Twentieth Century Mortality Trends in England and Wales

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This article examines trends in mortality over the Twentieth Century, using data from the ONS *Twentieth Century Mortality* CD-ROM. Firstly, we update analyses published in the *Health of Adult Britain* – changes in all-cause mortality rates, and rates for broad cause groups. These have been updated with new population estimates for 1982–2000, which take into account the results of the 2001 Census, and the analyses have been brought up to the end of the century. The ninth revision of the International Classification of Diseases was last used in England and Wales in 2000, so this article covers all the years in which the first to ninth revisions were in use. We have also extended analyses of specific diseases, focusing on diseases which were major causes of death, either at the beginning or the end of the century; diseases which had relatively comparable definitions over time; and on new analyses of ill-defined causes of mortality, which are currently of particular interest.

Introduction

This article examines trends in mortality during the Twentieth Century. We first examine changes in mortality from all causes of death combined and then look at the changes by broad Chapter of the International Classification of Diseases (ICD). The ninth revision of the ICD was last used in England and Wales in 2000, so this article covers all the years in which the first to ninth revisions were in use. This updates analysis already published[1] to the end of the century. New population estimates for 1982–2000, which take into account the results of the 2001 Census, have been used for the first time. We then move on to focus on selected specific causes of death. These are not exhaustive but focus on diseases which were major causes of death, either at the beginning or the end of the century; diseases which had relatively comparable definitions over time; and on new analyses of ill-defined causes of mortality, which are of particular interest currently. Potential problems in analysing mortality trends over such a long time period are also highlighted.

The way in which diseases have been described and classified has changed substantially over the last 100 years. For this reason care must be taken in interpreting trends in mortality by cause of death. They could reflect variations over time in the incidence of disease, detection or description of diseases, the case-fatality of specific diseases, statistical and classification artefacts, or new concepts of disease.[2] In particular, the coding of descriptions of causes of death from death certificates has changed substantially over time. The ICD has been revised nine times since 1901, to keep pace with advances in medical knowledge and discovery of new diseases. Annex 1 shows the revisions of the ICD, together with the periods during which each revision was used in England and Wales for coding mortality. The latest revision,

ICD-10, was introduced in 2001. This revision represents the largest revision to the ICD in 50 years, and it will fundamentally affect the way cause of death data are analysed in the future.[3–5] The analyses presented here therefore cover the complete period for which the first to ninth revisions were in use.

With each change in ICD, the appropriate codes must be chosen in order to analyse trends in mortality for specific causes of death. The rules governing the selection of the underlying cause of death may also change with ICD revisions or at other times. Between 1984 and 1992 ONS (then the Office of Population Censuses and Surveys), used different rules to select the underlying cause of death from those used in earlier or later years of ICD-9.[6] Failure to adjust for changes to the ICD, including the selection rules, can lead to discontinuities in the data. To aid comparisons, ONS and its predecessors published factors that can be applied to data to allow for such changes. These factors are generally useful in understanding trends around the time of the changes. It is problematic to use them to take account of changes over many revisions of the ICD, or to be confident in interpreting trend data produced in this way over long periods.

Another factor in identifying specific diseases is the detail given in the ICD. In ICD-9 there were over 5,000 codes, compared with under 200 in ICD-1. This means that many diseases cannot be identified comparably, or at all, for the whole 100 years. Others have discussed the problems in analysing data over time in more detail.[7] In this article, we have looked at a selection of causes for which we were able to obtain apparently comparable data over time.

Data and methods

The data used for this article are taken from the ONS *Twentieth Century Mortality* CD-ROM, a database of the numbers of deaths in each year for 1901 to 2000,[8] classified by age group, sex and underlying cause of death (at the most detailed level available). Population denominators come from mid-year population estimates based on data from decennial censuses, and take into account revisions made to these estimates following subsequent censuses. The most recent revisions to these estimates followed the 2001 Census, when population estimates were revised for 1982–2000. We have incorporated these changes. In later work we will look at the effect of these changes on the mortality of population subgroups particularly affected by the latest revisions, such as young men. Box 1 shows the main measures used in this article.

Changing trends in all-cause mortality

Much of the improvement in mortality rates since the Eighteenth Century occurred in the Twentieth Century, especially in infants.[9] Figure 1 shows that females had lower mortality than males throughout the Twentieth Century, after allowing for differences in the age structure of the population (age-standardised rate). This 'gap' started to widen after the Second World War but has been decreasing since the 1970s. The rate for females was closest to that for males at the end of the Twentieth Century. This may be due to smoking trends, as many of the major causes of death in England and Wales are affected by smoking, for example heart disease, lung cancer and respiratory diseases.

