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ORIGINAL ARTICLE

# European cancer mortality predictions for the year 2022 with focus on ovarian cancer

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**Background:** Cancer mortality rates, though not absolute numbers of deaths, have been decreasing over the last three decades in Europe.

**Materials and methods:** We estimated projections and the number of avoided deaths for total cancer mortality and 10 major cancer sites, between 1989 and 2022, for the European Union (EU), the UK, France, Germany, Italy, Poland and Spain using cancer death certification and population data since 1970 from the World Health Organization and Eurostat.

**Results:** In the EU, we predict 1 269 200 cancer deaths in 2022; corresponding age-standardized rates (world) fall 6% to 126.9 deaths/100 000 in men and 4% to 80.2/100 000 women since 2017. Male lung cancer is expected to fall 10% reaching 30.9/100 000. The rise in female lung cancer mortality slowed (+2% to 13.8/100 000). We estimated 369 000 (23%) avoided deaths in 2022 alone and a total of 5 394 000 (12%) deaths since the peak rate in 1988. Stomach, colorectal, breast and prostate cancers showed substantial declines, between 5% and 16% over the past 5 years. Pancreatic cancer remained stable in men (8.1/100 000) and rose 3% in women (5.9/100 000), becoming the third cause of cancer mortality in the EU (87 300 deaths), overtaking breast cancer (86 300 deaths). The fall in uterine cancers slowed down (−4%) to 4.7/100 000. Bladder cancer fell 9% in men, but was stable in women. Leukaemias fell more than 10%. Ovarian cancer mortality declined over the past decade in all considered countries. EU predicted rates were 4.3/100 000 (−13%) all ages, 1.2/100 000 (−26%) at 20-49, 15.3/100 000 (−11%) at 50-69 and 32.3/100 000 (−11%) at 70-79 years.

**Conclusions:** We predicted additional declines in cancer mortality rates for 2022. The slowdown in female lung cancer mortality reflects some levelling of smoking in women. Favourable ovarian cancer trends are likely to continue and are largely attributable to the spreading oral contraceptive use and some impact of improved diagnosis and management.

**Key words:** cancer, Europe, mortality rates, prediction models, ovarian cancer, COVID-19

## INTRODUCTION

We have been publishing cancer mortality predictions for the current year since 2011.[1] Data for 2017 for most European Union (EU) countries have now been made available. Consequently, our EU dataset was updated and validated. In 2022, the COVID-19 pandemic may have an impact on cancer mortality mainly in the elderly across Europe and our projections cannot account for this,[2,3] and should be considered when interpreting the present data.

In this work, we present cancer mortality predictions for the 10 major causes of cancer mortality and total cancer in the year 2022 for the EU (27 countries as of 2021), as well as the UK which has been examined separately since Brexit in 2021[4] and the five most populous EU countries. Additionally, we focus on ovarian cancer.

## MATERIALS AND METHODS

We obtained official death certification data from the World Health Organization (WHO) database for 10 major cancer sites and all cancers combined.[5] We recoded cancer deaths according to the 10th International Classification of Disease (ICD) Revision: total cancers (ICD codes C00-D48), stomach (C16), colorectal (C17-C21, C26), pancreas (C25), lung (C33-C34), breast (C50), uterus (cervix and corpus) (C53-C55), ovary (C56), prostate (C61), bladder (C67) and leukaemia

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(C91-C95).[6] Resident population estimates were retrieved from the same WHO database or, when data were missing, from the Eurostat database.[7] Figures were derived from 1970 to 2017 for the EU (current 27 member states, minus Cyprus due to data unavailability), from 1970 to 2016 for the UK, and from 1970 up to the most recent available years for the five European most populous countries (France, Germany, Italy, Poland and Spain).

We computed country- and sex- specific death rates for each 5-year age group (from 0-4 up to 85+ years) and calendar year or quinquennium. Age-standardized (world standard population) mortality rates were calculated for all ages and also for selected age groups for ovarian cancer.[8] We analysed the trend of age-standardized rates by fitting joinpoint regression models, including up to four joinpoints.[9]

We predicted mortality figures by fitting a logarithmic Poisson joinpoint regression model to the number of deaths in each 5-year age group. We identified significant changes in trends testing up to five joinpoints. Age-specific numbers of deaths for 2022 and the corresponding 95% prediction intervals (PIs) were estimated by fitting a linear regression model to the mortality data for each age group over the most recent trend segment identified by the joinpoint analysis. We then calculated age-specific and age-standardised death rates (and related 95% PIs) by using the predicted age-specific number of death counts. Corresponding predicted populations were retrieved from Eurostat.

We estimated the number of avoided deaths for the EU and the UK for the period 1988-2022 by comparing observed and predicted deaths to those expected on the basis of the 1988 age-specific peak rate.

## RESULTS

Table 1 displays predicted cancer deaths and age-standardized rates with corresponding 95% PIs for 2022, compared with the observed data for 2017 for the EU and 2016 for the UK. In Europe, total cancer mortality rates were predicted to decline over the 2017-2022 period, from 134.3/100 000 to 126.9/100 000 (−6%) in men and from 83.2/100 000 to 80.2/100 000 (−4%) in women. A decrease was also expected in the UK from 122.1/100 000 to 113.2/100 000 (−7%) in men and from 93.5/100 000 to 87.6/100 000 (−6%) in women. Due to population aging, however, the number of certified deaths was predicted to increase both in the EU (from 674 128 to 710 200 in men, and from 531 583 to 559 000 in women), and in the UK (from 90 410 to 95 100 in men, and from 79 930 to 81 700 in women). Only the cancer sites showing substantial falls in rates, including stomach, male lung, female colorectal and ovary in the EU, leukaemia, male colorectal and prostate, and female breast and ovary in the UK, did not show an increase in the absolute number of certified deaths.

