant fertility rate and modelling migration rates to accommodate the known population figures up to 2012 (central scenario). Two additional population projections were calculated, by assuming either an increasing (higher population growth scenario) or a decreasing (lower population growth scenario) fertility rate in the region, to include the ‘central’ prediction in a range of possible variability.

The RiskDiff (Valls *et al.*, 2009) tool was used to split the expected variation in the number of cases in 2009–2020 between changes in risk and in demography (population size and structure).

Statistical analyses were performed using Stata v.12 (StataCorp, 2011).

Results

For all cancers except nonmelanoma skin, a non-significant variation was observed in male incidence trends since 2005 (APC = 1.0), whereas there was a significant increase in women since 2000 (APC = 3.4) (Table 1). The number of incident cases registered is expected to increase, as compared with 2009, by 18.7% (13.3–24.0%) in 2015 and by 37.6% (29.2–45.9%) in 2020, with smaller increments in men. For 2020, over 20 000 new cancer cases are expected in the region (men: $n = 10\,236$, ASIR = 500.8/100 000; women: $n = 9820$, ASIR = 422.4/100 000) (Fig. 1 and Table 2). The net changes in the number of cases between 2009 and 2020 were 2819 (35.6%) and 3092 (46.4%) cases, respectively, for men and women, which can be partitioned into 1822 (23.0%) and 2478 (37.2%) cases due to an increment in risk, and to 997 (12.6%) and 614 (9.2%) due to the changes in the population structure and size (Fig. 2).

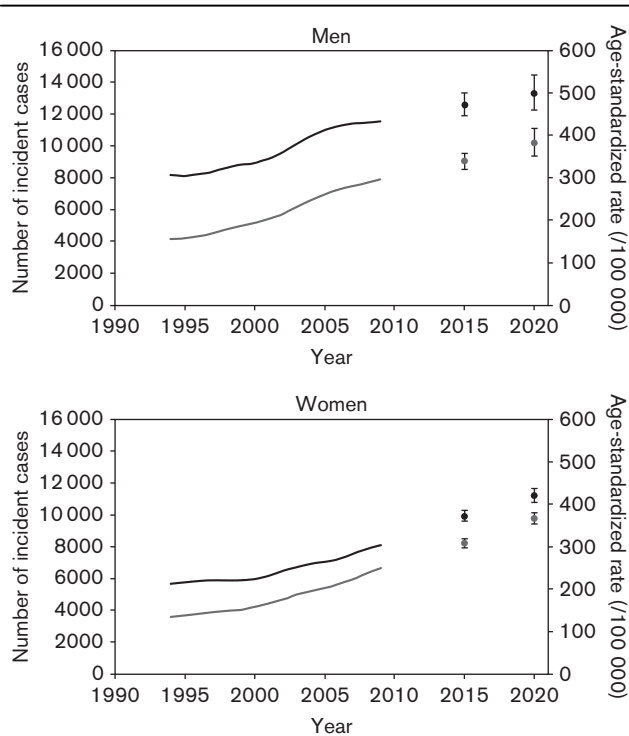
In the most recent years, statistically significant increases in ASIR were found for all cancer sites, except the

Table 1 Annual percent change and 95% confidence intervals in age-standardized (all ages, direct method, European standard population) incidence rates in the periods identified by jointpoint analysis, by cancer site and by sex, in 1994–2009

