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ORIGINAL ARTICLE

European cancer mortality predictions for the year 2020 with a focus on prostate cancer

G. Carioli[1], P. Bertuccio[2], P. Boffetta[3,4], F. Levi[5], C. La Vecchia[1*], E. Negri[2] & M. Malvezzi[1]

Departments of [1]Clinical Sciences and Community Health and [2]Biomedical and Clinical Sciences, Universitá degli Studi di Milano, Milan, Italy; [3]Tisch Cancer Institute, Icahn School of Medicine at Mount Sinai, New York, USA; [4]Department of Medical and Surgical Sciences, University of Bologna, Bologna, Italy; [5]Institute of Social and Preventive Medicine (IUMSP), Unisanté, University of Lausanne, Switzerland

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Background: Current cancer mortality figures are important for disease management and resource allocation. We estimated mortality counts and rates for 2020 in the European Union (EU) and for its six most populous countries.

Materials and methods: We obtained cancer death certification and population data from the World Health Organization and Eurostat databases for 1970–2015. We estimated projections to 2020 for 10 major cancer sites plus all neoplasms and calculated the number of avoided deaths over 1989–2020.

Results: Total cancer mortality rates in the EU are predicted to decline reaching 130.1/100 000 men (−5.4% since 2015) and 82.2 in women (−4.1%) in 2020. The predicted number of deaths will increase by 4.7% reaching 1 428 800 in 2020. In women, the upward lung cancer trend is predicted to continue with a rate in 2020 of 15.1/100 000 (higher than that for breast cancer, 13.5) while in men we predicted further falls. Pancreatic cancer rates are also increasing in women (+1.2%) but decreasing in men (−1.9%). In the EU, the prostate cancer predicted rate is 10.0/100 000, declining by 7.1% since 2015; decreases for this neoplasm are ∼8% at age 45–64, 14% at 65–74 and 75–84, and 6% at 85 and over. Poland is the only country with an increasing prostate cancer trend (+18%). Mortality rates for other cancers are predicted to decline further. Over 1989–2020, we estimated over 5 million avoided total cancer deaths and over 400 000 for prostate cancer.

Conclusion: Cancer mortality predictions for 2020 in the EU are favourable with a greater decline in men. The number of deaths continue to rise due to population ageing. Due to the persistent amount of predicted lung (and other tobacco-related) cancer deaths, tobacco control remains a public health priority, especially for women. Favourable trends for prostate cancer are largely attributable to continuing therapeutic improvements along with early diagnosis.

Key words: cancer, Europe, mortality rates, prediction models, prostate cancer

INTRODUCTION

Since 2011 we have been projecting cancer mortality trends for the current year in major countries from the European Union (EU) and in the EU as a whole.[1–3] We predicted steady declines in mortality rates by about 1.5% in men and 0.8% in women over recent years. These are similar to the US trends in males but proportionally smaller compared with those reported for women in the USA (−1.8%).[4] Nevertheless, due to population growth and ageing, the number of cancer deaths was still increasing.[5,6] Persistent disparities across countries in cancer rates were observed with generally higher rates and less favourable trends for Central and Eastern Europe.

This work provides an up-to-date picture of mortality patterns in the form of mortality counts and age-standardised rates in the EU for the year 2020, with a specific focus on prostate cancer.

MATERIALS AND METHODS

We extracted death certification data for all cancers combined and 10 major cancer sites from the World Health Organization (WHO) database.[7] We recoded cancer deaths according to the 10th International Classification of Disease (ICD) Revision[8]: total cancers (ICD codes C00–D48), stomach (C16), colorectum (C17–C21, C26), pancreas (C25), lung (C33–C34), breast (C50), uterus (cervix and corpus) (C53–C55), ovary (C56), prostate (C61), bladder (C67), and leukemias (C91–C95). We retrieved figures from 1970 to 2015 for the EU (defined as the 28 member states excluding Cyprus due to excessive missing data) and up to the most

*Correspondence to: Prof. C. La Vecchia, Department of Clinical Sciences and Community Health, Universitá degli Studi di Milano, Via Vanzetti 5, 20122 Milan, Italy. Tel: +39-02-503-20-863; Fax: +39-02-503-20-866
E-mail: carlo.lavecchia@unimi.it (C. La Vecchia).

recent available year for its six most populous countries: 2015 for France and Italy and 2016 for Germany, Poland, Spain, and the UK. We obtained corresponding resident population data, based on official censuses, from the same WHO database[7] and when data were missing from Eurostat.[9]

From the matrices of certified deaths and resident population we computed country- and sex-specific death rates for each 5-year age group (from 0–4 to 85+ years), calendar year, and quinquennium. We standardised mortality rates by age using the world standard population for all ages and, for prostate cancer, also for selected age groups.[10] We also fit joinpoint regression models[11] including up to four joinpoints to age-standardised rates.

To predict mortality figures we applied a Poisson joinpoint regression model[11] to the number of deaths (log scale) in each 5-year age group. This identified significant changes in trends testing up to five joinpoints. To estimate the age-specific number of deaths for 2020 and the corresponding 95% prediction intervals (PIs) we fitted a linear regression model to the mortality data for each age group over the most recent trend segment with at least 5 data points identified by the joinpoint model. Using the predicted age-specific- death counts from our model and the predicted populations (obtained from Eurostat[9]) we computed predicted age-specific and age-standardised death rates and their 95% PIs.

We estimated numbers of avoided total cancer deaths over the years 1989–2020 by comparing observed and expected deaths on the basis of the 1988 age-specific peak rates. We also estimated the number of avoided prostate cancer deaths since 1996, i.e. the peak EU rate for prostate cancer.