Figure 1 presents predicted age-standardized rates for 2022, and observed ones for 2017 (2016 for the UK), for all cancers combined and 10 major cancer sites, in the EU and the UK. In EU men, lung cancer showed the highest predicted rate (30.9/100 000), followed by colorectal (14.9/100 000) and prostate (9.5/100 000) cancers. Falls are expected for all these cancer sites by 10%, 5% and 7%, respectively. Substantial declines in male cancer mortality were also observed for stomach (−12%), bladder (−9%) and leukaemia (−14%). The pancreatic cancer rate was stable (8.1/100 000). Lung cancer also had the highest predicted rate in women (13.8/100 000) with an expected, but non-significant 2% increase compared with 2017. Rates declined for breast cancer (13.4/100 000, −7%) and colorectal (8.3/100 000, −8%). Both cancers of the uterus and ovary are expected to decrease (−4% and −7%, respectively), while an increase is expected for pancreatic cancer (+3%), which is predicted to surpass breast cancer in combined numbers of deaths. Favourable trends are expected for stomach cancer and leukaemia, while the bladder cancer rate was stable. Similar patterns emerged in UK men, except for a 5% decline in pancreatic cancer. Lung cancer had the highest rate in UK women, but with a favourable predicted 3% decline. Appreciable favourable changes also emerged for breast cancer (from 15.1/100 000 to 12.9/100 000, −15%) and ovarian cancer (from 5.5/100 000 to 4.6/100 000, −17%). Mortality from cancers of the colorectum, pancreas and bladder showed no appreciable change between the two periods. Predictions for stomach cancer and leukaemia were consistent with European trends, but UK rates remained consistently lower for gastric cancer. Female colorectal cancer in the UK remained higher than in the EU. The lower rates in total male cancer mortality in the UK compared with the EU and the higher ones in women are largely due to the lower lung cancer mortality rates in men, and to a combination of the higher lung and colon cancer mortality rates in women.

Figure 2 shows mortality trends for all neoplasms and 10 specific cancer sites in quinquennia (1970-1974 to 2010-2014), in the central year 2017, and predicted rates for 2022, in EU men and women. Male mortality from all cancers declined from the late 1980s, mainly driven by the fall in lung cancer mortality. A fall in gastric cancer has been evident since the 1970s. A favourable trend for most cancer sites emerged in the past decade too. Conversely, pancreatic cancer showed an increase over time. In women, a constant, but less marked decline was present over the four decades for all cancers combined. Breast cancer started to decline appreciably in the early 1990s. Marked decreases were also evident for colorectal, stomach and uterine cancer; the latter, however, has been levelling off in recent years. From the 1990s onwards, favourable trends also emerged for ovarian and bladder cancers and leukaemia. Female mortality from pancreatic and lung cancers has been increasing over time. In particular, lung cancer in the EU was predicted to overtake breast cancer in 2021, though the increase in lung cancer was less steep than in the past. Supplementary Figure S1, available at https://doi.org/10.1016/j.annonc.2021.12.007, displays analogous data for the UK, where male mortality for all cancers decreased over time, driven by a marked decrease in lung cancer mortality

**Table 1.** Number of predicted deaths and mortality rate for the year 2022 and comparison figures for 2017 (2016 for the UK), for the EU and for the UK, with 95% prediction intervals (PI)

