Trends in site-specific cancer mortality between 1979 and 2006 in Belgian compared to European men and women using the World Health Organization Mortality Database

Katrien Vanthomme[1], Hadewijch Vandenheede, Paulien Hagedoorn, Patrick Deboosere, Sylvie Gadeyne

Interface Demography, Department of Social Research, Faculty of Economic, Political and Social Sciences and Solvay Business School, Vrije Universiteit Brussel

[1] Corresponding author:
Katrien Vanthomme
Pleinlaan 2, 1050 Brussels, Belgium
E-mail: Katrien.Vanthomme@vub.ac.be
Tel: +32 2 614 81 28
Fax: +32 2 614 81 35

Funding:
This research was funded by the Research Foundation Flanders.

Abstract

Background

Cancer mortality constitutes a major health burden in Europe. Overall, cancer mortality is lower for women than for men, and trends are different for men and women and throughout Europe. This paper focuses on Belgium, which makes an interesting case study as during the 1980s it had the highest cancer mortality within Europe. This study aims to map out Belgian and European cancer mortality trends for both sexes between 1979 and 2006, and to link them with smoking trends.

Methods

Mortality and population data were obtained from the World Health Organization Mortality Database, and smoking prevalence data from the European Health for All Database. Age-standardized mortality rates were calculated by direct standardization using the European Standard Population.

Results

Overall, mortality decreased for the most common cancer sites in Belgium between 1979 and 2006. Yet, Belgian lung and breast cancer rates remain high compared to the remainder of Western Europe. As for the other European Regions, trends are often comparable to Western-European trends (e.g. for stomach cancer), yet occasionally they are not (e.g. for lung cancer). Furthermore, lung cancer mortality showed most between-country variation. Overall, smoking rates were declining, yet slower and later in women.

Conclusion

Generally, cancer mortality shows a favorable trend. Yet, the number of women dying of lung cancer is increasing in Belgium and Western Europe. Furthermore, Belgium remains the country with the highest European male lung cancer and female breast cancer mortality. Considering this and the current smoking prevalence, enduring tobacco control efforts should be made.

Keywords: Cancer; Mortality; Europe; Trends

Introduction

Cancer mortality constitutes a major health burden in Europe (1). In 2002, one quarter of the global burden of cancer was observed in Europe (2,3). Furthermore, in Europe almost half of the deaths in middle age are caused by cancer (2). Notwithstanding the fact that cancer mortality has been declining since the early 1990s, cancer mortality rates are still towering. Overall, cancer mortality is lower for women than for men (4–6). Also, the trends for both sexes are different. Additionally, several studies have observed different trends throughout Europe (2,6,7).

Together, cancers of the female breast, the digestive organs, the prostate and the lungs represent almost half of the burden of cancer in Europe (3). Lung cancer has increased since the end of the first world war (8,9) until the late 1980s (6,10,11), and still accounts for the largest number of cancer-related deaths among men (7,11). For women, lung cancer is the second most common cause of cancer death after female breast cancer. However, female lung cancer mortality rates are rapidly increasing, resulting in being the primary cause of female death in some areas such as Denmark and Western Scotland (1). Across Europe, an overall downward trend in female breast cancer mortality is observed in recent years (12).

The geographical setting of this study is Belgium which makes a particularly interesting case study, as during the 1980s Belgium had the highest cancer mortality of any European country (1). Furthermore, Belgian cancer mortality rates are typical of an industrialized country with high breast and colorectal cancer mortality in women and high lung, prostate and colorectal cancer mortality in men (13). Despite these elevated cancer mortality rates and the interesting industrialized setting, not much research has focused on cancer mortality trends in Belgium so far (14,15).

Because of the large impact cancer has on the health experience of men and women, it is important that the public health resources used to tackle this problem are correspondingly large (7). Therefore, it is essential to have adequate and up-to-date information on the evolution of cancer in order to formulate effective cancer control policies. Up-to-date cancer incidence and mortality data are a key resource in both planning and assessing the impact of cancer control programs at the national as well as at the European level (3). Additionally, considering the large differences in lifestyle (especially smoking), disease management and health policies within Europe, it is crucial to monitor the mortality trends within the European Region (3).

The aims of this paper are threefold. The first objective of this study is to gain insight into the burden of mortality for the most common cancers in Belgium during the 1980s-2000s for both men and women. The second objective is to compare the Belgian cancer mortality burden with the one in the other European regions (Northern Europe, Eastern Europe, and Southern Europe) as well as with the one in the other Western European countries. Between-country comparisons may provide clues on the mechanisms behind the burden of and on the trends in cancer mortality. To the extent that the burden of cancer mortality and its trends differ between countries, country characteristics are likely to play an important role. Therefore, a third objective of this paper is to probe into the smoking trend in Belgium as well as across Europe. Monitoring trends in smoking, one of the

most important risk factors of cancer, will allow for insight into the divergent trends in cancer mortality across Europe.

Data and methods

Data

Mortality and population data have been obtained from the World Health Organization (WHO) Mortality Database, updated as of March 2012 (16). This database contains all deaths recorded in national civil registration systems. For Belgium, national data are available from 1979 to 1999 and from 2004 to 2006. For the years 2000-2003, only regional data are available. Since Belgium is studied in its entirety, these regional data have not been taken into account. For this study period, data were also extracted for other European countries in order to be able to put Belgium's position in perspective. The division made by the United Nations was used to create the following European Regions: Northern Europe (consisting of Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway, Sweden and the United Kingdom); Eastern Europe (consisting of Belarus, Bulgaria, Czech Republic, Hungary, Poland, Republic of Moldova, Romania, Russian Federation, Slovakia and Ukraine); Southern Europe (consisting of Albania, Croatia, Greece, Italy, Malta, Portugal, Slovenia, Spain and The Former Yugoslav Republic of Macedonia); and Western Europe (consisting of Austria, France, Germany, Luxembourg, The Netherlands and Switzerland). Because of the focus on Belgium this country was isolated from the Western European Region.

The underlying cause-of-death categories were coded according to the International Classification of Diseases, the 9th Revision (ICD–9) for the period 1979–1998 and the 10th Revision (ICD–10) from 1999 onwards. The cancers on which will be focused in this paper are malignant neoplasms of trachea, bronchus and lung (ICD-9: B101 and ICD-10: C33-34), malignant neoplasms of stomach (ICD-9: B091 and ICD-10: C16), malignant neoplasms of colon, rectosigmoid junction, rectum, anus and anal canal (ICD-9: B093-B094 and ICD-10: C18-C21), malignant neoplasms of prostate (ICD-9: B124 and ICD-10: C61) and malignant neoplasms of breast (ICD-9: B113 and ICD-10: C50). These cancer sites were chosen since these are the most common ones in Belgium during the study period.

