VIA MEDICA

Artykuł oryginalny / Original article

Biuletyn Polskiego
Towarzystwa Onkologicznego
NOWOTWORY
2021, tom 6, nr 4, 249–260
© Polskie Towarzystwo Onkologiczne
ISSN 2543–5248, e-ISSN: 2543–8077
www.nowotwory.edu.pl

Lung cancer and breast cancer mortality trends among 45–74-year-old European women

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Introduction. We aimed to analyze and compare the most up-to-date breast and lung cancer mortality rates in European women aged 45–74.

Material and methods. The data on breast and lung cancer mortality in 1960–2017 were obtained from the World Health Organization Mortality Data Base and Eurostat. To determine the mortality trends and generate annual percent change, with 95% confidence intervals, joinpoint regression was applied.

Results. In most European Union (EU) member states (15 out of 28), lung cancer mortality was higher than breast cancer mortality, with either increasing or stable lung cancer mortality rates. In four other EU countries, breast and lung cancer mortality rates in the last reported year were almost equal or equal.

Conclusions. Lung cancer is becoming the leading cause of cancer deaths among European women. There is a need for ensuring women-targeted smoking cessation services to decrease tobacco-attributable lung cancer mortality.

Key words: lung cancer, breast cancer, women, mortality, tobacco, cancer prevention, Europe

Introduction

Breast cancer is the most prevalent female neoplasm worldwide. According to the International Agency for Research on Cancer (IARC), in 2018, globally, 2,261,419 women were diagnosed with breast cancer. Moreover, breast cancer is a leading cause of cancer deaths among women (684,996 deceases in 2018). According to the same global cancer statistics, lung cancer is the third-most-common female neoplasm and the second-most-common cause of female cancer deaths globally, with the number of incident cases at 770,828 and the number of deaths at 607,465 in 2018 [1]. In the European Union (EU; state of 2018 with 28 EU member states), breast cancer is still the most prevalent female neoplasm, however, lung cancer is now the leading cause of female cancer deaths [2].

While a systematic understanding of breast cancer risk factors is still unsatisfactory, it is already known that about 70–80% of female lung cancer cases are associated exclusively to tobacco smoking [3, 4]. Hence, cancer mortality trends are affected by changes in European tobacco consumption patterns. At the end of the 20th century, tobacco-related mortality decreased among men, and was stable or increased among women [5]. This phenomenon is evident in lung cancer, considered a good proxy for smoking prevalence estimations.

Although mechanisms underpinning cancer prevalence and mortality rates are not fully understood, their changes can be a valuable indicator for policymakers and stakeholders, enabling more tailored and efficient actions aimed at decreasing tobacco consumption in the EU and its suitable member states. This study aimed to analyze and compare the most recent female breast and lung cancer mortality rates in 31 European countries.

Jak cytować / How to cite:

Sulkowska U, Michałek IM, Didkowska J, Koczkodaj P. ***Lung cancer and breast cancer mortality trends among 45–74-year-old European women.*** *NOWOTWORY J Oncol* 2021; 71: 185–196.

Material and methods

The presented analysis is an update of the data published in the article by Sulkowska et al. in Nowotwory. Journal of Oncology 2015; 65 (5): 395–403, entitled *Lung cancer, the leading cause of cancer deaths among women in Europe* [5]. We followed previously applied methodology (including the same age group: 45–74 years old) to enable comparability of the data.

Source of the data

The analyzed data were obtained in a hybrid manner. First, we obtained data from the World Health Organization (WHO) Mortality Data Base (MDB) (data available as of 15th December 2019). The MDB contains the number of deaths by country, year, sex, age group, and cause of death. The cause of death is coded according to the International Classification of Diseases (ICD). We identified all female deaths due to breast and lung cancer registered in the MDB since 1960 in 28 EU member states and three non-member states, namely Norway, Russia, and Switzerland. The included diagnosis codes encompassed lung cancer (162–163 – ICD 7th revision; 162 – ICD 8th and 9th revisions; and C33 and C34 – ICD 10th revision) and breast cancer (170 – 7th revision; 174 – 8th and 9th revisions; and C50 – 10th revision). In cases where the data for additional (following) years were available in Eurostat, these were also included in our analysis (detailed data sources, by country, by year in table I). The mid-year population estimates were obtained from WHO MDB and Eurostat.

Statistical analysis

Crude annual mortality rates were defined as the number of new deaths per 100,000 person-years. In the denominator, we applied the mid-year population, defined as the population's size on the 31st of June. In all calculations, both the numerator and denominator came from the same data source, WHO MDB or Eurostat. To enable a comparison with other populations, we performed direct age-standardization for the Segi's World Standard Population [6]. For Luxembourg and Malta, the mortality rates were calculated as three-year moving averages (deploying the preceding and following year).

To determine mortality trends and to generate the annual percent change (APC), with 95% confidence intervals (CI), joinpoint regression was applied [7]. The best-fitting model was selected with permutations tests, with an overall significance level at 0.05 and the number of randomly permutated data sets for permutation set at 4499. Rates were considered to decrease if APC < 0 and 95% CI does not contain zero, and to increase if APC > 0 and 95% CI do not contain zero; otherwise, rates were considered stable.

Joinpoint analysis was performed using the Joinpoint Regression Program (version 4.3.1.0, National Cancer Institute, Bethesda, MD, USA).

Compliance with ethical standards

According to the WHO and Eurostat policies, the analyzed data can be freely used for scientific purposes. This study was conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [8].