| | Observed number of deaths 2017 | Predicted number of deaths 2022 (95% PI) | Observed ASR[a] 2017 | Predicted ASR[a] 2022 (95% PI) | % Difference 2022 versus 2017 | Observed number of deaths 2016 | Predicted number of deaths 2022 (95% PI) | Observed ASR[a] 2016 | Predicted ASR[a] 2022 (95% PI) | % Difference 2022 versus 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| | EU | | | | | UK | | | | |
| Men | | | | | | | | | | |
| Stomach | 31 225 | 30 100 (29 393-30 779) | 6.28 | 5.51 (5.36-5.65) | −12.3 | 2867 | 2600 (2482-2778) | 3.84 | 3.26 (3.05-3.47) | −15.1 |
| Colorectum | 82 267 | 86 000 (84 315-87 721) | 15.65 | 14.87 (14.55-15.19) | −5 | 10 935 | 11 200 (10 867-11 513) | 14.64 | 13.23 (12.76-13.69) | −9.6 |
| Pancreas | 39 718 | 43 500 (42 957-44 024) | 8.16 | 8.11 (8-8.21) | −0.7 | 4738 | 5000 (4843-5236) | 6.79 | 6.45 (6.12-6.78) | −5 |
| Lung | 162 423 | 161 700 (158 953-164 521) | 34.09 | 30.86 (30.17-31.54) | −9.5 | 19 357 | 19 100 (18 674-19 528) | 26.52 | 23.22 (22.63-23.8) | −12.5 |
| Prostate | 65 501 | 69 000 (67 847-70 079) | 10.22 | 9.49 (9.33-9.66) | −7.1 | 11 645 | 12 100 (11 625-12 546) | 12.67 | 11.53 (11.03-12.03) | −9 |
| Bladder | 28 839 | 30 000 (29 041-30 911) | 4.92 | 4.47 (4.34-4.6) | −9.2 | 3631 | 4000 (3821-4161) | 4.17 | 3.89 (3.67-4.11) | −6.7 |
| Leukemias | 21 519 | 22 200 (21 616-22 739) | 4.22 | 3.62 (3.43-3.81) | −14.2 | 2752 | 2800 (2687-2975) | 3.83 | 3.18 (2.91-3.44) | −17.1 |
| All cancers (malignant and benign) | 674 128 | 710 200 (700 760-719 584) | 134.25 | 126.91 (124.95-128.87) | −5.5 | 90 410 | 95 100 (93 953-96 317) | 122.09 | 113.16 (111.41-114.91) | −7.3 |
| Women | | | | | | | | | | |
| Stomach | 19 798 | 17 700 (17 027-18 308) | 2.9 | 2.43 (2.34-2.52) | −16.3 | 1603 | 1100 (896-1239) | 1.73 | 1.19 (0.99-1.39) | −31.3 |
| Colorectum | 67 239 | 66 900 (65 833-68 046) | 9.05 | 8.33 (8.18-8.47) | −8 | 9618 | 10 300 (9918-10 651) | 10.15 | 10.09 (9.63-10.55) | −0.6 |
| Pancreas | 39 553 | 43 800 (43 168-44 452) | 5.69 | 5.89 (5.77-6) | 3.4 | 4548 | 4800 (4600-5032) | 5.02 | 4.92 (4.6-5.24) | −2 |
| Lung | 74 723 | 82 600 (80 923-84 277) | 13.55 | 13.82 (13.44-14.19) | 2 | 16 328 | 17 300 (16 802-17 875) | 19.4 | 18.73 (18.12-19.35) | −3.4 |
| Breast | 83 769 | 86 300 (85 218-87 466) | 14.38 | 13.41 (13.19-13.64) | −6.7 | 11 512 | 10 700 (10 331-11 010) | 15.08 | 12.87 (12.37-13.36) | −14.7 |
| Uterus (cervix and corpus) | 27 080 | 28 300 (27 771-28 847) | 4.9 | 4.72 (4.62-4.83) | −3.6 | 3215 | 3600 (3463-3729) | 4.31 | 4.53 (4.33-4.74) | 5.2 |
| Ovary | 26 221 | 26 500 (25 965-27 117) | 4.63 | 4.32 (4.21-4.44) | −6.6 | 4235 | 4000 (3727-4280) | 5.52 | 4.57 (4.16-4.98) | −17.2 |
| Bladder | 9584 | 10 000 (9645-10 281) | 1.15 | 1.11 (1.07-1.15) | −3.2 | 1759 | 1900 (1745-1989) | 1.6 | 1.6 (1.47-1.73) | 0.1 |
| Leukemias | 17 299 | 18 000 (17 562-18 370) | 2.54 | 2.24 (2.13-2.34) | −12 | 1997 | 2000 (1893-2109) | 2.25 | 1.9 (1.7-2.1) | −15.6 |
| All cancers (malignant and benign) | 531 583 | 559 000 (553 144-564 829) | 83.21 | 80.17 (79.47-80.88) | −3.6 | 79 930 | 81 700 (80 181-83 242) | 93.45 | 87.63 (85.5-89.75) | −6.2 |

[a] ASR, age-standardized mortality rates using the world standard population.