For the entire study period 1979-2006, the absolute number of cancer deaths was obtained for each cancer site, sex, age group (<1, 1-4, 5-14, 15-24, 25-34, 35-54, 55-75, 75+) and country annually. Additionally, the mid-year population data reported to the WHO by its Member States were extracted for each sex, age group and country, in order to calculate the annual mortality rates.

Annual data about the percentage of regular daily smokers were extracted from the European Health for All Database (17), for both sexes and for the same countries and study period as mentioned above. This indicator measures the percentage of the population aged 15 years and older that smokes daily or on a regular basis. Data are mainly gathered by means of health interview surveys. These take place only occasionally and in some countries only since recently which results in a high percentage missing data over the study period, especially in Southern and Eastern Europe.

Analysis

Crude annual mortality rates were calculated for each cancer site, sex, age group and country by dividing the absolute number of deaths by the corresponding mid-year population. Moreover, for each cancer site, sex and country, the age-standardized mortality rates (ASMRs) have been computed by means of direct standardization using the 2013 European Standard Population (18). Additionally, to examine temporal mortality trends and to limit the annual variability due to a small number of deaths, for each cancer site, sex and country, the ASMR has been calculated for four-year periods by computing the average of the annual ASMRs. Due to the lack of Belgian mortality data for the years 2000-2003, the average rate for Belgium for the period 1999-2002 consists solely of the data for 1999, while the average rate for the period 2003-2006 consists of an average of the years 2004-2006. For the other countries, all yearly data were used to calculate the four-year average rates.

Changes in the four-year average site-specific cancer mortality rates over the study period were evaluated for each cancer site, sex and European region using Poisson regression modeling (19,20). This Poisson regression calculates rate ratios, which reflect the increase or decrease in cancer mortality compared to the first four years of the study period (i.e. 1979-1982).

Results

Trends in Belgian cancer mortality over time

Belgian male lung cancer mortality has been declining from the mid-1990s onwards (Figure 1). The ASMR dropped from 177 per 100,000 in the period 1979-1982 to 123 per 100,000 in 2003-2006. Since 1999-2002, this decrease was statistically significant with respect to the starting period 1979-1982 (Figure 2 and Table 1). The same was observed for stomach cancer for which the ASMR declined from 42 per 100,000 men in 1979-1982 to 13 per 100,000 in 2003-2006 (Figure 1). As of the early 1990s, this decrease was statistically significant compared to 1979-1982 (Figure 2 and Table 1). Belgian male colorectal and prostate cancer mortality decreased over the study period from 54 deaths per 100,000 in 1979-1982 to 39 per 100,000 in 2003-2006 (Figure 1). However, this decrease was not statistically significant (Figure 2 and Table 1).

As in men, the ASMR for stomach cancer in women declined from 22 deaths per 100,000 in 1979-1982 to 6 per 100,000 in 2003-2006 (Figure 1). Since the mid-1990s, this decrease was statistically significant compared to the starting period 1979-1982 (Figure 2 and Table 1). Colorectal cancer mortality as well as breast cancer mortality declined over the study period (from 41 and 50 deaths per 100,000 women in 1979-1982 to 26 and 42 per 100,000 in 2003-2006 respectively) (Figure 1, Figure 2 and Table 1). Unlike in men, women's lung cancer mortality increased from 14 deaths per 100,000 in 1979-1982 to 26 per 100,000 in 2003-2006 (Figure 1). However, this increase was not statistically significant (Figure 2 and Table 1).

Comparison with the European cancer mortality trends

Across Europe, a downward trend in male stomach cancer mortality was observed (Figure 1). Overall, this drop was statistically significant since the 1990s, except for Southern Europe where it started to drop in the period 2003-2006 (Table 1). Throughout the entire observation period, Belgian male stomach

cancer mortality rates were the lowest of Europe. As in Belgium, male colorectal cancer mortality decreased over the period 1979-2006 in Northern and Western Europe (Figure 1 and Table 1). On the contrary, in Eastern and Southern Europe, colorectal cancer mortality has been increasing. As for prostate cancer mortality, ASMRs were rather stable throughout the observation period. The only exception is Northern Europe, where a statistically significant increase in the ASMR since the mid-1990s resulted in an ASMR in 2003-2006, which was as high as the Belgian one at the start of the observation period (Figure 1 and Table 1). The highest between-country variation is observed for lung cancer. On the one hand, as in Belgium, in Northern and Western Europe a decreasing mortality trend was observed (Figure 1 and Table 1). Nowadays, these two regions are having the lowest lung cancer mortality rates in Europe. On the other hand, in Eastern and Southern Europe male mortality due to lung cancer remained stable. Belgium shows to be an atypical example of a Western-European country, with lung cancer mortality rates that are much higher than the average Western-European rate (in 2003-2006: 123/100,000 in Belgium versus 90/100,000 in the rest of Western Europe).
As in men, female stomach cancer mortality presents a downward trend across Europe (Figure 1). In most countries, this drop started in the 1990s, with Southern Europe being the exception (Table 1). As in men, Belgian women had the lowest stomach cancer mortality rates in Europe throughout the entire study period. Colorectal cancer mortality trends in women were also comparable to the trends in men, with a decreasing mortality in Northern and Western Europe and increasing mortality in Eastern and Southern Europe (Figure 1 and Table 1). In all European regions, with the exception of Eastern Europe, a modest decline in breast cancer mortality rates was observed (Figure 1 and Table 1). Yet, only in Western Europe, this decrease was statistically significant as of the period 2003-2006. However, Belgium seems to be an a-typical example. Belgian breast cancer mortality did not change statistically significant over time and is the highest of Europe. Also, for lung cancer mortality, Western Europe shows a different trend from the other European regions. The lung cancer mortality rate doubled between 1979-1982 and 2003-2006 (from 13 to 27 female deaths per 100,000) (Figure 1 and Table 1). Belgian lung cancer mortality rates are at the same level of the Western European average. In all other regions there was no significant change in female lung cancer mortality (Figure 1 and Table 1). Female lung cancer mortality rates are currently the most elevated in Northern Europe.

Smoking trends in Belgium and Europe

The percentage of regular smokers is declining in Belgium, for both sexes. Yet the decline started off later in women and is therefore less substantial compared to men (Figure 3). Overall, the percentage of smokers is lower in women compared to men. This decrease is not limited to Belgium, but is seen throughout Europe. For men, smoking prevalence is the lowest in Northern Europe and Belgium. However, the decline in smoking in Belgian men is more substantial than in Northern European men, especially in the period 1979 to 1992, while the percentage of daily smokers was initially lower in Northern Europe. This observation was also reflected in lung cancer mortality among men, which was initially lower among Northern European men, whereas now Belgian and Northern European men are at same level.