Results

Breast and lung cancer mortality rates in 1960–2017, analyzed by EU member states, manifested four different patterns:

- Group 1 – higher mortality from lung cancer than from breast cancer with increasing mortality rates of lung cancer;
- Group 2 – higher mortality from lung cancer than from breast cancer with stable or decreasing lung cancer mortality rates;
- Group 3 – almost equal or equal breast and lung cancer mortality rates in the last reported year;
- Group 4 – other EU countries (tab. I).

Non-EU countries were analyzed separately, as Group 5.

In the vast majority of countries in group 1, lung and breast cancer mortality rates intersected around 2010. In Poland the intersection occurred in 2004, and in Spain in 2016 (fig. 1 A). In Austria, Croatia, Germany, and Slovenia, the increase in lung cancer mortality rates was constant. In Poland, a very short period of trend stabilization was observed between 1968–1972, and in Luxembourg, lung cancer mortality rates decreased between 1971–1974. In Czechia, the trend began stabilizing in 2000. In Spain, in 1990, after years of a plateau, lung cancer mortality rates started increasing.

In group 2, time of the lung and breast mortality trends intersection varied widely, e.g., in Denmark it took place in 1991, in Sweden in 2001, and in Ireland in 2012 (fig. 1 B). Lung cancer mortality rates were sharply dropping in Belgium, Denmark, Sweden, and the United Kingdom. In Hungary, Ireland, and the Netherlands, the decrease was more gradual. The onset of decreasing rates for lung cancer mortality ranged from 1980 in Ireland to 2015 in Belgium.

In group 3, the breast and lung cancer mortality rates were almost equal or equal (fig. 1 C). In all countries in the group, lung cancer mortality increased; however, only in Italy was the increase constant. The trend plateaued in Finland and France in 1962–1974 and in 1960–1977, respectively.

In every country in group 4, lung cancer mortality has always been lower than breast cancer mortality (fig. 1 D). However, in some countries (Bulgaria, Cyprus, Estonia, Lithuania, Malta, Portugal, and Romania), the breast cancer mortality rate has been decreasing substantially and/or the lung cancer mortality rate has been sharply increasing, which might point toward future intersection of the rates.

Group 5 represents three non-EU countries (fig. 1 E). In Norway and Switzerland the rates intersected in 1998 and 2012, respectively. In Russia, such a phenomenon has never occurred.

Table I. Age-standardized mortality rates † (ASR) of breast and lung cancer, and the annual percentage change (APC) with a 95% confidence interval (95% CI), by joinpoint analysis segment

Country	Location	ASR 2010‡	ASR 018‡	Segment 1			Segment 2			Segment 3			Segment 4		
				Period	APC	95% CI	Period	APC	95% CI	Period	APC	95% CI	Period	APC	95% CI
Group 1															
Austria	beast	41.9	37.2	1960–1965	3.9*	1.6; 6.1	1965–1991	0.9*	0.7; 1.1	1991–2018	–2.4*	–2.5; –2.2			
	lung	45.8	51.4	1960–1978	1.2*	0.7 ;1.7	1978–2018	2.3*	2.1; 2.4						
Croatia	breast	53.8	42.2	1985–1999	2.4*	2.1; 2.7	1999–2003	–5.7*	–8.7; –2.5	2003–2015	–0.2	–0.7; 0.2	2015–2018	–5.5*	–8.5; –2.3
	lung	43.4	60.3	1985–2018	2.7*	2.5; 3.0									
Czechia	breast	40.7	34.1	1986–1994	0.1	–0.9; 1.2	1994–2005	–2.1*	–2.8; –1.4	2005–2008	–7.7	–15.9; 1.3	2008–2018	–1.9*	–2.6; –1.2
	lung	44.1	44.4	1986–2000	2.9*	2.3; 3.4	2000–2018	0.5*	0.1; 0.8						
Germany	breast	49.2	44.6	1973–1992	1.0*	0.8; 1.1	1992–2017	–1.8*	–1.9; –1.7						
	lung	45.8	52.4	1973–1980	2.0*	1.4; 2.5	1980–1991	3.8*	3.4; 4.1	1991–2013	3.0*	2.9; 3.1	2013–2017	1.1	–0.2; 2.5
Luxembourg	beast	49.0	45.1	1968–1986	1.7*	0.9; 2.5	1986–2004	–3.2*	–4.0; –2.3	2004–2016	–0.5	–2.0; 0.9			
	lung	41.2	46.4	1968–1971	20.3*	0.1; 44.6	1971–1974	–14.1	–40.5; 24.0	1974–1985	8.5*	5.5; 11.7	1985–2016	1.6*	1.0; 2.1
Poland	beast	43.5	45.4	1960–1964	14.9*	12.3; 17.4	1964–1981	2.2*	1.9; 2.4	1981–1992	0.4	–0.1; 1.0	1992–2018	–0.4*	–0.6; –0.3
	lung	58.4	64.4	1960–1968	4.6*	3.4; 5.9	1968–1972	–0.1	–5.3; 5.3	1972–1988	4.0*	3.5; 4.5	1988–2018	2.7*	2.6; 2.9
Slovenia	beast	46.4	39.9	1971–1993	1.5*	1.0; 2.0	1993–2018	–2.5*	–2.9; –2.1						
	lung	42.4	61.3	1971–2018	2.6*	2.4; 2.8									
Spain	beast	35.1	31.9	1960–1991	2.6*	2.4; 2.7	1991–2018	–2.2*	–2.4; –2.0						
	lung	25.2	32.9	1960–1973	0.9*	0.3; 1.5	1973–1989	–1.6*	–2.1; –1.2	1989–1996	2.0*	0.1; 3.9	1996–2018	5.4*	5.2; 5.7
Group 2															
Belgium	beast	56.6	44.7	1960–1986	1.1*	1.0; 1.3	1986–1997	–0.7	–1.4; 0.1	1997–2017	–2.7*	–2.9; –2.4			
	lung	51.5	48.2	1960–1966	–0.1	–2.6; 2.5	1966–2015	3.1*	3.0; 3.2	2015–2017	–7.6	–20.5; 7.4			
Denmark	beast	58.1	39.8	1960–1997	0.5*	0.4; 0.7	1997–2017	–3.8*	–4.1; –3.4						
	lung	89.6	73.8	1960–1973	5.0*	4.0; 6.0	1973–1984	7.6*	6.2; 9.1	1984–1997	2.9*	1.9; 4.0	1997–2017	–1.4*	–1.9; –0.9
Hungary	beast	53.3	49.6	1960–1976	2.9*	2.4; 3.3	1976–1995	1.1*	0.8; 1.5	1995–2018	–1.6*	–1.9; –1.4			
	lung	96.7	100.7	1960–1975	1.1*	0.6; 1.6	1975–1996	4.3*	4.0; 4.7	1996–2013	3.2*	2.7; 3.7	2013–2018	–0.4	–3.1; 2.5