Cancer site (ICD-10)	Men					Women				
	Period 1	APC (95% CI)	Period 2	APC (95% CI)	Period 3	APC (95% CI)	Period 1	APC (95% CI)	Period 2	APC (95% CI)
All cancers (except skin nonmelanoma)	1994–2001	1.8 (1.1–2.4)	2001–2005	5.2 (3.1–7.3)	2005–2009	1.0 (–0.1 to 2.1)	1994–2000	0.8 (–0.4 to 2.1)	2000–2009	3.4 (2.9–4.0)
Oesophagus (C15)	1994–2009	0.6 (–0.8 to 1.9)					1994–2009	–2.7 (–4.7 to –0.6)		
Stomach (C16)	1994–2009	–1.2 (–1.6 to –0.9)					1994–2009	–1.6 (–2.3 to –1.0)		
Colorectum (C18–C21)	1994–2001	2.1 (0.7–3.6)	2001–2009	4.6 (3.7–5.5)			1994–2009	2.4 (1.9–2.9)		
Pancreas (C25)	1994–2009	5.9 (3.4–8.5)					1994–2009	6.2 (3.1–9.5)		
Lung (C33–C34)	1994–2009	2.7 (2.0–3.4)					1994–2009	5.5 (4.2–6.9)		
Melanoma of the skin (C43)	1994–2009	6.3 (4.7–7.9)					1994–2009	5.3 (3.4–7.3)		
Female breast (C50)	NA	NA	NA	NA	NA	NA	1994–2009	3.5 (3.1–3.9)		
Cervix uteri (C53)	NA	NA	NA	NA	NA	NA	1994–2009	–2.6 (–3.4 to –1.8)		
Corpus uteri (C54)	NA	NA	NA	NA	NA	NA	1994–2001	–2.5 (–5.3 to 0.3)	2001–2009	4.6 (2.5–6.7)
Prostate (C61)	1994–2006	6.1 (4.8–7.4)					NA	NA	NA	NA
Kidney (C64)	1994–2009	6.1 (4.9–7.3)					1994–2009	3.7 (2.0–5.5)		
Bladder (C67)	1994–2009	3.3 (2.6–3.9)					1994–1997	–9.1 (–18.1 to 1.0)	1997–2000	9.5 (–11.1 to 34.8)
Brain and CNS (C70–C72)	1994–2009	2.6 (1.2–4.1)					1994–2009	3.0 (1.4–4.6)	2000–2009	1.0 (–0.6 to 2.6)
Thyroid (C73)	1994–2009	11.8 (9.5–14.1)					1994–2006	8.3 (7.1–9.6)	2006–2009	19.9 (12.7–27.4)
Non-Hodgkin lymphoma (C82–C85, C96)	1994–2009	3.3 (2.4–4.1)					1994–2009	2.9 (1.7–4.0)		

APC, annual percent change; 95% CI, 95% confidence interval; CNS, central nervous system; NA, not applicable.

Fig. 1



Trends in 3-year moving averages of the number of cases and age-standardized (all ages, direct method, European standard population) incidence rates in 1994–2009 (in grey and black, respectively) and predictions for 2015 and 2020, for all cancers except nonmelanoma skin, by sex.

stomach (both sexes), oesophagus, cervix and bladder (in women) and prostate (Table 1). However, the number of incident cases is expected to keep rising up to 2020, for all cancers considered in this study, except cervix cancer among women, although with large heterogeneity in the magnitude of variation according to cancer site and sex (Supplemental Figures 1, Supplemental digital content 1, <http://links.lww.com/EJCP/A24> and 2, Supplemental digital content 2, <http://links.lww.com/EJCP/A25>, Supplemental Table 1, Supplemental digital content 3, <http://links.lww.com/EJCP/A26>). For tumours common to both sexes, the number of incident cases was and is expected to remain generally higher in men, except for melanoma of the skin and thyroid cancer (Table 2).

Although stomach cancer presented significant declining incidence rates in the region, for both sexes (men: $APC = -1.2$; women: $APC = -1.6$), there was a slight increase in the number of incident cases, which is expected to increase by 3.1 and 4.3% in 2020 for men and women, respectively. In men, stomach is projected to remain the fourth most frequent cancer site in 2015, but it is expected to be replaced by bladder cancer in 2020. The net change in the number of cases was mainly attributable to demographic changes (Fig. 2).

Among women, oesophageal cancer presented a similar behaviour to stomach cancer, with significantly decreasing rates ($APC = -2.7$) but an increasing number of cases. However, rates in women for this cancer site are low, and oesophageal cancer is likely to remain as the 15th most common cancer in 2020.

Cervix was the only cancer site that presented decreasing trends in both the number of incident cases and ASIR ($APC = -2.6$) between 1994 and 2009, and these are expected to hold in the future. The number of incident cases is expected to drop just over 18% by 2020 (22.5% decrease due to lower risk and 4.2% increase due to demographic changes), and cervix cancer will likely drop from the 9th to the 11th most frequent cancer in women.

A decreasing ASIR trend was observed for prostate cancer between 2006 and 2008, although a higher rate was already observed in 2009. Assuming that an upward trend will be observed in the next years, prostate cancer is expected to remain the most common cancer in men, accounting for over 29% of all cancers predicted for 2020 (Table 2).