For men, smoking prevalence is the highest in Eastern Europe while for women it is the lowest in Eastern Europe. These results reflect the fact that the tobacco epidemic is at an earlier stage in Eastern Europe where nowadays smoking prevalence in men, which was at a high level, starts to decline whereas smoking prevalence in young women is rapidly rising (21).

Discussion

Overall, there is a decrease in mortality for the most common cancer sites in Belgium in the period 1979-2006. With that, Belgium follows the general course of cancer mortality in the Western European Region. Yet, in Belgium, rates of lung cancer and breast cancer are still high compared to the remainder of Western Europe. As for the other European Regions, trends are often comparable to Western-European trends (e.g. for stomach cancer), yet occasionally they are not (e.g. for prostate cancer and lung cancer).

Lung cancer mortality rates showed most between-country variation. In men, lung cancer mortality declined in Northern and Western Europe (also in Belgium) but remained stable in Eastern and Southern Europe. Yet, Belgium has a much higher lung cancer mortality rate than the average Western European rate. On the contrary in women, in Western Europe as well as in Belgium, lung cancer mortality increased while it remained stable in the other European regions. The highest female lung cancer mortality rates were observed in Northern Europe. Overall a downward smoking trend was observed with lower smoking levels and a more recent decline for women compared to men.

Methodological issues

A limitation of this study is the lack of data on confounding factors other than smoking. More specifically, information on socioeconomic characteristics and environmental exposures is lacking (22). These could be helpful in interpreting some of the observed trends. Furthermore, for this type of analysis an Age-Period-Cohort (APC) model should ideally be applied in order to unravel the effects of age, birth cohort and period of death (23). This type of analysis could provide clues on mechanisms behind the observed trends, for example changes in risk factor exposure (as suggested by birth cohort effects) or changes in medical interventions (as suggested by calendar period trends) (23,24). Unfortunately, this type of analysis could not be conducted due to the aggregated nature of the data. Another limitation is that two different versions of the International Classification of Diseases (ICD) were used to code the underlying cause of death during the study period. Although changes in coding could produce some variation in mortality rates, it is not likely that it could bias the comparability over time since differences between the revisions are limited (12). Although there might be some variation in accuracy and completeness between countries, death certification data are reliable and result in meaningful interpretations regarding trends for most European countries (25). Another limitation of this study is the unavailability of smoking data for the whole study period, especially in Southern and Eastern Europe.

Theoretical issues

Lung cancer

Lung cancer is the leading cause of cancer death in men in Belgium and Europe throughout the study period. Lung cancer mortality rates were much higher in men than in women but the gap is narrowing. In general, a decreasing trend is observed in men, in contrast to the increasing rates seen among women. These diverse trends are due to the different phases of the smoking epidemic men and women are in (6). Whereas in 1979-1982 the Belgian male-to-female ratio was 12.6/1, this has been reduced to 4.7/1 in 2003-2006. This observation applies to all European regions and was also found in other European studies (26).

The majority of lung cancers are caused by tobacco smoking (3). Reported fractions of lung cancer attributable to smoking were estimated at 90 and 60 per cent in men and women respectively (7,23). The trends and degree of lung cancer mortality rates in Europe have been related to the different phases in the tobacco epidemic (10,25,27). In short, stage one of the tobacco epidemic reflects the beginning of the smoking epidemic. During this early stage, smoking prevalence is low in men and women but at the end of this stage, smoking prevalence in men starts to increase. The link between smoking and disease is not yet evident during this first phase. In stage 2, smoking prevalence among men continues to rise rapidly. In women smoking prevalence lags behind that of men by one or two decades but is also increasing rapidly. Generally, tobacco control policies are not yet well developed. During the third stage, male smoking prevalence begins to decline whereas for women, an initial decline only starts at the end of this stage. The health hazards of smoking are well known at this moment and tobacco control laws are now being implemented. During the last and fourth stage, smoking prevalence continues to decline for both sexes, but only slowly. Smoke-free personal environments, legislation and work-site policies are a key issue in this phase (28).

Lung cancer mortality is associated with the levels of cigarette consumption of three to four decades ago (14,25,26,28). Therefore, the increasing trend in female lung cancer mortality is a consequence of women taking up smoking in the 1960s. Research states that Belgium has experienced all four phases of the smoking epidemic (28), which should result in a decline in smoking-attributable mortality, at least among men. Considering the slower and more recent decrease in smoking prevalence in women, combined with the three-to-four-decade lag between smoking prevalence and smoking-related mortality, it is likely that female lung cancer mortality will continue to increase in Belgium, as was suggested by our data and by previous research (5). Whilst breast cancer mortality is currently the leading cause of female cancer deaths in Belgium, as well as in Eastern, Southern and Western Europe, lung cancer might well overtake breast cancer mortality given the relatively recent and rather slow decrease in smoking prevalence. This is already the case in Northern Europe.

Belgian men have the highest lung cancer mortality rates in Europe, since the tobacco epidemic started off rather late in Belgium, and persisted longer compared to countries such as the UK (10). In women, lung cancer mortality rates are highest in Northern Europe, and Belgian female lung cancer mortality rates are rather average. Interestingly, our data showed that Eastern Europe had the lowest lung cancer mortality among women but the highest among men. This suggests that Eastern Europe is still in an earlier stage of the tobacco epidemic.

Currently in Eastern Europe, male smoking prevalence, which was a highly accepted practice, starts to decline whereas young women are increasingly taking up smoking (21). Additionally the persistent epidemic in this region is also due to delays in the implementation of tobacco preventive measures (10,29). Measures aiming at reducing tobacco smoking had already been introduced in the 1970's in countries such as the United Kingdom and Finland, whereas in countries such as Poland, the Tobacco Act was only implemented in the second half of the 1990s (29).
Considering the current percentage of Belgian male (28%) and female (19%) regular daily smokers, tobacco control should still be of high priority in Belgium, and more general in Europe. This tobacco control should not only be targeted at men but also increasingly at (young) women (7,14). Primary prevention remains crucial in reducing the high number of lung cancer deaths (3,25) and interventions to discourage the smoking uptake and encourage quitting should continuously be implemented. Possible examples include higher taxes; smoking regulations; protection from exposure to tobacco smoke; restricted tobacco advertisements; increasing the public awareness of the health hazards; and a more widespread access to smoking cessation treatments. Several efforts have already been made to tackle the tobacco epidemic, such as the implementation of the WHO Framework Convention on Tobacco Control in 2005 (30). This global agreement aims to protect people from the harmful consequences of tobacco by providing a set of tobacco control measures. These are implemented by the Member States at the regional, national and international levels in order to reduce the prevalence of tobacco consumption and the exposure to tobacco smoke (30).
Another factor known to increase the risk of lung cancer and thus lung cancer mortality is exposure to occupational carcinogens (such as a job history in the manufacturing of transport equipment, transport support services and manufacturing of metal goods) (7,31–33). In Western Europe, the proportion of lung cancer cases attributable to occupational factors has been estimated at 10% in men and 5% in women (10,34,35). Since Belgium is one of the most industrialized regions of North-West Europe (31), it should not come as a surprise that mortality from lung cancer in Belgium is one of the highest in Europe, at least in men. However, the overall impact of such occupational exposures in the development of lung cancer in the last decade is minimal compared to that of tobacco consumption (7). The control of asbestos and other industrial carcinogens has contributed to the reduction in male lung cancer mortality over the last decades (10).