Ireland	beast	55.0	46.9	1960–1975	1.9*	1.2; 2.6	1975–1994	0.3	−0.3; 0.8	1994–2017	−2.4*	−2.8; −2.1			
	lung	53.3	52.6	1960–1980	5.1*	4.5; 5.7	1980–2017	−0.2	−0.4; 0.1						
Netherlands	beast	56.1	43.2	1960–1967	1.5*	0.4; 2.5	1967–1994	0.0	−0.1; 0.2	1994–2018	−2.4*	−2.6; −2.3			
	lung	73.4	73.6	1960–1973	1.3*	0.7; 2.0	1973–1989	7.1*	6.6; 7.6	1989–2007	4.4*	4.0; 4.9	2007–2018	−0.2	−1.0; 0.6
Sweden	beast	40.6	32.7	1960–1988	-0.3*	−0.5; −0.2	1988–2005	−1.1*	−1.5; −0.7	2005–2017	−2.9*	−3.4; −2.3			
	lung	50.2	44.6	1960–1964	−1.0	−5.4; 3.5	1964–1991	4.3*	4.0; 4.6	1991–2005	2.8*	2.0; 3.5	2005–2017	−1.4*	−2.2; −0.6
United Kingdom	beast	48.2	42.3	1960–1976	1.1*	1.0; 1.3	1976–1989	0.4*	0.1; 0.6	1989–2001	−3.0*	−3.3; −2.7	2001–2017	−2.6*	−2.7; −2.4
	lung	63.1	56.9	1960–1975	4.8*	4.5; 5.0	1975–1988	2.4*	2.0; 2.8	1988–2001	−1.2*	−1.5; −0.8	2001–2017	−0.3*	−0.5; −0.1
Group 3															
Finland	beast	44.9	36.3	1960–1995	0.6*	0.4; 0.8	1995–2018	−1.6*	−1.9; −1.2						
	lung	31.2	30.8	1960–1962	19.9	−2.6; 47.4	1962–1974	−0.0	−1.4; 1.4	1974–1977	10.7	−10.0; 36.2	1977–2018	1.7*	1.5; 1.9
France	beast	48.4	44.4	1960–1974	1.5*	1.2; 1.8	1974–1997	0.3*	0.2; 0.5	1997–2016	−1.9*	−2.1; −1.8			
	lung	37.0	42.1	1960–1977	−0.1	−0.5; 0.3	1977–1996	3.2*	2.8; 3.5	1996–2008	5.3*	4.5; 6.1	2008–2016	2.4*	1.1; 3.6
Greece	beastt	41.3	38.2	1961–1963	24.5*	8.3; 43.1	1963–1980	4.4*	3.9; 5.0	1980–1993	0.4	−0.5; 1.2	1993–2017	−1.1*	−1.4; −0.8
	lung	28.1	33.6	1961–1965	6.9*	1.1; 12.9	1965–2005	0.4*	0.2; 0.6	2005–2017	4.4*	3.3; 5.5			
Italy	beast	45.7	42.5	1960–1970	2.1*	1.7; 2.5	1970–1990	0.9*	0.8; 1.1	1990–2017	−1.7*	−1.8; −1.6			
	lung	30.3	35.1	1960–1972	1.7*	1.2; 2.2	1972–1988	2.4*	2.1; 2.7	1988–1999	0.6*	0.0; 1.2	1999–2017	2.0*	1.8; 2.3
Group 4															
Bulgaria	beast	44.0	42.6	1964–1986	2.7*	2.3; 3.1	1986–2018	−0.2	−0.4; 0.0						
	lung	23.1	33.1	1964–2001	−0.1	−0.3; 0.2	2001–2018	2.7*	1.9; 3.5						
Cyprus	beast	36.4	44.6	2004–2018	−1.2	−2.4; 0.0									
	lung	14.0	22.6	2004–2018	1.6	−1.1; 4.4									
Estonia	beast	42.7	43.1	1981–1999	1.9*	1.1; 2.6	1999–2017	−2.4*	−3.0; −1.7						
	lung	24.1	26.4	1981–1983	−14.4	−33.4; 9.9	1983–1989	6.2*	0.5; 12.3	1989–2000	−1.5	−3.4; 0.4	2000–2017	1.3*	0.4; 2.2
Latvia	beast	56.4	47.3	1980–1994	2.2*	1.4; 3.1	1994–2017	−0.5*	−0.9; −0.1						
	lung	20.6	22.2	1980–2017	−0.1	−0.3; 0.2									