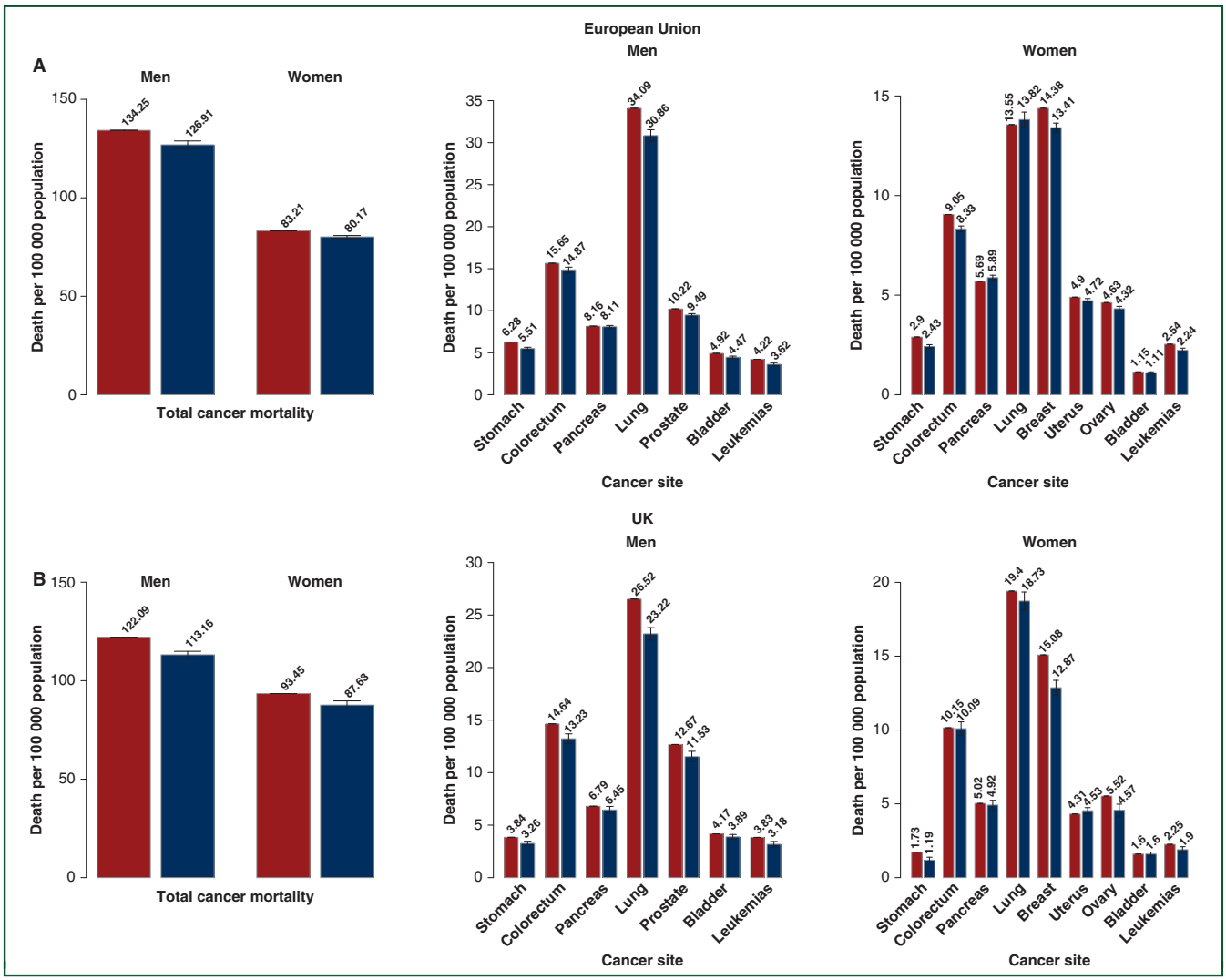


**Figure 1.** **(A) Bar-plots of age-standardized (world population) death rates per 100 000 persons for the year 2017 (red), and predicted rates for 2022 (blue) with 95% prediction intervals for total cancers and 10 major cancer sites in European Union men and women. (B) Bar-plots of age-standardized (world population) death rates per 100 000 persons for the year 2016 (red) and predicted rates for 2022 (blue) with 95% prediction intervals for total cancer and 10 major cancer sites in UK men and women.**

since the 1970s. In women, overall mortality started to decline from the late 1980s, when a marked decrease in breast cancer mortality began. Female lung cancer mortality overtook that of breast cancer during early 2000s. UK breast cancer mortality in the 1980s was ∼50% higher than in the EU, but it is now lower than in the EU. In particular, in the past decades a constant decrease in lung cancer mortality was observed. The decrease of uterine cancer mortality has come to a halt in the UK, where unfavourable trends are projected. Additional country-specific analyses are provided in Supplementary Tables S1-S8 and Supplementary Figures S2 and S3, available at https://doi.org/10.1016/j.annonc.2021.12.007.

Figure 3 displays total cancer averted deaths between the highest peak rate of 1988 and 2022 in men and women in the EU and Supplementary Figure S4, available at https://doi.org/10.1016/j.annonc.2021.12.007 presents averted deaths in the UK. In the EU, during this period, we estimated a total of 5 394 000 averted deaths (3 660 000 in men and 1 734 000 in women) of which 369 000 (262 000 in men and 106 000 in women) were averted in 2022 alone. These figures correspond to 12% of total cancer deaths avoided over the period, 14% in men and 9% in women. In 2022 alone, 22% of total cancer deaths (27% in men and 16% in women) are predicted to be avoided. In the UK, we estimated a total of 1 085 000 (735 000 in men and 350 000 in women) avoided deaths over the considered period, including 73 000 (49 000 in men and 24 000 in women) in 2022.

Table 2 presents predicted ovarian cancer mortality rates and related 95% PIs for 2022, compared with observed ones in the quinquennia 2005-2009, 2010-2014 and in the central year 2017, for all the considered countries plus the EU. Rates for selected age groups are also presented for the EU. Rates were declining in all the selected countries since 2010-2014. France had the lowest predicted rate in 2022 (3.4/100 000), along with the strongest decline (−22%) since the 2010-2014 quinquennium, followed by Spain (3.6/100 000, −6%), Italy (3.7/100 000, −12%), Germany