RESULTS

Table 1 gives the EU predicted number of deaths and age-standardised mortality rates for 2020 with corresponding 95% PIs as well as the observed figures for 2015 and the percentage differences between 2015 and 2020 in men and women. Overall cancer mortality rate in the EU is predicted to decline in men from 137.5/100 000 in 2015 to 130.1 in 2020 (−5.4%) and in women from 85.7 to 82.2 (−4.1%). The overall number of cancer deaths is however predicted to increase by 4.7% from 1 364 068 cancer deaths in 2015 (760 111 men, 603 957 women) to 1 428 800 in 2020 (798 700 men, 630 100 women).

Figure 1 displays EU age-standardised mortality rates observed for 2015 and predicted for 2020 with corresponding 95% PIs for total cancers and the 10 major cancer sites in men and women. The highest EU predicted rates in both sexes are for lung cancer—31.6/100 000 men and 15.1 in women. Lung cancer rates decline by 9.2% between 2015 and 2020 in men while they increase by 6.0% in women. The total deaths from lung cancer estimated for 2020 (182 600 men, 99 800 women) still are about 20% of all cancer deaths. In women, the predicted lung cancer mortality rate is now appreciably higher than that of breast cancer, 13.5/100 000 (−7.3% since 2015) and the number of deaths from lung cancer is also greater than that from breast cancer (99 800 and 95 900, respectively). The colorectal cancer rate for 2020 is 15.4/100 000 men and 8.6 in women with a smaller fall in men since 2015 (−4.2% in men versus −8.3% in women). Prostate cancer is the third predicted cause of cancer deaths in EU men with 78 800 deaths in 2020 and a rate of 10.0/100 000 (−7.1% since 2015). Pancreatic cancer predicted rates are 7.8 in men and 5.6 in women with inconsistent trends over time. Stomach cancer

Table 1. Number of predicted deaths and mortality rate for the year 2020, comparison figures for 2015, for the EU, with 95% prediction intervals (PIs) and the percentage differences between 2015 and 2020

	Observed number of deaths 2015	Predicted number of deaths 2020 (95% PI)	Observed ASR 2015	Predicted ASR 2020 (95% PI)	% difference 2020/2015
Men					
Stomach	34 666	33 700 (32 971–34 485)	6.28	5.53 (5.39–5.67)	−11.9
Colorectum	93 241	98 500 (96 750–100 316)	16.06	15.38 (15.08–15.68)	−4.2
Pancreas	42 462	45 900 (45 350–46 534)	7.91	7.76 (7.65–7.87)	−1.9
Lung	183 943	182 600 (179 799–185 440)	34.83	31.62 (31.02–32.21)	−9.2
Prostate	74 998	78 800 (77 646–80 026)	10.71	9.95 (9.78–10.11)	−7.1
Bladder	31 938	32 800 (32 036–33 618)	4.99	4.52 (4.38–4.65)	−9.4
Leukemias	23 713	25 100 (24 489–25 707)	4.39	3.87 (3.73–4.02)	−11.8
All cancers (malignant and benign)	760 111	798 700 (791 039–806 298)	137.53	130.09 (128.63–131.55)	−5.4
Women					
Stomach	22 162	20 300 (19 698–20 900)	2.91	2.51 (2.42–2.6)	−13.7
Colorectum	77 122	76 100 (74 944–77 260)	9.40	8.62 (8.48–8.75)	−8.3
Pancreas	42 201	46 200 (45 494–46 975)	5.53	5.60 (5.49–5.7)	1.2
Lung	88 502	99 800 (98 658–100 983)	14.28	15.13 (14.95–15.32)	6.0
Breast	93 903	95 900 (94 637–97 187)	14.54	13.48 (13.31–13.66)	−7.3
Uterus (cervix and corpus)	29 691	31 300 (30 656–31 974)	4.84	4.78 (4.67–4.89)	−1.2
Ovary	30 213	29 000 (28 330–29 696)	4.78	4.23 (4.11–4.36)	−11.5
Bladder	10 900	11 400 (11 114–11 656)	1.17	1.15 (1.12–1.18)	−1.9
Leukemias	19 137	19 800 (19 390–20 184)	2.63	2.27 (2.17–2.37)	−13.7
All cancers (malignant and benign)	603 957	630 100 (625 252–634 898)	85.68	82.16 (81.59–82.73)	−4.1

ASR, age-standardised mortality rates using the world standard population.

