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Original Paper

Cancer Mortality in Europe: Effects of Age, Cohort of Birth and Period of Death

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Death certification data for 19 cancers or groups of cancers, plus total cancer mortality, in 16 major European countries were analysed using a log-linear Poisson model with arbitrary constraints on the parameters to disentangle the effects of age, birth cohort and period of death. Three major patterns emerged including: first, the prominent role of cohort of birth in defining trends in mortality from most cancer sites (except testis or Hodgkin's disease, where newer treatments had a major period of death effect); and second, the major role of lung and other tobacco-related neoplasm epidemics in determining the diverging pattern of cancer mortality, for each sex and in various European countries and geographic areas. In most countries, the peak male cohort values were reached for generations born between 1900 and 1930. This was observed in women only for Denmark and the U.K., i.e. the two countries where lung and other tobacco-related neoplasm epidemics had already reached appreciable levels. This confirms the importance of cigarette smoking in subsequent generations as a major cause of cancer deaths in Europe. Further, there is a persistent rise in several cancer rates, again chiefly on a cohort basis, in Eastern Europe, which calls for urgent intervention to control the cancer burden in these countries. © **1998 Elsevier Science Ltd.**

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INTRODUCTION

TRENDS IN cancer mortality in Europe from 1955 onwards have been analysed in terms of age-specific and age-standardised rates [1–3], showing a number of heterogeneous patterns in various countries. For instance, male lung cancer mortality rates rose steeply in Eastern Europe, where rates in middle age reached the highest levels ever observed, but started to level off during the last two decades in Northern Europe. Stomach cancer rates fell throughout Europe for both sexes, although rates remained higher in Eastern Europe, whereas intestinal cancer rates tended to level off around the highest values in various areas of the continent. Breast cancer rates showed a moderate but steady increase, mostly in Southern and Eastern Europe.

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These heterogeneous patterns of trends reflect variable age, cohort and period of death effects. For most human cancers, in fact, there is often an interval of several decades between the first exposure to a carcinogen and the clinical appearance of or death from the disease. Consequently, recent trends in cancer mortality are strongly influenced by changes in exposures to carcinogens several decades ago, when the generations now experiencing the highest cancer incidence and mortality rates (i.e., the elderly ones, at least for most common cancers or epithelial carcinomas) were young [4, 5]. Thus, analyses of cancer mortality by cohort of birth can provide useful information and help explain some features of cross-sectional curves.

By contrast, other factors may influence cancer mortality in a short period of time for populations of all age groups, independently of the generation (or cohort) of birth. For instance, the identification and application of some effective

treatment for a certain neoplasm could lead to a general reduction in mortality over a few years and for various age groups. Likewise, there are carcinogens which act on one of the later stages of the process of carcinogenesis ('promoters'), whose introduction and diffusion in the population (or whose withdrawal) can in a short time modify cancer incidence and mortality [6].

Thus, the possibility of using appropriate statistical models to disentangle the effect of cohort of birth from that of calendar period of death is of considerable interest both for understanding the mechanisms of carcinogenesis and for evaluating the impact of newer diagnostic instruments and therapies on cancer mortality. These models also produce curves of cancer mortality over age after simultaneous allowance for the potential distorting effects of cohort of birth and period of death on age values [7–10].

Thus, a log-linear age, period and cohort Poisson model has been applied to mortality data for major cancer sites in 16 European countries. The findings are summarised in graphical form in this paper.

MATERIALS AND METHODS

Official cancer death certification numbers for 16 major European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom) were derived from the World Health Organisation (WHO) database. Germany includes the Federal Republic, plus the former Democratic Republic since 1970. Excluded were a few smaller countries (e.g., Ireland), those whose national entities have changed (e.g., Yugoslavia, Czechoslovakia), and some which have substantial data missing (e.g., Romania, Bulgaria) [1].

During the calendar period considered (1955–1992), four different Revisions of the International Classification of Diseases (ICD) were used. Classifications of cancer deaths were thus re-coded, for all calendar periods and countries, according to the Ninth Revision (ICD-9) [11]. Table 1 gives the 19 cancers or groups of cancers considered, plus all cancer mortality, together with the corresponding ICD codes under subsequent ICD Revisions. To improve comparability of data for various countries, different age groups and calendar periods, we pooled all intestinal sites (chiefly colon and rectum), all skin neoplasms (melanomas and non-melanomatous) and all non-Hodgkin's lymphomas. In addition to a few rare neoplasms, such as gallbladder and bile ducts, pleura, connective and soft tissue sarcomas, eye or thyroid, we also omitted cancers of the liver, uterus and brain, because of problems of reliability and validity of death certification [1, 5]. Data from Poland were missing for ovary, testis, bladder, kidney, non-Hodgkin's lymphomas, Hodgkin's disease and multiple myeloma. Due to the low numbers in females, data for oesophageal and laryngeal cancers were given only for males.

Estimates of the resident population, generally based on official censuses, were obtained from the same WHO database.

From these data, age-specific death certification rates for each 5-year calendar period and age group (from 30–34 years to 75–79 years) were derived. Deaths in the population aged over 79 years were not considered, since death certification is less accurate at elderly ages [5]. We chose the lower limit of age 30 years to reduce problems of random variation due to small numbers.

Cohorts were defined according to their central year of birth. For instance, the earliest possible cohort considered (i.e. 1880) relates to persons aged 75–79 years who died in the quinquennium 1955–1959: they could have been born in any of the 10 years from 1875 to 1884. When a single year was missing within a quinquennium, numerators and denominators were linearly interpolated from the previous and subsequent calendar years.

Statistical modelling

From the matrices of age-specific death rates for each 5-year calendar period and age group, the effects of age, cohort of birth and period of death were evaluated through a log-linear Poisson model, fitted using GLIM with appropriate user-supplied macros [9]. In simplified terms, the estimates presented are derived from the model including the three factors (age/cohort/period) which minimises the sum of the

Table 1. *Cancers or groups of cancers considered*

Type of cancer	6 ICD	7 ICD	8 ICD	9 ICD
Mouth or pharynx	140–148	140–148	140–148	140–149
Oesophagus	150	150	150	150
Stomach	151	151	151	151
Intestines, chiefly colon and rectum	152–154	152–154	152–154	152–154 + 159.0
Pancreas	157	157	157	157
Larynx	161	161	161	161
Skin, including melanoma	190 + 191	190 + 191	172 + 173	172 + 173
Breast, females	170	170	174	174
Ovary	175	175	183	183
Prostate	177	177	185	185
Testis	178	178	186	186
Bladder	181*	181*	188	188
Kidney	180	180	189*	189*
Hodgkin's disease	201	201	201	201
Non-Hodgkin's lymphomas	200 + 202 + 205	202 + 202 + 205	200 + 202 + 208 + 209	200 + 202
Multiple myeloma	203	203	203	203
Leukaemias	204	204	204–207	204–208
Total, all sites, all histologies	140–239	140–239	140–239	140–239

*And other urinary sites. ICD, International Classification of Diseases.

Euclidean distances from the three possible two-factor models (age/period; age/cohort; cohort/period). The procedure is conceptually similar, but not necessarily equivalent, to that described by Osmond and Gardner [12, 13]. In particular, the procedure of minimisation implemented by the GLIM macros is based on the least squares weighted on the inverse of the log likelihood of each two-factor model, taken as a measure of the accuracy of fit, whereas Osmond and Gardner [12] used as a measure of the accuracy of fit the mean residual sum of squares, minimising the sum of the distances (i.e., the sum of square roots of the sum of all squared coordinate differences between each two-factor and the three-factor model).

Identification of the components (age/period/cohort) included in the model should, in our opinion, be based upon criteria of biological plausibility and ease of interpretability, as a summary guide for the analysis of epidemiological data, rather than on the products themselves of the statistical methods used. Other methods, based upon the choice of different constraints on *a priori* knowledge (i.e., constraints given to the age values), often produce different parameter estimates, which are unbiased only when the constraints posed are strictly reflected in the data [7, 8, 10]. From the algebraic viewpoint, models including arbitrary constraints have, of course, similar limitations. However, whenever the constraints imposed produce easily interpretable parameter estimates, without privileging any parameter *a priori*, the resulting models are of interest as a summary guide for the analysis of epidemiological data.

Significance tests on the parameters of models interpolated using these methods are largely criticisable, since their significance should be tested not only in terms of their random variability (standard error), but also with reference to the unknown bias of the estimates introduced by the arbitrary constraints posed. Problems of estimation in age/period/cohort models are discussed in a separate report [9]. The model developed, in particular, has been shown to provide results similar to those obtained by other age–period–cohort methods [7, 8, 10, 13, 14].

Cohort and period of death values were averaged to unity. The age values are interpretable in terms of mean age-specific death rates throughout the periods considered. Cohort values related to earlier and more recent periods are based on fewer age-specific rates, and hence are less reliable than central ones. Further, more recent values are generally based on fewer deaths, since they refer to the younger age groups only, and are thus less stable.

Presentation of results

For each country, two graphs are presented according to cancer site and sex: the age effect is plotted on a single logarithmic scale, and can be interpreted in terms of rates per 100 000 population; cohort and period of death effects are presented, expressed in relative terms against their weighted average set to unity, using a linear scale. Whenever possible the same scale was used for all countries for each cancer site and sex.

General comment

A few general considerations are required for interpretation of the results [6–10, 12–14]. Firstly, problems relating to random variation differ in relation to age, period or cohort estimates. They are relatively minor for period of death values, which are based on broadly comparable numbers of deaths across subsequent calendar periods; for age values, problems are usually larger in the younger groups, when absolute numbers are smaller for most cancer sites.

Potential problems relating to random variation are even greater for cohort effects, since values related to earlier and more recent cohorts are based on fewer age-specific rates (for instance, the earliest and the most recent cohorts are based on only one observation, the 1885 and 1960 cohort on two, and so on). Again, values for more recent cohorts are based on fewer absolute numbers of deaths, since they refer to the younger age groups only. Therefore, changes in trends restricted to the most recent cohorts must be interpreted with caution, bearing in mind that they may provide important clues to future trends [5, 13, 15].

There are a few cancer sites for which the majority of age-specific rates are in the same direction (upwards or downwards). In such a situation, both cohort of birth and period of death values are in the same direction, and it is difficult to establish whether the major underlying trend is a cohort or period effect. This kind of undeterminancy is observed for a few common sites, such as cancer of the pancreas (upward cohort and period of death values) and the stomach (downward curves). There is also a systematic tendency for the model to give greater weight to the effect with a larger number of points, i.e. the cohort one [9, 14].

Age values estimated from the model may differ from actual age-specific rates, in the presence of strong period or cohort effects. They have, however, interesting implications in terms of defining the real age curve for certain neoplasms [16]. However, there are a few sites for which undercertification at elderly ages was substantial, though possibly this has happened less in recent years (e.g., for prostate cancer or multiple myeloma). In these situations, the corrections obtained through the model are insufficient, and the age curves remain undetermined.

Finally, and more importantly, there are the general identifiability problems of the model, due to the fact that age, period and cohort are limited by an insoluble constraint, since when two factors are given, the third is automatically defined. Thus, although various constraints can be posed to derive estimates of the effects, the model remains undefined. Consequently, although several interesting indications can be derived from the use of models taking into account age at death, cohort of birth and period of death, their results should be chiefly viewed as a guide towards summarising overall tendencies, and age-specific rates [1] should be considered before any conclusions are drawn.

RESULTS

Cancer of the mouth or pharynx

Major differences were observed in the age and cohort effects for cancers of the mouth or pharynx in males across various European countries. The age values were highest in Hungary and France, and the cohort values were so heterogeneous as to require the adoption of various scales. Younger cohorts showed substantial rises in Hungary (over 10-fold), Germany (over 5-fold), Austria, Belgium, Poland and Spain (around or over 3-fold). In general, most recent cohorts showed some upward trend in all countries except Finland and Sweden, whereas in several countries, including Austria, France, Italy, Spain and, particularly the U.K., some decline was apparent for generations born before 1920.

Oral cancer is strongly related to alcohol, tobacco and their interaction [17]. Thus, the cohort trends reflect the rises in alcohol consumption over recent decades, mostly in Central and Eastern Europe, where also tobacco consumption has substantially increased, although other factors, including diet, may have played some role [18, 19]. Period of death trends were much less evident, indicating that most of the trends from oral and pharyngeal cancer are attributable to cohort effects.

Although the absolute values are much smaller, the pattern of trends was similar for females, particularly with reference to some substantial rise for the cohort effects for Central and Eastern European countries.

Cancer of the oesophagus

The figures for oesophageal cancer in males were partly, but not totally, consistent with those of oral and pharyngeal cancers. Figures for females are not presented, given the low number of cases for several countries. With reference to the age effects, high values were registered in France, as for oral cancer, but also in Finland and the U.K., which had low values for oral cancer. A major rise in the cohort effect in Eastern and Central Europe was also observed for oesophageal cancer, and cohort trends were upwards in Spain and the U.K. In any case, as for oral cancer, most trends in mortality from oesophageal cancer were also attributable to cohort effects.

This is not surprising, since these two sites share their major risk factors (tobacco and alcohol), although their roles may vary in quantitative terms [18–20]. Still, increased alcohol consumption over recent decades has probably played a notable role in the upward cohort trends for oesophageal cancer [18].

Stomach

The major differences in age values for stomach cancer reflect the still appreciable differences in gastric cancer mortality across Europe [21], with steepest age curves for both sexes in Hungary and Poland, but also Portugal, Italy, Austria and Germany as compared to most of Northern Europe and, chiefly, France and Greece. Most cohort and period of death effects were substantially and steadily downwards. However, the declines for the cohort effects were earlier and often steeper in Northern and Central European countries, whereas in Italy, Spain and Portugal, as in Eastern Europe, the cohort effect started to decline from generations born since the beginning of the century. Portugal, in particular, showed only modest and inconsistent declines.

In a few countries where gastric cancer mortality is now low, including Belgium, France, Germany, Switzerland and the U.K., there is an indication of a levelling of cohort trends for most recent generations. This suggests that an asymptote in the fall of gastric cancer mortality may have been reached in the young, although overall age-standardised rates will continue to decline for several decades [13, 15].

The widespread favourable trends in cohort and period of death effects for gastric cancer mortality are not clearly understood, but almost certainly reflect the effects of a more affluent diet over the last few decades, richer in fresh fruit and vegetables, of improved food storage and conservation (including refrigeration and less use of salt), as well as better hygiene, with a lower prevalence of *Helicobacter pylori* infection [22, 23]. These favourable changes, which essentially reflect a better socio-economic level, have been slower to occur and less widespread in a few countries of Southern and chiefly Eastern Europe, where there is therefore still ample scope for further reduction in gastric cancer rates [21].

Cancer of the intestines, chiefly colon and rectum

Two main patterns were observed for both sexes. One, including most of Northern and Central Europe, shows stable or—more recently—favourable cohort trends. These trends were even more favourable for most recent generations of women in several Northern European countries, including not only the U.K., but also Finland and Sweden, with relatively low baseline rates. In contrast, in Southern and, mostly, Eastern Europe, which started from lower colorectal cancer mortality, substantial upward cohort trends were observed, tending to level off only for most recent generations, mostly among females. The period of death values were unremarkable for both sexes, indicating that most trends for colorectal cancer are due to underlying cohort effects.

Diet has a considerable role on colorectal carcinogenesis [24, 25], and the rises in cohort effect probably reflect a 'Westernisation' of the diet in Southern and Eastern European countries. Likewise, the recent favourable cohort patterns in Northern and Central Europe possibly reflect increased fruit and vegetable intake, and potential declines in meat and saturated fat intake in recent generations. The more favourable pattern in females may be due to earlier or greater dietary changes among women, or to a role of exogenous female hormones in reducing colorectal cancer risk [26, 27].

Cancer of the pancreas

The highest age values for pancreatic cancer mortality were observed in Nordic countries and Hungary. Cohort trends were upwards in most countries, particularly Southern and Central Europe and in Hungary for both sexes. The changes were relatively limited, although moderately upwards, in Sweden, Switzerland and the U.K. No clear pattern was observed for period of death values.

Cancer of the pancreas is another tobacco-related site [28], and part of the increase in cohort effect is attributable to the rise in cigarette smoking across subsequent generations [29], mostly in Southern and Eastern Europe, particularly since most trends are similar to those of lung cancer. However, other factors, mainly diet [30], may have unfavourably influenced cohort trends for pancreatic cancer. Improved diagnosis and certification of the disease may also have played a role on national death rates.