Stomach cancer
The decreasing trend in stomach cancer observed in Belgium reflects the general European trend (5,23,36). Various reasons are given for this marked and widespread decline. One of them is the decline in the prevalence of Helicobacter pylori infection; the main identified risk factor for gastric cancer (5,23,36,37). Other contributing factors are: the introduction of refrigeration which improved the way of preserving fresh food, with higher vitamin C content and reduced salting, and the availability of a more varied diet with an increased consumption of fruit and vegetables (2,5,23,36,37). Furthermore, the drop in smoking prevalence (duration as well as number of cigarettes smoked) could partly

explain the decreasing stomach cancer mortality rates (2,5,23,36). Additionally, advancements in management (diagnosis and treatment) of gastric cancer have been reported as contributing factors (23).

Colorectal cancer
Previous research has shown that colorectal mortality is expected to decline in both European men and women starting from 2009 (5). Our data suggest that this decline has already started in Northern and Western Europe whereas colorectal cancer mortality rates were still increasing in Eastern and Southern Europe. Better disease management (early diagnosis through screening and improvements in therapies), together with improved dietary habits and avoidance of a sedentary lifestyle and obesity, contributes to a decline in colorectal mortality (2,3,5,38).

Prostate cancer
As in colorectal cancer, previous research has shown that steady declines in European prostate cancer mortality are predicted starting in 2009 (5). However, our data suggest that this decline has only already started in Western Europe. This trend is related to advancements in treatment, such as hormone therapy, a wider adoption of radical prostatectomy in the elderly, and radiotherapy (4,5). A less likely and more contested contributing factor may be the introduction of prostate-specific antigen testing. Such testing might result in an increased detection of latent cancers and higher survival rates due to the early stage at diagnosis (2).

Breast cancer
Female breast cancer mortality has been declining during the study period, but still remains the leading cause of cancer death in Belgian women. This declining trend is seen throughout Europe, the only exception being Eastern Europe. Earlier diagnosis and better management are reasons suggested for this positive trend (12,20,22,39). Moreover, substantial improvements in breast cancer treatments (antiestrogens (tamoxifen) and poly-chemotherapy) played a major role in this favorable trend. Furthermore, current therapies are more age- and tumor-specific, and an integrated organization of the provision of breast cancer care has taken place (12). Additionally, mammographic screening might have increased (early) diagnosis and improved survival, although there is no full agreement on that (12,20,22,39,40). Furthermore, when looking at the evolution of the age-specific female breast cancer mortality rates, an increase was noticed among women aged 75 years and older. This has also been noticed in other European studies, and is likely not to reflect the mortality of women diagnosed in that age range but rather an increased survival in the younger age groups, which leads to an older age at dying among survivors (20).

In conclusion, mortality for the most common cancers shows a favorable trend towards lower mortality. Yet, the number of women dying of lung cancer is increasing in both Belgium and Western Europe. Furthermore, despite positive trends, Belgium is still the country with the highest male lung cancer mortality and female breast cancer mortality in Europe. Considering this as well as the

current smoking prevalence, enduring efforts should be made to reduce this smoking prevalence.

Adopting a European perspective, we conclude that the cancer mortality trend is more positive in Northern and Western Europe compared to Eastern and Southern Europe. It is crucial in the battle against cancer to continuously monitor not only these cancer mortality trends but also the trends in smoking prevalence (21). Furthermore, tobacco control remains of high priority. Additionally, the analysis of temporal trends in cancer incidence is essential since cancer mortality is the joint outcome of cancer incidence and survival. Trends in cancer mortality can be influenced both by differences in cancer risk (resulting in variations in cancer incidence) and differences in the effectiveness of cancer management (resulting in variations in cancer survival) (1,41). For some of the cancer sites studied, trends in cancer mortality rates can primarily be explained by variation in incidence and thus variation in risk factors (e.g. lung cancer); while for other cancer sites trends in mortality can be explained by both variations in incidence and survival (e.g. stomach and colorectal cancer). For those cancer sites, insight in the incidence trends could be helpful in understanding the mortality trends. Although this kind of analysis was beyond the scope of this paper, it would certainly be an interesting topic for further research.

Acknowledgments
This research was funded by the Research Foundation Flanders.

Conflicts of interest
The authors declare that they have no competing interests.

Key points

- Overall, Belgian mortality for the most common cancers shows a favorable trend towards lower mortality. However, female lung cancer mortality is increasing in Belgium and Western Europe and Belgium remains the country showing the most elevated male lung cancer and female breast cancer mortality rates.
- The cancer mortality trends are more positive in Northern and Western Europe compared to Eastern and Southern Europe.
- It is crucial in the battle against cancer to continuously monitor cancer mortality trends within Europe as well as smoking prevalence trends.
- Furthermore, enduring efforts should be made to reduce the smoking prevalence, especially in young women and in Eastern Europe.

References

1. Döbrössy L. Cancer mortality in central – eastern Europe : facts behind the figures. Lancet Oncol. 2002;3(June):374–81.

2. Karim-Kos HE, de Vries E, Soerjomataram I, Lemmens VEPP, Siesling S, Coebergh J-WW. Recent trends of cancer in Europe: a combined approach of incidence, survival and mortality for 17 cancer sites since the 1990s. Eur J Cancer. 2008;44(10):1345–89.

3. Ferlay J, Steliarova-foucher E, Lortet-Tieulent J, Rosso S, Coebergh J-WW, Comber H, et al. Cancer incidence and mortality patterns in Europe : Estimates for 40 countries in 2012. Eur J Cancer. 2013;49(6):1374–403.

