Background: We predicted cancer mortality figures in the European Union (EU) for the year 2017 using most recent available data, with a focus on lung cancer.

Materials and methods: We retrieved cancer death certification data and population figures from the World Health Organisation and Eurostat databases. Age-standardized (world standard population) rates were computed for France, Germany, Italy, Poland, Spain, the UK and the EU overall in 1970–2012. We obtained estimates for 2017 by implementing a joinpoint regression model.

Results: The predicted number of cancer deaths for 2017 in the EU is 1,373,500, compared with 1,333,400 in 2012 (+3%). Cancer mortality rates are predicted to decline in both sexes, reaching 131.8/100,000 men (−8.2% when compared with 2012) and 84.5/100,000 women (−3.6%). Mortality rates for all selected cancer sites are predicted to decline, except pancreatic cancer in both sexes and lung cancer in women. In men, pancreatic cancer rate is stable, in women it increases by 3.5%. Lung cancer mortality rate in women is predicted to rise to 14.6/100,000 in 2017 (+5.1% since 2012, corresponding to 92,300 predicted deaths), compared with 14.0/100,000 for breast cancer, corresponding to 92,600 predicted deaths. Only younger (25–44) women have favourable lung cancer trends, and rates at this age group are predicted to be similar in women (1.4/100,000) and men (1.2/100,000). In men lung cancer rates are predicted to decline by 10.7% since 2012, and falls are observed in all age groups.

Conclusion: European cancer mortality projections for 2017 confirm the overall downward trend in rates, with a stronger pattern in men. This is mainly due to different smoking prevalence trends in different generations of men and women. Lung cancer rates in young European women are comparable to those in men, confirming that smoking has the same impact on lung cancer in the two sexes.

Key words: cancer, Europe, mortality, projections, lung cancer, tobacco

Introduction

Since official cancer mortality figures become available with a few years lag, we developed a method to predict mortality figures for all cancers and six major types of cancers in the European Union (EU) and the six largest countries of the Union [1, 2]. We were also able to validate our estimates [3]. Similar approaches have long been used in the USA [4]. Despite uncertainties inherent in any prediction, these are useful to understand patterns and trends in risk factor exposure for major cancers, and for public health planning.

In the present work, we predicted the number of cancer deaths and mortality rates for 2017 with specific focus on lung cancer, and its recent trends in the two sexes, various age groups and countries [5, 6].

Materials and methods

This work updates the previous articles on European cancer mortality predictions, and it uses similar methods [1–3].

We considered official death certification data for cancer of the stomach, colorectum, pancreas, lung, breast, uterus (cervix and corpus), prostate, as well as leukaemia and total neoplasms (malignant and benign) from the WHO database (WHOSIS) [7].
We derived figures for the EU (28 countries as of July 2013) in the period 1970–2012 and up to the most recent available year for the 6 largest EU countries: France (2013), Germany (2014), Italy (2012), Poland (2014), Spain (2014) and the UK (2013).

Using the matrices of certified deaths and resident populations, we computed age-specific death counts and rates for each 5-year age group (from 0–4 to 85+ years), sex and calendar year. We obtained age-standardized rates (world standard population) per 100 000 men and women, at all ages, using the direct method [8]. For lung cancer, we also computed rates for the ages 25–44, 45–64, 65–74 and 75+ years, for the EU.

We fit a logarithmic Poisson count data joinpoint regression model to the number of certified deaths in each 5-year age group in order to identify the most recent trend segment [9]. Thus, we applied a linear regression to mortality data for each 5-year age group over the most recent trend segment identified by the joinpoint model to compute the predicted age-specific certified numbers of deaths and the corresponding 95% prediction intervals (PIS). We estimated 95% PIS using a standard error accounting for the variability of the new observation [10]. Predicted standard death rates with 95% PI were computed using the predicted age-specific certified numbers of deaths and the corresponding 95% prediction intervals (PIS). We estimated 95% PIs using a standard error accounting for the variability of the new observation [10]. Predicted standardized cancer mortality rate in both sexes. In men, the rate is 33.3/100 000, corresponding to 183 400 predicted deaths (24% of total male cancer deaths), and to a −10.7% fall in rates since 2012. In women, the predicted rate is 14.6/100 000, corresponding to 92 300 deaths (15% of total female cancer deaths) and a 5.1% rise in rates since 2012. Overall, lung cancer is predicted to cause 275 700 deaths in both sexes combined in 2017, corresponding to about 20% total cancer deaths.