Cancer of the larynx

Laryngeal cancer in males shows major differences in age values, with the highest levels in France, Italy, Spain, Hungary and Poland, and the lowest levels in Sweden and the U.K. The cohort pattern was characterised by substantial rises in Austria, Germany, Hungary and Poland, and also in Denmark, and by declines in Italy and Switzerland. This is another neoplasm linked to alcohol and tobacco, but its cohort trends are only partly similar to those described for cancers of the oral cavity, pharynx and oesophagus. This confirms that the role of these two major risk factors is, at least in quantitative terms, different for various upper digestive and respiratory tract neoplasms [17, 31]. The epidemic of laryngeal cancer in recent generations of German and

Hungarian males indicates the importance of intervention on its major recognised risk factors (alcohol and tobacco) on a public health scale.

Cancer of the lung

Major differences were observed in age values for lung cancer, with the highest levels for males in Belgium, Finland and the U.K. and the lowest in Portugal and Sweden. The highest levels for females were in Denmark, the U.K. and Hungary. In males, cohort values were upwards in most countries for generations born until the beginning of the century. They started to level off and then decline in Finland and the U.K. for generations born around 1910, and to stabilise in most other Northern and Central European countries for cohorts born around 1910, and in Italy after 1930. In France, Portugal, Spain, Poland and particularly Hungary, male lung cancer cohort values were persistently upwards. Period of death values were appreciably downwards in Finland and the U.K., and upwards in France, Spain, Poland and Hungary.

Age values were much lower for females, but most cohort trends were steadily upwards, particularly in The Netherlands, Sweden, Switzerland, Hungary and Poland. In the U.K. and Denmark, where the highest rates of lung cancer in females were reached [32], some decline in cohort values have been observed for the youngest generations.

Lung cancer is the major tobacco-related site, and its trends essentially reflect the smoking habits of men and women in various European countries [33]. The cohort pattern in males indicates that the epidemic is now levelling off in most of Northern Europe, but is still expanding in Southern and, particularly, Eastern Europe, where the youngest generations of males have exceedingly high mortality. In females, the epidemic is still in the early phases in most of Europe, but is now spreading across subsequent generations of women in most countries.

Cancer of the skin, including melanoma

On the basis of death certification data only, all skin cancers, including melanomas and non-melanomatous cancers, could be considered. However, most deaths at younger and middle age, and hence in most recent cohorts, are due to melanomas. Thus, the upwards trends observed for cohorts born after 1900 and, mostly, after 1920 in several countries, are largely or totally attributable to increased mortality from melanomas. In contrast, the declines for earlier generations in France, Italy, Spain, Portugal and the U.K. are likely, at least in part, due to decreased mortality from squamous cell carcinoma, a typical neoplasm of the elderly, associated with long-term exposure to UV radiation [34], which was common in farmers in the past.

The pattern of cohort trends is heterogeneous. Switzerland, for instance, which had one of the highest age values for skin neoplasms, shows no major cohort pattern, whereas Poland, which also had high rates, showed a dramatic rise in younger cohorts, also observed—though to a lesser extent—in France, Spain and Portugal. These countries, however, started from substantially lower age values. The period of death trends were unremarkable in most countries. Thus, inspection of cohort patterns for skin cancer in Europe indicates that an epidemic of melanoma—probably due to changed patterns of exposure to sunshine (mainly acute intermittent exposure) [35]—has occurred, and is still spreading across younger generations in most European countries. This epidemic is quantitatively heterogeneous and includes the major outlier of Poland, where skin cancer rates in younger generations of both sexes are now exceedingly high.

Cancer of the breast

Age values for breast cancer tended to be higher in Northern Europe, and lower in Southern and Eastern countries. Cohort values showed two patterns, since most Northern European countries showed no noteworthy trend, while there were appreciable rises in cohort values in Spain, Portugal, Hungary, Poland and, to a lesser extent, in Italy too. Period of death values were stable in most countries. It seems, therefore, that subsequent generations of women from originally low-risk countries experienced an increased breast cancer risk, thus leading to a levelling of breast cancer mortality rates across Europe. This probably reflects more uniform reproductive, hormonal and perhaps dietary factor exposures among younger women in various European countries [1, 24]

Cancer of the ovary

Age values for ovarian cancer tended to be higher in Northern and Central Europe than in Southern and Eastern European countries. In most Northern and Central European countries, cohort values increased up to generations born around 1920 or 1930, and declined for younger ones [36]. In Italy, the trend was downward only for more recent generations, while in Spain and Greece cohort values were steadily upwards. Period of death values were moderately downwards in a few Central and Northern European countries. The favourable cohort trends for most recent generations in several countries are partly or largely attributable to the introduction of oral contraceptives, which consistently protect against ovarian carcinogenesis [37], and have been used by women born from 1920 onwards.

Cancer of the prostate

For prostate cancer there were major differences in age values, with lower levels in Southern Europe and Poland, and higher levels in Central and Northern Europe. Cohort values were moderately upwards in most countries, with a hint of reversal of trends in most recent generations in some of them. The rise in cohort values was greater in Poland, Hungary, Greece and Spain. Period of death values were unremarkable in most countries. Little is known of the aetiology and determinants of prostatic cancer [38, 39]. In particular, it is unclear whether the rises are partly or largely attributable to improved diagnosis and certification of the disease across subsequent age groups and generations [40].

Cancer of the testis

The age values of testicular cancer have two peaks in most countries, one due to teratomas, at young age, and a second one, including seminomas and other histological types, later in age and in the elderly [39]. In most European countries, both cohort of birth and period of death values were downwards, essentially reflecting better treatment of the disease. The downward trends, however, were generally earlier in Northern Europe than in Southern and, particularly, Eastern European countries, where there was a considerable delay in the introduction of modern integrated therapies for the disease [41].

Cancer of the bladder

Although absolute levels were much higher in males, in both sexes the highest age values for bladder cancer were in Denmark, the U.K., Germany and, for males, Hungary. Cohort values for males in most of Western Europe increased up to the generations born around 1920–1940, and declined thereafter. Steady upward trends were observed in Spain and Hungary. A few period of death values tended to decline, though moderately. The pattern of cohort and period of death values in several countries were similar for females, although generally less consistent, possibly due to smaller absolute numbers.

This is another neoplasm linked to tobacco smoking, but also to occupational exposure to aromatic amines and other chemicals [42]. The pattern of cohort trends indicates that the worst exposed generations in most European countries were those born in the first decades of the current century, with subsequent declines in most recent decades.

Cancer of the kidney

The age values for kidney cancer in both sexes were higher in Scandinavian countries and Central Europe, including Austria, Germany and Hungary [43]. As for bladder cancer, the worst exposed cohorts of males tended to be those born between 1920 and 1940, with subsequent declines. Major exceptions were Hungary, Portugal and Spain, showing steady increases in cohort values. For females, most cohort values were upwards. Period of death values up to most recent generations were unremarkable in most countries. Cigarette smoking is the best recognised risk factor for kidney cancer, and the pattern of cohort trends, mostly in males, is consistent with those of other tobacco-related neoplasms, reflecting the pattern of exposure to tobacco across subsequent generations of males and females in various European countries [29]. Other factors, including nutrition and diet, occupation, selected medical history and drug use may also have had some effect on renal cancer rates in various countries [39, 44, 45].

Hodgkin's disease

This is another neoplasm with a peculiar age curve, showing a peak at very young age, and another peak at more advanced ages [39, 50]. In most Western European countries, cohort of death values were appreciably downwards for generations born after 1900, and period of death values after 1975. This is essentially due to the substantial improvements in the treatment of the disease over the last three decades. In Hungary, the favourable trends were delayed for both cohort and period of death values, suggesting that the adoption of efficacious treatments was delayed in Eastern Europe [41, 51].

Non-Hodgkin's lymphomas

In both sexes, the highest age values were in Scandinavian countries and Switzerland [46]. Cohort values were appreciably upwards up to recent generations in all European countries, though to a variable extent, some reversal of trends being observed only in a few countries for most recent cohorts, although based on very small numbers and hence unstable estimates. Period of death values were also somewhat upwards, although to a considerably lower degree.

The widespread rises in non-Hodgkin's lymphomas are therefore essentially attributable to a cohort effect. The reasons are not clearly understood, but these trends are only partly attributable to improved diagnosis and certification. Impaired immunological status is a recognised correlate of lymphoma risk, and may be due to various factors, including increased exposure to sunshine and, hence, UV radiation [47–49].

Multiple myeloma

Diagnosis and certification of multiple myeloma have greatly improved over the last few decades, chiefly since the introduction of serum electrophoresis [5]. Thus, the highest age values in Scandinavian countries are probably at least partly attributable to earlier and better case ascertainment and certification, and the steep upward trends for earlier generations of both sexes in most countries are partly or largely artefactual. Not surprisingly, therefore, the cohort values tend to level off in several countries in generations born after 1920. Period of death values are generally inconsistent. Apart from ionising radiation, little is known about the causes of multiple myeloma, and, apart from better diagnosis, it is difficult to interpret the systematic upward trends observed [39].

Leukaemias

A steep rise in age values was observed at an elderly age in both sexes. Cohort values for most countries showed earlier rises, up to the generations born around 1920, and subsequent levelling off or declines. Period of death values also tended to decline in several countries for both sexes. These downward trends, together with the falls in recent generations for cohort values, are attributable to improved treatment of the disease, whereas the rises in earlier cohorts are at least partly due to improved diagnosis and certification in the elderly [39, 51].

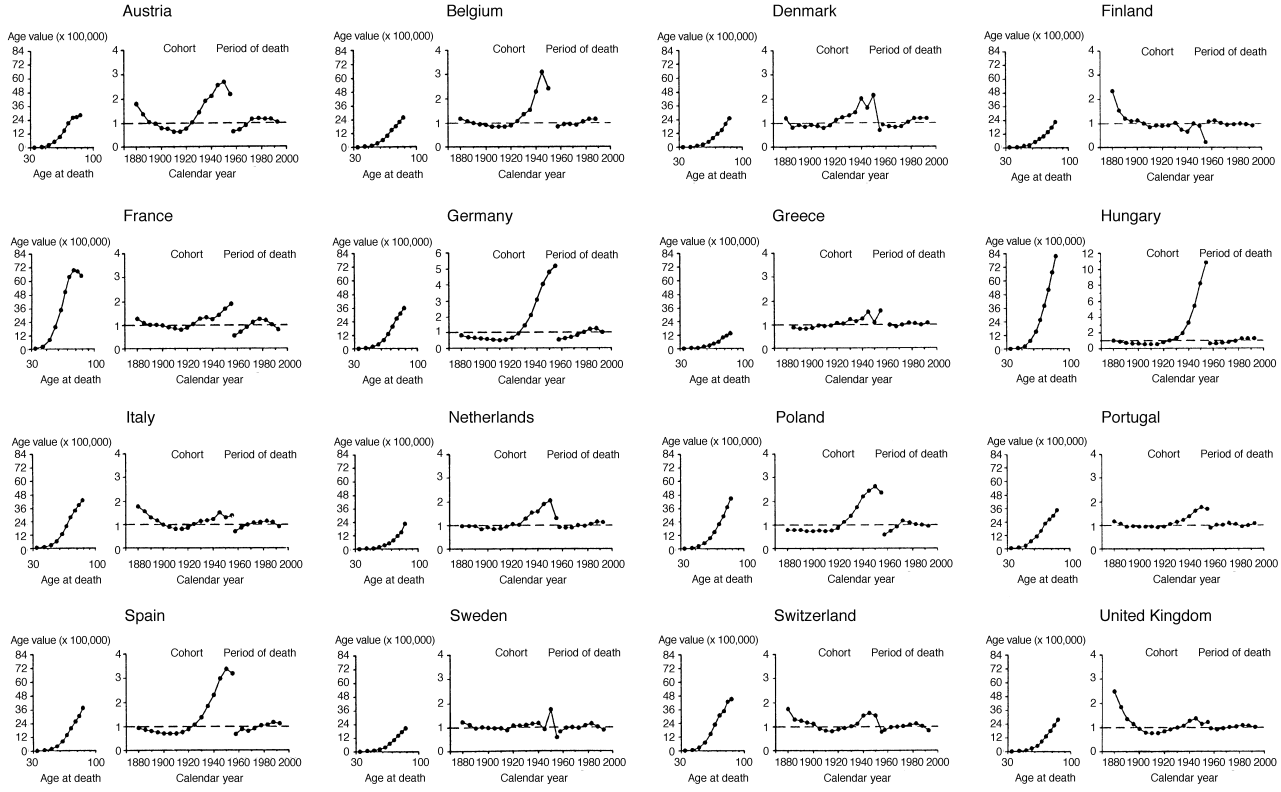
All neoplasms, benign and malignant

Values and trends for total cancer mortality reflect the complexity of the pattern of trends for major cancer sites. In most countries, the peaks for male cohort values were reached for generations born early this century, i.e. between 1900 and 1930. This was reproduced in women only for Denmark and the U.K., i.e., the two countries where the lung and other tobacco-related neoplasm epidemics have already reached appreciable levels in females [1, 33]. Thus, in both sexes and for most countries, the pattern of cohort trends essentially reflects the shape of the tobacco-related cancer epidemic, again confirming the importance of cigarette smoking as a major cause of cancer death in Europe [28, 33, 52–54].

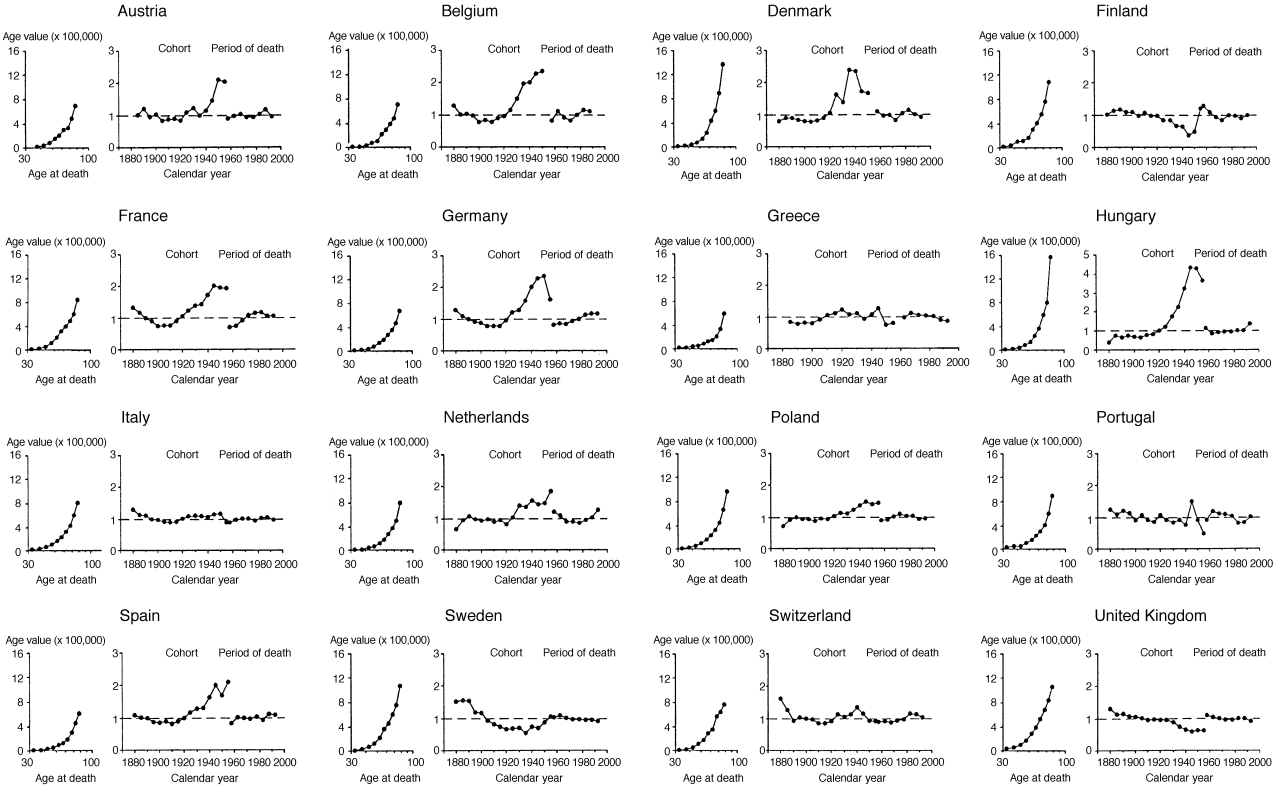
Cohort trends for females were generally more favourable, since in most European countries the tobacco-related cancer epidemic is still in its early phases in women, and favourable trends across subsequent generations have been observed for stomach, cervix uteri and, in most recent cohorts, for colorectal cancer too. However, in Spain, Portugal and Greece, where age values were relatively low, cohort trends for females were not downwards. Likewise, in Poland and, particularly, in Hungary, female cohort values were stable and male values appreciably and steadily upwards, again confirming the major increases in cancer rates in Eastern Europe across recent time periods, and, chiefly, younger generations. This is again largely related to tobacco, plus some, though more difficult to quantify, contributions of various aspects of diet and, possibly, other environmental factors. This calls for urgent intervention to control the cancer mortality burden in Eastern Europe [55].