Lithuania	beast	53.1	43.0	1981–1994	2.8*	1.9; 3.7	1994–2011	–0.8*	–1.5; –0.2	2011–2018	–3.8*	–5.9; –1.6			
	lung	15.5	17.7	1981–2002	–0.9*	–1.7; –0.1	2002–2018	1.5*	0.3; 2.8						
Malta	beast	62.3	42.1	1968–1975	5.0*	2.0; 8.2	1975–1994	0.1	–0.6; 0.8	1994–2016	–3.3*	–3.8; –2.8			
	lung	22.4	32.6	1968–1973	–23.0*	–31.7; –13.3	1973–1976	56.9	–7.8; 166.9	1976–1992	–0.1	–2.3; 2.2	1992–2016	2.8*	1.7; 3.9
Portugal	beast	40.2	38.3	1960–1991	1.5*	1.3; 1.7	1991–2017	–1.6*	–1.9; –1.4						
	lung	17.3	21.8	1960–1982	2.4*	1.8; 2.9	1982–1997	0.6	–0.4; 1.7	1997–2017	2.7*	2.1; 3.4			
Romania	beast	47.5	47.8	1969–1988	2.2*	1.9; 2.4	1988–2000	1.1*	0.5; 1.7	2000–2018	–0.4*	–0.7; –0.2			
	lung	29.6	37.1	1969–1989	0.8*	0.5; 1.1	1989–2018	1.8*	1.7; 2.0						
Slovakia	beast	45.6	49.6	1992–2001	1.0	–0.1; 2.2	2001–2006	–3.9*	–7.6; –0.1	2006–2018	0.5	–0.2; 1.3			
	lung	32.9	31.4	1992–1995	–5.0	–13.6; 4.5	1995–2018	2.5*	2.1; 3.0						
Group 5															
Norway	beast	39.6	32.1	1960–1996	0.1	–0.0; 0.3	1996–2017	–2.9*	–3.2; –2.5						
	lung	59.4	50.4	1960–1965	0.2	–4.2; 4.9	1965–1997	6.0*	5.7; 6.3	1997–2017	0.2	–0.3; 0.8			
Switzerland	beast	45.5	37.6	1960–1988	0.4*	0.2; 0.5	1988–2017	–2.4*	–2.6; –2.2						
	lung	43.1	42.7	1960–2006	3.7*	3.5; 3.9	2006–2017	–0.1	–1.7; 1.5						
Russia	beast	54.6	48.4	1980–1994	3.1*	2.9; 3.3	1994–1999	2.0*	0.9; 3.1	1999–2009	0.0	–0.3; 0.3	2009–2015	–2.4*	–3.0; –1.9
	lung	17.3	17.8	1980–1988	1.6*	1.0; 2.3	1988–1993	–0.7	–2.6; 1.2	1993–2003	–3.0*	–3.5; –2.5	2003–2015	0.1	–0.2; 0.5

† New cases diagnosed per 100,000 person-years, age-adjusted to the Segi's World Standard Population

‡ For Luxembourg and Malta, the mortality rates were calculated as three-year moving averages (deploying the preceding and following year)