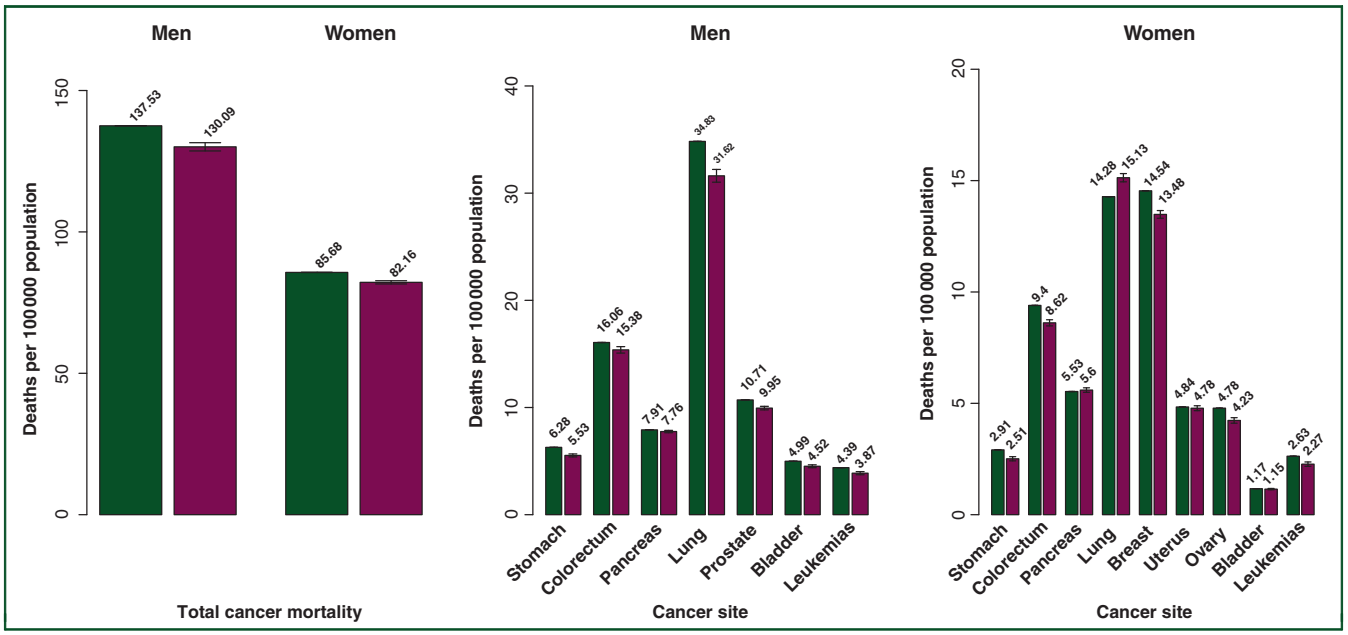

Figure 1. Bar-plots of age-standardised (world population) death rates per 100 000 persons for the year 2015 (left columns) and predicted rates for 2020 (right columns) with 95% prediction intervals for total cancers and 10 major cancer sites in EU men and women.

rates continue to decline steadily (around −12% in men and −14% in women) reaching values of 5.5/100 000 in men and of 2.5 in women for 2020. Uterine and ovarian cancer rates for 2020 are 4.8/100 000 (−1.2% fall since 2015) and 4.2 (−11.5%), respectively. Leukemia rates decline over 10% between 2015 and 2020 in both sexes. Bladder cancer rates decrease by 9.4% (4.5/100 000) in men but only by 1.9% in women (1.2/100 000).

Figure 2 shows EU mortality trends for all cancers and the 10 major cancer sites between 1970 and 2020. In EU men, all cancer mortality has been declining since the late 1980s mainly driven by favourable mortality rates from lung and stomach cancers. Male trends for colorectal, prostate, and bladder cancers increase up to the early 1990s and then decrease. In EU women, all cancer mortality rates fell over the whole period studied. Steady declines were observed in female mortality trends for breast cancer since the 1990s and for colorectal, stomach, and uterine cancers over the whole period. Ovarian cancer rose until 1990 and then declined thereafter. The lung cancer trend in women has been increasing over the whole period with rates overtaking those of breast cancer in the mid-2010s. In both sexes, pancreatic cancer trends showed steady rises over the studied period; in men, however, in the predicted period there is a levelling of rates. Mortality from leukemias declined in both sexes. Additional country-specific data and analyses are available in the supplementary Tables S1—S9 and Figures S1 and S2, available at *Annals of Oncology* online. Trends and predictions are less favourable in Poland than in Western Europe and total mortality remains consequently higher in both sexes.

Figure 3 displays mortality trends in quinquennial rates for prostate cancer in the EU as a whole and in its six most populous countries between 1970 and 2020. Prostate cancer rates rose up to the late 1980s in France and Italy to then decline up to 2020. In the UK, Germany, as well as in the EU as a whole rates were higher and decreases started about 5 years later. Spain had an increasing trend up to the late 1990s, falling thereafter. Poland showed the most unfavourable trend; starting from the lowest rate in the 1970—1974 quinquennium, the trend increased up to the early 2000s, had a tendency to stabilise to then rise again up to 2020. Thus, Polish cancer rates are now the highest predicted.

Table 2 shows all age mortality rates from prostate cancer observed in 2005—2009 and 2010—2014 and those predicted for 2020 with corresponding 95% PIs in the six studied countries and for the EU also for the 45—64, 65—74, 75—84, and 85+ age groups. Percentage differences between rates in 2010—2014 and 2020 are included as well. The lowest prostate cancer rates in 2020 are in Italy (5.8/100 000), Spain (7.2), and France (7.3), which also have the greatest declines between 2010—2014 and 2020 with per cent changes over 20%. Germany and the UK have predicted rates of about 11/100 000 men with falls of 7.4% and 9.0% since 2010—2014, respectively. The Polish predicted trend rises by 17.9%, reaching a rate of 14.7. Considering age-group-specific trends in the EU, rates for men aged 45—64 decline by 8.4% and those for men aged 65—74 and 75—84 decline by about 14%. The fall was 5.8% at age 85 and over.

Figure 4 displays joinpoint analysis results for the EU annual prostate cancer mortality rates in all ages and in selected age groups between 1970 and 2020. In the EU, prostate cancer mortality trends for the truncated ages 45—64 and 75—84 started to decline around 1990