Age, cohort and period of death values for cancer mortality in selected European countries. Age values are estimated per 100 000 population, cohort and period of death values are given in relative terms to their weighted average set to unity.

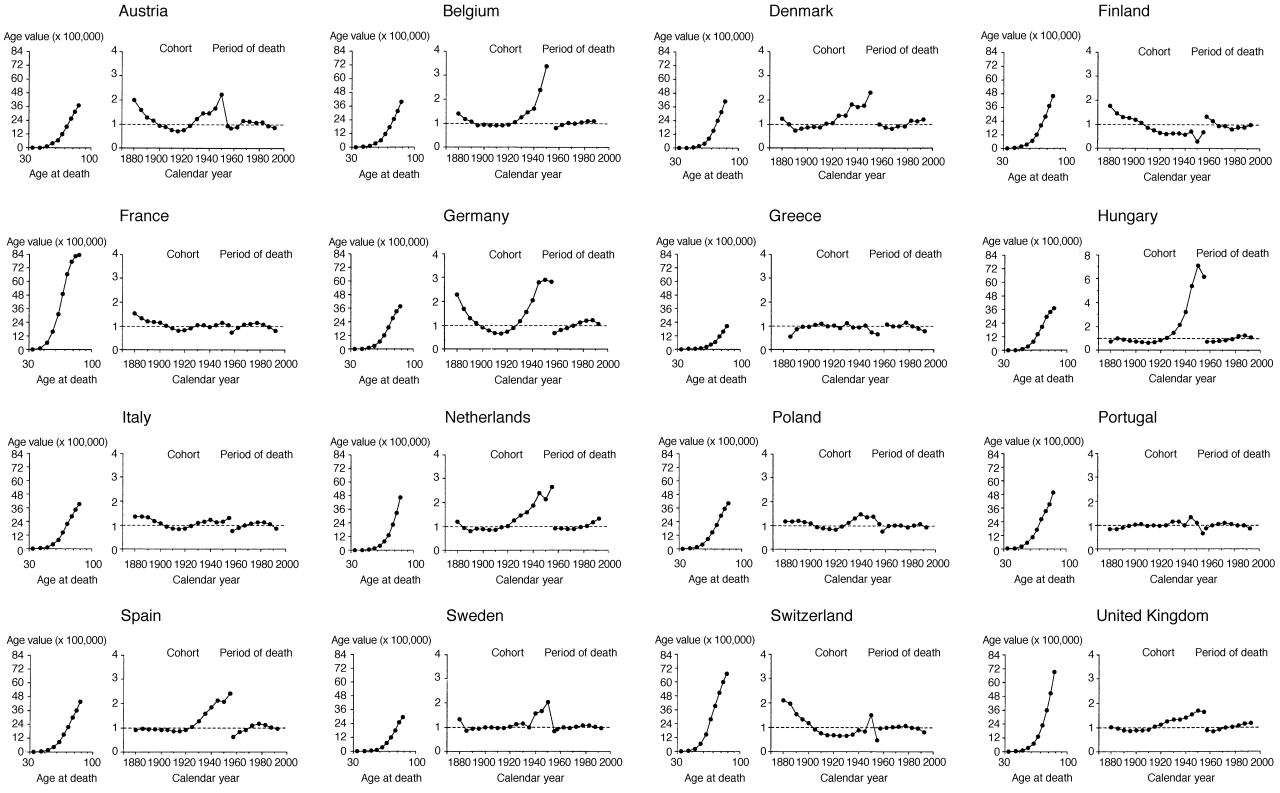
Cancer of the mouth or pharynx — males



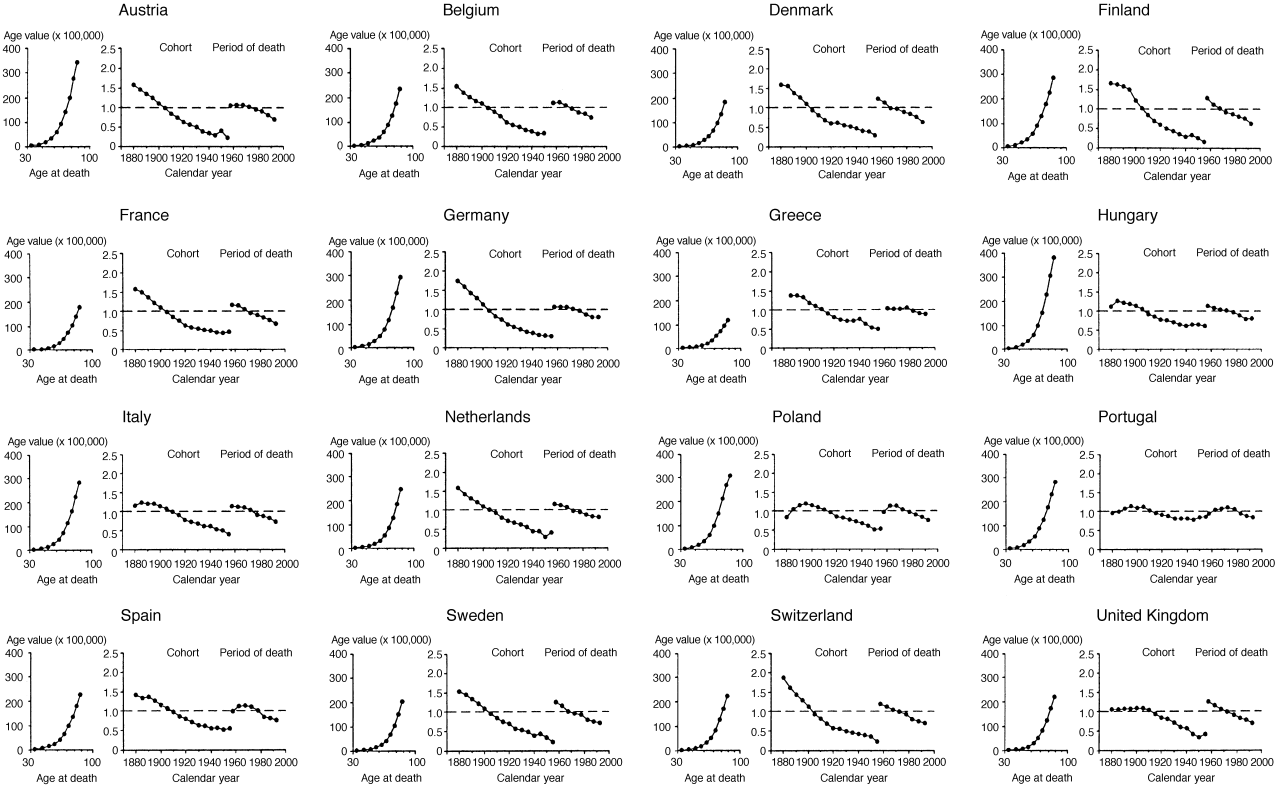
Cancer of the mouth or pharynx — females



