Introduction

Tobacco smoking remains the most serious single public health problem in Europe, and trends in lung cancer mortality in younger adults can provide a useful indication of earlier trends in this health determinant. In the first half of the 20th century, when the lung cancer epidemics among males were generally in their ascending phase, this disease was very rarely observed among females; reflecting the universality of smoking among males and rarity of smoking among females.\(^1,2\)

In the following 50 years, there was a widespread tendency for lung cancer epidemics among females to follow the trajectories set earlier by males, first in northern Europe and then also in southern as well as in eastern Europe.\(^3\) Conversely, in the second half of the 20th century, male lung cancer rates peaked and then started to decline in several European countries, although this reversal of trends occurred at different points in time and peak rates in different countries.

Notwithstanding these favourable trends, lung cancer is generally still the most frequent neoplasm among males and it is becoming so also among females in many European countries.

We have analysed trends in lung cancer mortality in order to make inferences about preceding trends in smoking and concurrent trends in other smoking caused diseases. We have done this because the historical data on smoking prevalence in Europe are scarce and were collected by inconsistent methodologies. We have focused on the youngest age group (20–44 years), because the temporal lag from past tobacco exposure to observed mortality is appreciably shorter than in overall age group. Observations made on the youngest age group are also robust predictors of future changes as the relevant cohorts age.

The article discusses the extent to which male and female lung cancer mortality rates in the European Union (EU) and Russia have recently tended to converge and to identify the main patterns of convergence. The study is intended to inform evolving priorities in tobacco control.

Methods

The countries included in this review are the 15 member states of the European Union prior to 2004 (the ‘EU15’, corresponding roughly to western Europe) and the ten new EU member states in central and eastern Europe, plus Russia (referred to herein as EU10 + 1, corresponding, roughly to eastern Europe). Cyprus was excluded because data are lacking in the WHO mortality statistics and Malta was excluded because the number of lung cancer deaths among females aged 20–44 years were insufficient to produce stable rates.

Annual data on deaths from lung cancer were taken from the World Health Organization (WHO) mortality database. Midyear population estimates were taken from the same source. Annual age-specific mortality rates were derived for 5-year age groups, and age-standardized rates for the age range 20–44 years were calculated using the world standard population.\(^1\) The age range was truncated at 44 to minimize the lag between changes in lung cancer mortality and changes in tobacco exposure. The sex ratio is defined as the ratio of the male to female age standardized rates.

The software ‘Joinpoint’ was used to break the mortality time series into chunks that could be adequately represented by linear trends. It does this by several Permutation tests.\(^6\) The junctions of these linear trends are referred to as ‘joinpoints’. For each national time series, the data reported here is confined, separately for each sex, to the last series of years that can be adequately represented by a linear trend, i.e. the trend since the last joinpoint.

Convergence of male and female lung cancer mortality at younger ages in the European Union and Russia

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Background: Lung cancer epidemics emerged first among males in European countries in the first half of the 20th century and then among females in the second half. We have explored the recent convergence in sex ratios. Methods: Age-standardized (world standard) lung cancer mortality rates at ages 20 to 44 years were derived from WHO for 26 countries separately from the beginning of their data series to 2002. The most recent periods in which trends could be adequately represented as linear were determined using the software package ‘Joinpoint’. Countries were classified by their statistically significant trends for each sex in these periods. Results: Lung cancer mortality among young adult males tended to decrease. Among females there were significant recent increases in eight (‘Pattern 1’) countries and no significant trend in 16 (‘Pattern 2’) countries. Rates decreased in both sexes in the UK and rose in both sexes in Portugal. The extent to which sex ratios had actually converged by 2002 varied widely, with values still above 3 in six eastern countries and below 1 in Scandinavia, the Netherlands and Ireland. Conclusion: At the beginning of 21st century, there is a general tendency for sex ratios for lung cancer mortality to converge towards 1, but with considerable variation in the extent to which such convergence has been realized.

Keywords: convergence, Europe, lung cancer, sex ratio, tobacco
Figure 1 was produced basing on the Joinpoint results. Where trends were significant, the rates since the last joinpoint year to 2002 were represented by their linear trend. Where slopes were insignificant, the lines were drawn horizontally at the mean level for the years between the last joinpoint and 2002. The countries were sorted by the sex ratio in 2002, within each pattern. Figure 2 was derived using sex ratios in two time points: the most recent joinpoint—where it was the same in both sexes—or the more recent of the joinpoints for each sex and 2002. The sex ratios in these two time points were linked to show the most recent linear trend. The countries were grouped into four panels depending on the sex ratio ranges: 5–3, 3–2, 2–1 and <1.