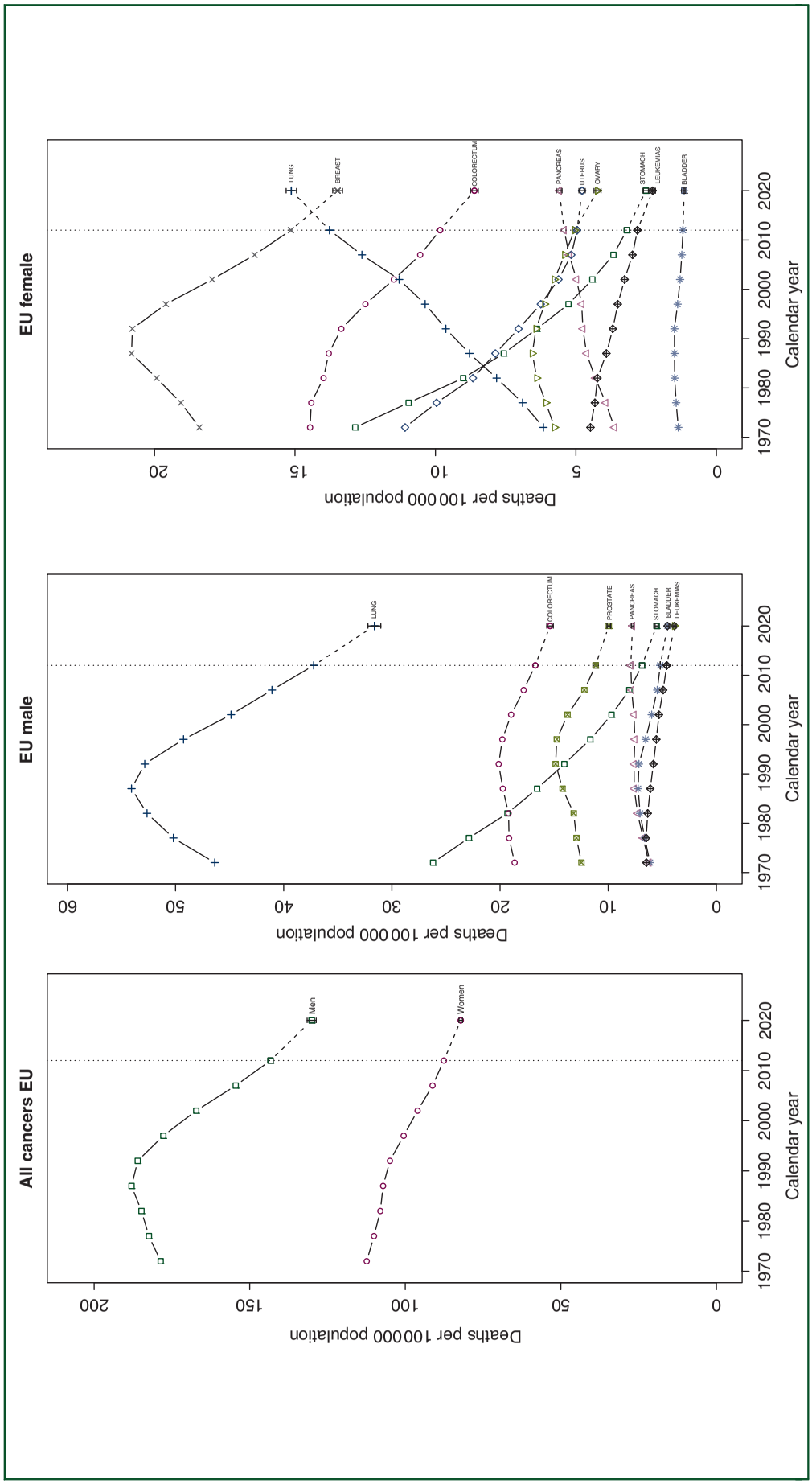

Figure 2. Age-standardised (world population) cancer mortality rate trends in quinquenniums from 1970–1974 to 2010–2014 and predicted rates for 2020 with 95% prediction intervals for all neoplasms and both sexes (left) and each cancer site under study for men (centre) and women (right) in the EU.

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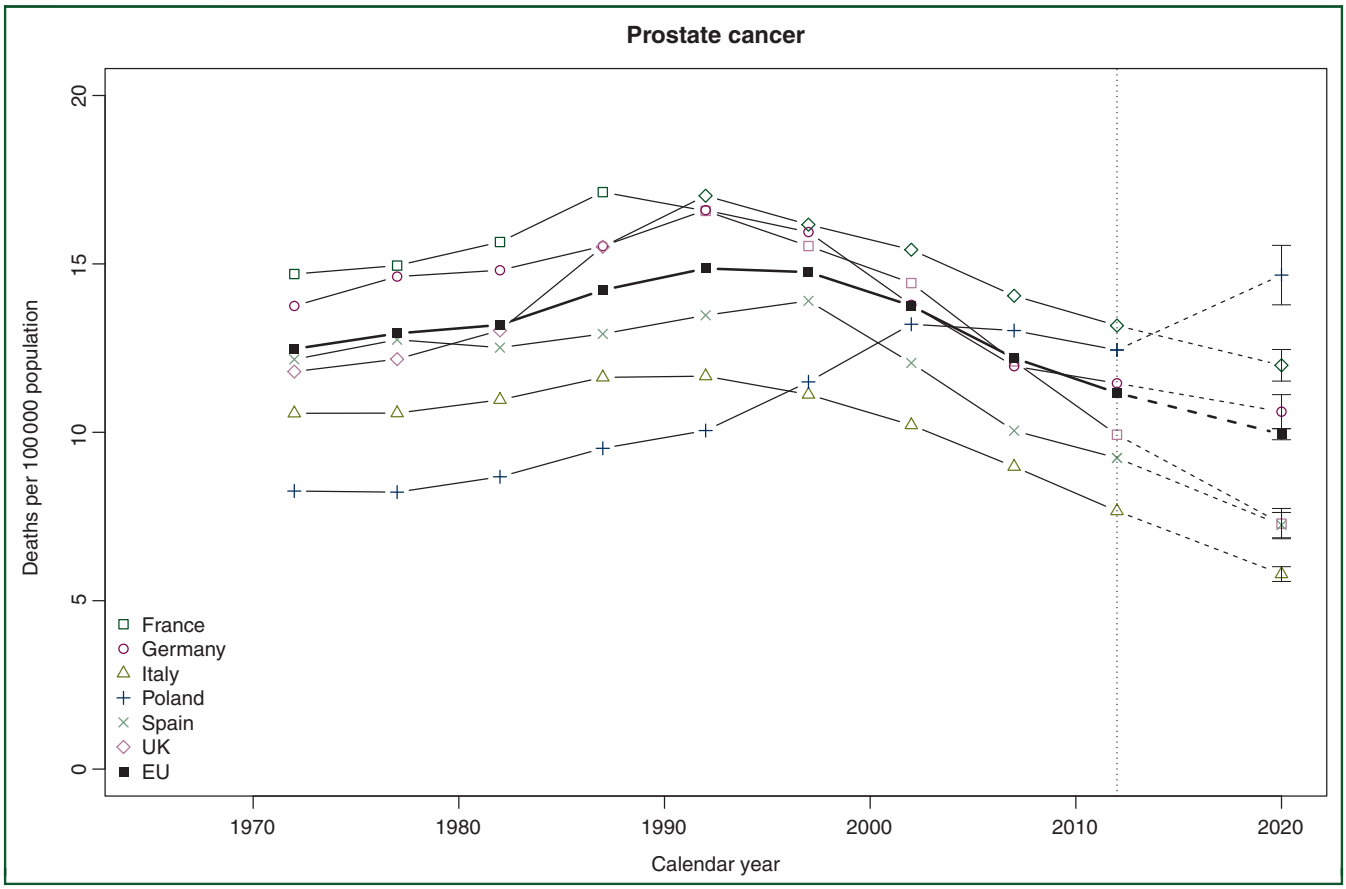