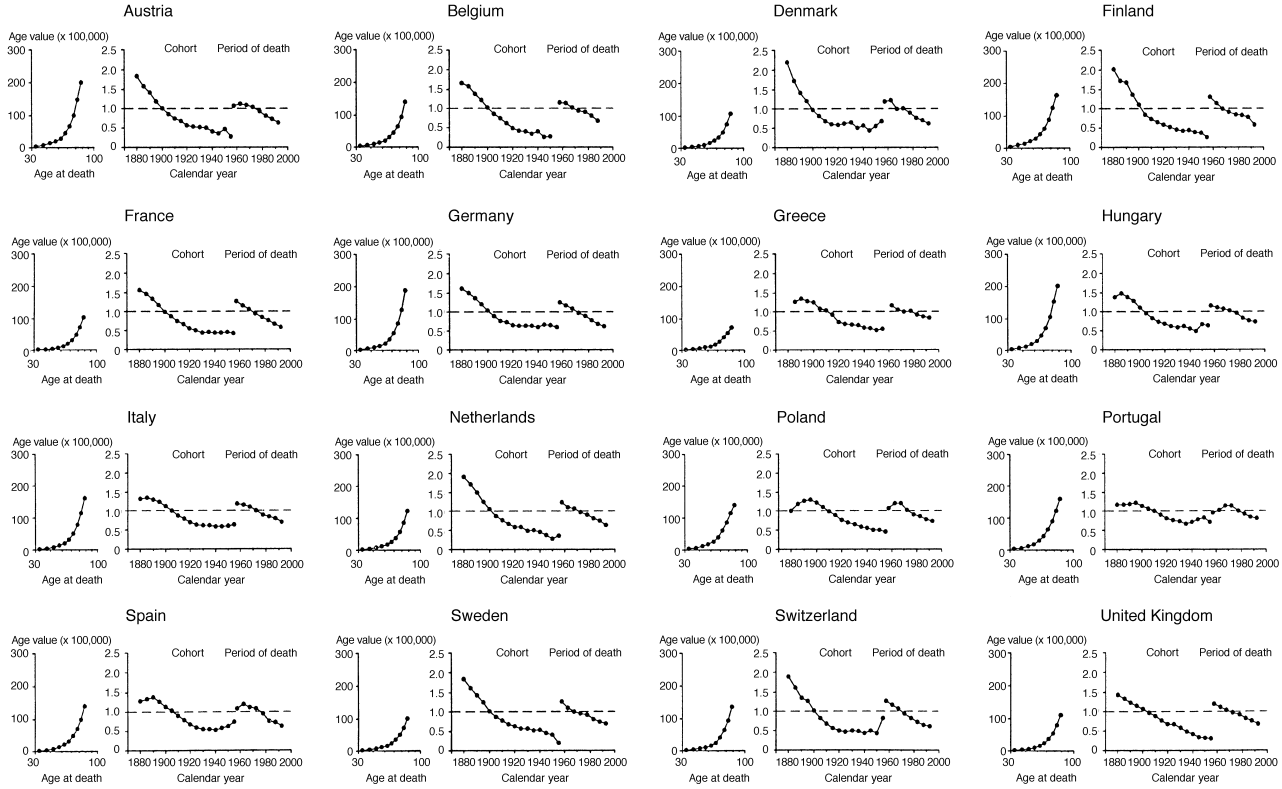
Cancer of the oesophagus — males



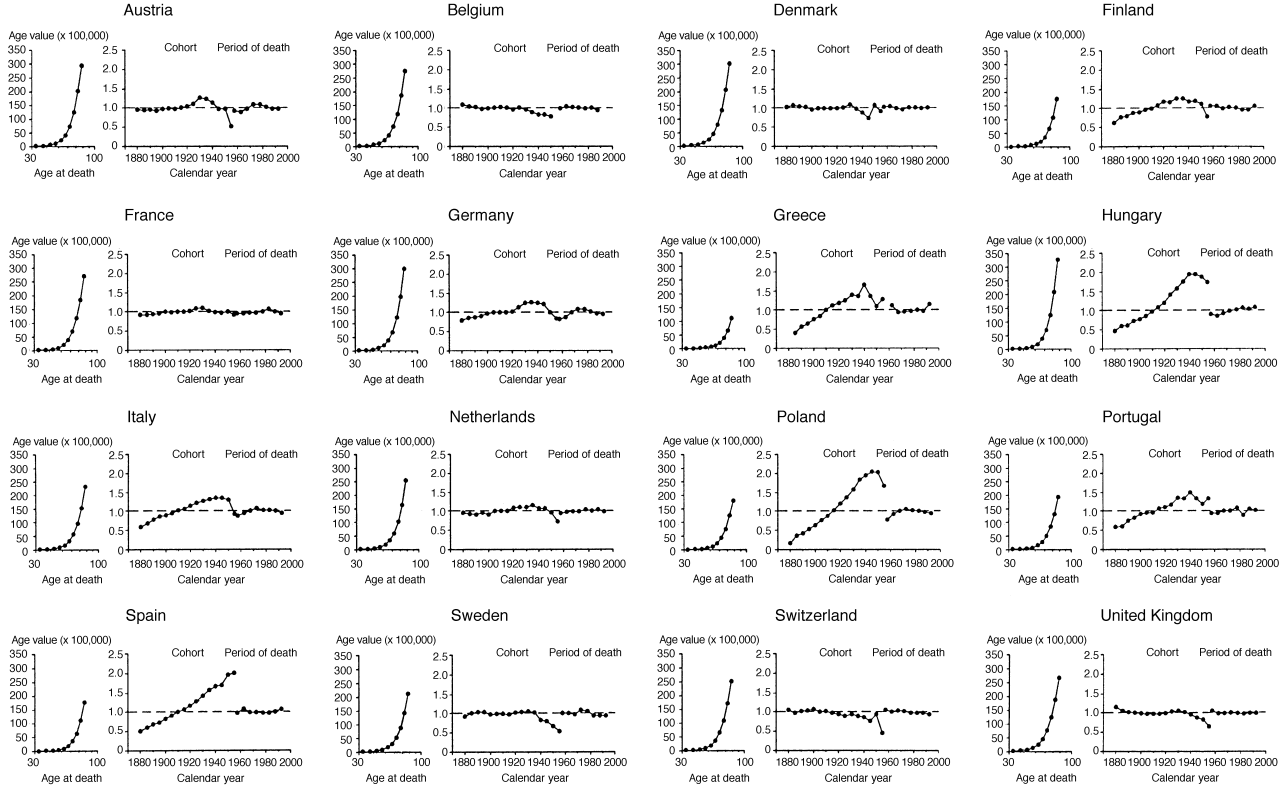
Cancer of the stomach — males



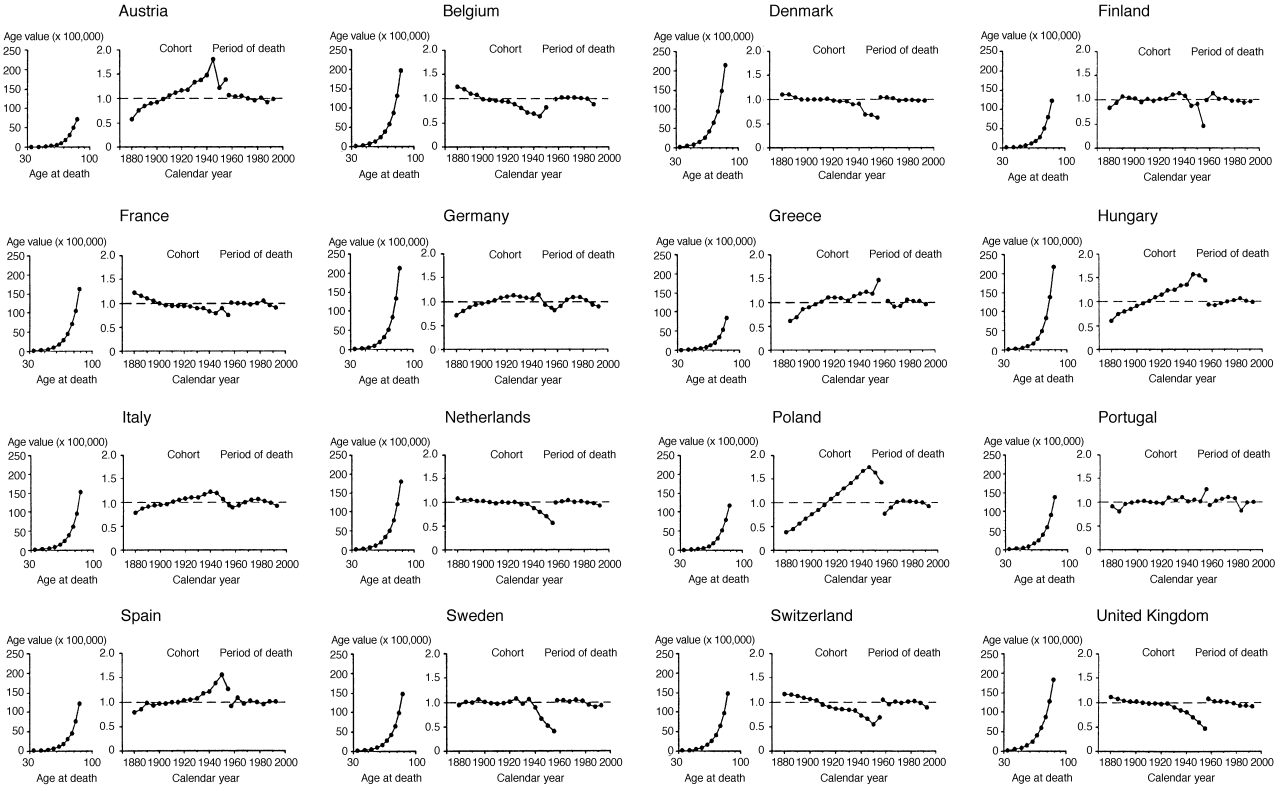
Cancer of the stomach — females



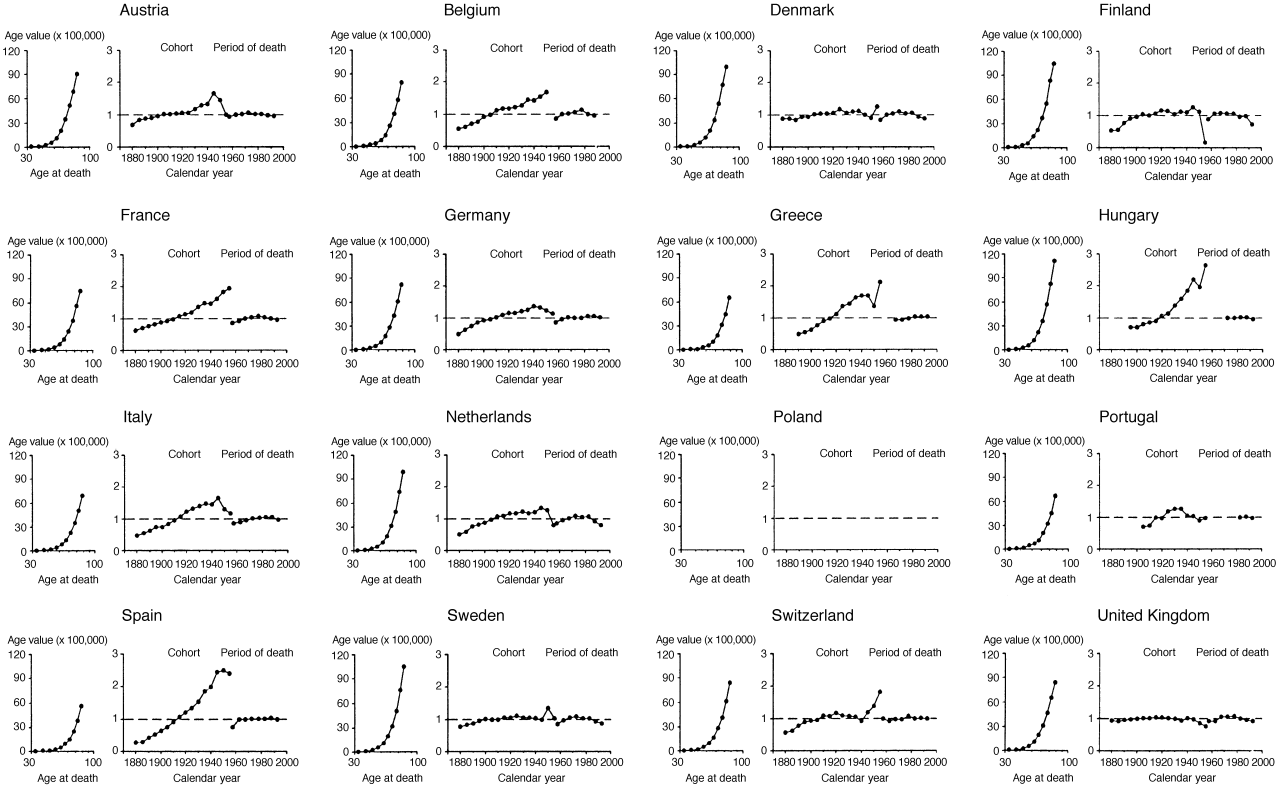
Cancer of the intestines — males



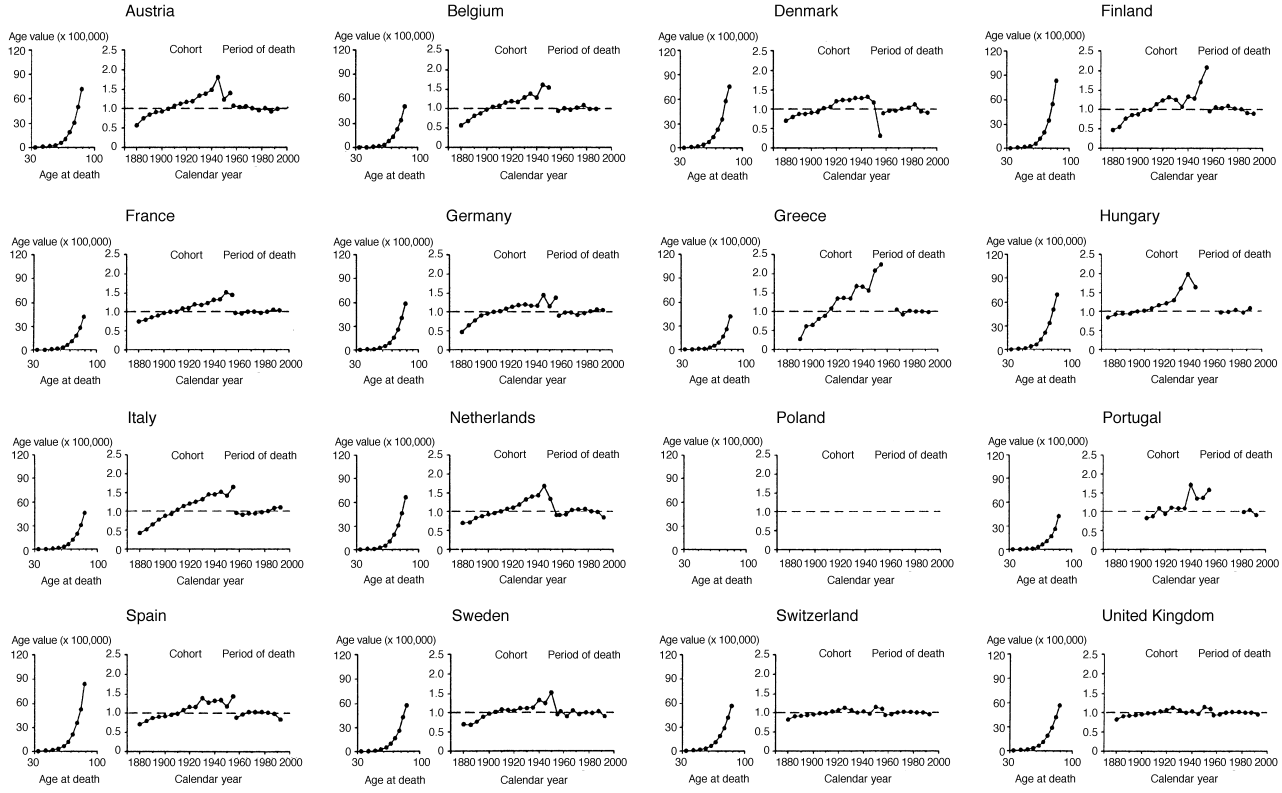
Cancer of the intestines — females



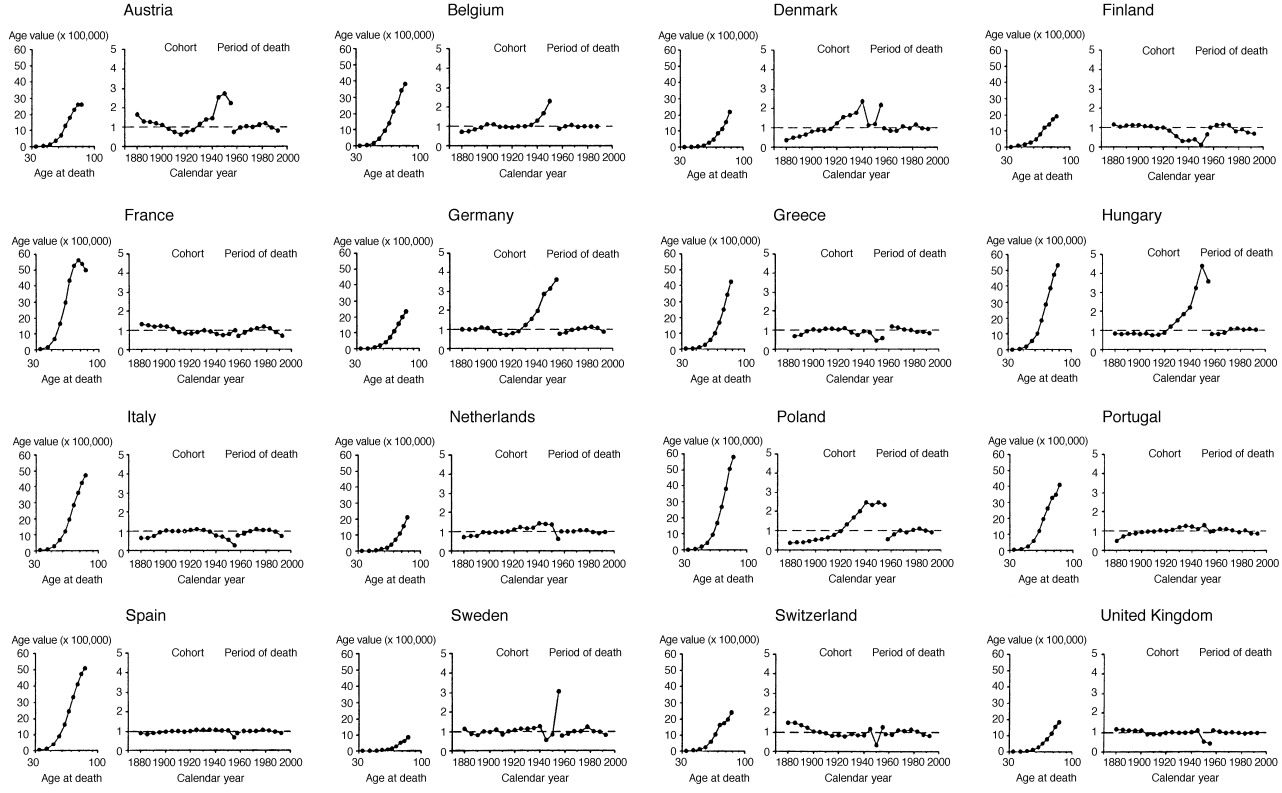
Cancer of the pancreas — males