Figure 2 shows that the proportion of all deaths occurring in the younger age groups fell throughout the Twentieth Century while an increasing proportion were occurring in the 65 and over age group in both sexes. By 2000, 83 per cent of all deaths in England and Wales occurred at ages 65 and over compared with less than 25 per cent a century earlier. Infant mortality accounted for 25 per cent of all deaths in 1901 but less than 1 per cent at the end of the century. Women had a higher proportion of deaths at older ages than men throughout the century.

Box one

Main measures used in the article

Age-specific mortality rate

Specific rates related to a particular group, in this case defined by age and by sex. They are calculated as

$$\text{age-specific mortality rate} = \frac{\text{deaths in age/sex group}}{\text{mid-year population in age/sex group}} \times 100{,}000$$

Infant mortality rate

$$\text{This is defined as } \frac{\text{Deaths under age 1 in year}}{\text{live births in same year}} \times 1{,}000$$

Directly age-standardised mortality rate

Directly age-standardised rates make allowances for differences in the age structure of the population, over time and between sexes. The age-standardised rate for a particular disease is that which would have occurred if the observed age-specific rates for the disease had applied in a given standard population. In this article we have used the European Standard Population. This is a hypothetical population standard, which is the same for both males and females allowing standardised rates to be compared for each sex, and between sexes.

Figure 1 Age-standardised annual mortality rate, all causes of death combined, by sex, 1901–2000