* APC statistically significant

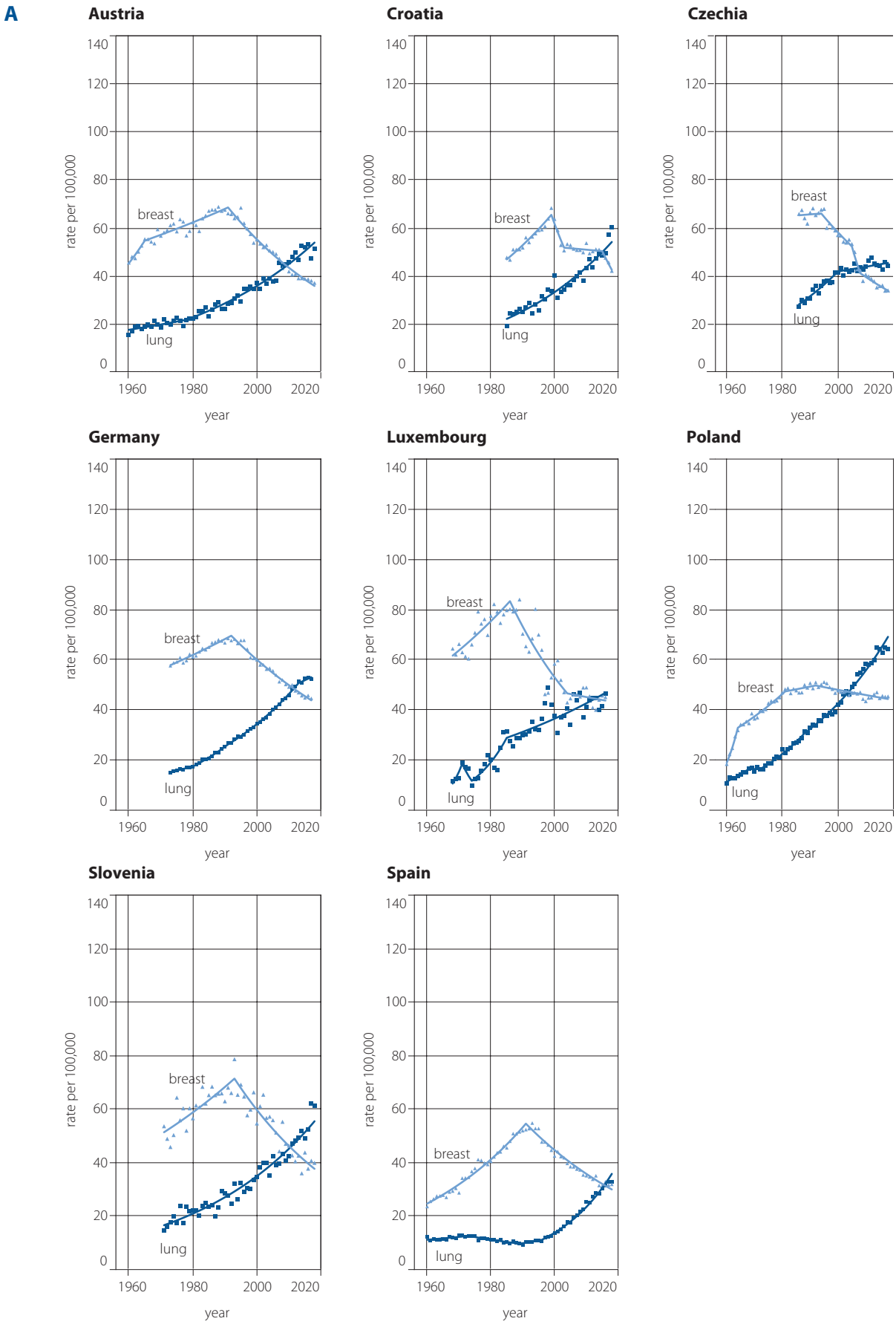

Figure 1. A. Breast and lung cancer mortality rates among women aged 45–74-years-old. Group 1 – EU countries with higher mortality from lung cancer than from breast cancer with increasing lung cancer mortality rates

B

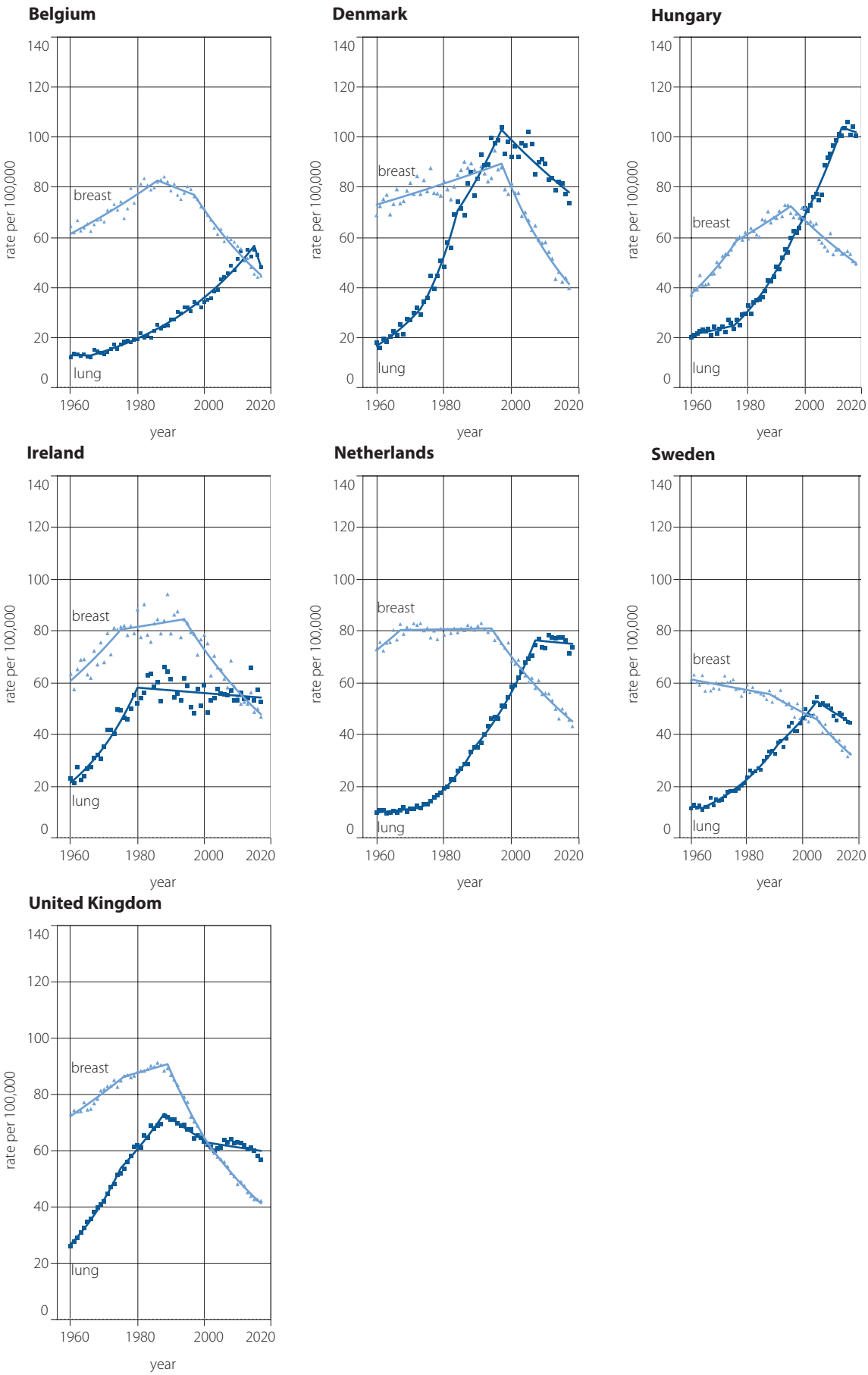

Figure 1. B. Breast and lung cancer mortality rates among women aged 45–74-years-old. Group 2 – EU countries with higher mortality from lung cancer than from breast cancer with stable or decreasing lung cancer mortality rates