Melanoma of the skin was more common in women, and sex differences are expected to hold up to 2020, although men presented a slightly higher APC in incidence rates than did women (6.3 vs. 5.3) during 1994–2009. Furthermore, the percentage change in the number of cases diagnosed between 2009 and 2020 is quite similar between sexes, at $\sim 30\%$, mainly due to an increase in risk (by 18.3% among men and 24.8% among women) (Fig. 2).

The steepest ASIR increase in 1994–2009 was observed for thyroid cancer ($APC = 11.8$ among men; $APC = 8.3$ in 1994–2006 and $APC = 19.9$ in 2006–2009 among women), and the corresponding number of incident cases is expected to increase by over 30% for both sexes (from 140 and 788 cases in 2009 to 186 and 1055 cases in 2020, respectively, for men and women) (Table 2). The net increase in thyroid cancer cases among men was mainly attributable to an increased risk of developing cancer, whereas in women it was mostly due to the changes in population size and structure (Fig. 2).

During 1994–2009, for lung cancer, the APC for women was nearly twice as high as that observed in men (5.9 vs. 2.9); this translates into one of the largest projected percentage changes (69.4%) in the number of incident cases among women from 2009 to 2020 (Table 2).

Among men, the five most frequent cancers (prostate, colorectum, lung, stomach and bladder) will account for a larger proportion of all cases diagnosed in a year, varying from 68% in 2009 to 82% in 2020. Among women, the top five cancers (breast, colorectum, stomach, thyroid and corpus uteri) accounted for nearly 65% of all female cancers diagnosed in 2009, and this proportion is expected to remain relatively stable up to 2020.

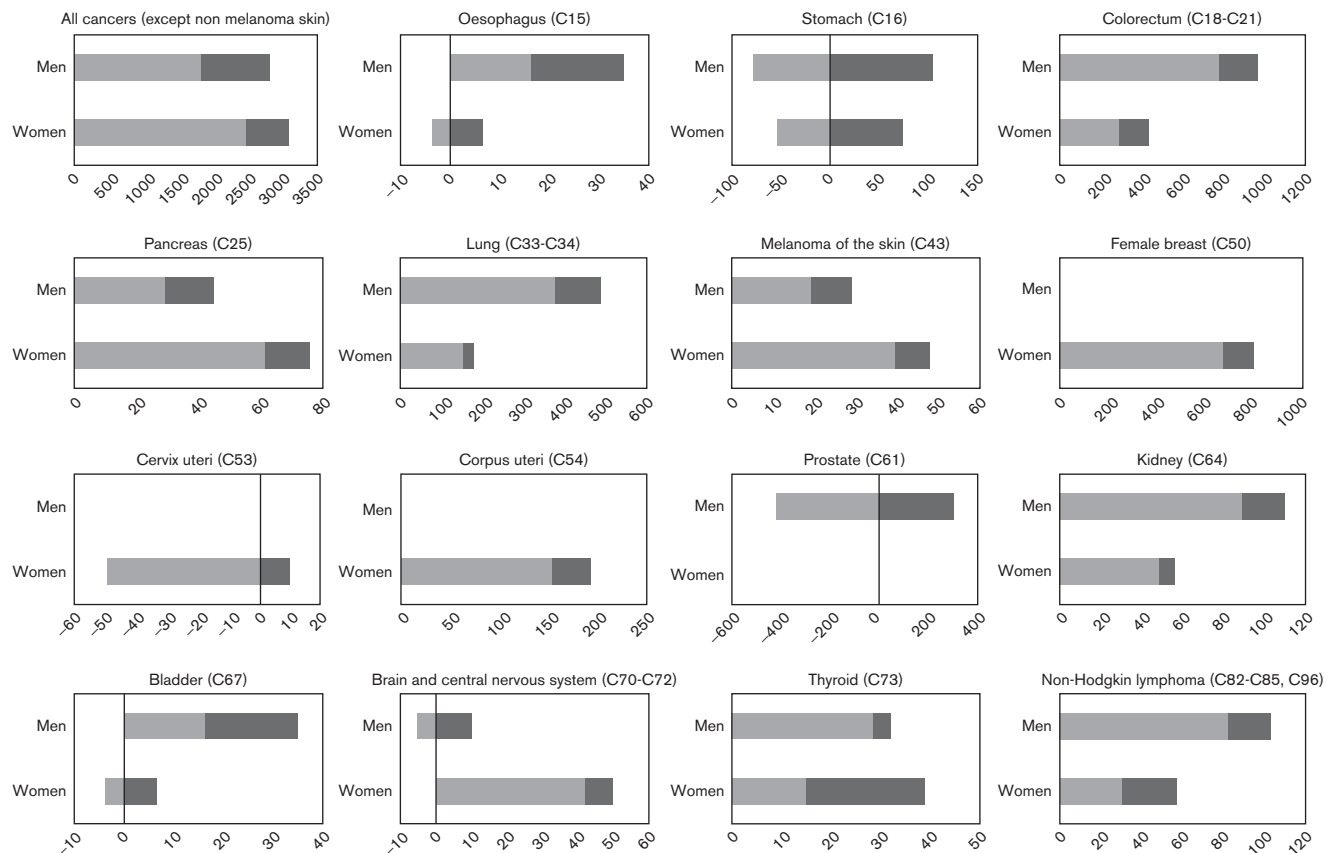
Table 2 Number of cases registered in 2009 and predictions for 2015 and 2020, and corresponding percentage changes, by cancer site and by sex, according to a central scenario of a stable fertility rate at 1.28, and the range of variability in predictions for 2020, calculated using scenarios of lower and higher population growth