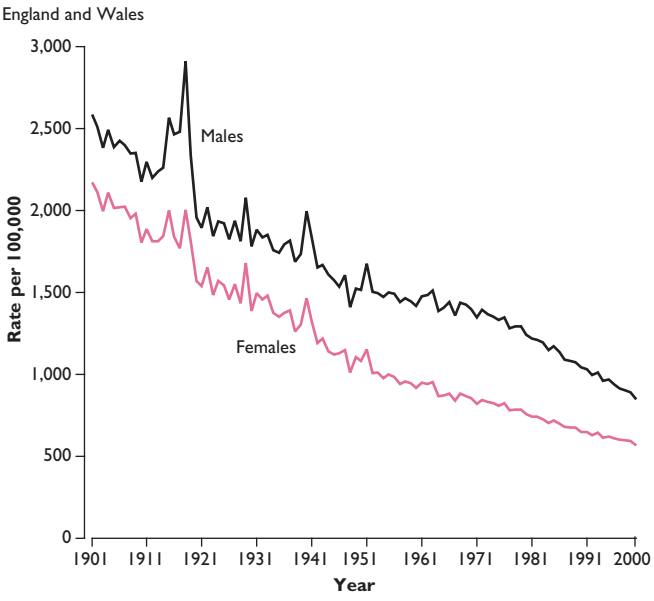


Figure 2 Percentage of deaths by age group, males and females, selected years

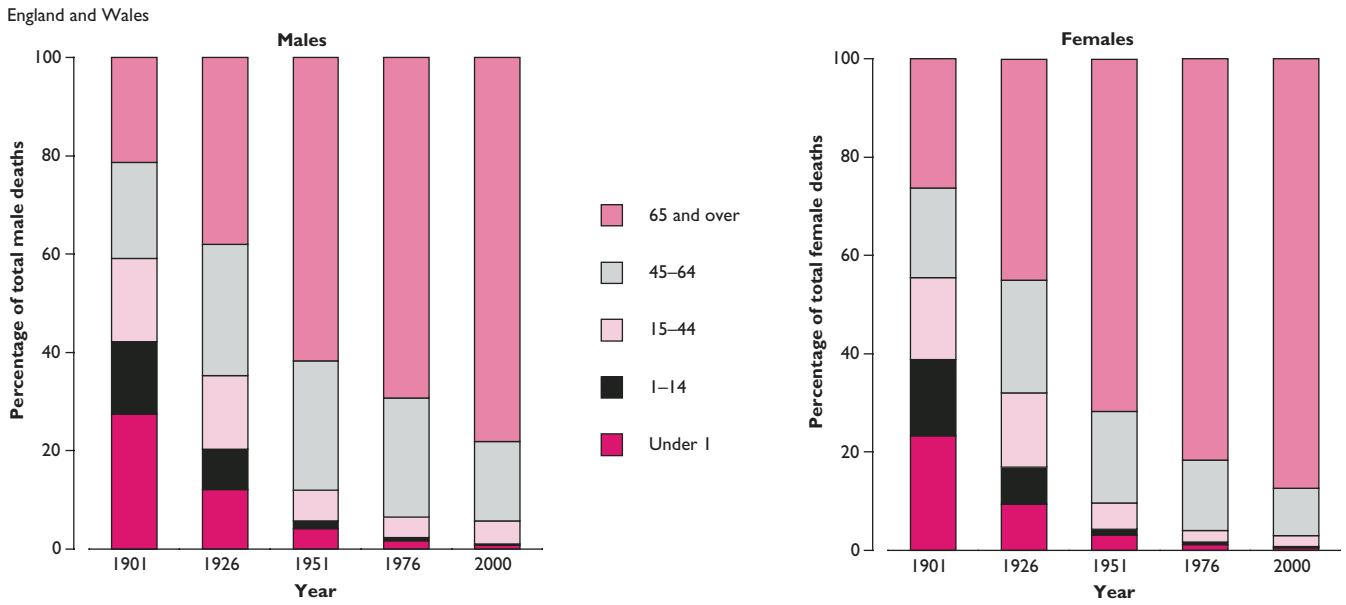


Figure 3a shows that the infant mortality rate has fallen dramatically throughout the Twentieth Century. This decline began abruptly around the beginning of the century, with rates being stable before this. The early part of this decline has been attributed to rising standards of living, especially improvements in nutrition, improvements in hygiene and the decline in mortality from airborne diseases.[10] Infant mortality may have been declining as early as 1860 in some rural communities, but in many towns infant mortality didn't begin to decline until well after 1900.[11]

The peaks of infant mortality in the earlier part of the century coincided with hot summers when diarrhoeal disease played a part in many deaths. During the Second World War there was a peak in infant mortality rates, mainly due to increased pneumonia and bronchitis, which may have been due to fuel shortages during the very cold winters of 1940 and 1941 and also to the disorganisation caused by evacuations early in the war.[12] In the later years of the War, infant mortality began to decline steeply. This may be an effect of the national food policy, which concentrated on the health of expectant mothers and infants and children.[13]

There was a steady decline in infant mortality in the second half of the Twentieth Century, with some exceptions. A rise in 1970 was due to an influenza epidemic in the winter of 1969/70. Another rise, in 1986, was associated with exceptionally cold weather in February of that year.[12] Infant mortality had been declining since the 1986 rise, and continued to decline to the end of the century. However, the rate of infant mortality decline was slower in the 1990s, around 2–3 per cent per year compared with 6 per cent per year in the late 1980s.

Figure 3b shows age-standardised all-cause mortality rates by sex and age group from 1901 to 2000 for England and Wales. A decrease in mortality can be seen in all age groups and both sexes, with the most dramatic falls observed in children. Falls in adults aged 45 and over have been confined to the second half of the century in men but happened throughout the century in women. Rates for those aged between 15 and 44 declined earlier in the century, but tapered off in later years.

Figure 3b shows that there were increases in death rates around both the First and Second World Wars. However, analysis of mortality, particularly among males, during these time periods should be interpreted with caution. On the *Twentieth Century Mortality* CD-ROM, during the periods 1915–1920 and 1940–1949, population figures correspond to the civilian resident population, so members of the armed forces were excluded even if resident in England and Wales. Deaths in the military occurring in England and Wales were included in the deaths figures for the First World War, but not the Second. Deaths in the military occurring overseas were not included in either the First or Second World War figures.