Figure 3. Age-standardised (world population) cancer mortality rate trends for all ages in quinquenniums from 1970–1974 to 2010–2014 and predicted rates for 2020 with 95% prediction intervals for prostate cancer in studied countries and in the EU as a whole.

(supplementary Table S9, available at *Annals of Oncology* online); men aged 65–74 showed an earlier fall (since the late 1980s) and a flatter pattern over the period.

Figure 5 shows EU total cancer averted deaths between the highest rate in 1988 and 2020 in men and women. Over the years between 1989 and 2020, for the EU, we estimated a total of 5 685 000 avoided cancer deaths (3 796 000 in men and 1 889 000 in women). In 2020, we predicted 406 000 averted deaths (282 000 in men and 124 000 in women). For prostate cancer (Figure 6) we estimated 462 000 avoided cancer deaths over the 32-year period and 40 000 in 2020 alone. Thus, over 12% of cancer deaths were avoided in men over the last three decades and over 14% over recent years due to prostate cancer alone.

DISCUSSION

Total cancer mortality predictions for 2020 in the EU are favourable with a 5% decline in rates in men and 4% in women since 2015. Nevertheless, the number of deaths

Table 2. Age-standardised prostate cancer mortality rates for all ages in selected European countries and for the EU as a whole for all ages, 45–64, 65–74, 75–84, and 85+ years in the 2005–2009 and 2010–2014 quinquenniums and predicted for 2020 with percentage differences between 2010–2014 and 2020

	ASR 2005–2009	ASR 2010–2014	Predicted ASR 2020 (95% PI)	% difference 2020 2010–2014
France	12.11	9.93	7.29 (6.84–7.74)	−26.6
Germany	11.96	11.46	10.61 (10.11–11.12)	−7.4
Italy	8.98	7.66	5.79 (5.57–6.01)	−24.4
Poland	13.02	12.44	14.67 (13.79–15.55)	17.9
Spain	10.05	9.24	7.24 (6.87–7.62)	−21.6
UK	14.05	13.17	11.99 (11.52–12.46)	−9.0
EU				
All ages	12.21	11.17	9.95 (9.78–10.11)	−11.0
Truncated 45–64 years	8.02	7.45	6.82 (6.38–7.27)	−8.4
Truncated 65–74 years	72.91	66.41	57.17 (55.05–59.29)	−13.9
Truncated 75–84 years	248.11	219.81	189.95 (184.88–195.02)	−13.6
Truncated 85+ years	658.55	623.13	587.05 (575.68–598.42)	−5.8

ASR, age-standardised mortality rates using the world standard population.