Results

Figure 1 shows, for each sex for each country, the lung cancer mortality trends for the longest recent periods since the most recent change in trend. The longest such period is 44 years in the case of males and females in the Netherlands and Portugal and the shortest is 7 years in France. Countries with significantly declining male rates (i.e. all except Portugal) are grouped into three on the basis of the trend in their female rates. In eight ‘Pattern 1’ countries (Romania, Spain, Slovenia, Belgium, France, Italy, Finland and Netherlands), there have been significant recent increases in female rates and it is these converging male and female rates that have produced the convergence in sex ratios.

In 16 ‘pattern 2’ countries (Latvia, Bulgaria, Russia, Lithuania, Poland, Slovak, Czech Republic, Hungary, Austria, Germany, Luxembourg, Denmark, Sweden, Ireland, Greece, Estonia), the only statistically significant trend has been the decrease in male rates and it is this which has produced a convergence of the sex ratio. Female rates over the period since the most recent joinpoint are represented by horizontal lines at the mean rate for the period, with open circles indicating the values for the first and last years in this period.

Portugal and the UK are placed together at the base of figure 1 as countries not conforming to either main pattern. Portugal’s rising male rate is combined with a significantly rising female rate. The UK is distinctive in showing significantly decreasing rates in both sexes.

Figure 2 puts countries into four groups on the basis of their sex ratios in 2002. Within each group, national trend lines are identified. Countries in the group where convergence has progressed least (upper left) are exclusively from south-eastern Europe, the Baltic States and Russia. At the other end are the Scandinavian countries plus Ireland and the Netherlands where lung cancer mortality in the age range of interest is now higher in females than males (lower right). Other countries are distributed across the middle two groups.

Discussion

Because 80–90% of lung cancer in European populations is attributable to smoking, lung cancer mortality rates provide a convenient indicator of temporal trends in the cumulative hazard from past smoking. When attention is focused on the youngest age groups able to yield stable rates, the temporal lag from past tobacco exposure to observed mortality is minimized.

Until the 1990s, and then only in the youngest age groups in some countries (figure 2, panel 4), lung cancer mortality rates have been higher, generally much higher, in males than in females—because the smoking epidemics in males preceded those in females. The downward slopes of the sex ratios for almost all countries in figure 2 show how these sex differences are now eroding or reversing.

Most favourable is the circumstance where the convergence of the lung cancer sex ratio is a consequence of receding smoking epidemics in both sexes. Unfortunately, such a mortality pattern is observed only in United Kingdom, where for the last few decades among males and last decade among females the lung cancer mortality rates have declined. However, national smoking data for Britain show that the decline in smoking slowed substantially during the 1990s suggesting that the observed decline in lung cancer may also be about to falter.

We have identified two common patterns of convergence. In both lung cancer mortality decreases among males, they differ by whether the trend in females is upwards (Pattern 1) or apparently stable (Pattern 2). In Pattern 1, the sex ratio diminishes not only because mortality decreases among males but also because it increases among females, a pattern which is unfavourable because it indicates a rising burden of smoking attributable disease in females.

Portugal stands out as the sole country where the smoking epidemics are still ascending in both sexes—with a rising sex ratio due to faster increases among males than females.

In Europe—as in Australia, Canada and United States—the main cause of lung cancer mortality convergence among males and females in the youngest age group has been a significant decrease of lung cancer mortality among males. In many European countries, female rates show no significant recent trends, although modest increases in rates are widespread. Substantial continuing increases in female rates are most evident in the Netherlands, France, Spain and Italy.

Sweden’s experience is distinctive. It was the first to show sex ratio convergence, and, in the last decade, these equalizing cohorts have reached middle-age (45–64 years). Lung cancer mortality is still higher there among males after the age of 65 years. The very low smoking prevalence among Swedish males (however, partly replaced by oral tobacco) historically corresponded with low level of lung cancer in this country.

Despite the knowledge of lung cancer aetiology for over 50 years, attempts at primordial prevention in females—that is preventing smoking from ever becoming widespread—have failed. Lung cancer will probably become the most numerous smoking attributable disease in females.