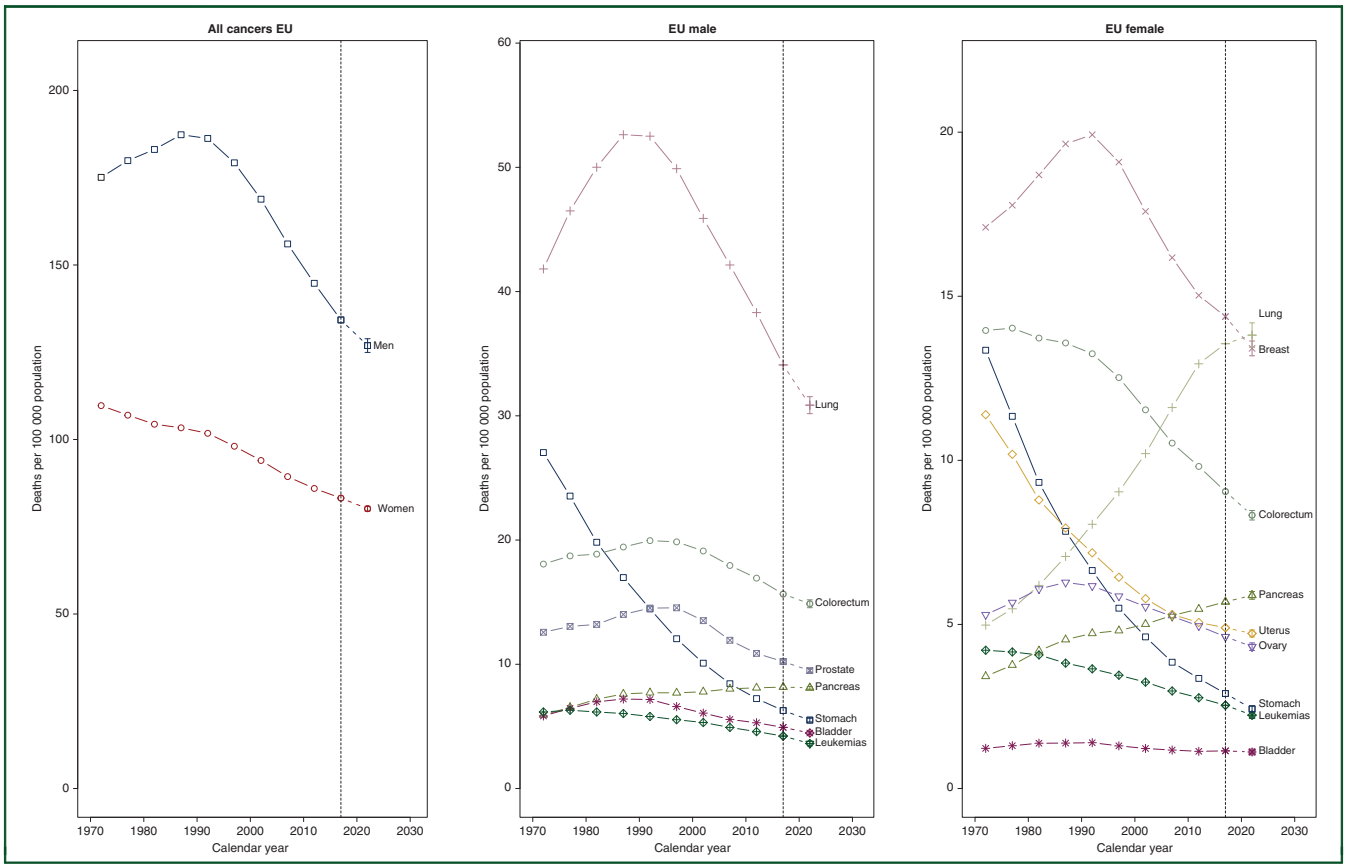


**Figure 2.** **Age-standardized (world population) cancer mortality rate trends in quinquennia from 1970-1974 to 2010-2014 and the central year 2017, and predicted rates for 2022 with 95% prediction intervals, for all neoplasms and both sexes (left) and each cancer site under study for men (centre) and women (right), in the European Union (EU).**

(4.3/100 000, −16%) and Poland (6.1/100 000, −12%). Nevertheless, Spain and Poland showed stable rates between 2017 and 2022. The UK presented a 22% reduction in ovarian cancer mortality rates between the considered periods, with a predicted rate of 4.6 in 2022. Since 2010-2014, in the EU, mortality rates declined 26% in women aged 20-49 years and 11% in both the 50-69 and 70-79 age groups.

Figure 4A displays mortality trends for ovarian cancer rates in quinquennia (1970-1974 to 2010-2014) and the central year 2017 (2016 for France and UK), for the EU and its five considered countries, plus the UK. The sixfold gap in mortality rates between the highest rate in the UK and the lowest one in Spain in the 1970s has shrunk over the last decades. Predicted rates were consistent with this trend, with a slower decline in Poland, which had the highest predicted rate in 2022. Mortality rates from ovarian cancer in the EU increased up to the late 1980s, with a subsequent steady decrease. All European countries showed similar trends. In France and Italy, changes were consistent with European trends, while in Spain and Poland mortality trends started to decrease later (late 1990s and late 2000s, respectively). In Germany, a marked decrease appeared after the early 1980s. In contrast, mortality trends in the UK have declined since the 1970s, and predicted rates for 2022 approached the European average. Figure 4C gives the avoided number of ovarian cancer deaths compared with the top rate in 1988. During the 34-year period 1988-2022, a total of ∼111 000 cancer deaths have been avoided in the EU. Of these, ∼8000 are predicted to be avoided in 2022 alone.

Figure 4B presents joinpoint analysis of age-standardized ovarian cancer mortality rates for the EU, for all ages and selected age groups, along with predictions for 2022. In the past decades, ovarian cancer mortality decreased for all ages and for all age groups. In particular, in women aged 50-69 years and 70-79 years the decline started between the end of the 1980s and the early 1990s, while mortality rates for women aged 20-49 years declined during the whole considered period.

## DISCUSSION

Falls in total cancer mortality in men and women were predicted in the EU and agreed with other similar works.[10] In 2022, ∼369 000 deaths were averted compared with the peak cancer mortality rate of 1988 and >5 million over the past 34 years. This is consistent with the patterns reported for the USA,[11] which had lower rates and faster falls. In the EU, lung and colon cancer were still the leading causes of cancer death, making up >30% cancer deaths between them at nearly 400 000 deaths predicted in 2022. Pancreatic cancer is predicted to surpass breast cancer, becoming the