Figure 3a Infant mortality rate, 1901–2000

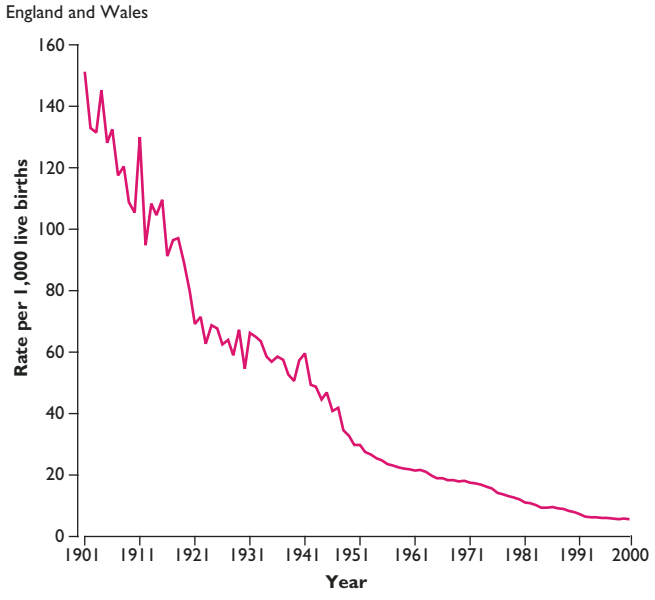
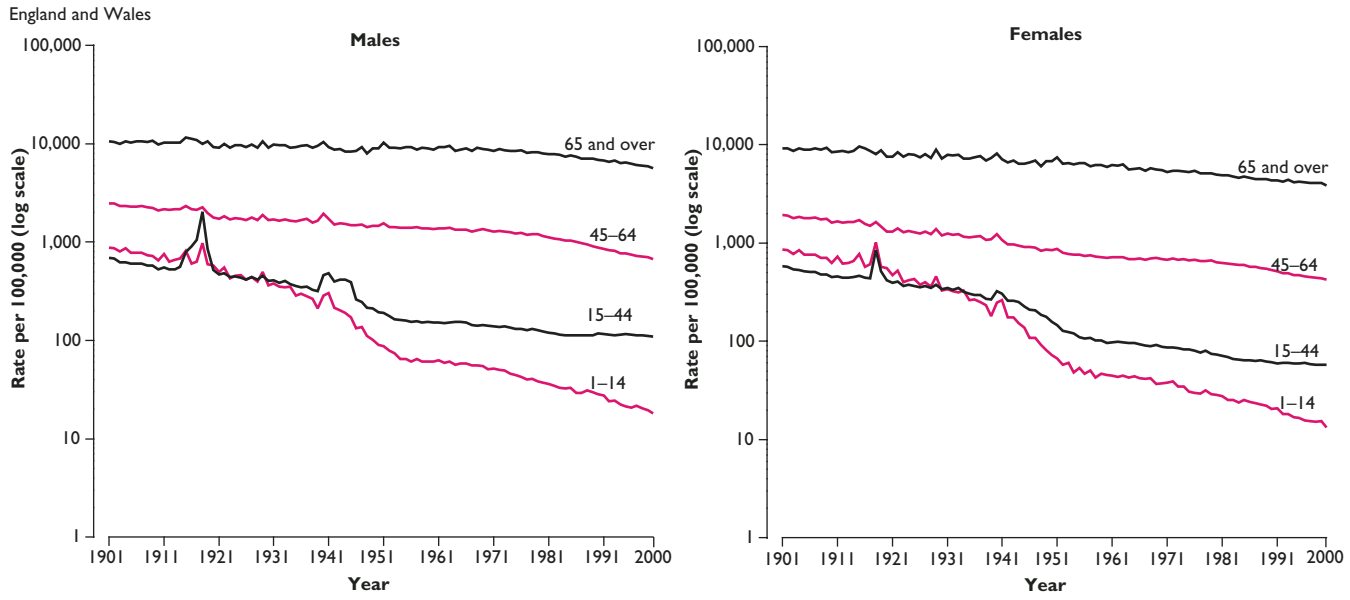


Figure 3b **Age-standardised all-cause mortality rate by sex and broad age group, 1901–2000**



Since the end of the Second World War there has been a widening gap in mortality rates for men and women in the 15–44 age group. The age-standardised death rate in men (110 per 100,000) was almost double that for women (58 per 100,000) in 2000, partly as a result of the steep falls in maternal mortality during the century.

Trends in mortality by underlying cause of death

This section examines trends in mortality during the Twentieth Century for selected causes of death. In all cases, the figures relate to the underlying cause of death, defined by the World Health Organisation (WHO)[14,15] as:

a) the disease which initiated the train of events directly leading to death; or
b) the circumstances of the accident or violence which produced the fatal injury.

How the underlying cause of death is selected from all the diseases and conditions listed on the death certificate has been described in detail elsewhere.[16] The ICD codes used to select the causes examined in this article are given in Annex 1.

Trends for broad disease groups

Figure 4 shows mortality by broad cause group (Chapter of the ICD) for 1911– 2000. It clearly shows the dramatic decline in infectious disease mortality that took place in the Twentieth Century. Poliomyelitis, diphtheria, tetanus, whooping cough, measles, mumps and rubella were all virtually eliminated during the second half of the century, following the introduction of childhood immunisation.[17] Infectious disease mortality rates have begun to increase since the early 1990s. HIV/AIDS was included in this chapter from 1993 onwards, when automatic cause coding was introduced. Before that it was coded to the endocrine chapter. A clear increase in infectious disease mortality rates can be seen from 1992 to 1993, especially among males.