Results

Table 1 shows the total numbers of predicted cancer deaths (rounded to the nearest hundred) and rates with the corresponding 95% PIs for 2017, in the EU as a whole, for the neoplasms under study. Table 1 also includes the 2012 recorded data.

Table 1. Number of predicted deaths and mortality rates for the year 2017 and comparison figures for most recent data (2012), for the EU as a whole, with 95% prediction intervals

<table>
<thead>
<tr>
<th>European Union</th>
<th>Observed number of deaths 2012</th>
<th>Predicted number of deaths 2017</th>
<th>Lower prediction limit (95%)</th>
<th>Upper prediction limit (95%)</th>
<th>Observed ASR&lt;sup&gt;a&lt;/sup&gt; 2012</th>
<th>Predicted ASR&lt;sup&gt;a&lt;/sup&gt; 2017</th>
<th>Lower prediction limit (95%)</th>
<th>Upper prediction limit (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>36 304</td>
<td>33 700</td>
<td>33 040</td>
<td>34 365</td>
<td>6.92</td>
<td>5.81</td>
<td>5.69</td>
<td>5.93</td>
</tr>
<tr>
<td>Colorectum</td>
<td>92 508</td>
<td>97 100</td>
<td>95 975</td>
<td>98 223</td>
<td>16.96</td>
<td>16.06</td>
<td>15.85</td>
<td>16.26</td>
</tr>
<tr>
<td>Pancreas</td>
<td>39 812</td>
<td>43 600</td>
<td>42 998</td>
<td>44 236</td>
<td>7.11</td>
<td>6.91</td>
<td>6.79</td>
<td>7.02</td>
</tr>
<tr>
<td>Lung</td>
<td>185 621</td>
<td>183 400</td>
<td>181 144</td>
<td>185 751</td>
<td>37.27</td>
<td>33.32</td>
<td>32.82</td>
<td>33.72</td>
</tr>
<tr>
<td>Prostate</td>
<td>71 810</td>
<td>76 100</td>
<td>74 858</td>
<td>77 317</td>
<td>11.08</td>
<td>10.31</td>
<td>10.11</td>
<td>10.51</td>
</tr>
<tr>
<td>Leukaemias</td>
<td>23 594</td>
<td>24 400</td>
<td>23 765</td>
<td>25 058</td>
<td>4.58</td>
<td>4.08</td>
<td>3.92</td>
<td>4.25</td>
</tr>
<tr>
<td>All cancers (malignant and benign)</td>
<td>745 281</td>
<td>761 900</td>
<td>755 723</td>
<td>768 173</td>
<td>143.48</td>
<td>131.77</td>
<td>130.56</td>
<td>132.98</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>23 501</td>
<td>21 500</td>
<td>20 945</td>
<td>22 103</td>
<td>3.20</td>
<td>2.76</td>
<td>2.67</td>
<td>2.85</td>
</tr>
<tr>
<td>Colorectum</td>
<td>78 027</td>
<td>78 600</td>
<td>77 538</td>
<td>79 719</td>
<td>9.89</td>
<td>9.31</td>
<td>9.16</td>
<td>9.46</td>
</tr>
<tr>
<td>Pancreas</td>
<td>39 692</td>
<td>43 800</td>
<td>43 200</td>
<td>44 375</td>
<td>5.43</td>
<td>5.62</td>
<td>5.53</td>
<td>5.72</td>
</tr>
<tr>
<td>Lung</td>
<td>82 076</td>
<td>92 300</td>
<td>90 675</td>
<td>93 662</td>
<td>13.54</td>
<td>14.55</td>
<td>14.29</td>
<td>14.81</td>
</tr>
<tr>
<td>Breast</td>
<td>91 847</td>
<td>92 600</td>
<td>91 362</td>
<td>93 791</td>
<td>15.19</td>
<td>14.03</td>
<td>13.79</td>
<td>14.27</td>
</tr>
<tr>
<td>Uterus (cervix and corpus)</td>
<td>28 973</td>
<td>29 500</td>
<td>28 688</td>
<td>30 059</td>
<td>4.98</td>
<td>4.71</td>
<td>4.61</td>
<td>4.82</td>
</tr>
<tr>
<td>Leukaemias</td>
<td>18 869</td>
<td>19 500</td>
<td>19 083</td>
<td>19 930</td>
<td>2.74</td>
<td>2.42</td>
<td>2.33</td>
<td>2.52</td>
</tr>
<tr>
<td>All cancers (malignant and benign)</td>
<td>588 140</td>
<td>611 600</td>
<td>607 203</td>
<td>615 923</td>
<td>87.65</td>
<td>84.51</td>
<td>83.79</td>
<td>85.23</td>
</tr>
</tbody>
</table>