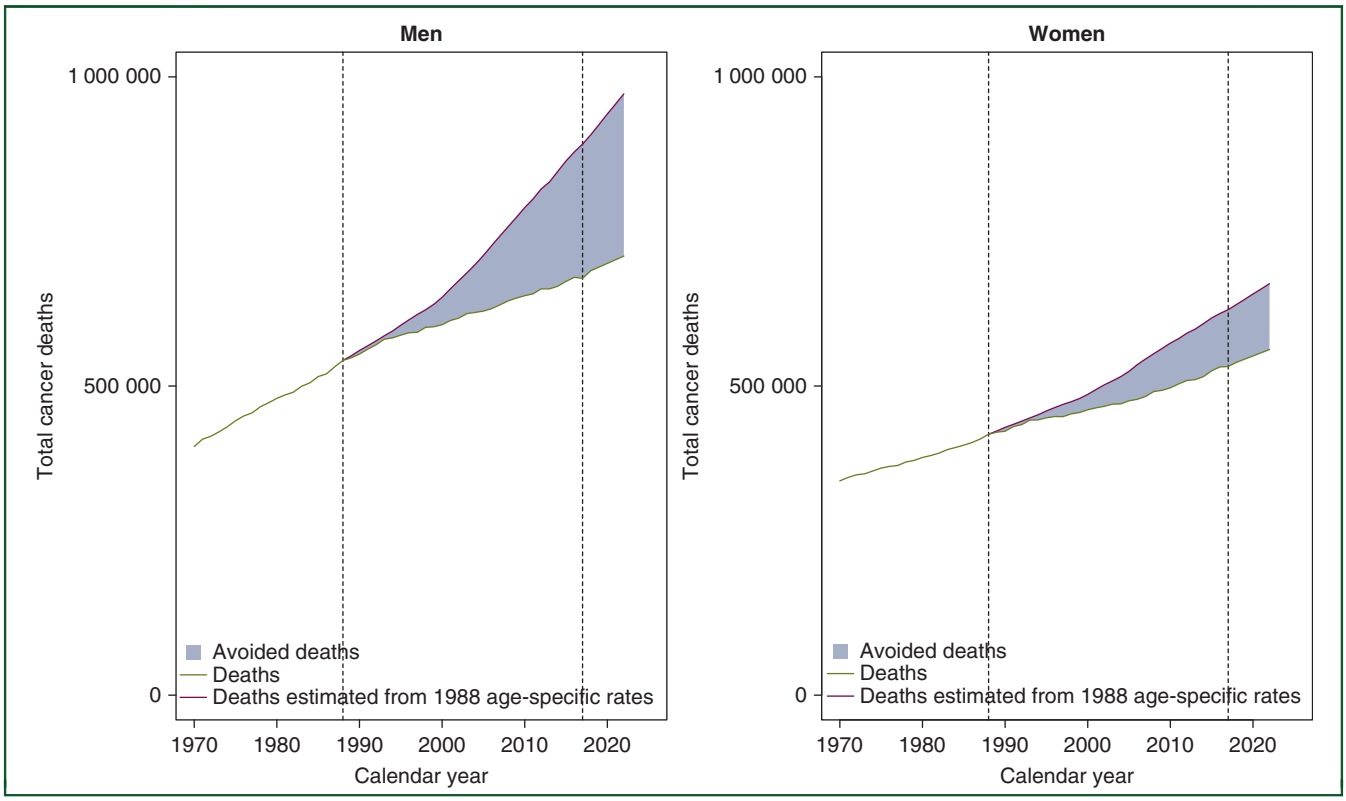


**Figure 3.** **Total avoided cancer deaths for European Union men and women between the top rate in 1988 and 2022; observed numbers of cancer deaths from 1970 to 2017 and predicted cancer deaths from 2018 to 2022 (green line); estimated numbers of total cancer deaths by applying 1988 age-specific peak mortality rate (red line). During the 34 years period 5 394 000 cancer deaths have been avoided (3 660 000 in men and 1 734 000 in women). In 2022 alone, 262 000 in men and 106 000 in women are predicted to be avoided, for a total of 369 000.**

third cause of cancer death in the EU, largely due to it being the only major cancer with a lack of therapeutic progress in men and unfavourable trends in women. The UK has a lower total cancer mortality rate in men, but a higher one in women. The differences between the rates in total cancer mortality between the EU and the UK are strongly dependant on the historic prevalence of the consumption of tobacco—the main avoidable risk factor responsible for nearly 27% of cancer deaths in the European region[12]—in successive generations of men and women.

In the detailed analysis of ovarian cancer, mortality rates have been falling in the EU and are expected to continue doing so in the foreseeable future for all the age groups considered. Favourable trends had already been registered and predicted for the EU and other high income countries with rates and trends for the EU being similar to those seen in the USA, and a clear gradient in rates, from high rates in North East Europe to low ones in South West Europe, was also observed.[13] Furthermore, incidence data for England, France and Germany also showed favourable trends.[14]

**Table 2.** **Age-standardized ovarian cancer mortality rates for all ages in selected European countries, and for the European Union as a whole for all ages, 20-49, 50-69 and 70-79 years in the 2005-2009, 2010-2014 quinquennia and the year 2017 (2016 for France and the UK), and predicted for 2022, with percentage differences between 2010-2014 and 2022**

| | ASR 2005-2009 | ASR 2010-2014 | ASR 2017 | Predicted ASR 2022 (95% PI) | % Difference 2022 2010-2014 |
|---|---|---|---|---|---|
| France | 4.72 | 4.33 | 3.89 | 3.37 (3.1-3.63) | −22.3 |
| Germany | 5.33 | 5.05 | 4.6 | 4.25 (4.02-4.48) | −15.8 |
| Italy | 4.41 | 4.21 | 4.08 | 3.72 (3.45-3.99) | −11.6 |
| Poland | 7.11 | 6.87 | 6.4 | 6.05 (5.59-6.52) | −11.9 |
| Spain | 3.92 | 3.79 | 3.69 | 3.56 (3.32-3.8) | −6.1 |
| UK | 6.63 | 5.83 | 5.52 | 4.57 (4.16-4.98) | −21.6 |
| EU | | | | | |
| All ages | 5.24 | 4.95 | 4.63 | 4.32 (4.21-4.44) | −12.7 |
| Truncated 20-49 years | 1.78 | 1.59 | 1.4 | 1.17 (1.07-1.27) | −26.4 |
| Truncated 50-69 years | 18.35 | 17.17 | 15.62 | 15.26 (14.63-15.89) | −11.1 |
| Truncated 70-79 years | 37.03 | 36.46 | 36.7 | 32.34 (31.04-33.63) | −11.3 |

ASR, age-standardized mortality rates using the world standard population; PI, prediction interval.