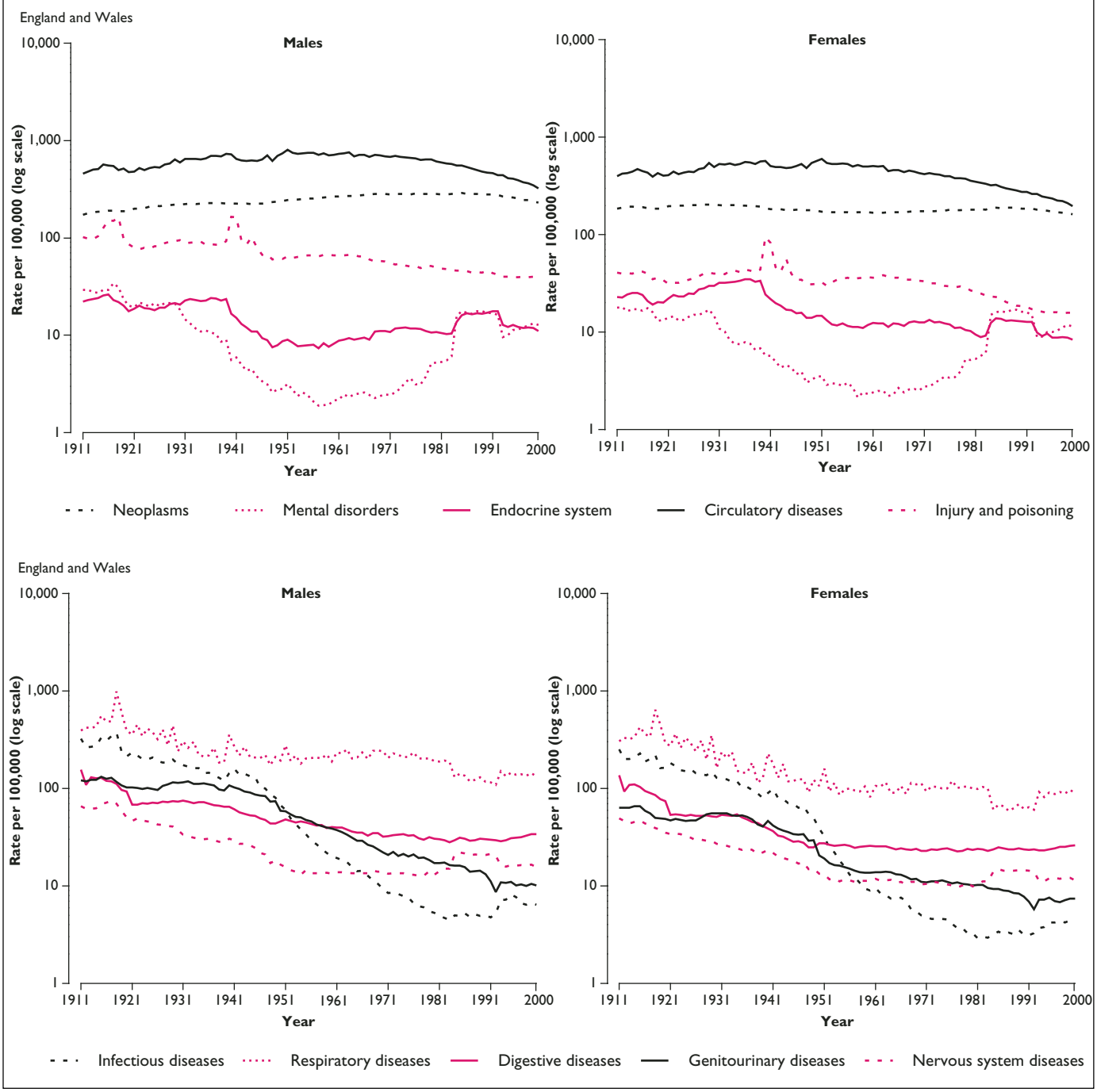
Due to the stigma attached to people dying from HIV and its related conditions some deaths will not have HIV infection as the underlying cause of death in ONS records. Doctors may certify the deaths as due to a complication such as pneumonia, and indicate on the death certificate that they may be in a position to later provide further information on the cause of death. The late information provided in this way accounted for about 32 per cent of deaths finally coded to HIV infection in ONS records in the 1990s.[18] Though the number of deaths from HIV/AIDS undoubtedly declined sharply in the late 1990s, because of improved survival on better treatment, ONS figures on these causes are incomplete.