<sup>a</sup>ASR, age-standardized mortality rates using the world standard population.

Overall, 1 373 500 EU deaths from cancer are predicted in 2017 (761 900 men and 611 600 women), when compared with 1 333 421 (745 281 men and 588 140 women) in 2012. The corresponding projected age-standardized rates for 2017 are 131.8/100 000 men and 84.5/100 000 women, compared with 143.5/100 000 men and 87.7/100 000 women recorded in 2012. Thus, an 8.2% fall in rates for men and a 3.6% fall in women are predicted between 2012 and 2017, while the absolute number of deaths is expected to increase by about 40 000 (+3.0%).

In the EU, in 2017, lung cancer has the highest predicted age-standardized cancer mortality rate in both sexes. In men, the rate is 33.3/100 000, corresponding to 183 400 predicted deaths (24% of total male cancer deaths), and to a −10.7% fall in rates since 2012. In women, the predicted rate is 14.6/100 000, corresponding to 92 300 deaths (15% of total female cancer deaths) and a 5.1% rise in rates since 2012. Overall, lung cancer is predicted to cause 275 700 deaths in both sexes combined in 2017, corresponding to about 20% total cancer deaths.

Breast cancer projected rate in 2017 is 14.0/100 000 women, the second highest rate in women. However, the total number of deaths remains slightly higher for breast cancer (92 600) than for lung cancer. Between the ages of 45 and 74 years, more deaths from lung than breast cancer were predicted, while in young and elderly women breast cancer deaths remain more frequent. Colorectal cancer has predicted rates of 16.1 in men and 9.3/100 000 in women, corresponding to 97 100 deaths in men and 78 600 in women (about 13% of total cancer deaths in both sexes), and with, respectively, 5.3% and 6.7% falls in rates since 2012. Prostate cancer has the third highest projected rate (10.3/100 000 with a 6.9% fall since 2012), and accounts for about
10% of the total cancer deaths in men. Pancreatic cancer rates remain approximately stable in men, with a predicted rate of 7.9/100 000, while in women it rises to 5.6/100 000 (+3.5%, compared with 2012). The total number of pancreatic cancer deaths (87 400) corresponds to about 6% of all cancer deaths. Cancers of the uterus, stomach and leukaemias represent 2, 4 and 3%, respectively, of total cancer deaths, and their falls since 2012 ranged between −16% (stomach in men) and −5% (uterus).

Figure 2 gives trends in all ages total cancer mortality rates for men and women in the EU overall in quinquennia centred from 1972 to 2012, and the predicted rates for 2017 with PIs. In men, rates have been declining since the late 1980s, while in women rates declined during the whole studied period. However, recent falls were largest in men.

Figure 3 shows mortality trends for each selected cancer site in the EU. Stomach cancer has the greatest proportional falls in mortality in both sexes. Lung cancer in men also shows considerable falls over the last few years, while in women the rate rises steadily. Lung cancer in women shows a steady upward trend over the entire period. The supplementary appendix, available at Annals of Oncology online, provides country-specific data and analyses (supplementary Tables S1–S9 and Figure S1, available at Annals of Oncology online).

Table 2 gives all ages standardized mortality rates for lung cancer in the 2005–2009 quinquennium and in 2012, the predicted age standardized rate for 2017 and the percent difference between 2017 and 2012, in the six selected countries and in the EU as a whole. Moreover, for the EU, Table 2 shows specific figures for the age groups 25–44, 45–64, 65–74 and 75+ years.