C

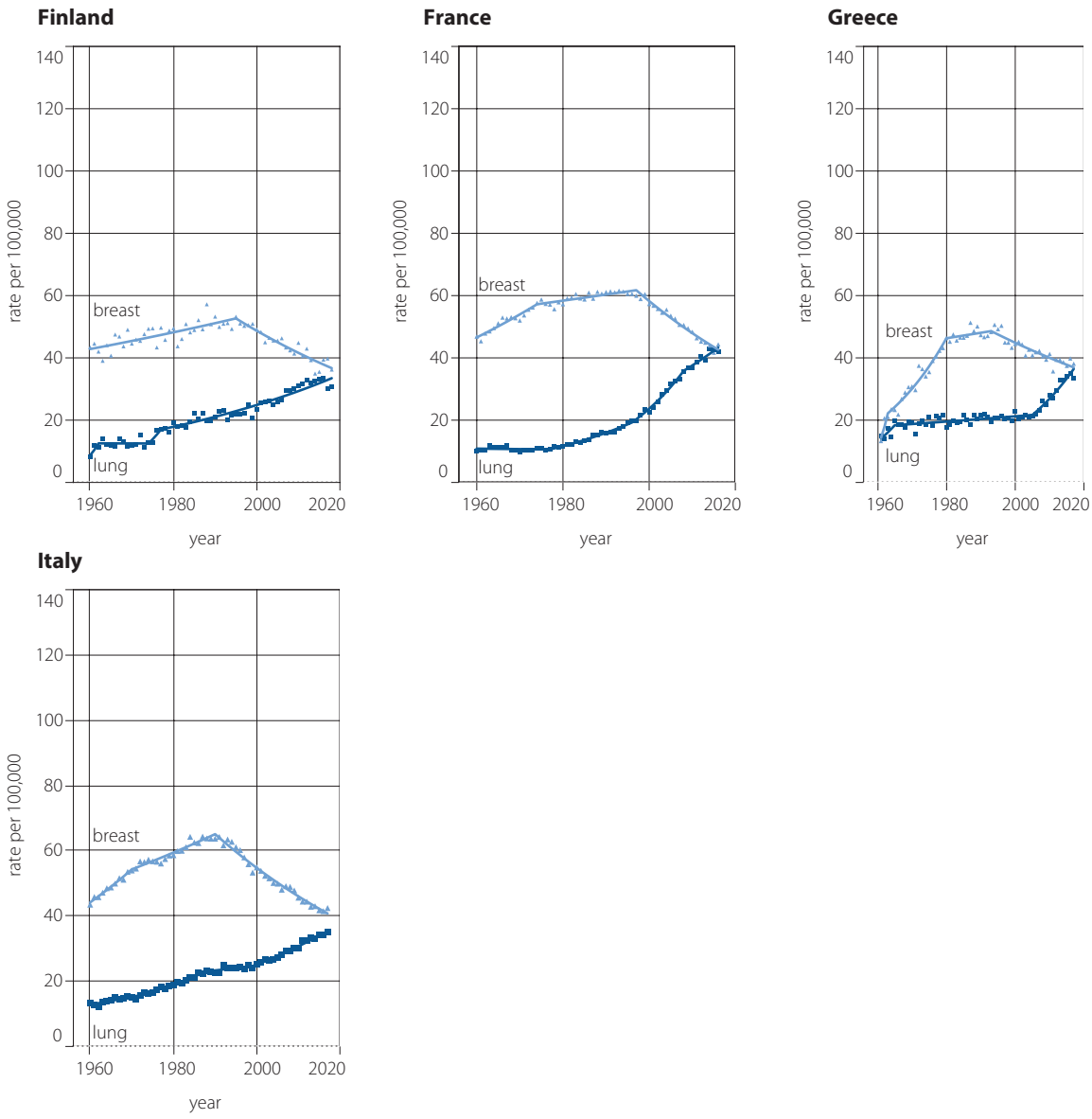

Figure 1. C. Breast and lung cancer mortality rates among women aged 45–74-years-old. Group 3 – EU countries with almost equal or equal breast and lung cancer mortality rates in the last reported year