In countries with good tobacco exposure statistics, for instance in northern Europe, time trends for lung cancer mortality among both males and females are consistent with preceding trends for tobacco exposure. In the UK, for example, between 1950 and 2000 smoking prevalence equalized between males and females. Data on sex-specific smoking prevalence in Poland, available since 1974, also fit well into a picture of convergence in smoking followed by a convergence in lung cancer mortality.

At the beginning of the 21st century, the smoking sex ratio among young adults (20–44 years) is ‘very close’ to 1 not only in the majority of northern European countries (for instance Sweden (0.7), UK (1.2)), but also in France (1.2), Italy (1.2), Spain (1.2), Hungary (1.2) and Bulgaria (1.3). The ratio is a little higher in Poland (1.5) and Czech Republic (1.7).

Historical data on smoking prevalence in eastern Europe are mostly lacking. In Poland, the smoking sex ratio averaged 3.1 in 1974 and decreased to 1.5 in 2002—due both to increases
Pattern 1: the phenomenon of convergence negative for females and positive for males

Pattern 2: the phenomenon of convergence indifferent for females and positive for males

Exceptions: positive — UK, negative — Portugal

Figure 1 Age-standardized (World standard population) lung cancer mortality rates at ages 20–44 years per 100,000 person years, by sex, for the most recent periods (to 2002) that can be adequately represented by a linear trend (Determined using ‘Joinpoint’ software). Countries of the ‘EU15’ (western Europe) and the eight new and two accession states in central and eastern Europe plus Russia (‘EU10 + 1’, central and eastern Europe) are placed in Pattern 1 when female rates are rising significantly and in Pattern 2 when female rates show no significant trend. Sorted by the sex ratio value in 2002, within each pattern.
among females and decreases among males.\textsuperscript{15} For most eastern European countries, early smoking data, where they exist, are fragmentary and lacking in comparability. Better quality and comparable data are mainly recent.

The convergence of smoking prevalence and lung cancer death rates among men and women in many countries supports the idea that males and females may be equally susceptible to lung cancer from a given amount of cigarette smoking.\textsuperscript{10}

Better quality and more comparable data are available on tobacco exposure among schoolchildren\textsuperscript{16,17} making it possible to trace changes in smoking initiation over time.

Two large surveys, HBSC (Health Behaviour in School-age Children)\textsuperscript{16} and GYTS (Global Youth Tobacco Survey),\textsuperscript{17} using consistent definitions and methodology are available. In the majority of western European countries, especially in northern Europe, a process of equalization of the initiation phase of experimental smoking (at least one cigarette during last month) has been observed between girls and boys. In eastern Europe, there was still a substantial sex difference in smoking initiation in the past. However, the social, economical and cultural transformation has led to a levelling of experimental smoking among boys and girls. The prevalence of experimental smoking among Polish girls aged 13–15 years rose from 16% in 1990 to 28% in 1999, whilst over the same period there was little change in boys (30% in 1990 and 32% in 1999).\textsuperscript{18}

Data on trends in tobacco exposure among teenagers suggest that the decline in lung cancer mortality may slow. In the coming decades, stagnation is possible.

Taking into consideration the size of lung cancer mortality risks arising mostly from tobacco smoking and the trend in sex ratios that we have noted, a higher strategic priority need to be given to tobacco control in younger females in many countries.

In Europe, there is a need to establish robust, valid and comparable monitoring systems for smoking prevalence. Validation and calibration using biomarkers (cotinine) is necessary in order to correct for the under-reporting biases evident in the self-report surveys.\textsuperscript{19} An important element is monitoring of the population exposure to tobacco smoke (active smoking). Tracing the situation development is possible only by monitoring the health losses due to smoking, but first of all monitoring smoking prevalence among children, youth and adults. Most important, however, is to implement effective tobacco control measures to stop and reverse the increasing trend in tobacco smoking prevalence among young women in Europe.

It seems that just as lung cancer emerged to threaten males in the 20th century, it is doing so for females in the first half of 21st century, however, generally at a lower level.
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Key points

- In the decade to 2002, lung cancer mortality sex ratios at age 20–44 years have generally been narrowing across Europe, with values falling below 1 in Scandinavia, the Netherlands and Ireland. There is no clear east/west gradient.
- Lung cancer mortality rates in Europe are declining among young males, except in Portugal (where rates are also rising for females).
- Female rates have continued to rise significantly (in the youngest age group) in many European Union countries (Romania, Spain, France, Slovenia, Belgium, Italy, Finland, Netherlands and Portugal).
- The lung cancer epidemics are receding in both sexes in the United Kingdom.

References


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