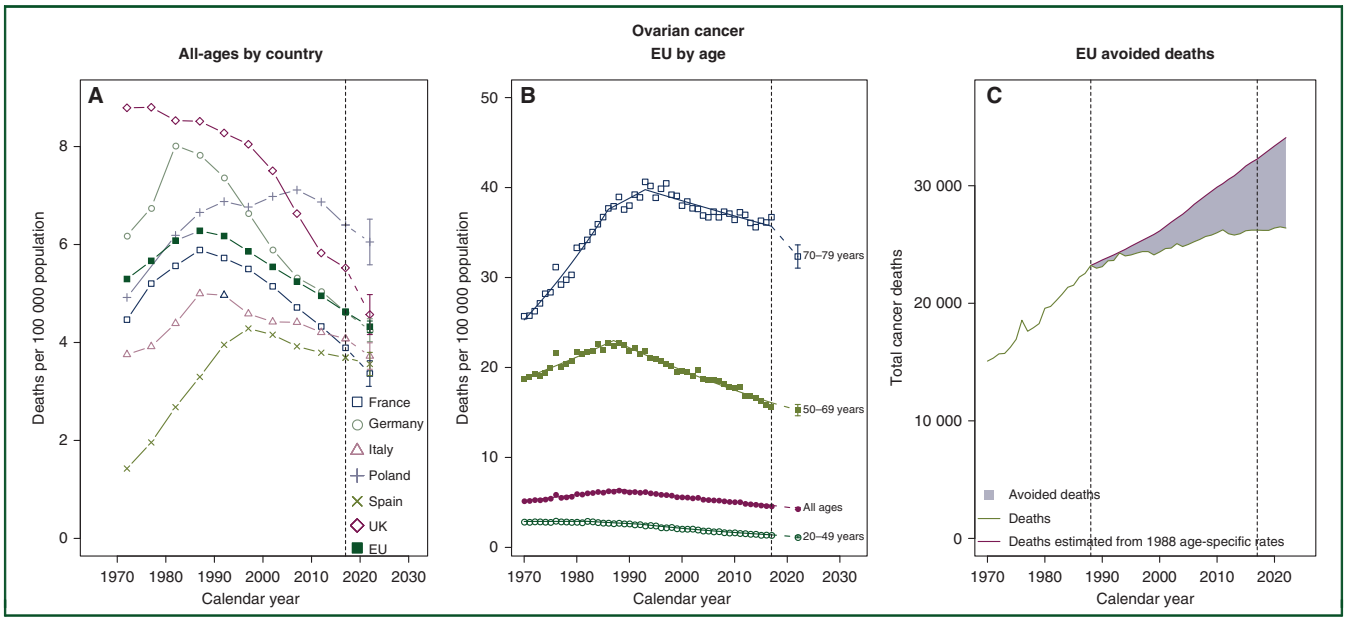


**Figure 4.** **(A) Age-standardized (world population) ovarian cancer mortality rate trends in quinquennia from 1970-1974 to 2010-2014 and the central year 2017 (2016 for France and the UK), predicted rates for 2022 with 95% prediction intervals in studied countries and in the European Union (EU) as a whole. (B) Annual cancer age-standardized (world population) death rates in the EU per 100 000 for all ages (full circles), 20-49 (empty circles), 50-69 (full squares) and 70-79 (empty squares) age-groups from 1970 to 2019, the resulting joinpoint regression models and predicted rates for the year 2022 with 95% prediction intervals. (C) Total avoided ovarian cancer deaths for EU between the top rate in 1988 and 2022 (light grey area); observed numbers of cancer deaths from 1970 to 2017 and predicted cancer deaths from 2018 to 2022 (green line); estimated numbers of total cancer deaths by applying 1988 age-specific peak mortality rate (red line). During the 34-year period, a total of 111 000 cancer deaths have been avoided. In 2022 alone, 8000 are predicted to be avoided.**

These favourable recorded and predicted trends likely find their main driving factor in the long-term protection of oral contraceptives (OCs) and their use throughout the European populations.[15,16] OC use accounts for most of the observed falls as well as the differences between countries; they have been widely used in the UK and other northern European countries from generations born in the 1930s, while in southern countries they became common later. Long-term use of OCs reduces the risk of ovarian cancer by 40% in middle-aged and elderly women.[16] A reduced use of hormone replacement therapy (HRT) may also have had a favourable effect in the UK and Germany where their use has been more widespread.[17] Reproductive, menstrual and hormonal factors are unlikely to have had a relevant effect at the population level, and if anything lower parity would have increased ovarian cancer rates.[15] Beneficial effects of diet particular to the Mediterranean dietary pattern on ovarian cancer risk may be partially responsible for the lower rates recorded and predicted in Spain and Italy.[18] In addition, overweight and obesity, as well as a lack of physical activity, have been linked to the risk of ovarian cancer.[19] However, all these factors are minor compared with the long-term protective effect of OCs, and their influence on population level statistics is hard to quantify. Furthermore, ovarian cancer has so far escaped all screening attempts.[20]

Besides the increased use of OCs in subsequent generations of European women, and some favourable impact of the decreased use of menopausal HRT across Europe since the early 2000s,[17] some impact of reduced case fatality and increased survival is likely, though this is not easy to quantify on a population level.[21] This includes early diagnosis, improved surgery and its adoption in elderly women, and the use of platinum-based drugs since the 1980s, taxanes in the 1990s and more recently gemcitabine, intraperitoneal chemotherapy and possibly bevacizumab.[22,23] Poly(ADP-ribose) polymerase (PARP) inhibitors have greater efficacy in subpopulations with BRCA mutations or other conditions leading to homologous recombination deficiency.[23-25]