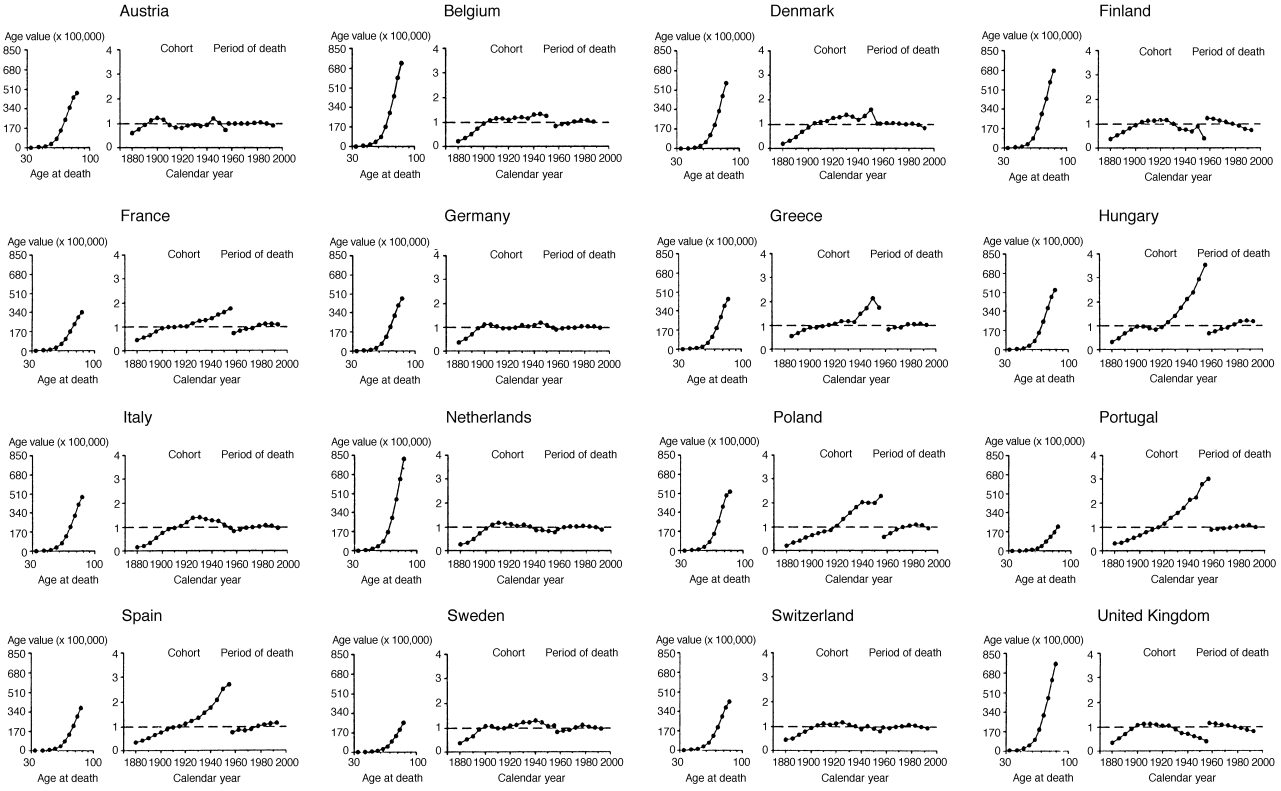
Cancer of the pancreas — females



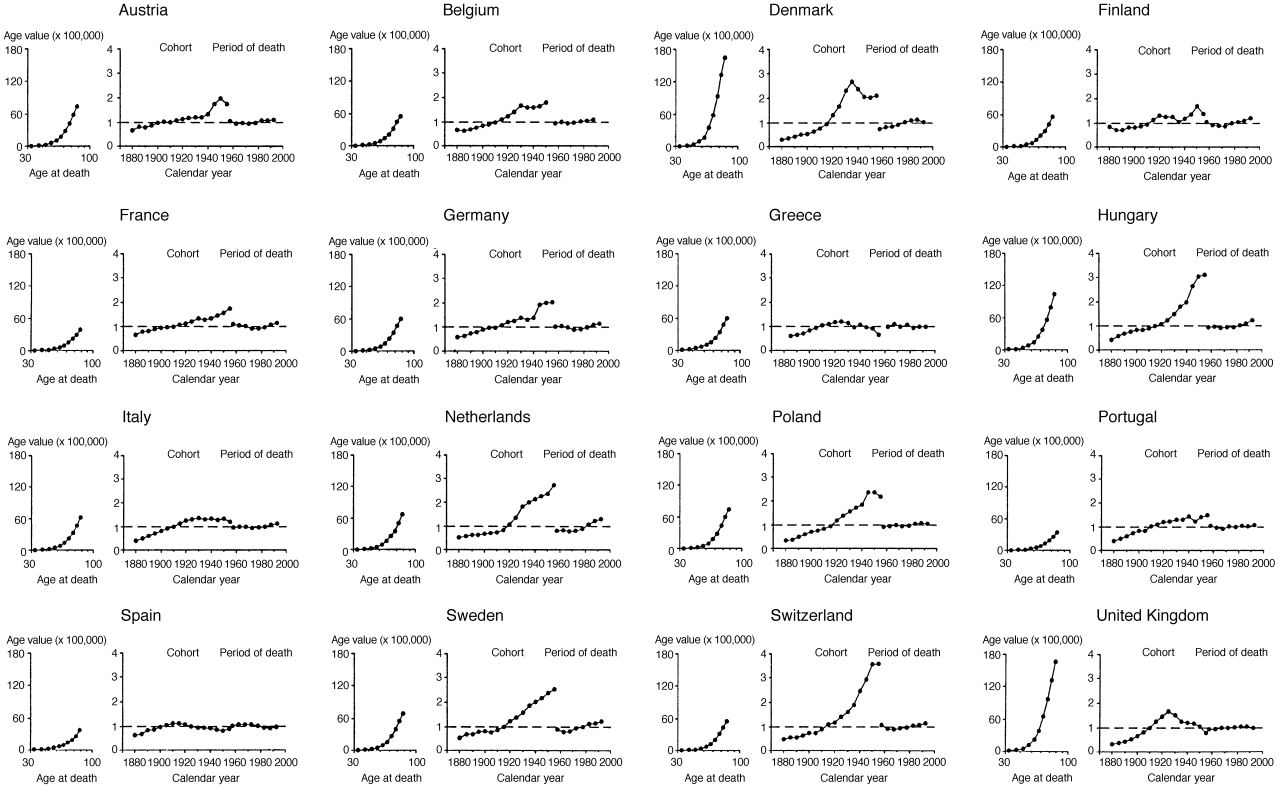
Cancer of the larynx — males



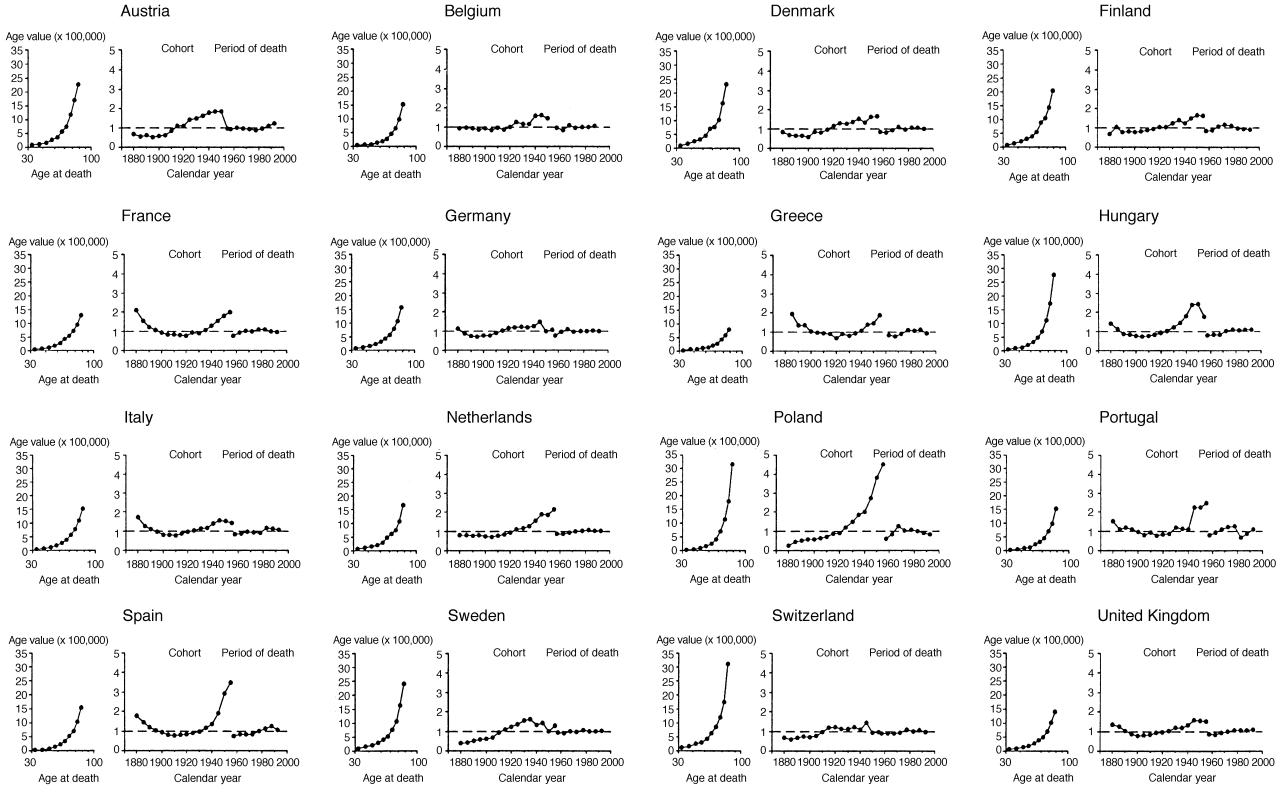
Cancer of the lung —males



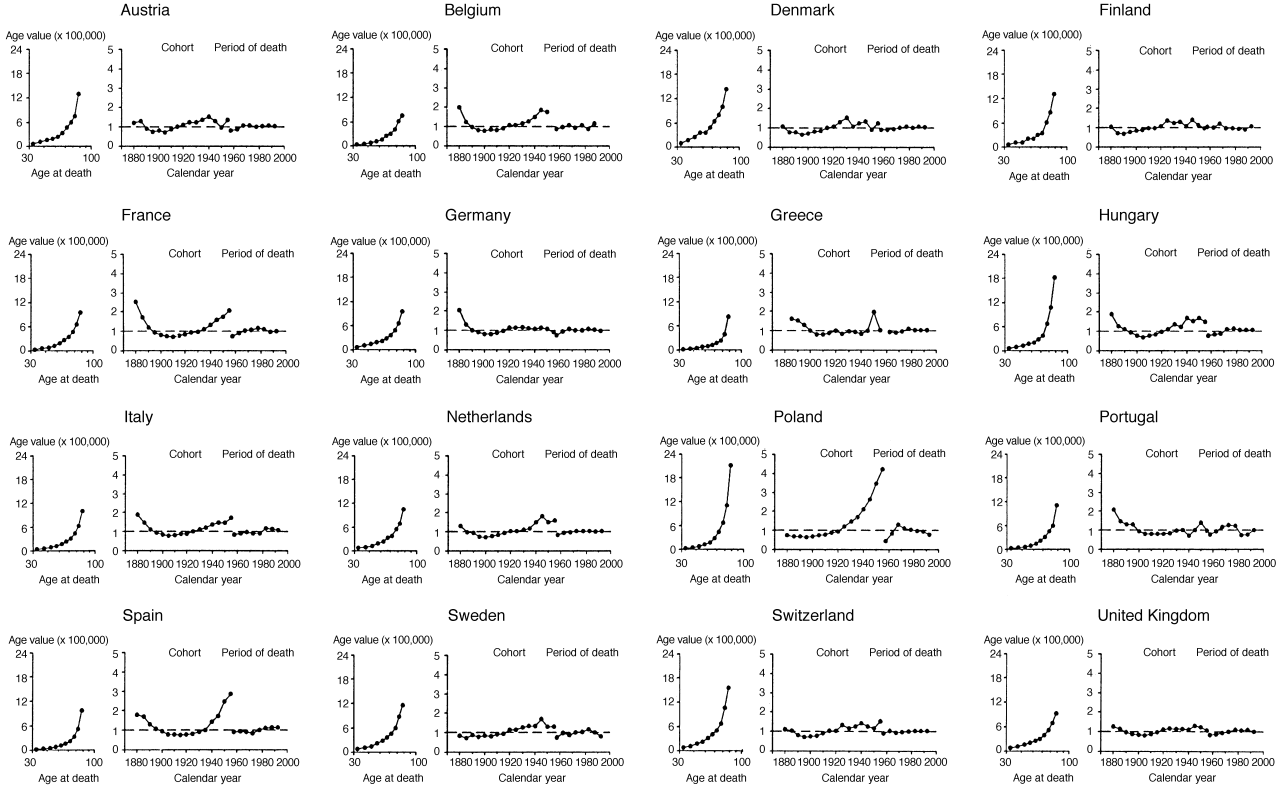
Cancer of the lung — females



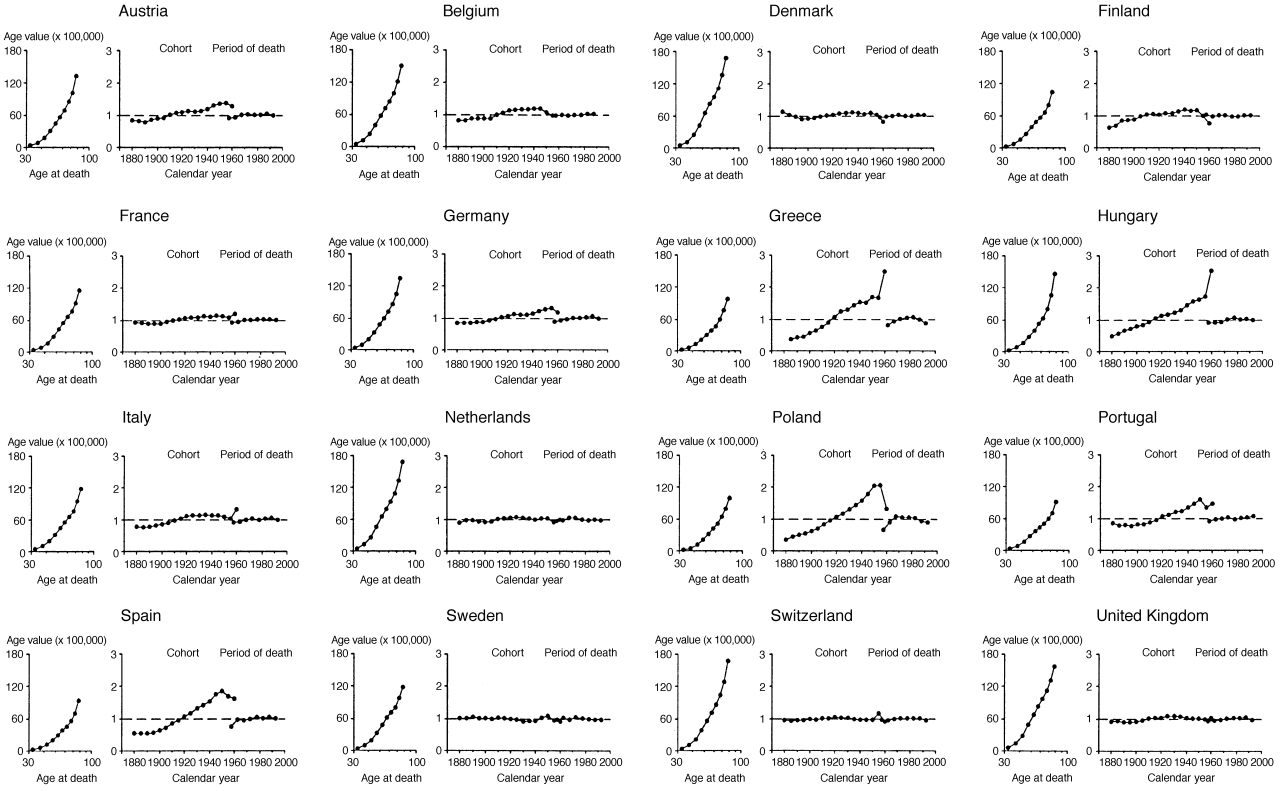
Cancer of the skin, including melanoma — males



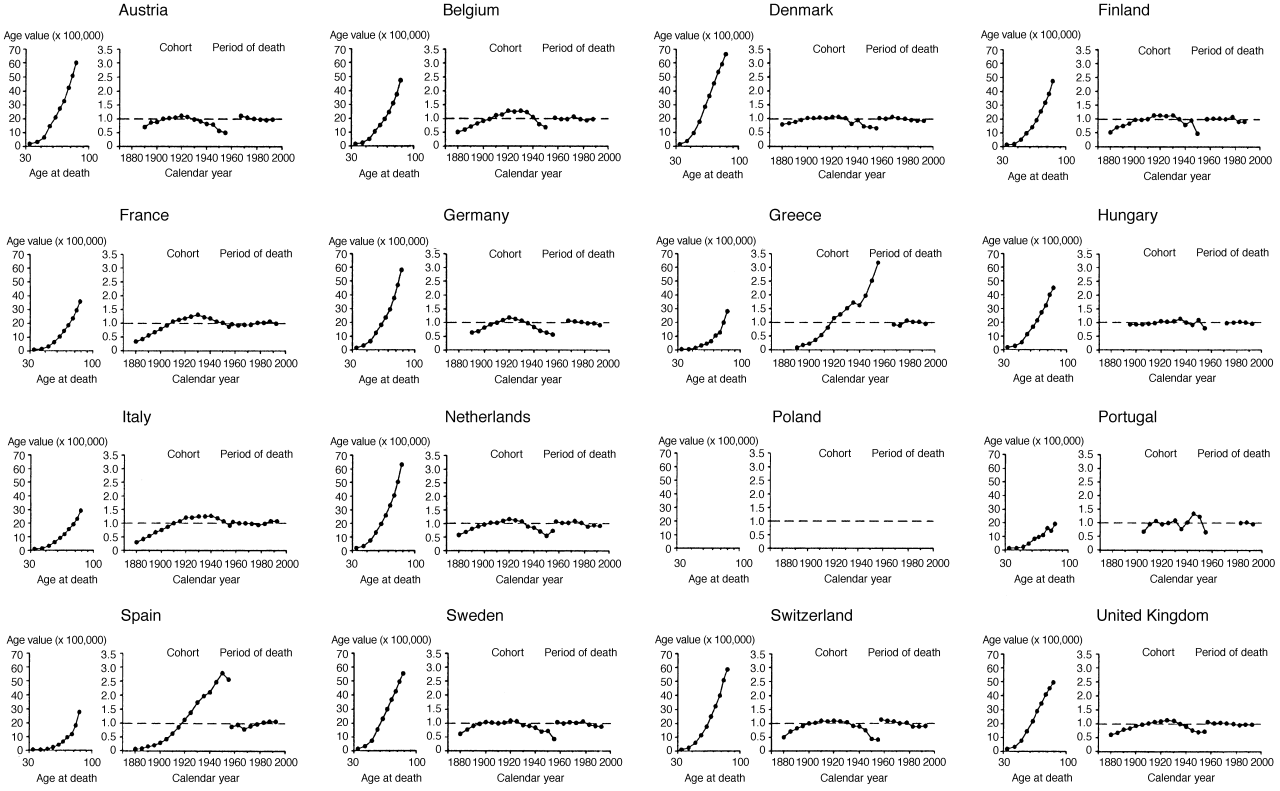
Cancer of the skin, including melanoma — females