D

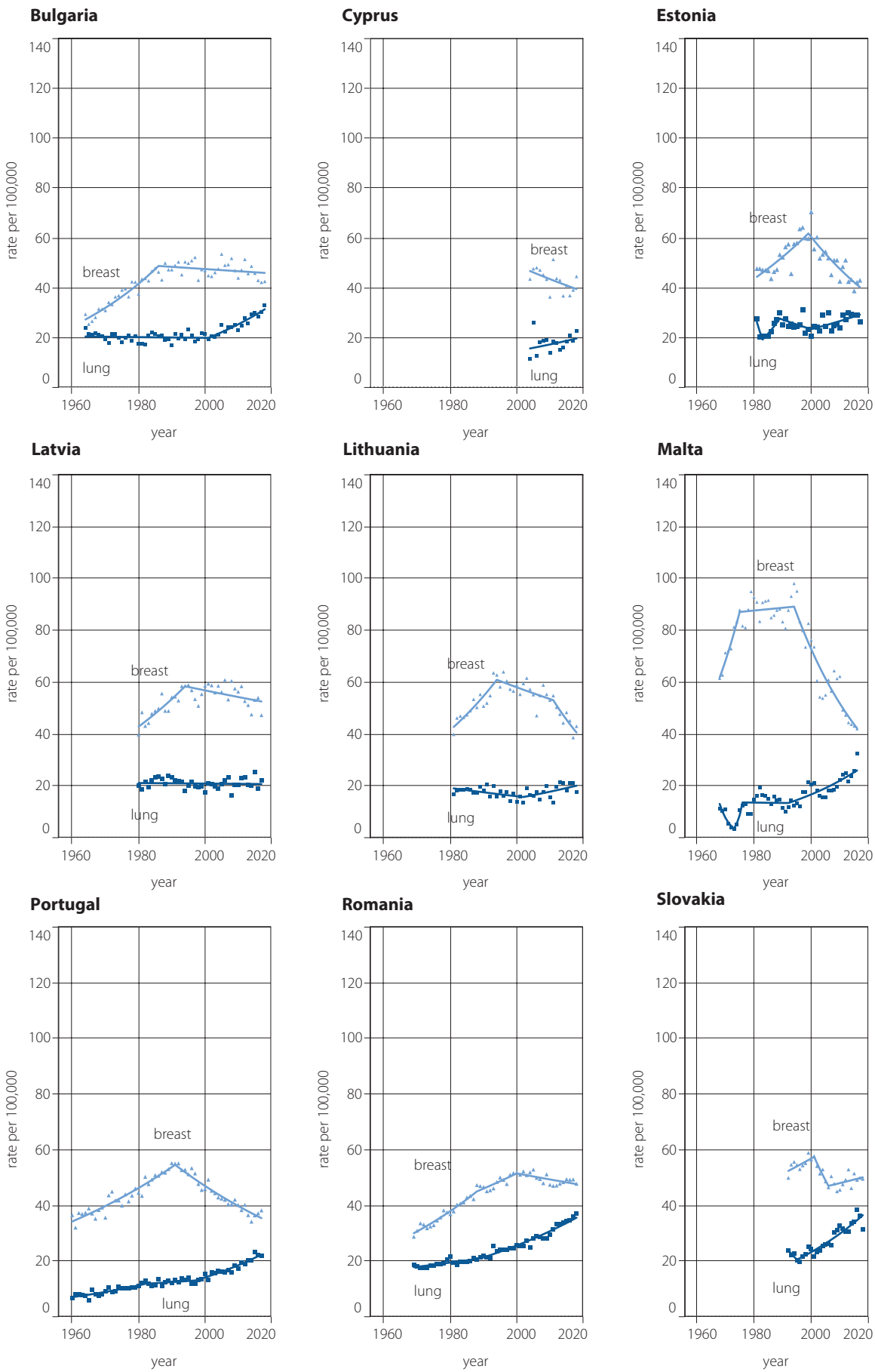

Figure 1. D. Breast and lung cancer mortality rates among women aged 45–74-years-old. Group 4 – other EU countries

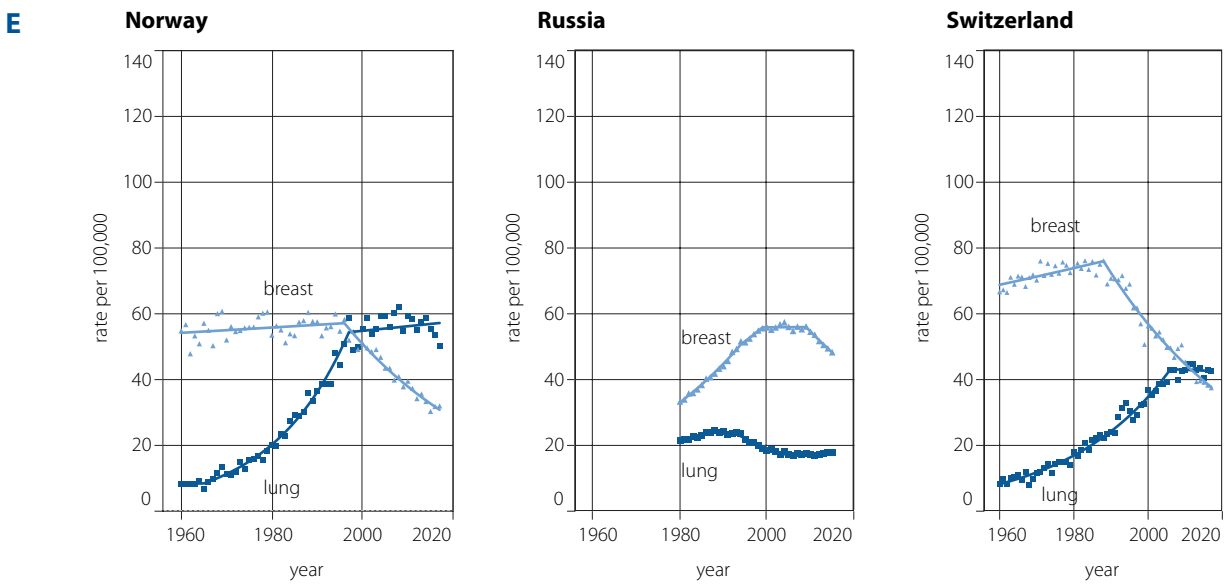

Figure 1. E. Breast and lung cancer mortality rates among women aged 45–74-years-old. Group 5 – non-EU countries