Cancer site (ICD-10)	Men						Women					
	Lower-higher estimates ^a 2020			% Change			Lower-higher estimates ^a 2020			% Change		
	2009	2015	2020	2009–2015	2009–2020	Lower-higher change 2009–2020	2009	2015	2020	2009–2015	2009–2020	Lower-higher change 2009–2020
All cancers (except skin non-melanoma)	7916	9057	10236	14.4	29.3	28.4–31.0	6663	8243	9820	23.7	47.4	46.7–49.2
Oesophagus (C15)	168	186	202	10.7	20.2	19.0–20.8	31	32	32	3.2	3.2	3.2–6.5
Stomach (C16)	721	729	743	1.1	3.1	1.8–4.7	493	497	514	0.8	4.3	4.3–6.7
Colorectum (C18–C21)	1443	1939	2421	34.4	67.8	66.7–70.4	1024	1234	1464	20.5	43.0	42.7–45.6
Pancreas (C25)	123	141	175	14.6	42.3	41.5–44.7	99	135	170	36.4	71.7	70.7–74.7
Lung (C33–C34)	909	1151	1360	26.6	49.6	48.6–51.6	248	338	420	36.3	69.4	68.5–71.8
Melanoma of the skin (C43)	106	116	141	9.4	33.0	32.1–34.9	160	176	212	10.0	32.5	31.3–33.8
Female breast (C50)	NA	NA	NA	NA	NA	NA	1743	2177	2541	24.9	45.8	44.9–46.9
Cervix uteri (C53)	NA	NA	NA	NA	NA	NA	220	195	179	–11.4	–18.6	–19.1 to –17.7
Corpus uteri (C54)	NA	NA	NA	NA	NA	NA	299	398	501	33.1	67.6	67.2–69.6
Prostate (C61)	1733	2351	3016	35.7	74.0	73.1–76.5	NA	NA	NA	NA	NA	NA
Kidney (C64)	198	248	307	25.3	55.1	53.5–56.6	91	116	138	27.5	51.6	50.5–52.7
Bladder (C67)	580	724	873	24.8	50.5	49.8–53.3	140	168	194	20.0	38.6	37.9–41.4
Brain and CNS (C70–C72)	157	153	177	–2.5	12.7	11.5–14.0	104	133	155	27.9	49.0	48.1–50.0
Thyroid (C73)	140	149	186	6.4	32.9	30.7–33.6	788	934	1055	18.5	33.9	33.0–34.3
Non-Hodgkin lymphoma (C82–C85, C96)	265	305	356	15.1	34.3	33.2–35.8	230	250	292	8.7	27.0	26.1–28.3

CNS, central nervous system; NA, not applicable.

^aLower scenario of population growth: decreasing fertility rate, from 1.28 in 2009 to 1.24 in 2020. Higher scenario of population growth: increasing fertility rate, from 1.28 in 2009 to 1.32 in 2020 (Instituto Nacional de Estadística, 2014b).