4. La Vecchia C, Bosetti C, Lucchini F, Bertuccio P, Negri E, Boyle P, et al. Cancer mortality in Europe, 2000-2004, and an overview of trends since 1975. Ann Oncol. 2010;21:1323–60.

5. Malvezzi M, Bertuccio P, Levi F, La Vecchia C, Negri E. European cancer mortality predictions for the year 2013. Ann Oncol. 2013;24(February):792–800.

6. Bray FI, Weiderpass E. Lung cancer mortality trends in 36 European countries: secular trends and birth cohort patterns by sex and region 1970-2007. Int J Cancer. 2010;126(6):1454–66.

7. Bray FI, Tyczynski JE, Parkin DM. Going up or coming down? The changing phases of the lung cancer epidemic from 1967 to 1999 in the 15 European Union countries. Eur J Cancer. 2004;40(1):96–125.

8. Witschi H. Profiles in Toxicology. A Short History of Lung Cancer. Toxicol Sci. 2001;64:4–6.

9. Doll R, Hill AB. Smoking and Carcinoma of the lung. Preliminary Report. Br Med J. 1950;143:329–36.

10. Malvezzi M, Bosetti C, Rosso T, Bertuccio P, Chatenoud L, Levi F, et al. Lung cancer mortality in European men: trends and predictions. Lung Cancer. 2013;80(2):138–45.

11. Janssen-Heijnen M, Coebergh J-WW. The changing epidemiology of lung cancer in Europe. Lung Cancer. 2003;41(3):245–58.

12. Amaro J, Severo M, Vilela S, Fonseca S, Fontes F, La Vecchia C, et al. Patterns of breast cancer mortality trends in Europe. The Breast. 2013;22:244–53.

13. Zeeb H, Razum O, Blettner M, Stegmaier C. Transition in cancer patterns among Turks residing in Germany. Eur J Cancer. 2002;38(5):705–11.

14. Van Hemelrijck MJJ, Kabir Z, Connolly GN. Trends in lung cancer death rates in Belgium and The Netherlands: a systematic analysis of temporal patterns. J Community Health. 2009;34(3):188–94.

15. Humblet PC, Lagasse R, Levêque A. Trends in Belgian premature avoidable deaths over a 20 year period. J Epidemiol Community Health. 2000;54(9):687–91.

16. World Health Organization. WHO Mortality Database. [accessed on 2013 Dec 9]. Available from: http://apps.who.int/healthinfo/statistics/mortality/whodpms/

17. World Health Organization. European Health for All Database. [accessed 2014 Jan 23]. Available from: http://data.euro.who.int/hfadb/

18. Office for National Statistics. Implementation of the 2013 European Standard Population. 2013 p. 20.

19. Amphlett B, Lawson Z, Abdulrahman GO, White C, Bailey R, Premawardhana L, et al. Recent trends in the incidence, geographical

distribution, and survival from thyroid cancer in Wales: 1985-2010. Thyroid. 2013;23(11):1470–8.

20. Cabanes A, Vidal E, Pérez-Gomez B, Aragones N, Lopez-Abente G, Pollan M. Age-specific breast , uterine and ovarian cancer mortality trends in Spain : Changes from 1980 to 2006. Cancer Epidemiol. 2009;33:169–75.

21. Zatoński W, Przewoźniak K, Sulkowska U, West R, Wojtyła A. Tobacco smoking in countries of the European Union. Ann Agric Environ Med. 2012;19(2):181–92.

22. Autier P, Boniol M, Gavin A, Vatten LJ. Breast cancer mortality in neighbouring European countries with different levels of screening but similar access to treatment : trend analysis of WHO mortality database. Br Med J. 2011;343:1–10.

23. Malvezzi M, Bonifazi M, Bertuccio P, Levi F, La Vecchia C, Decarli A, et al. An age-period-cohort analysis of gastric cancer mortality from 1950 to 2007 in Europe. Ann Epidemiol. 2010;20(12):898–905.

24. Tarone RE, Chu KC, Gaudette LA. Birth cohort and calendar period trends in breast cancer mortality in the United States and Canada. J Natl Cancer Inst. 1997;89(3):251–6.

25. Bosetti C, Malvezzi M, Rosso T, Bertuccio P, Gallus S, Chatenoud L, et al. Lung cancer mortality in European women: trends and predictions. Lung Cancer. 2012;78(3):171–8.

26. The Lancet. The threat of lung cancer in European women. Lancet. 2013;381(9867):600.

27. Mackenbach JP, Huisman M, Andersen O, Bopp M, Borgan J-K, Borrell C, et al. Inequalities in lung cancer mortality by the educational level in 10 European populations. Eur J Cancer. 2004;40:126–35.

28. Lopez AD, Collishaw NE, Piha T. A descriptive model of the cigarette epidemic in developed countries. Tob Control. 1994;3:242–7.

29. Tyczynski JE, Bray F, Aareleid T, Dalmas M, Kurtinaitis J, Plesko I, et al. Lung cancer mortality patterns in selected Central, Eastern and Southern European countries. Int J Cancer. 2004;109(4):598–610.

30. World Health Organization. WHO Framework Convention on Tobacco Control. 2003 Sep p. 42.

31. Droste JHJ, Weyler JJ, Meerbeeck JP Van, Vermeire PA, Sprundel MP Van. Occupational risk factors of lung cancer : a hospital based case-control study. Occup Environ Med. 1999;56:322–7.

32. Tyczynski JE, Bray FI, Parkin DM. Lung cancer in Europe in 2000: epidemiology , prevention , and early detection. Lancet Oncol. 2003;4:45–55.

33. Deboosere P, Gadeyne S. Sterfterisico's naar beroep in België. Brussel; 2009 p. 35. Report No.: 3.

34. Bardin-Mikolajczak A, Lissowska J, Zaridze D, Szeszenia-Dabrowska N, Rudnai P, Fabianova E, et al. Occupation and risk of lung cancer in Central and Eastern Europe: the IARC multi-center case-control study. Cancer Causes Control. 2007;18(6):645–54.

35. De Matteis S, Consonni D, Bertazzi PA. Exposure to occupational carcinogens and lung cancer risk. Evolution of epidemiological estimates of attributable fraction. Acta Biomed. 2008;79 Suppl 1(3):34–42.

36. Bertuccio P, Chatenoud L, Levi F, Praud D, Ferlay J, Negri E, et al. Recent patterns in gastric cancer: a global overview. Int J Cancer. 2009;125(3):666–73.

37. Kelley JR, Duggan JM. Gastric cancer epidemiology and risk factors. J Clin Epidemiol. 2003;56(1):1–9.

38. Chauvenet M, Cottet V, Lepage C, Jooste V, Faivre J, Bouvier A-M. Trends in colorectal cancer incidence: a period and birth-cohort analysis in a well-defined French population. BMC Cancer. 2011;11(1):282.