Discussion

The presented analysis depicts a substantial increase in female lung cancer mortality across the vast majority of European countries (tab. II). In comparison with our previous analysis on female lung and breast cancer mortality in the EU [5] (the last reported year was 2010), we noticed progressive cancer mortality changes. Previously we had forecasted further increases in lung cancer mortality and the intersection of both analyzed trends for 12 EU countries. This forecast proved to be true for Belgium, Croatia, Spain, Ireland, Germany, and Slovenia, in our current analysis. However, in Finland, France, Greece, and Italy, the trends have not intersected yet. Contrary to our earlier predictions, the current analysis shows that in Estonia and Slovakia breast cancer mortality is still higher than lung cancer mortality.

Considering the most up-to-date data on tobacco use, we know that at present in the EU about 47 million women currently smoke. Moreover, the advanced stage of tobacco epidemic was observed in 12 UE member states, where smoking prevalence among women is higher than 15% [9]. According to the Institute for Health Metrics and Evaluation (IHME), an exceptionally high smoking-attributable disease burden is observed in Bulgaria, Croatia, Greece, Hungary, and Poland, with the disability-adjusted life years index ranging between 17.5% and 20% [10]. Trends reported in our analysis are following the IHME data. Noteworthy, in Poland and Croatia, the increase is very sharp, and Hungary is characterized by the highest lung cancer mortality rate among all 31 analyzed countries (>100 per 100,000).

The presented analysis implies that greater efforts are needed to ensure a decline in lung cancer mortality rates. Several possible courses of action are mainly related to more restrictive anti-tobacco policies. Raising the excise tax for tobacco products is one of the most effective tools to achieve this goal [11], particularly among women who are more responsive to such measures than men [12]. Another solution is banning menthol and slim cigarettes, perceived as being more feminine tobacco products, targeted primarily at this group of users [13, 14]. Some of these solutions have already been introduced under the Tobacco Products Directive (2014/40/EU) [15]. However, the decline in lung cancer mortality observed in our analysis should not yet be connected with the enforcement of this particular law, since it has been in force too short to impact the mortality statistics. Notwithstanding, effective implementation of the Directive should be a priority for European policymakers, since it may further reduce lung cancer mortality among EU women.

The strength of the analysis is in the completeness of the analyzed cause-of-death data, which was close to 100%, except for Cyprus, where it was 68% [16]. The most important limitation of the study results from the possible cross-national differences in coding practices, particularly in codes for ill-defined and unknown causes. This should be taken into account when comparing mortality rates for specific causes across countries. However, since we assessed time trends of mortality rates within the countries in this study, the presented results' generalizability should not be limited.

Table II. Completeness † of cause-of-death data and their source by years included

Country	WHO MDB		Eurostat
	Years included	Completeness	Years included
Austria	1960–2017	100%	2018
Belgium	1960–2016	100%	2017
Bulgaria	1964–2015	100%	2016–2018
Croatia	1985–2016	100%	2017–2018
Cyprus	2004–2016	68%	2017–2018
Czechia	1986–2017	100%	2018
Denmark	1960–2015	100%	2016–2017
Estonia	1981–2016	100%	2017
Finland	1960–2016	100%	2017–2018
France	1960–2015	100%	2016
Germany	1973–2016	100%	2017
Greece	1961–2016	100%	2017
Hungary	1960–2017	100%	2018
Ireland	1960–2015	100%	2016–2017
Italy	1960–2015	100%	2016–2017
Latvia	1980–2015	100%	2016–2017
Lithuania	1981–2017	99%	2018
Luxembourg	1968–2016	100%	2017
Malta	1968–2015	100%	2016–2017
Netherlands	1960–2016	100%	2017–2018
Norway	1960–2016	100%	2017
Poland	1960–2016	100%	2017–2018
Portugal	1960–2016	100%	2017
Romania	1969–2017	100%	2018
Russia	1980–2015	100%	–
Slovakia	1992–2014	100%	2015–2018
Slovenia	1971–2015	100%	2016–2018
Spain	1960–2016	100%	2017–2018
Sweden	1960–2016	100%	2017
Switzerland	1960–2016	100%	2017
United Kingdom	1960–2016	100%	2017

†– available for the WHO MDB only; WHO MDB – the World Health Organization Mortality Data Base

Conclusions

In many European countries during the last decades, lung cancer has become the leading cause of cancer deaths among women. Ensuring the implementation of gender-tailored evidence-based smoking cessation services and primary smoking prevention actions should be a priority for European healthcare policymakers to decrease tobacco-attributable lung cancer mortality.

Acknowledgments

We are grateful to the WHO and Eurostat and all of the competent authorities of the countries concerned for providing cause-of-death data. The WHO and Eurostat are responsible only for the provision of the original information. The presented material does not imply the expression of any opinion whatsoever on the part of the WHO, Eurostat, or other parties involved in original data transmission. The authors assume full responsibility for the analyses and interpretation of these data.

Conflict of interests: none declared

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Received: 14 Jan 2021
Accepted: 23 Jan 2021

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