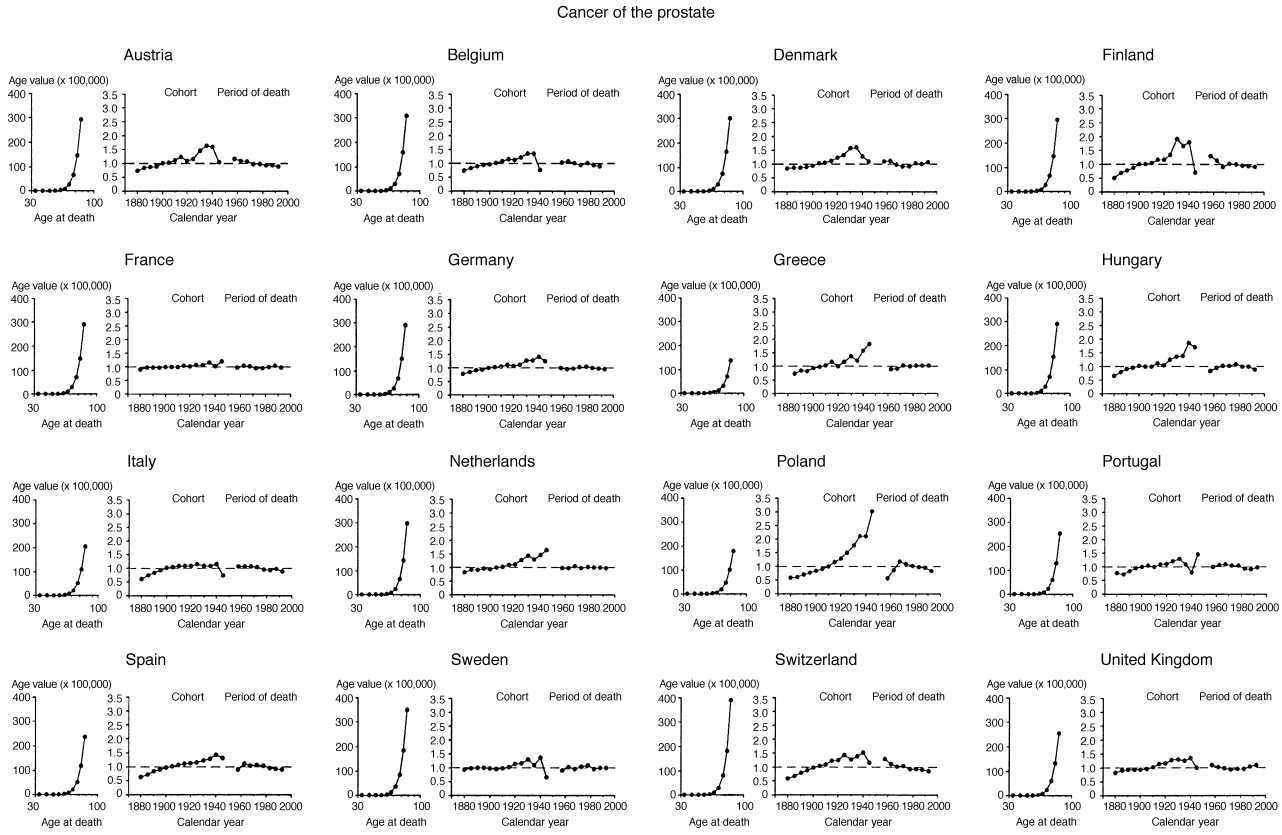


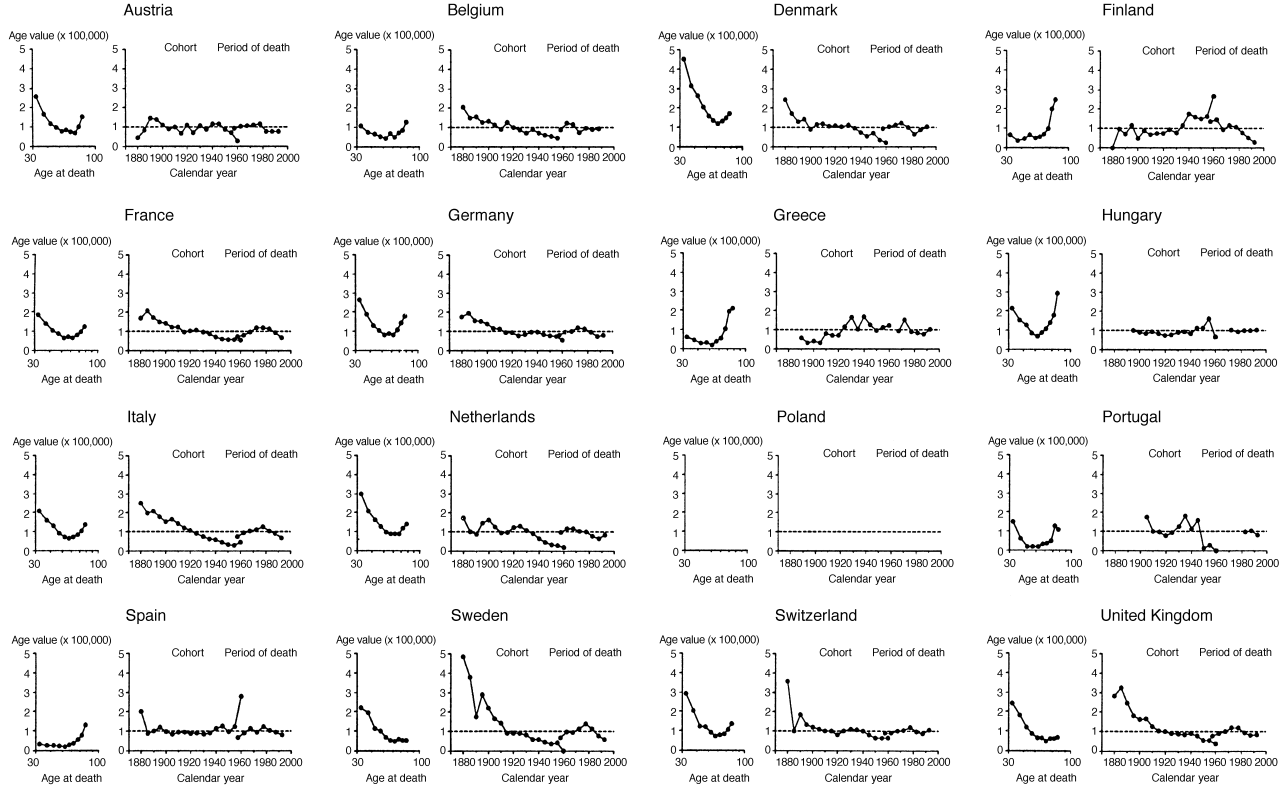
Cancer of the breast —females



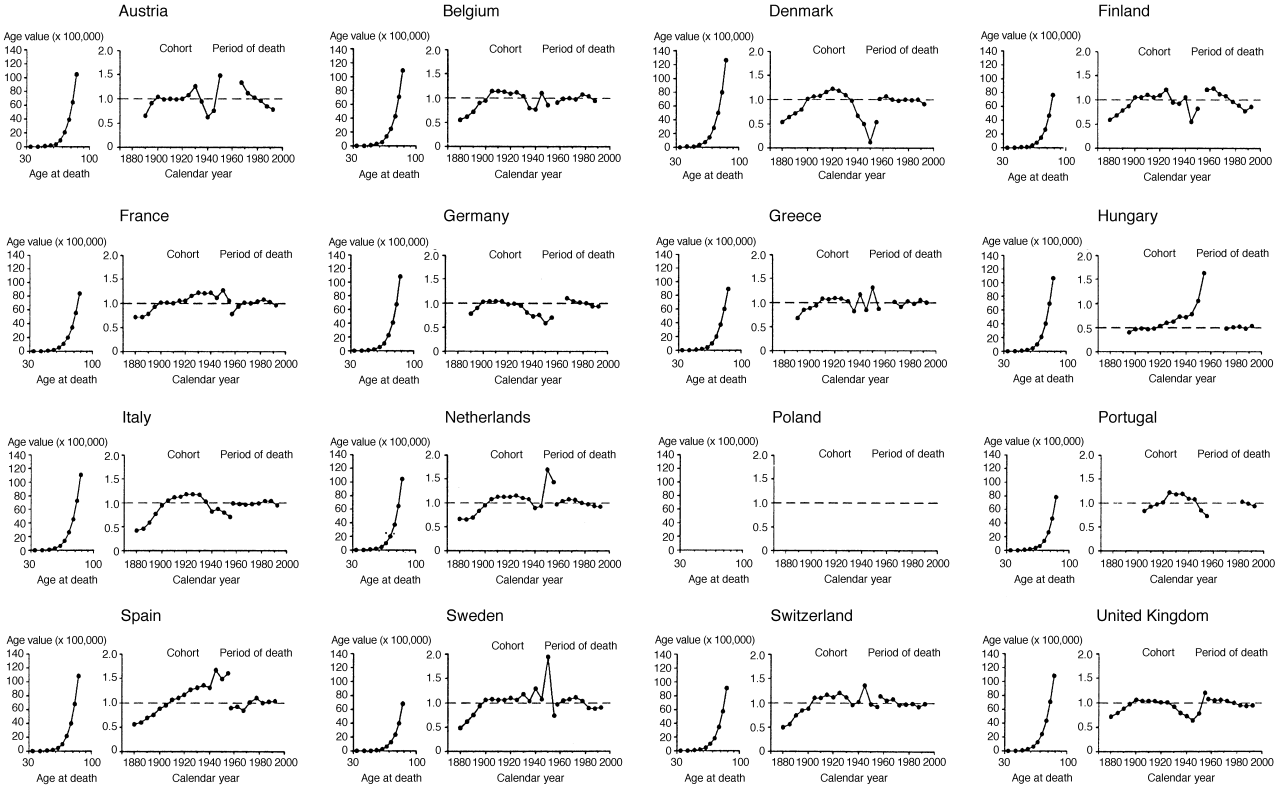
Cancer of the ovary



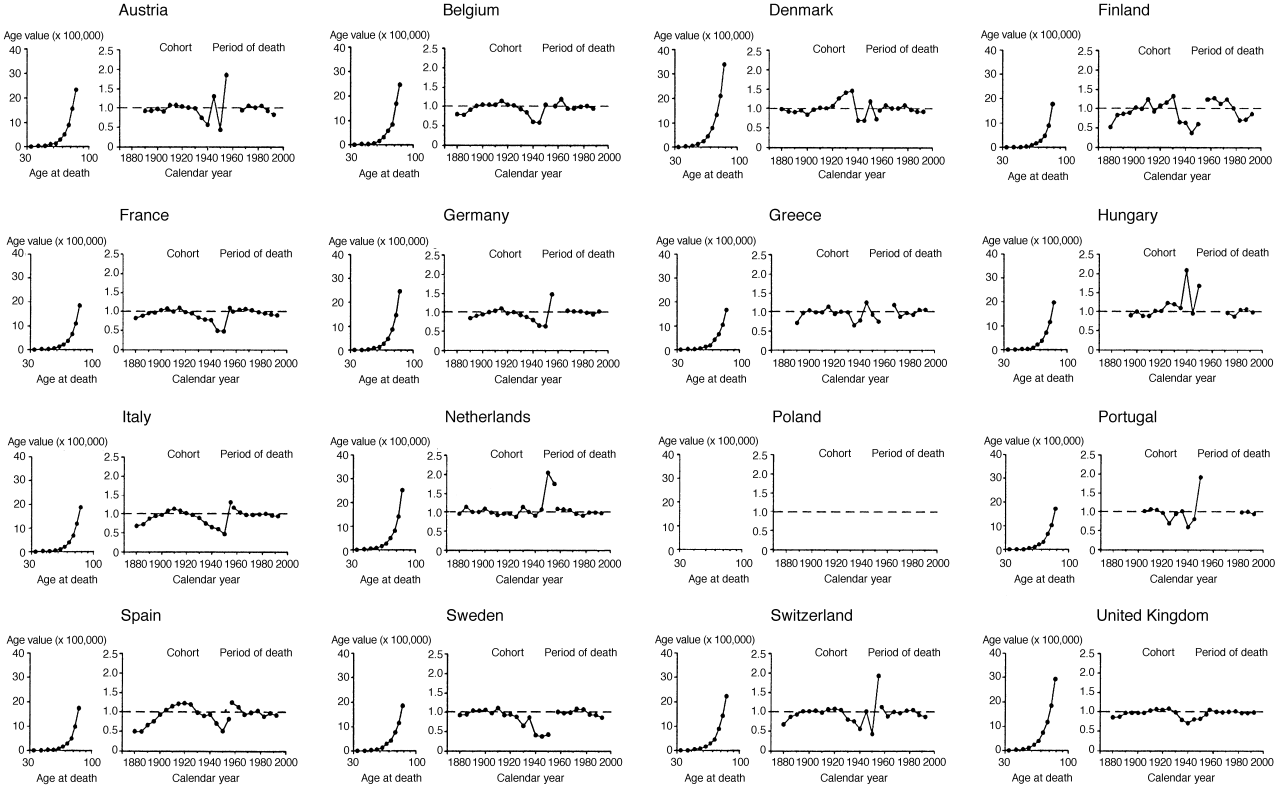

Cancer of the prostate
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Hungary
Italy
Netherlands
Poland
Portugal
Spain
Sweden
Switzerland
United Kingdom
Age value (x 100,000)
Cohort
Period of death
Age at death
Calendar year


Cancer of the testis
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Hungary
Italy
Netherlands
Poland
Portugal
Spain
Sweden
Switzerland
United Kingdom
Age value (x 100,000)
Cohort
Period of death
Age at death
Calendar year