Respiratory disease mortality also declined over the century. In the years between 1984 and 1992 about 25 per cent fewer deaths were allocated to respiratory diseases, purely as a result of a change in the rules used to select the underlying cause of death. During this period deaths affected by this change were mainly assigned to diseases of the nervous and endocrine systems and mental disorders. Mental disorders also showed an increase from a low in the 1960s, even when this coding change is taken account. In 1992, 92 per cent of deaths in this chapter were due to psychoses, and 72 per cent to senile and presenile organic psychotic conditions, largely dementia.[1]

Mortality from neoplasms did not decline during the Twentieth Century. It remained relatively stable in females, but increased slightly for males until the early 1980s. From then it declined for both sexes to the end of the century. Circulatory diseases have risen and fallen during the century. The main cancers, ischaemic heart disease and stroke are discussed in more detail later in the article.

Diseases of the digestive and genitourinary systems declined at similar rates during the first part of the century, but since the 1950s, genitourinary diseases have declined much more rapidly. In both males and females, mortality rates from digestive diseases have hardly changed since the early 1950s. The lack of decline, and possibly even an increase at the end of the century, in mortality from digestive disorders is largely due to increasing mortality from cirrhosis of the liver, which rose substantially between 1979 and 2000, particularly for males.[19]

Figure 4 **Age-standardised mortality rates by ICD Chapter and sex, 1911–2000**



Mortality from injury and poisoning, including accidents, suicide and homicide, as well as deaths where the intent could not be determined, declined slowly throughout the century, with peaks around both the First and Second World Wars for men and the Second World War for women. This was not just as a result of enemy action, for example road traffic accidents involving pedestrians saw a sharp increase in 1939, due to the abolition of street lighting. In the later part of the war, as people became accustomed to blackouts, rates returned to their pre-war levels. In contrast, suicide rates fell during the war, after high rates during the 1930s.[20]

Analysis has shown that accidental mortality generally declined from a peak in the 1930s, and that this trend was greater for men than for women and greater for children than adults.[21] Suicide rates fluctuated over the century, rates were much higher in older age groups in the earlier years, but there were substantial increases in rates for younger age groups, especially young men, since the 1950s. The most recent review of suicide trends by ONS was published in 1998,[22] and we plan to update this work in a future article.

Trends for specific causes of death

We now move on to discuss trends for some specific causes of death, beginning with tuberculosis and influenza, moving on to look at ischaemic heart disease, stroke and some specific cancers. Finally we examine trends in mortality from ill-defined conditions.

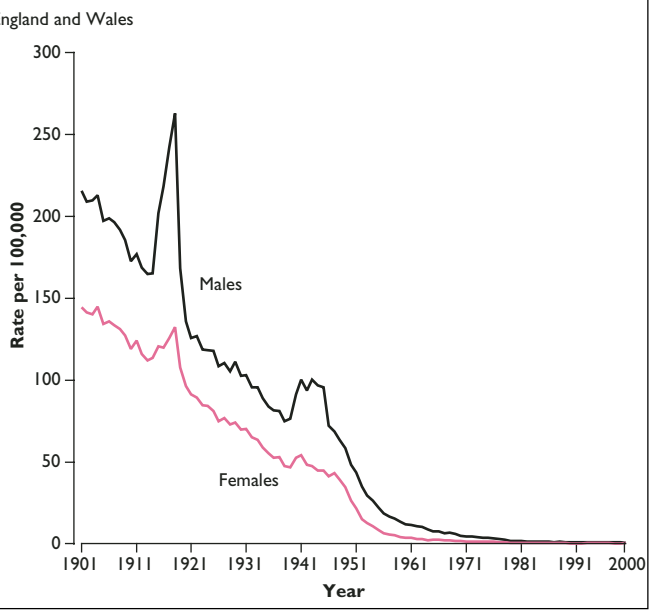
Tuberculosis 1901–2000

'Consumption' and 'phthisis' are terms historically used to describe tuberculosis (TB). TB is caused by the bacterium *Mycobacterium tuberculosis* and mainly affects the lungs and lymph glands although any part of the body can become infected. The disease is usually spread through coughing and the airborne bacillus can be suspended in the atmosphere of poorly ventilated areas for several hours. Only 30 per cent of healthy people who are exposed to the TB bacillus will become infected and only 5–10 per cent of these will develop clinical TB,[23] although this will depend on the extent of the exposure. Overcrowding, poor nutrition, poor health, poverty and unemployment have been shown to have a strong association with incidence of tuberculous disease.[24,25]