Fig. 2



Variation in the number of cancer cases between 2009 and 2020, due to changes in the risk of developing the disease (light grey) or in demographic factors (dark grey), by cancer site and by sex.

Discussion

Up to 2020, the number of incident cases of cancer in northern Portugal is expected to increase, by ~30% in men (from 7916 in 2009 to 10 236 in 2020) and by nearly 50% in women (from 6663 in 2009 to 9820 in 2020). Among the most frequent cancers in the region, stomach (both sexes) and oesophageal and cervix (in women) cancers were the only ones presenting a significant decline in ASIR between 1994 and 2009, and cervix was the only one with a decreasing number of incident cases in that entire period. For all other sites, except the bladder (in women) and prostate (in men), a significantly increasing ASIR trend was found in the most recent years. Thyroid and lung cancers were among those with the steepest increases in the number of incident cases expected for 2020, especially among women.

Timeliness and completeness of case ascertainment remain the most important indicators of data quality in a cancer registry, and there must be a trade-off between these indicators, because registries often delay the dissemination of results to achieve higher completeness. A recent assessment of the quality of data from cancer

registries in Europe concluded that the median latency for completion of incidence ascertainment was 18 months, and additional time required for dissemination was in the order of 3–6 months, with wide variations (Zanetti *et al.*, 2015). Although RORENO has not attained this timeliness, a quantitative evaluation of case ascertainment has yielded high levels of completeness for gastric cancer [a cancer of poor prognosis (De Angelis *et al.*, 2014; Allemani *et al.*, 2015)] and concluded that no meaningful improvements in completeness could be expected after 3 years since diagnosis, which may be considered, in this context, a minimum lag to be respected between diagnosis and the publication of valid incidence estimates (Castro *et al.*, 2012). As some delay is necessary in the publication of results from population-based cancer registries, short-term predictions based on the extrapolation of historical trends may provide valid up-to-date figures to support cancer prevention and control efforts (Ferlay *et al.*, 2013b). Unlike the expected long-term estimates, for short-term predictions, the naive assumption that the recent trends will not change meaningfully in the next few years holds true for most cancers. The exception would be the evidence of

variation in the exposure to cancer determinants between the most recent trends and those expected in the short term but not yet observable. However, as the lag times for the relation between most exposures and cancer are relatively long, it is unlikely that recent trends in the frequency of cancer determinants will influence the incidence estimates for the next decade. In contrast, contemporary changes in the access and use of cancer screening are expected to have an important impact on cancer incidence rates, which is not captured in historical trends but may be necessary to incorporate in data analysis to provide accurate predictions.

Tobacco use is the single greatest avoidable risk factor for cancer mortality worldwide, causing an estimated 22% of cancer-related deaths per year (World Health Organization, 2011). It is a risk factor for many types of cancer, including cancers of the lung, kidney, bladder, pancreas, stomach and cervix (Araújo *et al.*, 2011). About 80% of the worldwide lung cancer burden in men and at least 50% of the burden in women can be attributed to smoking alone (Ezzati *et al.*, 2005). In Portugal, the prevalence of smoking increased among women, especially in those aged 31–50 and 51–70 years (from 4.6 and 0.1% in 1988 to 16.4 and 4.5% in 2008, respectively) and decreased among men, with the steepest declines in those aged up to 30 years (from 41.8% in 1988 to 28.8% in 2008) and those aged at least 71 years (from 15.1% in 1988 to 4.6% in 2008) (Carreira *et al.*, 2012a). This is the most likely cause of a more marked increase in lung cancer rates among women than among men, although the latter were still showing a significant increase up to 2009, reflecting the long time lag between exposure and outcome (IARC, 2004).

There is a link between overweight and obesity and many types of cancer such as colorectum, breast, endometrium and kidney (World Health Organization, 2011), and in Portugal the increasing prevalence of overweight and obesity (from 51.9 to 55.1% among men and from 43.5 to 47.0% among women, between 1998 and 2005) is very likely an important contributor to current and future cancer incidence rates (Carreira *et al.*, 2012b).