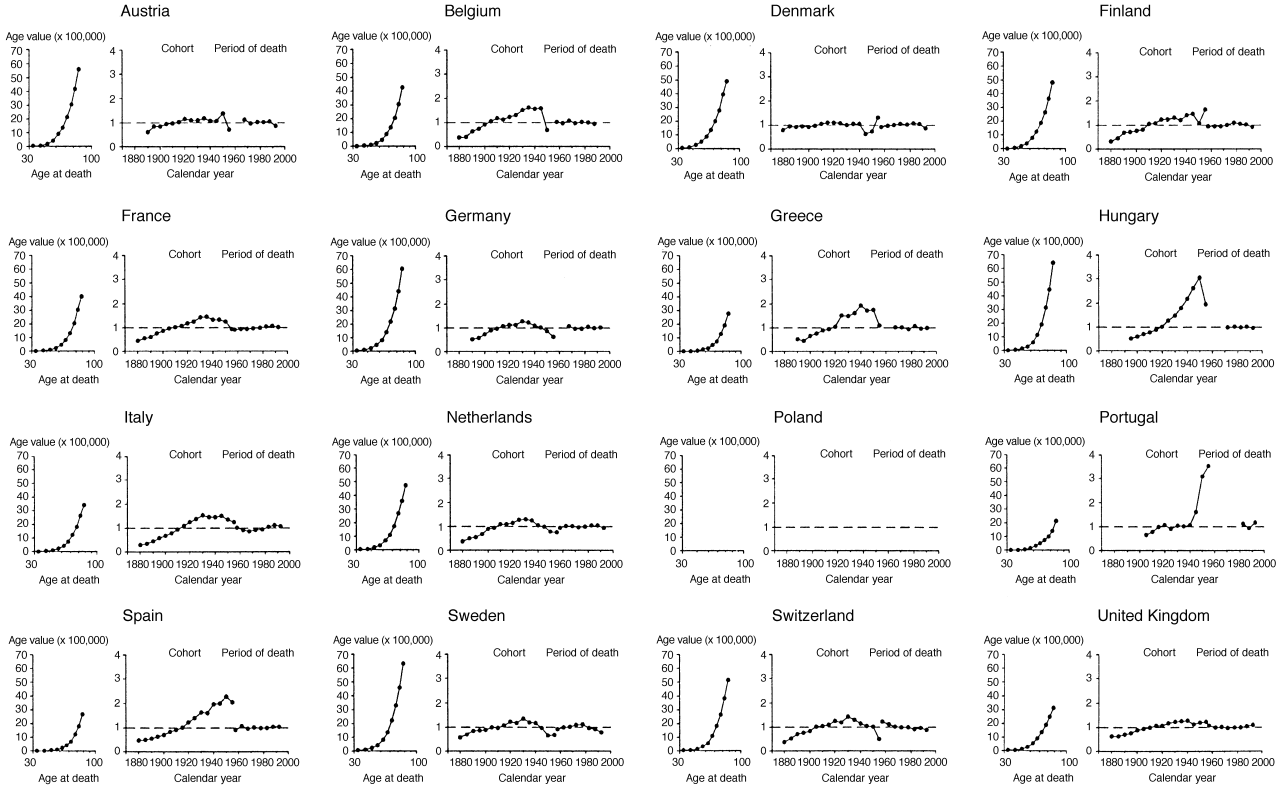
Cancer of the bladder — males



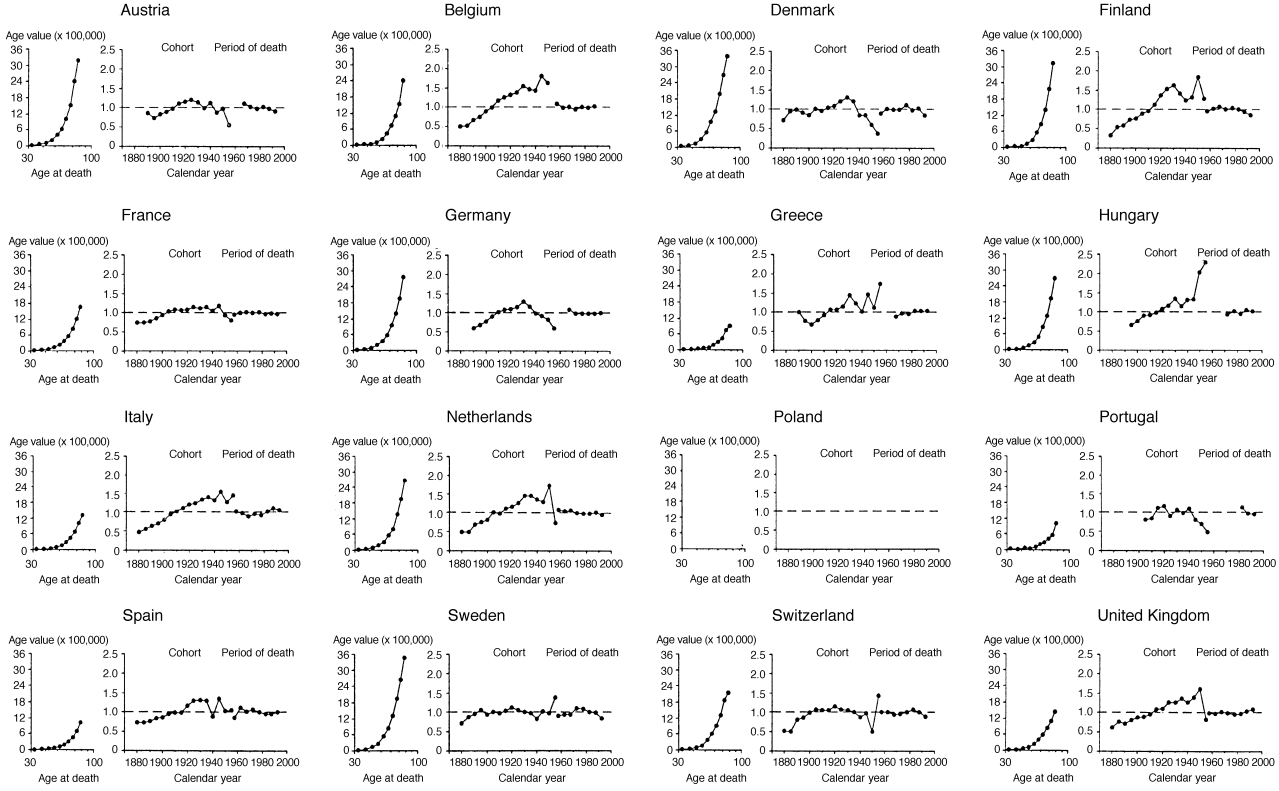
Cancer of the bladder — females



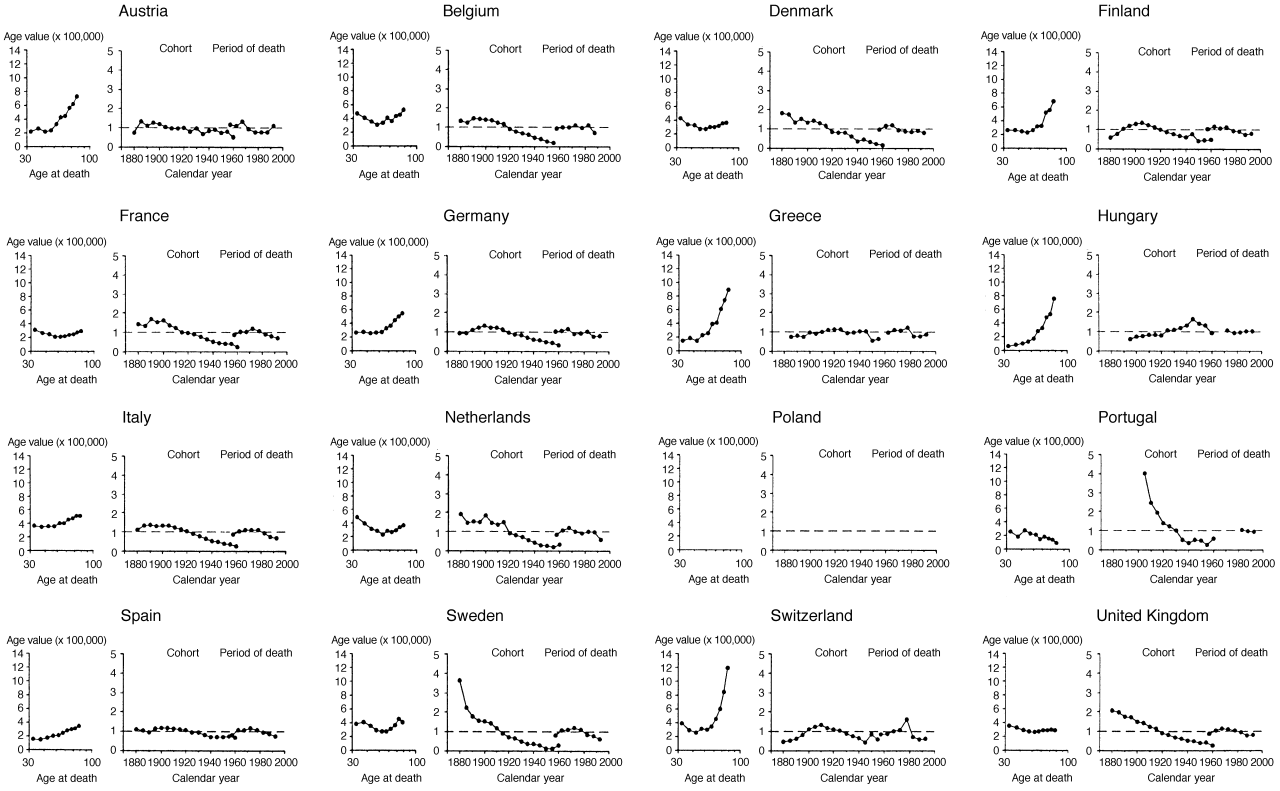
Cancer of the kidney — males



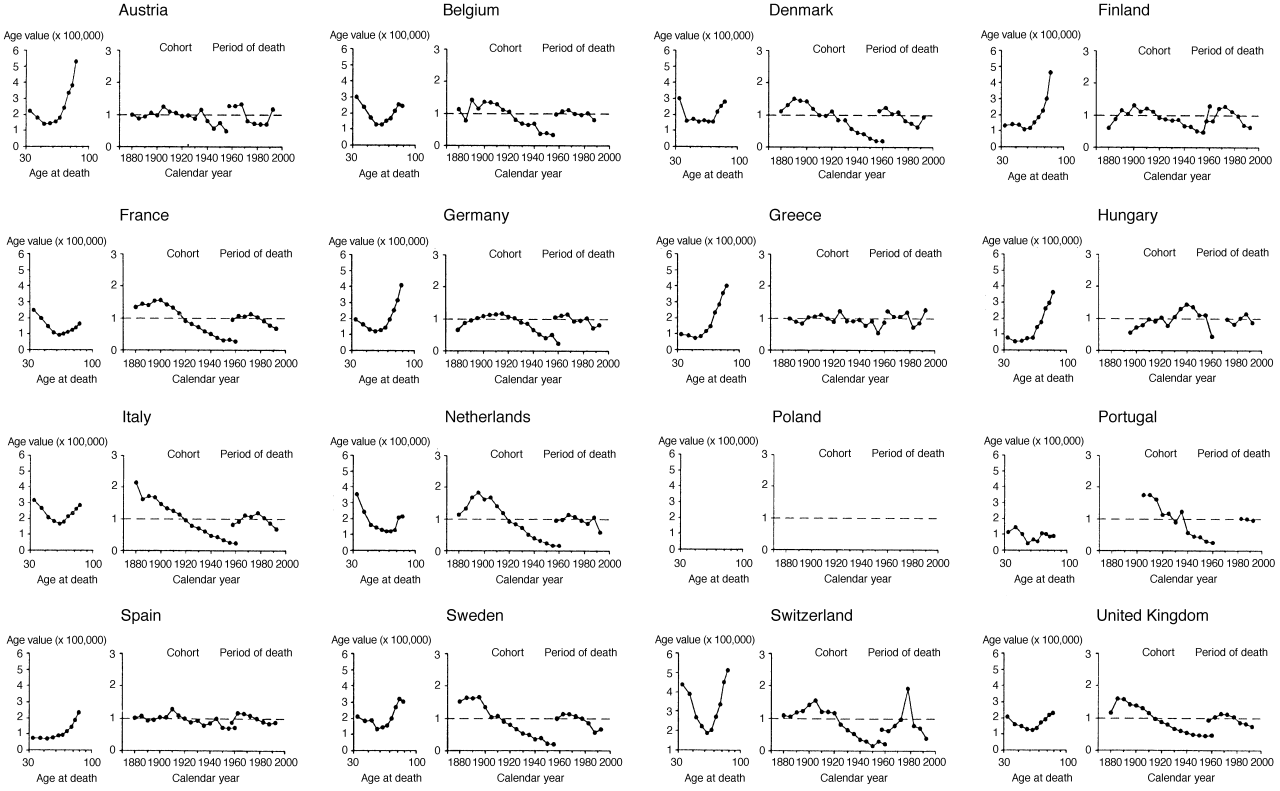
Cancer of the kidney — females



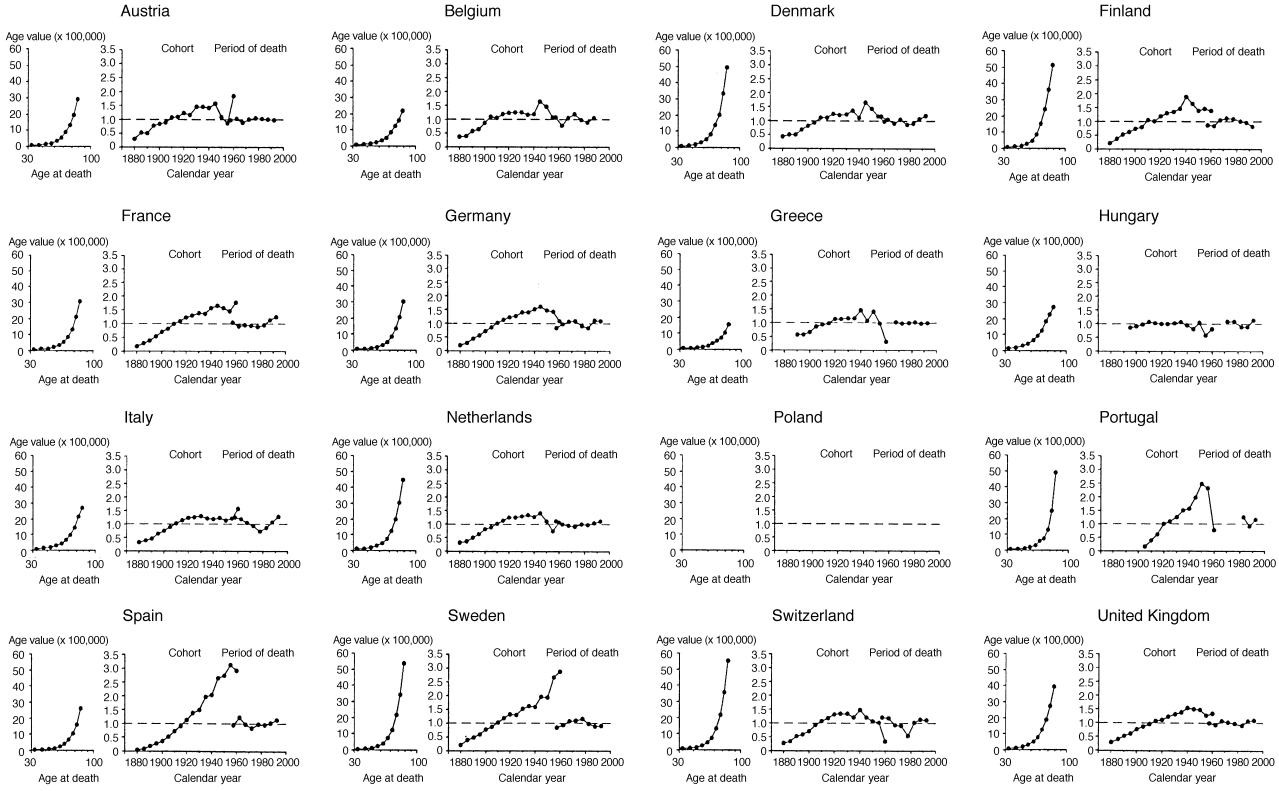
Hodgkin's disease — males



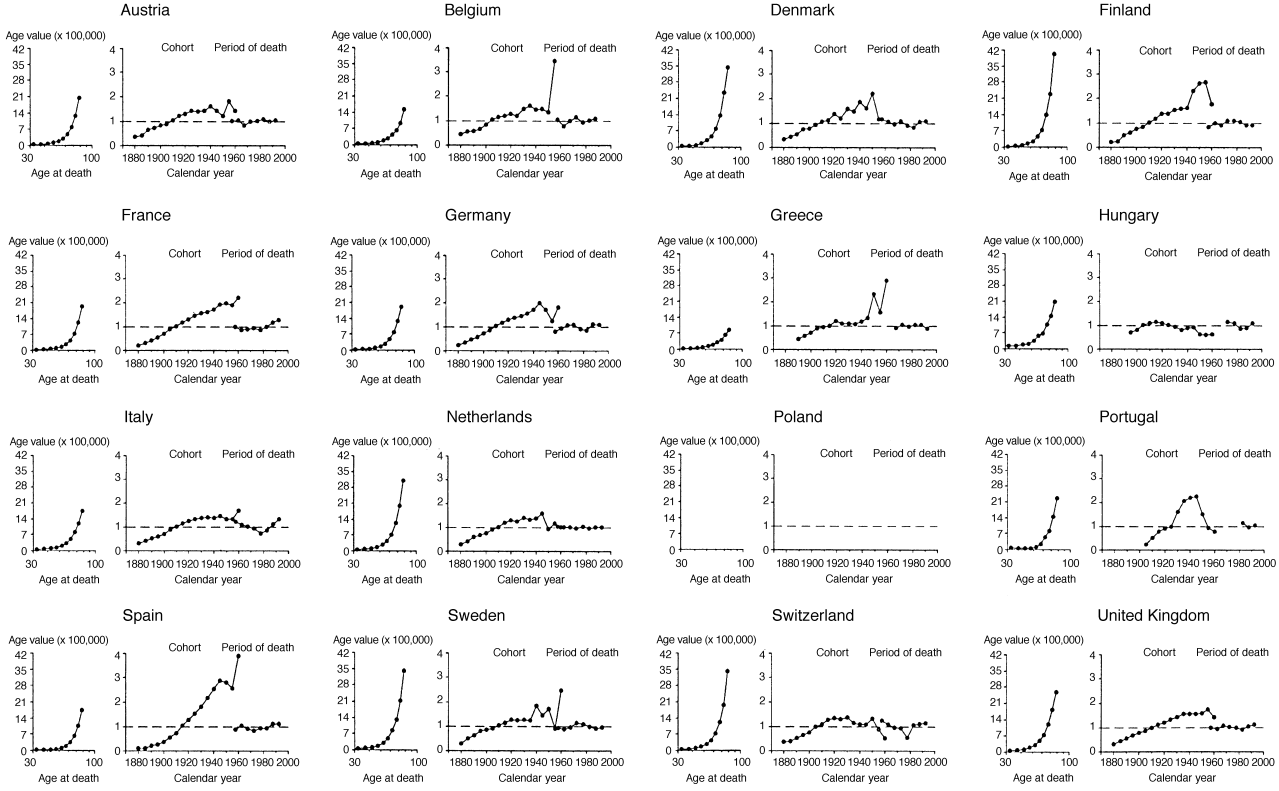
Hodgkin's disease — females



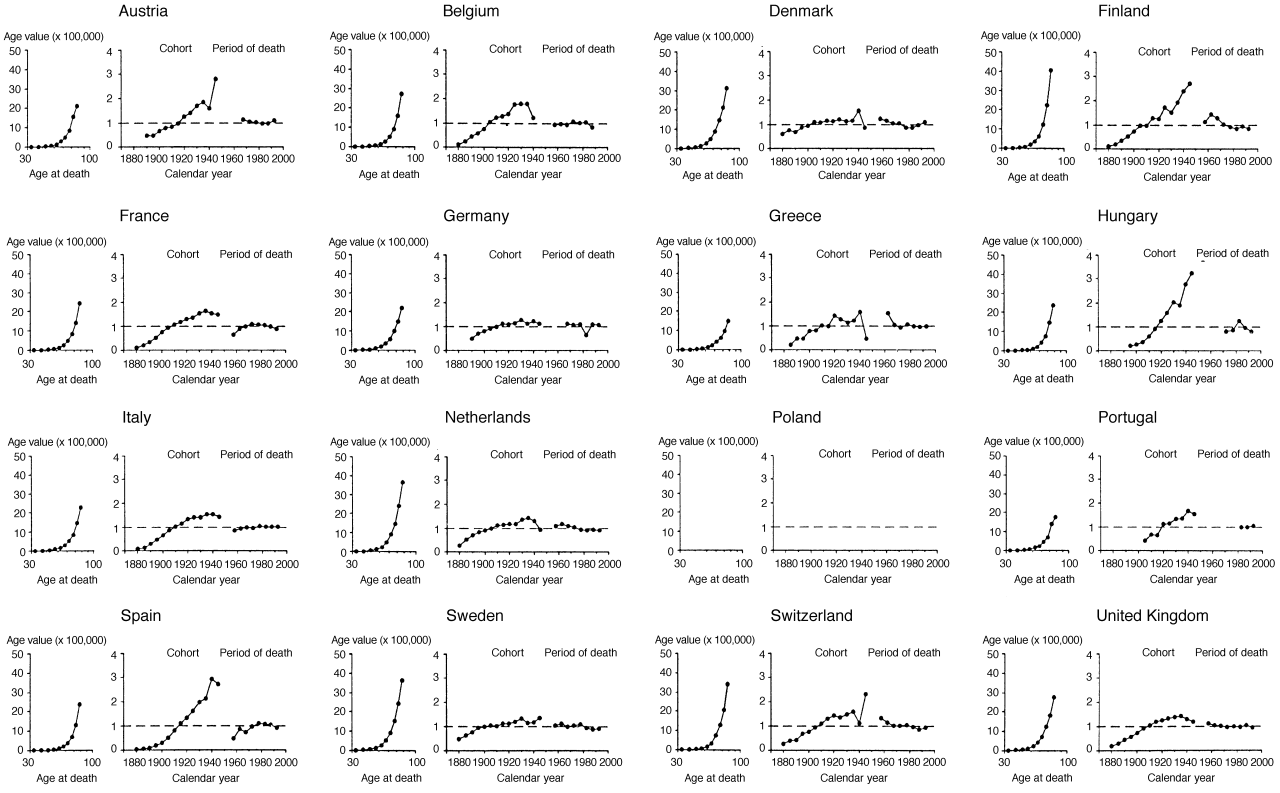
Non Hodgkin's lymphomas — males



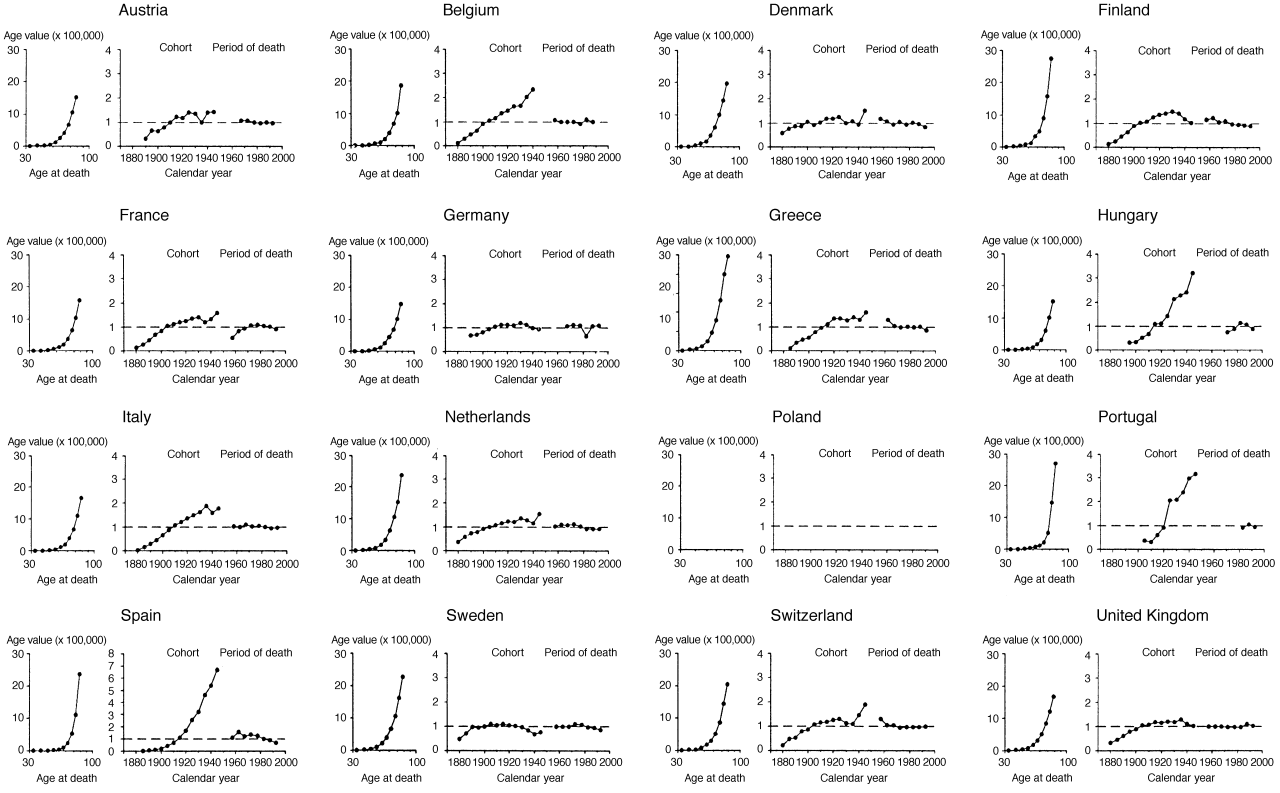
Non Hodgkin's lymphomas — females

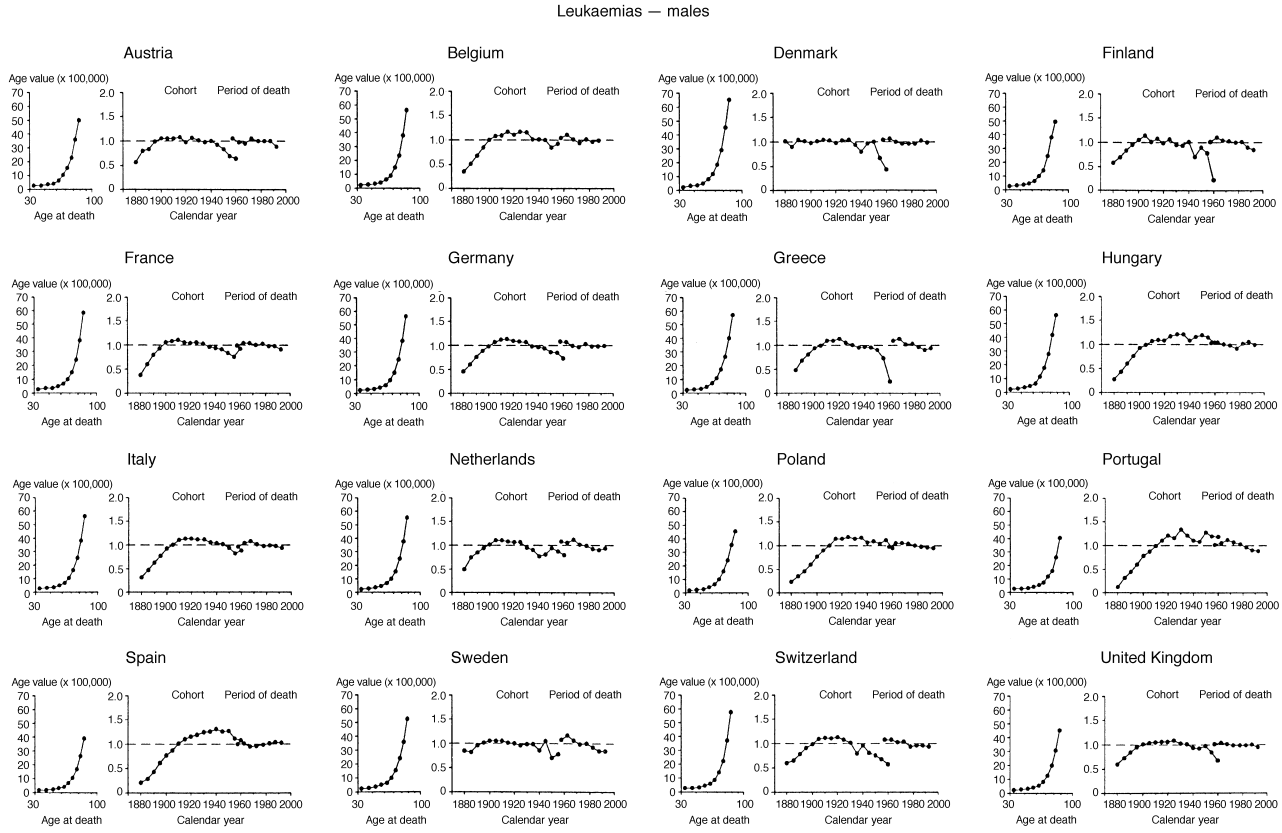


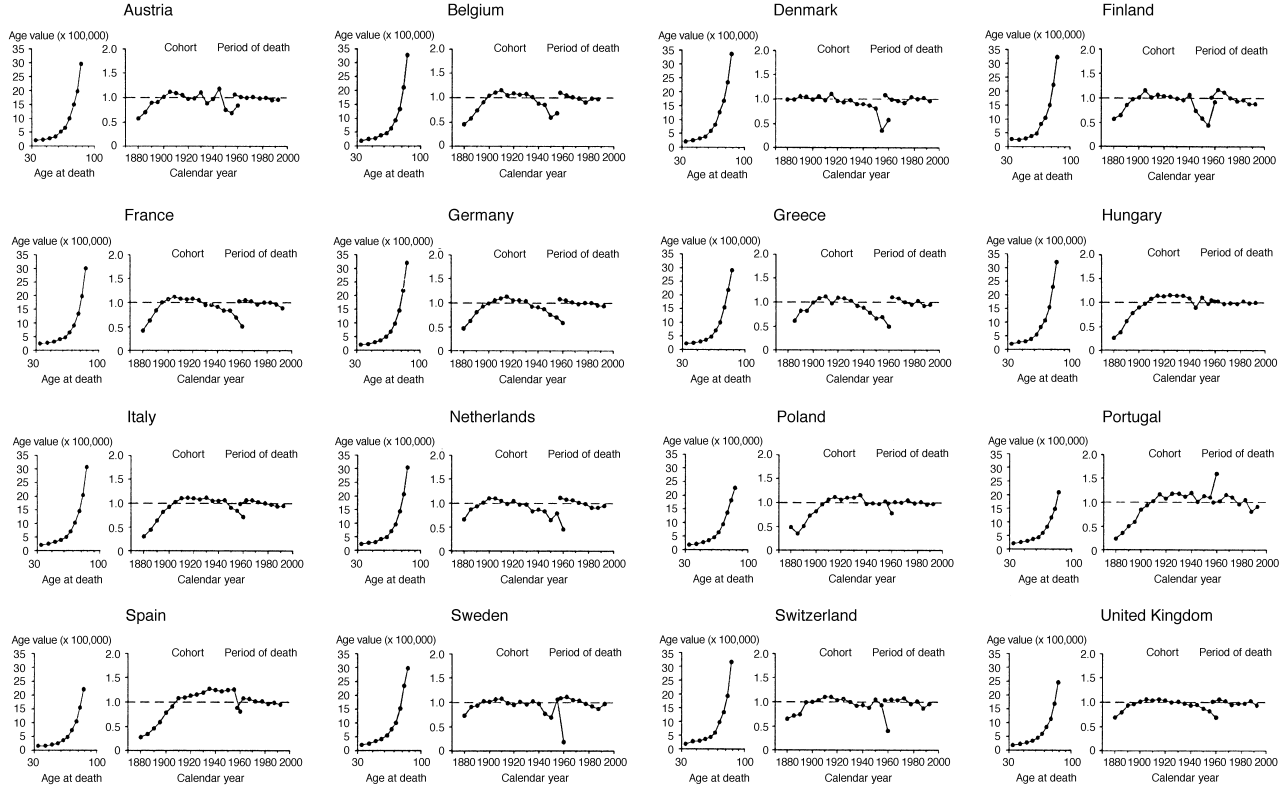
Multiple myeloma — males



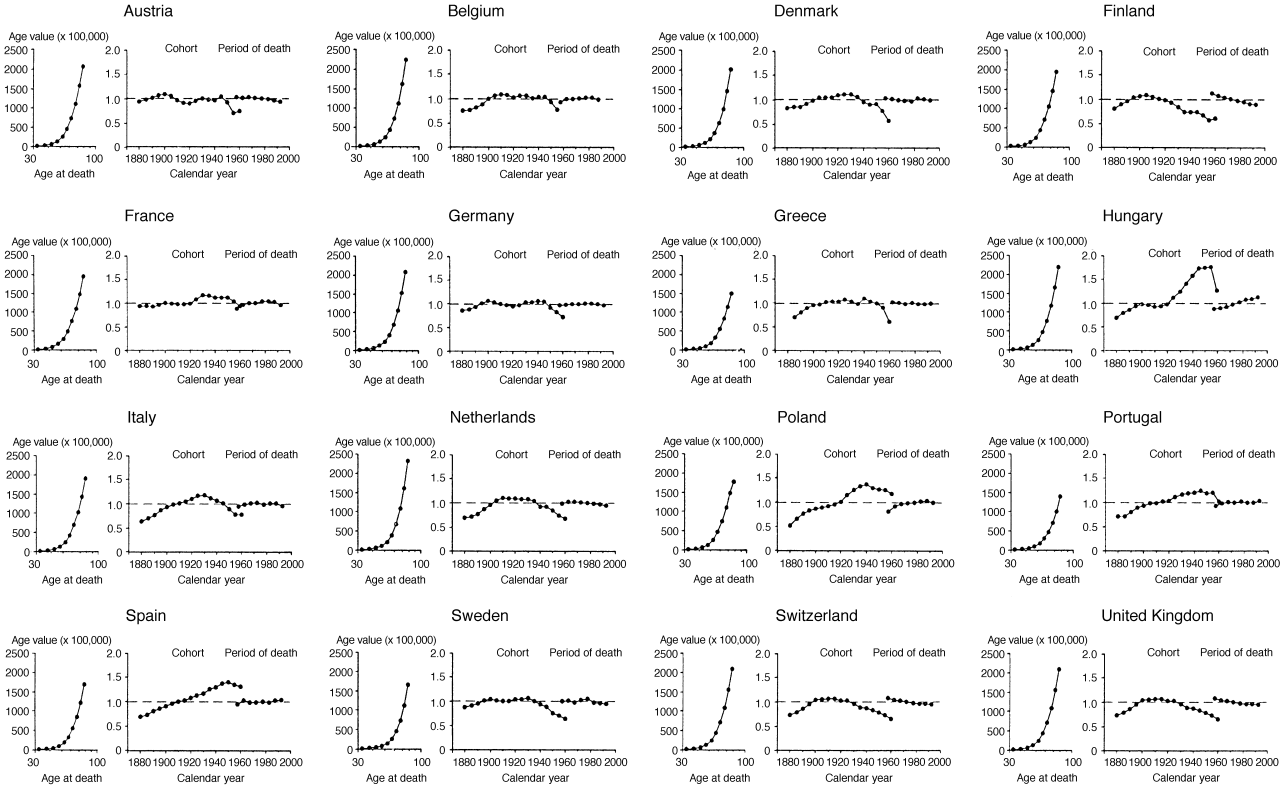
Multiple myeloma — females



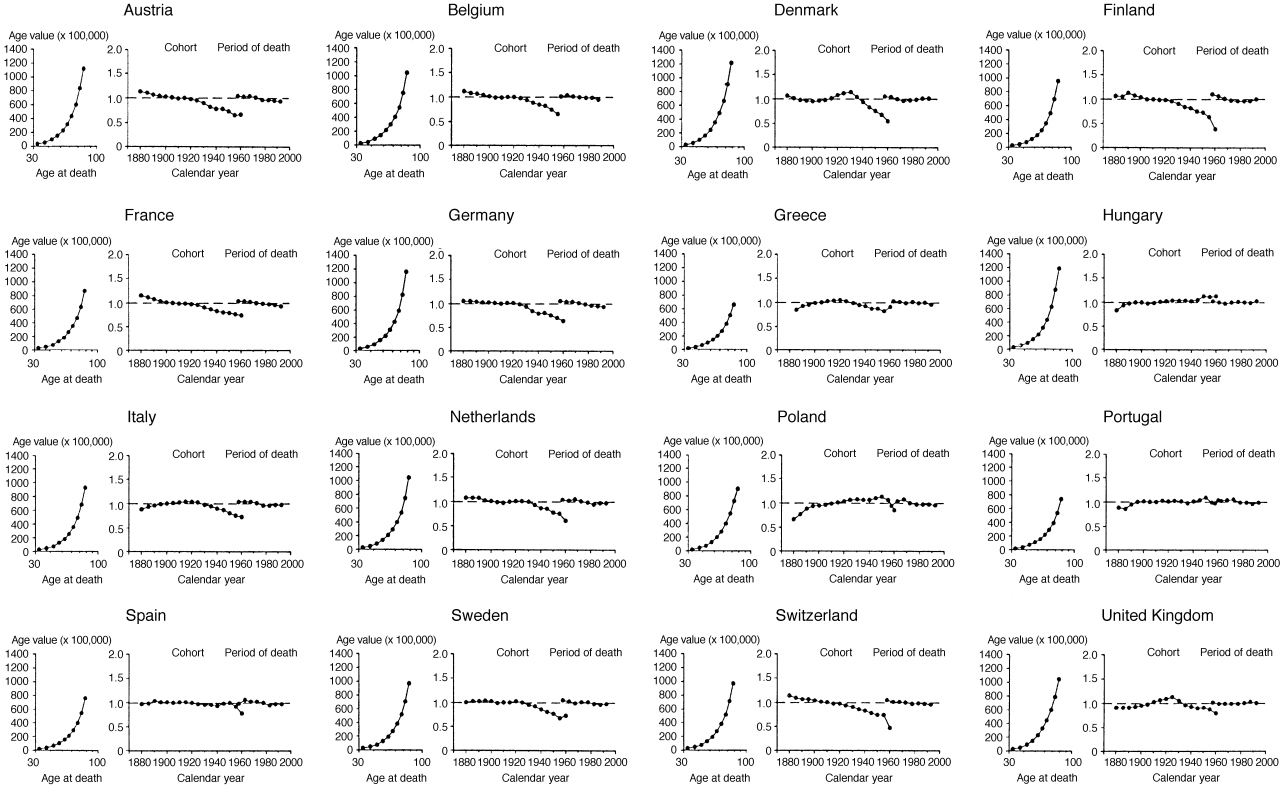

Leukaemias — males
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Hungary
Italy
Netherlands
Poland
Portugal
Spain
Sweden
Switzerland
United Kingdom
Age value (x 100,000)
Cohort
Period of death
Age at death
Calendar year


Leukaemias — females
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Hungary
Italy
Netherlands
Poland
Portugal
Spain
Sweden
Switzerland
United Kingdom
Age value (x 100,000)
Cohort
Period of death
Age at death
Calendar year

All neoplasms, benign and malignant — males



All neoplasms, benign and malignant — females



CONCLUSIONS

Within the complexity of the large number of trends presented, at least three major patterns emerged from the present analysis of age, period and cohort patterns in cancer mortality in Europe:

1. The prominent role of cohort of birth in defining trends in mortality from most cancer sites;
2. The major role of lung and other tobacco-related neoplasm epidemics in the diverging pattern of cancer mortality in each sex and various European countries and geographic areas;
3. A persistent rise in cancer rates, again chiefly on a cohort basis, in Eastern Europe.

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