Figure 5 shows age-standardised mortality rates for TB by sex in England and Wales from 1901 to 2000. There was a large increase in the death rate during the First World War. This was partly due to overcrowding and housing shortages,[26] co-morbidity with influenza during the pandemic of 1918–19 and under-nutrition.[27] However, since deaths in the military which occurred in England and Wales were included in First World War mortality figures, this could be due to a numerator-denominator bias, as military personnel were not included in the population estimates. The mortality rate for males during the peak in 1918 was double that for females (263 and 132 per 100,000 respectively).

An increase in TB can also be seen during the Second World War, which was also more marked in males than females. It could be speculated that this was due to wartime conditions and circumstances, for example soldiers living in close proximity or other factors related to active service. However, health selection could have played a part, with only the healthier men being drafted into the armed forces.[28] However, the overall trend in TB mortality is one of decline with a very steep

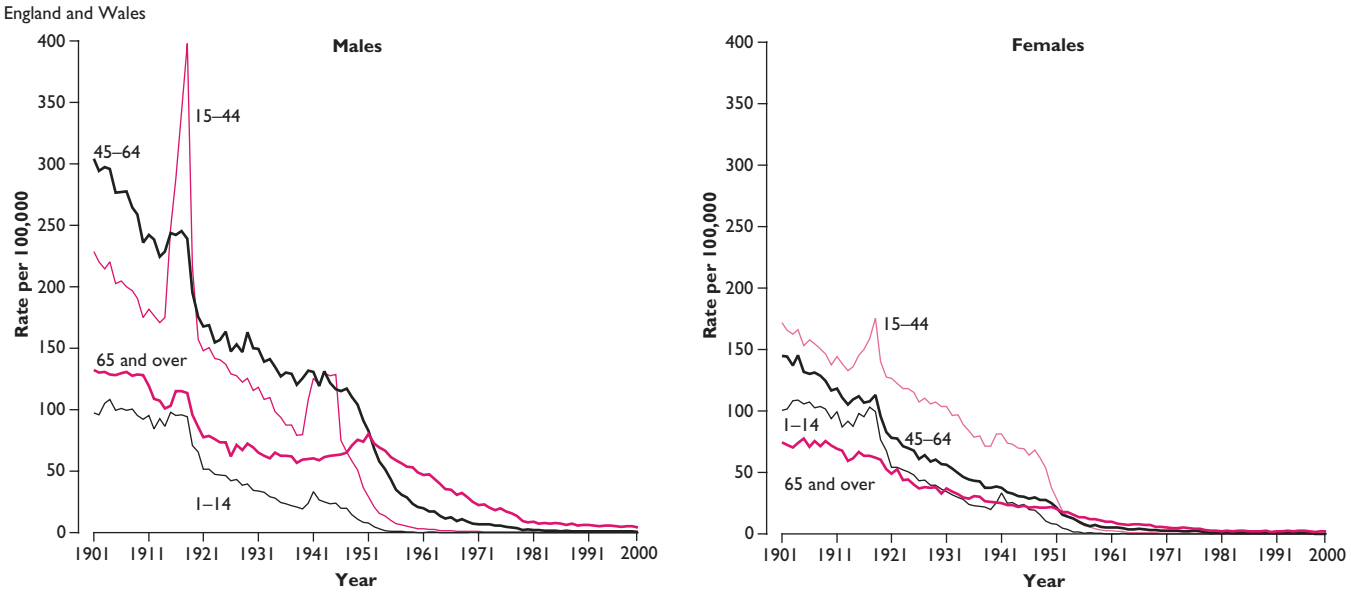
Figure 5 Age-standardised tuberculosis mortality by sex, 1901–2000



decrease after 1950. This was when Bacillus Calmette-Guérin (BCG) vaccination was beginning to be introduced into the school population and effective antibiotics were becoming available to treat TB.[29] It is generally considered that the treatment had more effect on mortality rates than the BCG vaccine.[30]

Figure 6 shows age-standardised rates for TB by age group for both sexes from 1901 to 2000. In males the mortality rates were usually highest in those aged 45–64 until the early 1950s. In females, however, those aged 15–44 had the highest rate until the same period. This difference was noted in the *1921 Decennial Supplement to the Registrar General's Annual Reports*, but an explanation was not given.[27] The oldest age groups had the highest rate for both sexes by the end of the Twentieth Century.