39. Levi F, Lucchini F, Negri E, La Vecchia C. The fall in breast cancer mortality in Europe. Eur J Cancer. 2001;37:1409–12.

40. Levi F, Lucchini F, Negri E, Boyle P, La Vecchia C. Cancer mortality in Europe, 1995-1999, and an overview of trends since 1960. Int J Cancer. 2004;110(2):155–69.

41. Phelan JC, Link BG. Controlling disease and creating disparities: a fundamental cause perspective. Journals Gerontol Ser B. 2005 Oct;60B Specia(Ii):27–33.

Figures and tables

Figure 1. Evolution of the age-standardized site-specific cancer mortality rates per 100,000 for the period 1979-2006, by sex and European Region

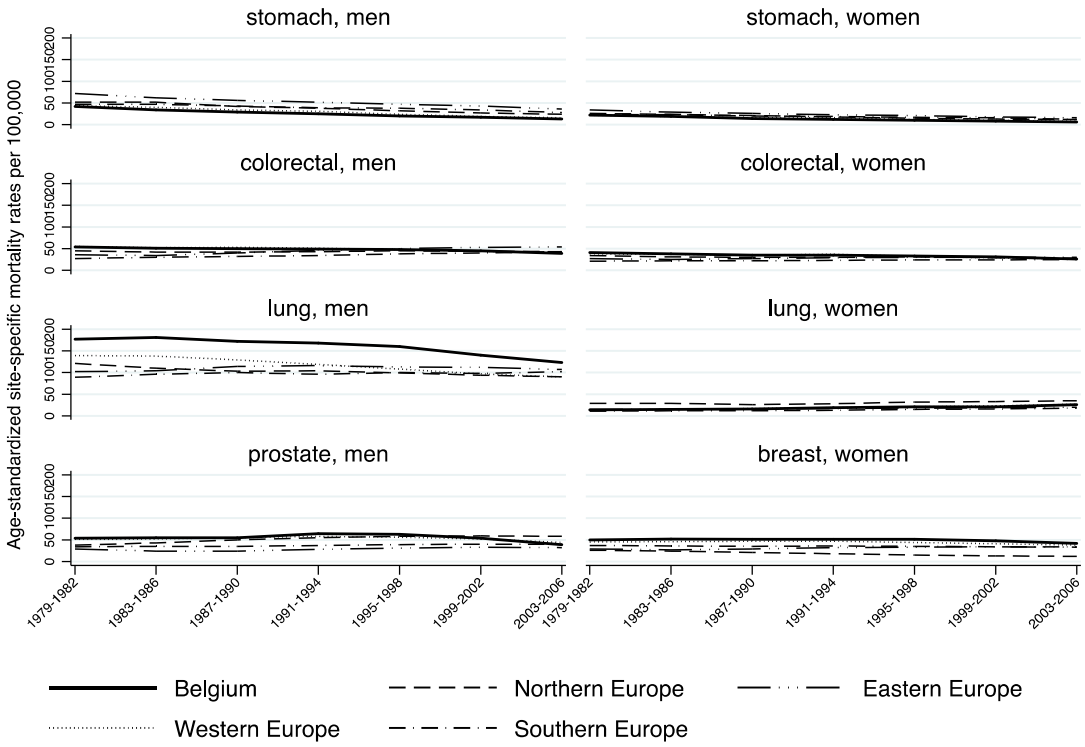

Figure 2. Site-specific Belgian cancer mortality rate ratios (and 95% Confidence Intervals) for the period 1979-2006, by sex

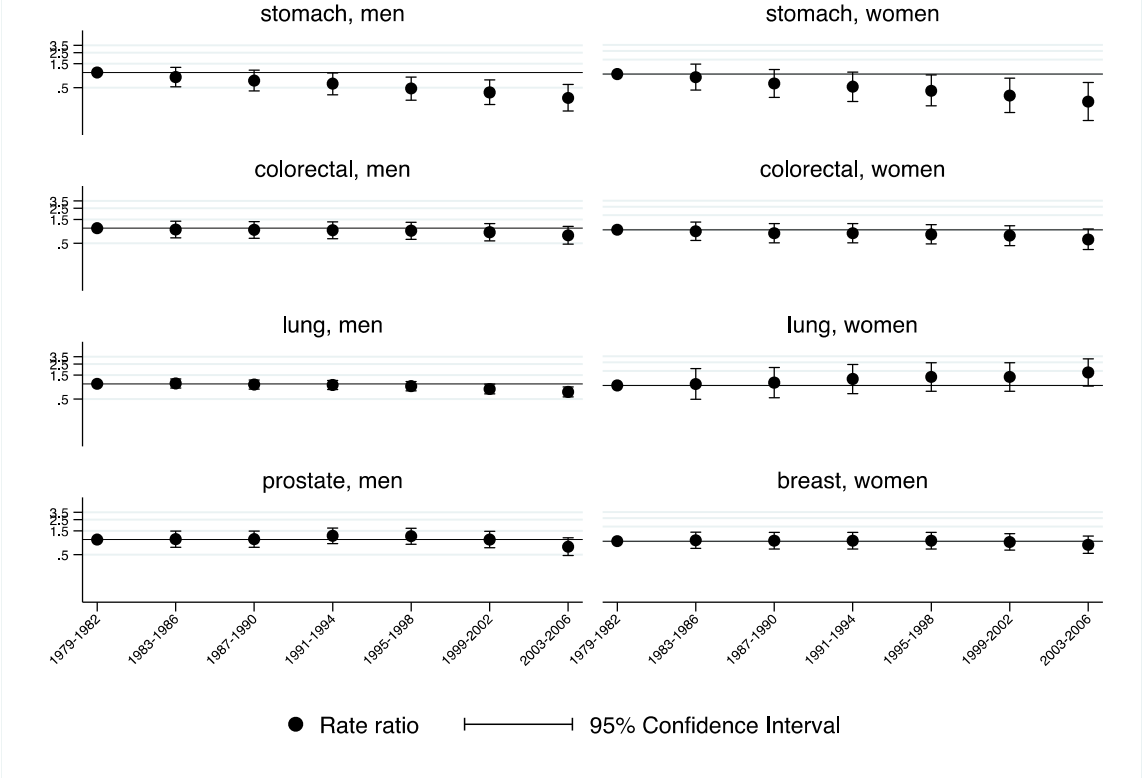

Figure 3. Evolution of the percentage of regular daily smokers in the population aged 15 years and older for the period 1979-2006, by sex and European Region