In 2005–2009, overall lung cancer mortality rates among men ranged between 33.1 (the UK) and 62.0/100 000 men (Poland); all countries show downwards trends for 2017 between 25.7 (the UK) and 46.8/100 000 men (Poland). The overall decline in EU male, between 2012 and 2017, is 10.7%, and in all age groups the patterns are favourable, particularly in the 25–44 group (−48.5%). In women, the lowest rate for 2005–2009 was 6.3 in Spain, while the highest was 20.5/100 000 in the UK. Apart from the UK, all countries have unfavourable trends and predicted rates vary between 8.8 (Spain) and 19.1/100 000 women (the UK). Only young women show favourable patterns (−15.1%).

Figure 4 shows joinpoint analysis for lung cancer age-standardized mortality rates for the EU, in both sexes, in the five studied age groups, along with predictions for 2017 and corresponding PIs. In men, all age groups display a downward trend since late 1980s/early 1990s. Women aged 25–44 years increased up to the late 1980s, and decline moderately thereafter. All other age groups show upwards trends.

Figure 5 gives the estimated number of avoided cancer deaths for EU men and women between the top rate in 1988 and 2017 (light grey area, light green online). Over the 30 years period considered, 2,893,054 cancer deaths in men and 1,471,216 in women (for a total of 4,364,270) have been avoided. In 2017, 253,915 are predicted to be avoided in men and 107,780 in women, for a total of 361,695.

**Discussion**

EU mortality rates from all cancers combined and from most site-specific cancers are predicted to further fall to 2017, confirming the favourable trends in cancer mortality registered in Europe and other areas of the world over the last two decades [12, 13]. However, the fall in age-standardized rates is not reflected in the total number of deaths, since these are still expected to rise moderately, due to the continuous population’s increase in size and ageing [14]. Despite a steady substantial decline in breast cancer mortality, the predicted fall in overall cancer mortality was smaller in women than in men (−4% versus −8%).

This essentially reflects the different trends in lung and other tobacco-related cancers between the two sexes [15]. In fact, lung cancer mortality in women is still rising, to reach an overall predicted rate of 14.6/100 000 in 2017, while it is decreasing by 11% in men. In the age group 25–44, predicted lung cancer rates in the EU are similar in men and women, reflecting the similar smoking patterns in the young generations of the two sexes over recent...
decades [16]. This confirms that the impact of smoking on lung cancer is the same in men and women [17]. Despite the persisting unfavourable trends, female lung cancer rates remain consistently lower in the EU (except the UK and Poland) than in the USA [4], and are unlikely to reach the high levels reached in the USA during the 1990s [18]. Only in the UK, where female lung cancer rates approached 20/100,000, trends appear to be levelling off, but the rise in other countries remains substantial, particularly in France and Spain, where smoking became common in women in the 1970s [19]. In general, all former non-market economy countries of central and eastern Europe have higher lung cancer rates in men, and the pattern of trends reported for Poland are reasonably representative of the area.

The other major neoplasm showing no favourable predictions is pancreatic cancer. Similar trends were registered for the USA [4, 20]. Tobacco is the major recognized risk factor for pancreatic cancer, but its attributable fraction is 15–25% in most populations [21, 22]. Thus, at least in men, some fall would have been expected, and indeed the recent trends were no longer rising. No real progress has been made in the screening, management and treatment of pancreatic cancer, and the increased prevalence of overweight, obesity and diabetes, mostly in northern Europe, may have unfavourably affected pancreatic cancer rates [23].

The predicted downward trends for colorectal cancer and leukaemias in both sexes, as well as for cancers of the prostate [24], breast and uterus [25], likely reflect improved diagnoses, management and treatment of these neoplasms over the last three decades [26, 27] and are expected to continue in the near future.