Stomach cancer is the site with the longest and most consistent declines, particularly in the UK with a predicted 30% fall in women since 2016. This is largely attributable to a reduced prevalence in *Helicobacter pylori* infection,[26] together with some contribution of improved lifestyle conditions, such as better food conservation through refrigeration and a reduction in the consumption of food preserved through salting, smoking and pickling in subsequent generations.[27,28]

The favourable trends in colorectal cancer are largely attributable to progress in early diagnosis, screening, treatment and management of the disease.[29,30] The less favourable rates and trends in Poland likely reflect lesser and later adoption of these protocols there, and probably in other countries of central and eastern Europe. The consistently lower rates and more favourable trends in women from cohorts born after the 1930s suggest a possible favourable effect of female hormones.[31,32] Better lifestyle habits and greater adherence to screening and early diagnosis in women are the key factors of the sex difference in colorectal cancer mortality. Recent data show a rise in colorectal cancer mortality below age 50 years in the UK,

particularly in women;[33] this may be linked to unfavourable lifestyle and metabolic factors (e.g. overweight/obesity, sedentary lifestyle and alcohol consumption).

There is a lack of progress in males and an unfavourable trend in female pancreatic cancer mortality, which shows abysmal survival, with <5% five-year survival rate. Pancreatic cancer patterns are influenced by historic smoking prevalence, overweight, together with diabetes and the metabolic syndrome, as well as heavy alcohol consumption[34,35] although all these factors are only responsible for a fraction of the disease. Very few advancements in diagnosis and treatment have been made over recent years.[36] Increases in pancreatic cancer mortality have been seen in the USA as well, and they were greater in late middle age and in the elderly population.[37]

The patterns and trends in lung cancer mortality in men and women in the EU and the UK are largely due to historic differences in smoking prevalence. In the UK, the most affected male cohort was that born in the 1910s; in most other EU countries it mainly concerned cohorts born between the 1920s and 1940s. Furthermore, UK women started smoking during World War II, while most other EU women initiated smoking in the 1970s. In the UK, smoking cessation started earlier.[38,39] For the other major EU countries and the EU as a whole, mortality from this cancer has been rising in women over the whole period; however, a slowdown in mortality is predicted in the near future. Our results confirm this with shallower rising estimated annual percent changes in the most recent periods in most studied countries. This suggests a peak in mortality for lung cancer in women in the near future as hypothesized in past cohort studies,[40] highlighting the importance and success of tobacco control policies.[41] Decreased occupational exposure to asbestos and other occupational and environmental carcinogens has also had some role in the falling lung cancer rates in men, though quantification is difficult in various European countries and populations.[42]

The favourable trends in breast cancer mortality in the EU and the UK are largely a consequence of better treatment, particularly in countries with high coverage of essential cancer services.[43,44] In addition, population-based screening programmes contributed to these favourable trends. Poland is the only examined country that displays no gains. This may be attributable to later and less systematic adoption of more effective therapies and disease management protocols, as well as screening.[45] A decline in menopausal HRT use after 2003 may have also played a favourable role in breast cancer rates.[17,46]

The favourable trends in uterine cancer (including both cancers of the cervix and the corpus uteri) are slowing down. This may be the result of approaching an asymptote of the effect of cervical cancer screening.[47,48] In addition, increased overweight, obesity and diabetes affect the rates of endometrial cancer.[49]

The favourable trends in prostate cancer mortality are attributable to improved treatment and management of the disease, as well as some recent improvements in early diagnosis and prostate-specific antigen (PSA) screening.[50-52] Poland is the only country examined that started with low rates, but showed rising projected trends reflecting similar trends to other Eastern and central Eastern European countries, such as those already projected for the Russian Federation and Ukraine.[53]

The higher rates and greater falls in male bladder cancer, including the greater difference between the lowest and highest predicted rates (fourfold between Poland and Germany) are mostly determined by the declined prevalence of smoking and decreased exposure to occupational carcinogens in men. A small part of the favourable male trend may also be due to the adoption of new early diagnosis, treatment and disease management protocols, further justifying differences in patterns between countries with varying timely adoption of these regimens.[54-56]

The consistent long-lasting falls in mortality from leukaemia are the consequence of the continued effort and innovation in the management and care—diagnostic, therapeutic and at the protocol and disease management level—for this varied group of neoplasias.[57-59]

Predicted statistics for cancer mortality should be interpreted with caution. To limit issues of excessive variability, they have only been applied to large populations and to the major cancer sites. We have compared our 2017 predictions to the most recent available EU data, and estimates for total cancer mortality numbers of deaths and age-standardised rates are within 1% of the observed data, while the individual cancer sites are within 5%.[60] Our cancer death estimate for 2022, however, may be influenced by the COVID-19 pandemic. In principle, COVID-19 may have had a harvesting effect on the fragile and/or elderly, thus leading to a fall in certified cancer deaths. The Covid-19 pandemic may, however, have delayed diagnosis and treatment of cancers, particularly during the spring of 2020 and to a lesser extent 2021, thus leading to a subsequent rise in cancer mortality.[61-64] The recorded excess mortality was mainly in patients on systemic anticancer therapy in the short term. Long-term effects in mortality depend on the timing of adjustments in therapy and diagnosis.[65]

In summary, this report confirms predicted declining mortality rates for most major cancers and total cancers in both sexes in Europe estimated at 6% for men and 4% for women over the past 5 years. The lack of favourable progress in pancreatic cancer, resulting in this disease becoming the third cause of cancer deaths, should be an alarm bell to EU health institutions. The most notable good news is that female lung cancer is finally showing a slowdown in mortality rates underscoring the importance and effectiveness of tobacco control policies. Ovarian cancer shows favourable predicted trends that should continue falling in the near future, since these falls are also seen in young and middle-aged women.

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## DISCLOSURE

The authors have declared no conflicts of interest.

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