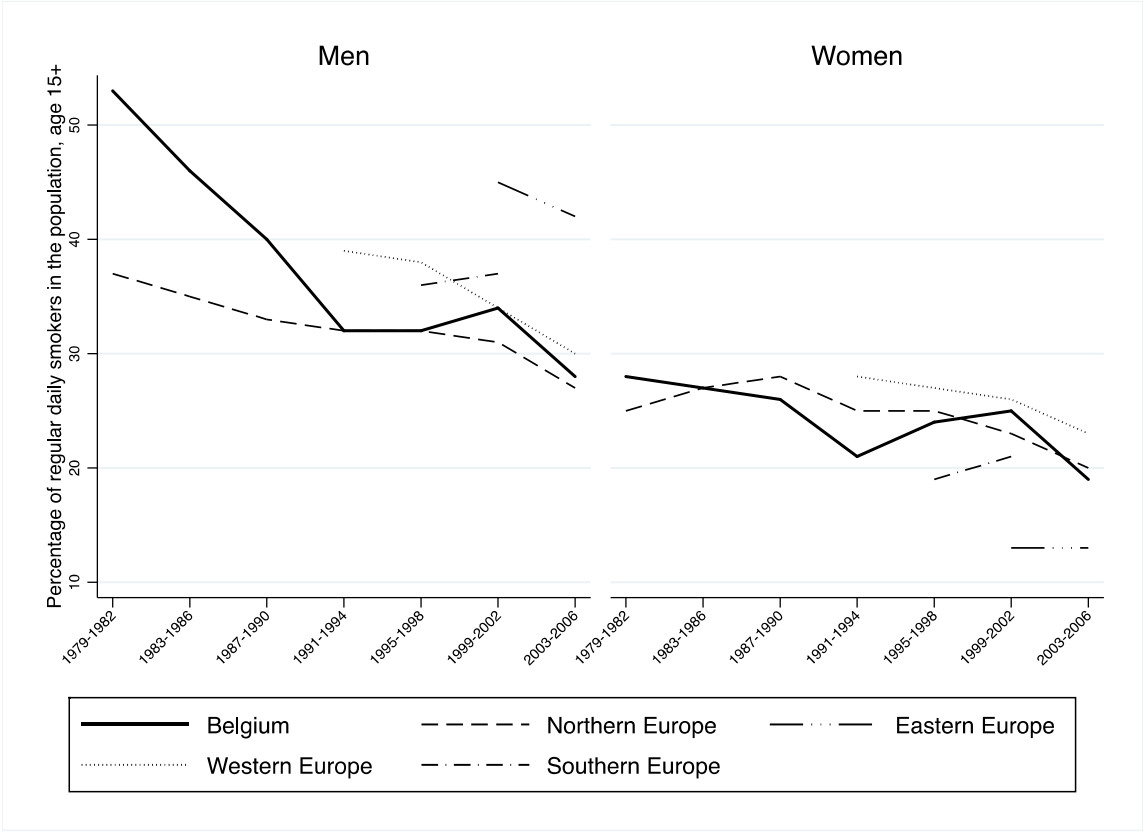

Table 1. Site-specific cancer mortality rate ratios (and 95% Confidence Intervals) for the period 1979-2006, by sex and European Region

	Stomach		Colorectal		Lung		Prostate	
Men	**MRR°**	**(95% CI)***	**MRR**	**(95% CI)**	**MRR**	**(95% CI)**	**MRR**	**(95% CI)**
Belgium								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.81	(0.52-1.27)	0.94	(0.64-1.38)	1.02	(0.83-1.26)	1.02	(0.70-1.48)
1987-1990	0.69	(0.43-1.11)	0.93	(0.63-1.36)	0.97	(0.79-1.20)	1.02	(0.70-1.48)
1991-1994	**0.60**	**(0.36-0.98)**	0.91	(0.62-1.34)	0.95	(0.77-1.17)	1.19	(0.83-1.70)
1995-1998	**0.48**	**(0.28-0.81)**	0.89	(0.60-1.31)	0.90	(0.73-1.12)	1.17	(0.81-1.68)
1999-2002	**0.40**	**(0.23-0.71)**	0.83	(0.56-1.24)	**0.79**	**(0.63-0.99)**	1.00	(0.69-1.46)
2003-2006	**0.31**	**(0.17-0.58)**	0.72	(0.48-1.09)	**0.69**	**(0.55-0.87)**	0.72	(0.48-1.09)
Northern Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	1.00	(0.68-1.47)	0.93	(0.61-1.42)	0.91	(0.70-1.18)	1.13	(0.73-1.75)
1987-1990	0.81	(0.54-1.21)	0.93	(0.61-1.42)	0.85	(0.65-1.11)	1.32	(0.86-2.01)
1991-1994	0.73	(0.48-1.11)	0.96	(0.63-1.45)	0.86	(0.66-1.12)	1.45	(0.96-2.19)
1995-1998	**0.62**	**(0.40-0.96)**	1.00	(0.66-1.51)	0.82	(0.63-1.07)	**1.53**	**(1.01-2.30)**
1999-2002	**0.52**	**(0.33-0.83)**	0.98	(0.65-1.48)	0.78	(0.59-1.02)	**1.55**	**(1.03-2.33)**
2003-2006	**0.46**	**(0.28-0.75)**	0.96	(0.63-1.45)	**0.74**	**(0.57-0.98)**	**1.53**	**(1.01-2.30)**
Eastern Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.86	(0.61-1.21)	0.94	(0.59-1.51)	1.02	(0.78-1.34)	0.83	(0.48-1.42)
1987-1990	0.78	(0.55-1.10)	1.11	(0.71-1.74)	1.12	(0.86-1.46)	0.83	(0.48-1.42)
1991-1994	0.72	(0.51-1.03)	1.28	(0.83-1.98)	1.14	(0.87-1.48)	0.97	(0.57-1.62)
1995-1998	**0.65**	**(0.45-0.94)**	1.39	(0.90-2.13)	1.11	(0.85-1.45)	1.07	(0.64-1.77)
1999-2002	**0.60**	**(0.41-0.87)**	1.47	(0.96-2.25)	1.10	(0.84-1.44)	1.14	(0.69-1.87)
2003-2006	**0.50**	**(0.34-0.75)**	1.50	(0.98-2.29)	1.05	(0.80-1.38)	1.10	(0.67-1.82)
Southern Europe								
1979-1982	1.00		1.00		1.00		1.00	