Likewise, continuous falls are predicted for gastric cancer, probably due to the long term effects of the decreased prevalence of Helicobacter pylori infection in subsequent generations and
Figure 3. Age-standardized (world population) EU male and female cancer mortality rate trends in quinquennia from 1970–1974 to 2005–2009 plus the year 2012 and predicted rates for 2017 with 95% prediction intervals (PIs). Men: stomach (squares), colorectum (circles), pancreas (triangles), lung (crosses), prostate (xs) and leukaemias (diamonds). Women: stomach (squares), colorectum (circles), pancreas (triangles), lung (crosses), breast (xs), uterus (diamonds) and leukaemias (inverted triangles).

Table 2. Age-standardized lung cancer mortality rates for all ages in different selected European countries, in men and women

<table>
<thead>
<tr>
<th>Country</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASR(^a) 2005–2009</td>
<td>ASR(^a) 2012</td>
</tr>
<tr>
<td>France</td>
<td>41.90</td>
<td>37.96</td>
</tr>
<tr>
<td>Germany</td>
<td>34.99</td>
<td>32.08</td>
</tr>
<tr>
<td>Italy</td>
<td>38.39</td>
<td>34.43</td>
</tr>
<tr>
<td>Poland</td>
<td>61.95</td>
<td>53.66</td>
</tr>
<tr>
<td>Spain</td>
<td>42.89</td>
<td>39.72</td>
</tr>
<tr>
<td>EU All ages</td>
<td>41.07</td>
<td>37.27</td>
</tr>
<tr>
<td>Truncated 25–44 years</td>
<td>2.91</td>
<td>2.35</td>
</tr>
<tr>
<td>Truncated 45–64 years</td>
<td>89.45</td>
<td>79.00</td>
</tr>
<tr>
<td>Truncated 65–74 years</td>
<td>289.34</td>
<td>266.73</td>
</tr>
<tr>
<td>Truncated 75+ years</td>
<td>439.20</td>
<td>411.66</td>
</tr>
</tbody>
</table>


\(^a\)ASR, age-standardized mortality rates using the world standard population.
Figure 4. Annual lung cancer age-standardized (world population) death rates in the EU per 100,000 for all-ages, 25–44, 45–64, 65–74 and 75+ years age groups from 1970 to 2012, the resulting joinpoint regression models, and predicted rates for the year 2017 with 95% PIs. On the left, men and women at all-ages (full squares and full circles, respectively) and at 25–44 years (empty squares and empty circles), on the right, men and women at 45–64 years (full squares and full circles), at 65–74 years (empty squares and empty circles) and at 75+ years (triangles and inverted triangles).

Figure 5. Total avoided cancer deaths for EU men and women between the top rate in 1988 and 2017 (light grey area, light green online); observed numbers of cancer deaths from 1970 to 2012 and predicted cancer deaths from 2013 to 2017 (black line, blue online); estimated numbers of total cancer deaths by applying 1988 age-specific peak mortality rate (dark grey, red online). During the 30 years period a total of 4,364,270 cancer deaths have been avoided (2,893,054 in men and 1,471,216 in women). In 2017 alone 253,915 are predicted to be avoided in men and 107,780 in women, for a total of 361,695. ASR, age specific rate.
across countries [28]. Still, major differences in gastric cancer mortality remain across Europe [29], with rates about twice as high in Poland compared with the UK.

Short term predictions of deaths and rates from major cancer sites provide a reasonable picture of current cancer burden in the EU, and have proven to be satisfactory robust for the EU and its major countries [3]. Still, none of the proposed models is able to estimate sudden fluctuations or major changes in slopes. Thus, as for any prediction, due caution is required for interpretation and inference.

In conclusion, cancer mortality rates are predicted to decline further in the EU, mainly in men following the decreased prevalence of smoking in subsequent generations in recent calendar decades. The persistent unfavourable trends in female lung cancer resulted in similar mortality rates in both sexes in the young, confirming the similar impact of tobacco on lung cancer in men and women.

**Funding**

This work was conducted with the contribution of the Italian Association for Cancer Research (AIRC, project N. 14360), MIUR (Ministero dell’Istruzione, dell’Università e della Ricerca), with a SIR (Scientific Independence of Young Researchers) 2014 grant (project RBSI1465UH), and with the European Cooperation in Science and Technology—COST Action BM1204 EU-Pancreas.

**Disclosure**

The authors have declared no conflicts of interest.

**References**