Regarding gastric cancer, the trends observed in this study were in accordance with the worldwide steady decline of incidence and mortality rates over the last five decades (Ferro *et al.*, 2014). This decline has been mainly attributed to an increase in socioeconomic status, namely through improved food preservation practices and reduction in the frequency of *Helicobacter pylori* infection (Howson *et al.*, 1986; Parkin *et al.*, 2001). As evidence supports a nondecreasing trend in *H. pylori* infection in the Portuguese population (Lunet, 2011; Peleteiro *et al.*, 2014), the above-mentioned factors may have had a larger impact on the decreasing gastric ASIR obtained in the region in the last decades and projected for the near future.

Observed trends for thyroid cancer are also in accordance with worldwide estimates, which depict a steep increase in incidence, especially in women (Li *et al.*, 2013; Vigneri *et al.*, 2015). The upward trends in thyroid cancer incidence have been mainly attributed to improved ascertainment and diagnosis, and largely reflect overdiagnosis of indolent disease – that is, small papillary carcinomas (Vigneri *et al.*, 2015). Some countries have also detected increasing incidence rates for larger tumours but not for follicular carcinomas (Li *et al.*, 2013; Davies and Welch, 2014); therefore, it would be necessary to evaluate both histology-specific and tumour size-specific trends of thyroid cancer in northern Portugal to understand the extent to which the observed increasing rates reflect overdiagnosis.

In Portugal, organized screening programmes are planned and implemented independently in each region (North, Centre, Lisboa and Vale do Tejo, Alentejo and Algarve) by the corresponding Regional Health Administration, which causes inequalities in the access to screening across geographical areas (Parkin *et al.*, 2001; Bastos *et al.*, 2010). For colorectal cancer, there was no organized screening programme in Portugal up to 2009, despite the European Council Recommendation (2003/878/EC) to perform faecal occult blood tests in both men and women aged 50–74 years (Bastos *et al.*, 2010; Pinto *et al.*, 2010). The overall increasing ASIR observed for colorectal cancer may thus be attributable not to organized but to opportunistic screening – especially by endoscopic methods – as well as to changes in the exposure to risk factors. In northern Portugal, the breast cancer screening programme started in 1999, targeting women aged 45–69 (Bastos *et al.*, 2010; Bento *et al.*, 2014), but only 12.5% of the eligible population was covered in 2009, with a participation rate of 60.6% (ARS-Norte, 2010), which may explain the steady increase in the number of incident cases and ASIR observed in our study. For cervix cancer, a pilot programme was started in northern Portugal in 2009 (ARS-Norte, 2010); however, a large proportion of the population undergoes opportunistic screening (Alves *et al.*, 2009; Oliveira *et al.*, 2014), which likely contributed to the detection of premalignant diseases and a consequent decrease in the risk of cervix cancer.

Predicting cancer incidence largely depends on the projections of the resident population. We assessed this point by providing a range of variability in the number of predicted cases for 2015 and 2020 (using different scenarios for the evolution of population growth in the region, assuming increasing or decreasing fertility rates, in addition to stable fertility) and by evaluating the contribution of demographic changes to the expected number of cases. The differences in the percentage of changes obtained for 2009–2020 between the two alternative scenarios did not exceed 4%. However, the true impact of the current Portuguese context of emigration, low birth and ageing population (Instituto Nacional de

Estatística, 2014a) on the estimates provided in this work can only be assessed in future studies providing a comparison between predicted and observed numbers of cancer cases and rates.

The major strength of this study is the provision of up-to-date figures for cancer control by using data on the most frequent cancer sites registered in a relatively young population-based cancer registry. The usefulness of these estimates in comparison with the ones provided by the GLOBOCAN (Ferlay *et al.*, 2013a) project for Portugal as a whole is that, in this work, estimates were calculated using data provided by a population-based cancer registry covering the geographical area under analysis, instead of using data from neighbouring regions/countries to perform such estimates. Furthermore, as there are marked differences within the country [namely, for some cancer types such as stomach (Lunet *et al.*, 2004) or thyroid (ROR-Centro, 2015), which are much more common in northern Portugal than in the rest of the country], this study provides further detailed information that is useful in the context of cancer control policies in this region.

In conclusion, this study contributes to a broader understanding of cancer burden in the north of Portugal, by providing incidence predictions up to 2020, which are useful in the context of cancer control policy making, and provide the basis for keeping population-based incidence estimates up to date.

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Conflicts of interest

There are no conflicts of interest.

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