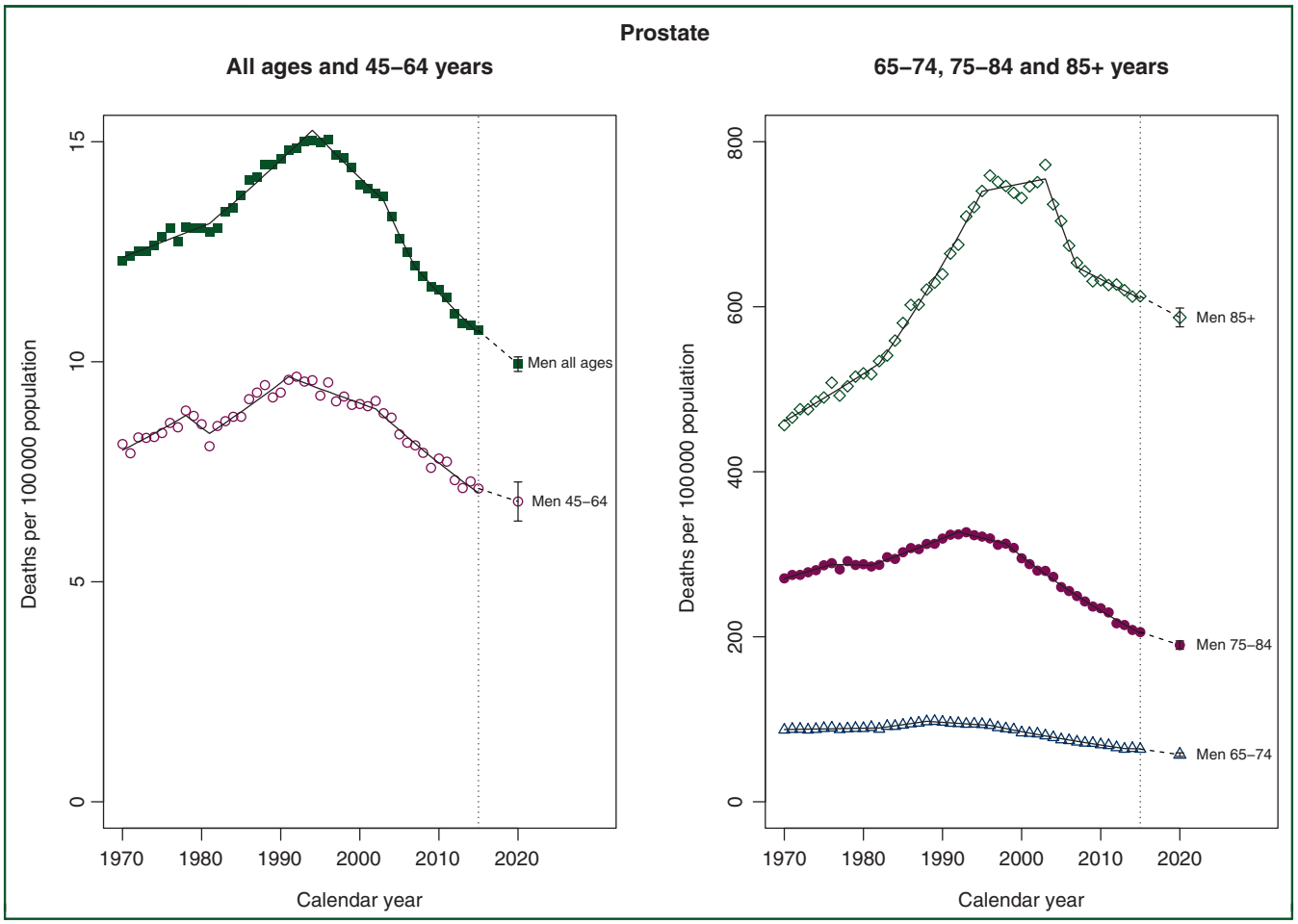

Figure 4. Annual prostate cancer age-standardised (world population) death rates in the EU per 100 000 for all ages, 45—64, 65—74, 75—84, and 85+ age-groups from 1970 to 2015, the resulting joinpoint regression models, and predicted rates for the year 2020 with 95% prediction intervals.
On the left all ages (full squares) and 45—64 (empty circles) age groups; on the right 65—74 (empty triangles), 75—84 (full circles), and 85+ (empty diamonds) age groups.

continues to rise due to population ageing. There is no consistent decline in pancreatic cancer mortality, which remains therefore a major public health issue. Lung cancer rates in women continue to increase, reaching an over 15/100 000 rate in 2020. As in previous reports, trends are less favourable and cancer rates continue to be appreciably higher in Poland as compared with major Western European countries, thus indicating a persistent gap in cancer mortality between Central-Eastern and Western Europe.[12]

Tobacco remains the main cause of cancer mortality in Europe and the more marked decline in overall cancer mortality trends in men compared to women largely reflects the differences in past smoking patterns between the two sexes.[13] Reduced occupational exposure to asbestos and other lung carcinogens, which has likely affected more males than females, may also partly explain the more favourable trend in men. Lung cancer in both sexes combined still accounts for around 20% of total predicted cancer deaths, highlighting the persisting importance and priority of tobacco prevention programmes.[14,15]

The pancreas is the only cancer site not showing consistent declines. Nevertheless, predictions for men in 2020 are levelling in the EU overall though with appreciable differences on a country level. The different patterns of tobacco smoking in subsequent generations of men and women cannot entirely explain the less marked decrease compared with other tobacco-related cancers. Excessive weight and diabetes play a role in its etiology and have been increasing in most European countries over the last few decades.[16] Still, their role in such unfavourable patterns for both sexes can hardly be quantified and pancreatic cancer mortality trends and predictions remain difficult to explain.[17]

Bladder cancer predicted rates in EU men are around fourfold higher than those in women. Besides the important effect of tobacco, occupational carcinogens such as aromatic amines may also explain this gap. The reduced occupational exposure to aromatic amines over the last several decades may account for the much more favourable trends and predictions in men than women.[18]

The persisting favourable trends in stomach cancer mortality in both sexes across Europe including countries with lower rates are likely due to the reduction in *Helicobacter pylori* infection, decreased smoking levels in men, healthier diet, and better food conservation.[19]