1983-1986	1.00	(0.67-1.50)	1.11	(0.66-1.87)	1.08	(0.81-1.44)	1.03	(0.64-1.65)
1987-1990	0.91	(0.60-1.38)	1.19	(0.71-1.98)	1.12	(0.84-1.50)	1.03	(0.64-1.65)
1991-1994	0.83	(0.54-1.27)	1.26	(0.76-2.09)	1.08	(0.81-1.44)	1.09	(0.68-1.73)
1995-1998	0.81	(0.53-1.24)	1.41	(0.86-2.30)	1.12	(0.84-1.50)	1.15	(0.72-1.82)
1999-2002	0.72	(0.47-1.12)	1.48	(0.91-2.41)	1.10	(0.83-1.47)	1.18	(0.74-1.86)
2003-2006	**0.60**	**(0.37-0.95)**	1.59	(0.98-2.58)	1.15	(0.86-1.52)	1.18	(0.74-1.86)
Western Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.91	(0.59-1.39)	0.95	(0.65-1.38)	0.99	(0.78-1.26)	1.02	(0.69-1.50)
1987-1990	0.77	(0.49-1.21)	0.96	(0.66-1.41)	0.93	(0.73-1.18)	1.08	(0.74-1.58)
1991-1994	0.70	(0.44-1.12)	0.93	(0.63-1.36)	0.86	(0.67-1.09)	1.14	(0.78-1.66)
1995-1998	**0.55**	**(0.33-0.90)**	0.87	(0.59-1.29)	**0.78**	**(0.60-1.00)**	1.10	(0.75-1.60)
1999-2002	**0.43**	**(0.25-0.74)**	0.80	(0.54-1.19)	**0.70**	**(0.54-0.90)**	1.02	(0.69-1.50)
2003-2006	**0.36**	**(0.21-0.64)**	0.75	(0.50-1.12)	**0.65**	**(0.50-0.84)**	0.86	(0.58-1.29)

Women	**Stomach**		**Colorectal**		**Lung**		**Breast**	
Belgium								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.86	(0.47-1.60)	0.93	(0.60-1.44)	1.07	(0.52-2.22)	1.07	(0.52-2.22)
1987-1990	0.64	(0.33-1.24)	0.85	(0.54-1.34)	1.14	(0.56-2.34)	1.14	(0.56-2.34)
1991-1994	0.55	(0.27-1.10)	0.85	(0.54-1.34)	1.36	(0.68-2.71)	1.36	(0.68-2.71)
1995-1998	**0.45**	**(0.22-0.96)**	0.80	(0.51-1.27)	1.50	(0.76-2.95)	1.50	(0.76-2.95)
1999-2002	**0.36**	**(0.16-0.82)**	0.76	(0.47-1.21)	1.50	(0.76-2.95)	1.50	(0.76-2.95)
2003-2006	**0.27**	**(0.11-0.67)**	0.63	(0.39-1.04)	1.86	(0.97-3.56)	1.86	(0.97-3.56)
Northern Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.92	(0.53-1.61)	0.91	(0.56-1.48)	1.00	(0.60-1.67)	1.00	(0.60-1.67)
1987-1990	0.81	(0.45-1.44)	0.88	(0.54-1.44)	0.90	(0.53-1.52)	0.90	(0.53-1.52)
1991-1994	0.69	(0.38-1.26)	0.88	(0.54-1.44)	0.97	(0.57-1.62)	0.97	(0.57-1.62)
1995-1998	0.58	(0.31-1.09)	0.91	(0.56-1.48)	1.10	(0.67-1.82)	1.10	(0.67-1.82)

1999-2002	**0.50**	**(0.26-0.97)**	0.85	(0.52-1.40)	1.14	(0.69-1.87)	1.14	(0.69-1.87)
2003-2006	**0.46**	**(0.23-0.91)**	0.82	(0.50-1.36)	1.21	(0.74-1.97)	1.21	(0.74-1.97)
Eastern Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.85	(0.52-1.40)	0.93	(0.54-1.60)	1.00	(0.49-2.05)	1.00	(0.49-2.05)
1987-1990	0.76	(0.46-1.27)	1.00	(0.59-1.70)	1.07	(0.53-2.16)	1.07	(0.53-2.16)
1991-1994	0.68	(0.40-1.15)	1.07	(0.64-1.81)	1.13	(0.57-2.27)	1.13	(0.57-2.27)
1995-1998	0.62	(0.36-1.06)	1.11	(0.66-1.87)	1.20	(0.60-2.38)	1.20	(0.60-2.38)
1999-2002	**0.53**	**(0.30-0.94)**	1.11	(0.66-1.87)	1.27	(0.64-2.49)	1.27	(0.64-2.49)
2003-2006	**0.47**	**(0.26-0.85)**	1.11	(0.66-1.87)	1.33	(0.68-2.60)	1.33	(0.68-2.60)
Southern Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	1.00	(0.56-1.78)	1.05	(0.58-1.90)	1.09	(0.48-2.47)	1.09	(0.48-2.47)
1987-1990	0.87	(0.48-1.58)	1.05	(0.58-1.90)	1.09	(0.48-2.47)	1.09	(0.48-2.47)
1991-1994	0.83	(0.45-1.52)	1.10	(0.61-1.98)	1.18	(0.53-2.64)	1.18	(0.53-2.64)
1995-1998	0.74	(0.39-1.38)	1.14	(0.64-2.05)	1.36	(0.63-2.97)	1.36	(0.63-2.97)
1999-2002	0.70	(0.37-1.32)	1.14	(0.64-2.05)	1.45	(0.68-3.13)	1.45	(0.68-3.13)
2003-2006	0.52	(0.26-1.05)	1.19	(0.67-2.13)	1.64	(0.77-3.46)	1.64	(0.77-3.46)
Western Europe								
1979-1982	1.00		1.00		1.00		1.00	
1983-1986	0.86	(0.47-1.60)	0.97	(0.62-1.53)	1.15	(0.55-2.42)	1.15	(0.55-2.42)
1987-1990	0.73	(0.38-1.38)	0.92	(0.58-1.46)	1.31	(0.64-2.69)	1.31	(0.64-2.69)
1991-1994	0.73	(0.38-1.38)	0.97	(0.62-1.53)	1.46	(0.72-2.96)	1.46	(0.72-2.96)
1995-1998	0.55	(0.27-1.10)	0.84	(0.53-1.35)	1.62	(0.81-3.23)	1.62	(0.81-3.23)
1999-2002	**0.45**	**(0.22-0.96)**	0.76	(0.47-1.24)	1.77	(0.90-3.49)	1.77	(0.90-3.49)
2003-2006	**0.36**	**(0.16-0.82)**	0.68	(0.42-1.13)	**2.08**	**(1.07-4.03)**	**2.08**	**(1.07-4.03)**

Results significant at the p<0.05-level are presented in Bold.
° Mortality rate ratios and * 95% Confidence Intervals