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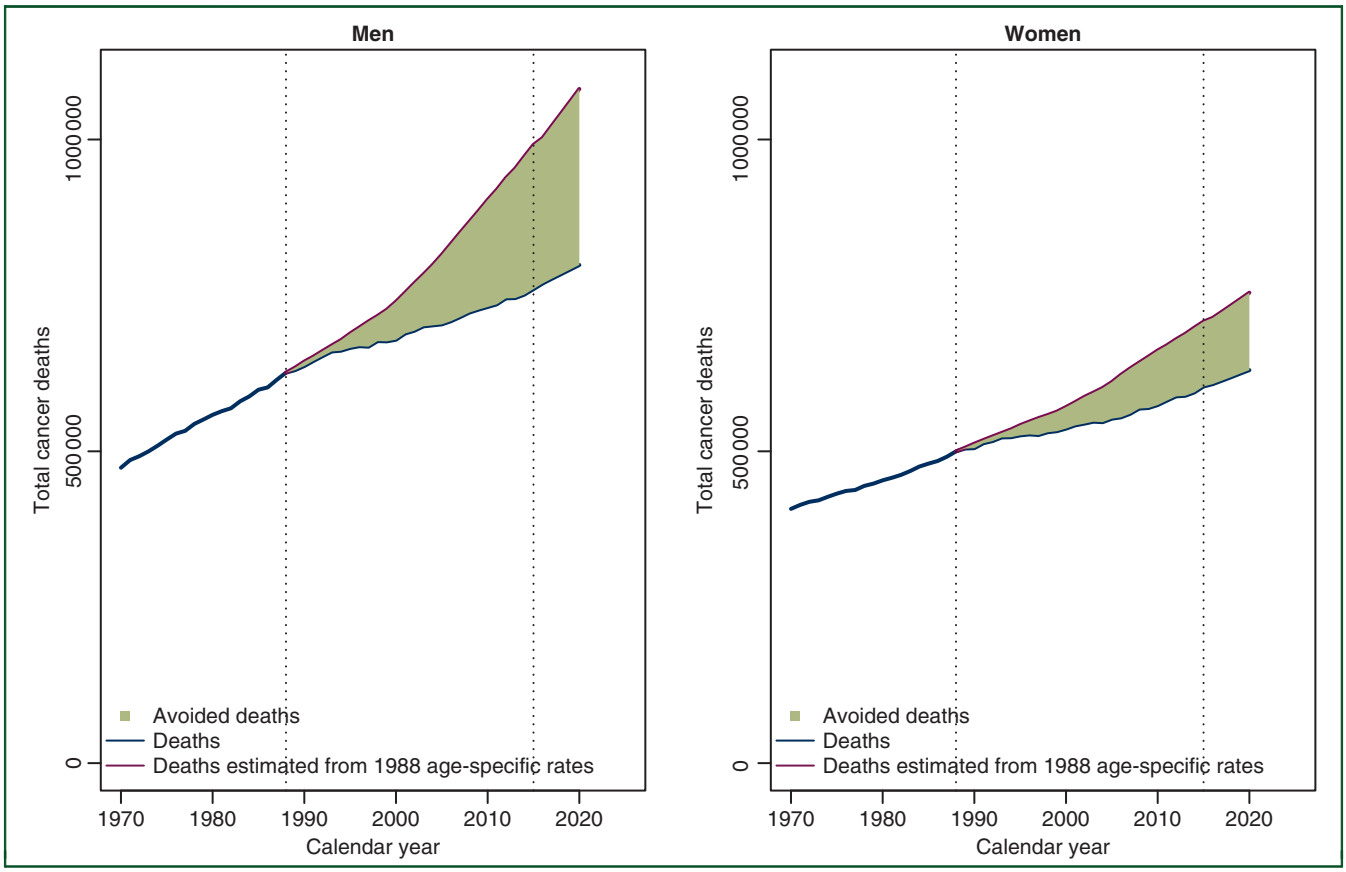

Figure 5. Total avoided cancer deaths for EU men and women between the top rate in 1988 and 2020; observed numbers of cancer deaths from 1970 to 2015 and predicted cancer deaths from 2016 to 2020; estimated numbers of total cancer deaths by applying 1988 age-specific peak mortality rate.
During the 32-year period 5 685 000 cancer deaths have been avoided (3 796 000 in men and 1 889 000 in women). In 2020 alone the number of cancer deaths predicted to be avoided are 282 000 in men and 124 000 in women for a total of 406 000.

The decreasing trends in colorectal cancer are a consequence of progresses in screening, early diagnosis, and treatment.[20] The reason for the persisting more favourable trend in women remains largely unexplained.

Major falls over the last three decades were observed in breast cancer as well, reflecting advancements in terms of early diagnosis and treatment.[3,21] A favourable role of the declining use of hormone replacement therapy after 2003 on breast cancer rates is also possible.[22]

Death certification data from the WHO do not permit differentiation between cervical and endometrial cancer; declines in rates from uterine cancer are mainly due to cervical cancer screening and early diagnosis.[23] Improvements in disease management likely influence the falling rates of uterine cancer, which are difficult to quantify. The levelling of rates observed in the most recent period probably reflects trends in endometrial cancer mortality.

The spread of oral contraceptive use across Europe largely influenced the declining trends in ovarian cancer, in the UK earlier and subsequently in other countries. The declining use of hormone replacement therapy and the role of improved diagnosis and treatment, though difficult to quantify, has also positively influenced trends for this cancer site.[24]

The adoption of modern treatment of acute and chronic leukemias in adults also (i.e. new immunotherapeutics, antibodies, tyrosine kinase inhibitors) is the most likely underlying reason for the continuous falls in overall mortality from leukemias.[25]

Although prostate cancer is a frequent neoplasm, only limited modifiable risk factors are recognised, thus limiting the scope of primary prevention. Obesity, and lack of physical activity are determinants of prostate cancer, but the recent patterns in the prevalence of these risk factors in Europe[16] cannot account for the favourable trends. Globally, the highest mortality rates are registered in North and West Africa and in the Caribbean (age-standardised rates of 23 to 27/100 000 men) due to African ancestry and genetic susceptibility. The lowest rates are in Asian countries (3 to 8/100 000 men). Most European countries ranked in the middle with values from 8 to 14/100 000.[26] Within Europe, large (over twofold) and apparently persisting differences in prostate cancer mortality between Italy and Poland and the UK are observed and remain partly or largely unexplained. The smaller and later declines in mortality trends that are observed in some Central and Eastern countries[27–29] are probably partly due to a delayed and limited access to modern effective treatments[26,30] and Poland is the only major European country not showing favourable trends and predictions in prostate cancer rates. Mortality rates have been declining since the 1990s in Western and Northern

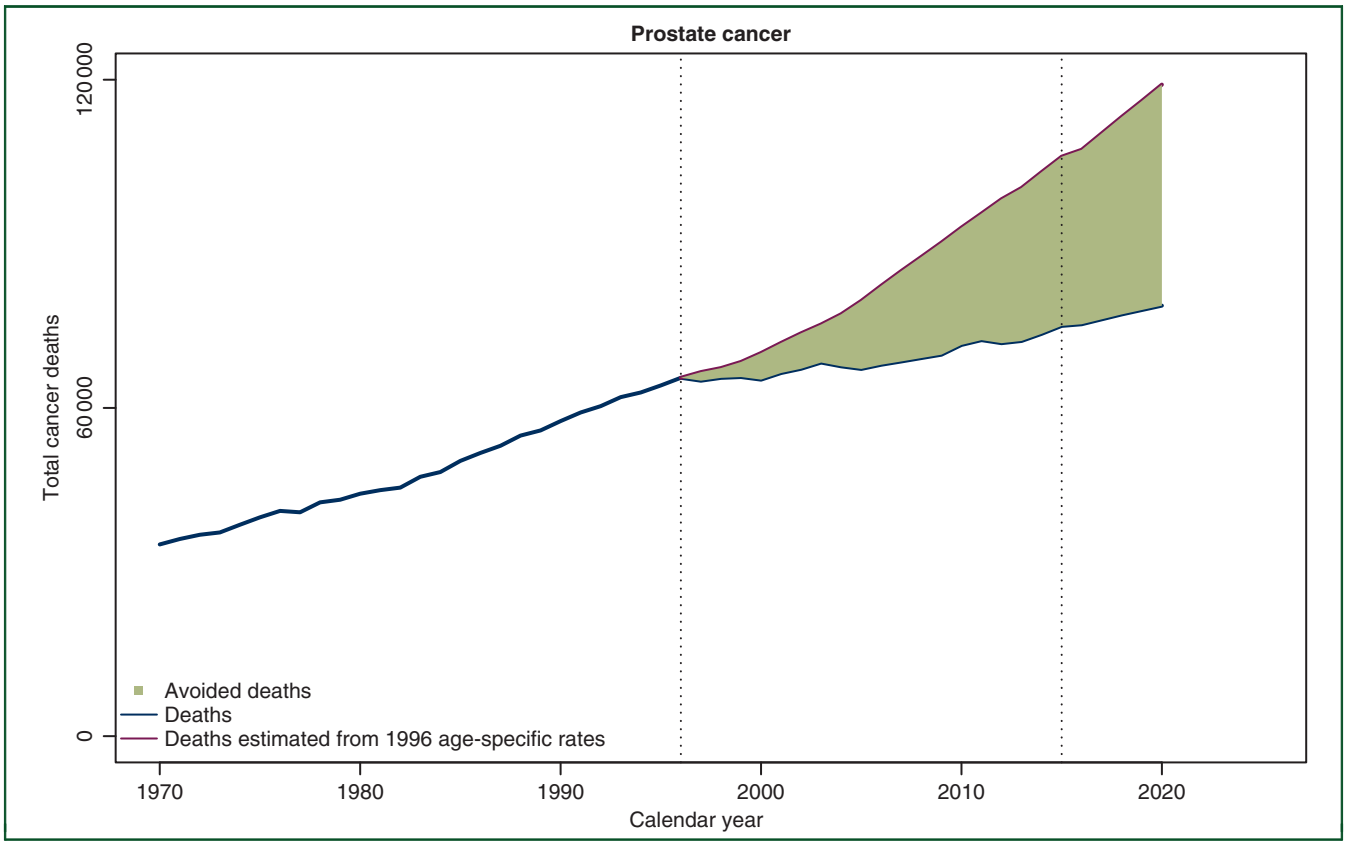

Figure 6. Total avoided prostate cancer deaths for the EU between the top rate in 1988 and 2020; observed numbers of cancer deaths from 1970 to 2015 and predicted cancer deaths from 2016 to 2020; estimated numbers of total cancer deaths by applying 1988 age-specific peak mortality rate.
During the 32-year period a total of 462 000 cancer deaths have been avoided. In 2020 alone 40 000 are predicted to be avoided.

countries; thus the geographical variability in rates across those European areas has been reducing somewhat.[26,27] Still, the difference between the rates in Italy (5.8) and those in the UK (12.0) or Poland (14.7) can only be partly related to our knowledge of the disease.[31]

These favourable trends mainly reflect improvements in prostate cancer therapy, including the technological advances observed for surgery and radiotherapy.[32] The key therapy for metastatic prostate cancer remains androgen deprivation therapy (ADT).[33] Over the last decade, abiraterone acetate and enzalutamide have been proved to ameliorate clinical outcomes in cancer unresponsive to previous ADT. These drugs along with earlier hormonal and chemotherapy administration improved survival up to 5 years,[32,34] thus avoiding prostate cancer deaths in a population of elderly patients.

Evaluating the impact of earlier diagnosis, i.e. the changed frequency of prostate-specific antigen (PSA) measurement over the years on prostate cancer mortality—besides its major role on disease incidence—is difficult.[35] PSA has been generally recommended at age 50—69 or 75 but its impact on mortality may well be reflected at older ages too. The analysed data indicate a decline between age 65 and 84 but a smaller one below age 64. This may, however, be due to greater aggressiveness of prostate cancer at younger ages. The falls in the over 85-year-olds are likely underestimated due to population ageing, since no further age adjustment is possible for this age group. Prostate cancer is common in elderly and older elderly men, where validity of death certification is lower. Most likely, improved certification validity would have increased prostate cancer rates over recent years. Thus, the predicted fall in prostate cancer rates may be somewhat underestimated, though quantification is not possible.

Like any prediction, our estimates should be considered with caution. We only considered major cancers and the largest European countries, however, thus limiting the scope for random variation. Recent changes in trends and major cohort effects would be difficult to detect with the models employed; our previous predictions proved to be reliable and valid. In fact, comparing observed cancer deaths for 2015—now available in the WHO database—with our previous predictions[28] showed that the errors in our predictions were about 2% or less for all neoplasms considered.

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DISCLOSURE

The authors have declared no conflicts of interest.

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