Figure 6 Age-standardised mortality rate per 100,000 for tuberculosis by sex and broad age group, 1901–2000



The peaks during the First and Second World Wars can clearly be seen in the 15–44 year age groups, although all age groups were affected. During the First World War an increase in death rates can be seen in all ages, but during the Second World War the rise was mainly seen in those aged under 45 and more so in men than women. This is consistent with the health selection effects described above. There was a rise of just over 20 per cent in the mortality rates of men aged 65 and over after the Second World War but this was curtailed in the 1950s by the introduction of effective medical treatments.

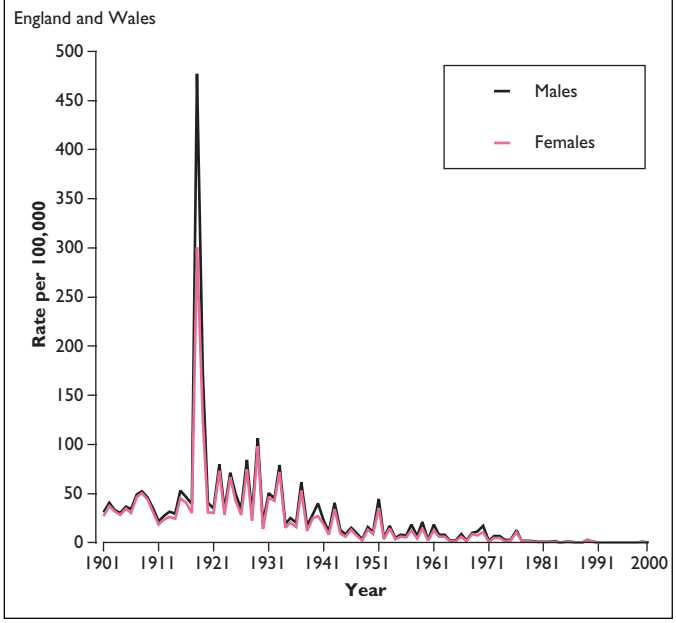
The incidence of TB is once again increasing with HIV positive individuals, immigrants from areas of high prevalence, and health care workers all at increased risk. Mortality rates, however, have been very low. There may be some signs of an increase in mortality rates from TB in young men, but rates have been variable year on year.

Influenza 1901–2000

Figure 7 shows age-standardised mortality rates for influenza by sex in England and Wales from 1901 to 2000. It clearly shows the influenza pandemic that occurred just after the First World War in 1918–19. This pandemic killed between 20 and 50 million people worldwide and in England and Wales during the 46 weeks 23rd June 1918 to 10th May 1919 there were almost 152,000 deaths for which influenza was the underlying cause.[31] This was the highest mortality figure for an epidemic ever recorded since registration began in England and Wales in 1837.

Unlike other strains of the influenza virus which usually strike the old and infirm or the very young, the influenza strain of the 1918–19 epidemic tended to attack young, healthy adults in the prime of life.[32] The age-standardised mortality rate in 1918 for men aged between 15 and 44 was more than twice that for women of the same age (730 and 343 per 100,000 respectively) and far exceeded that for men aged 65 and over (438 per 100,000). This is in direct contrast with other influenza epidemics where those at older ages were affected to a much greater degree. This is generally assumed to be associated with the unusually high virulence of the virus, although this is not proven. In addition, a large proportion of the population may have been particularly vulnerable following the war, affecting men more than women, which may explain the difference in death rates between the sexes. The problems with numerator-denominator bias and health selection effects during the First World War, described earlier for TB, will also have had an impact on influenza mortality rates.

Figure 7 Age-standardised influenza mortality by sex, 1901–2000



There have been several influenza epidemics since 1918–19, but in recent years they have been associated with cold winters, for example in 1969/70, 1972/73, 1976/77 and 1989/90. In the 1989/90 winter over 2,500 more deaths had influenza as their underlying cause than in 1988/89.[33] The last epidemic in England and Wales was in winter 1996/97, when 375 deaths had an underlying cause of influenza. However, it is likely that influenza is frequently under-diagnosed, and it can be a contributory factor in deaths from other causes.[34] It has been estimated that 1 influenza death is associated with 15 excess winter deaths from other causes.[35] There have been difficulties in diagnosing influenza over the century, and up until 1933 it could not be confirmed diagnostically, although it was recognised as a clinical diagnosis. Even so, very few people whose death is triggered by influenza have this confirmed microbiologically, and so apparent changes in trends may simply reflect changes in diagnostic fashion.

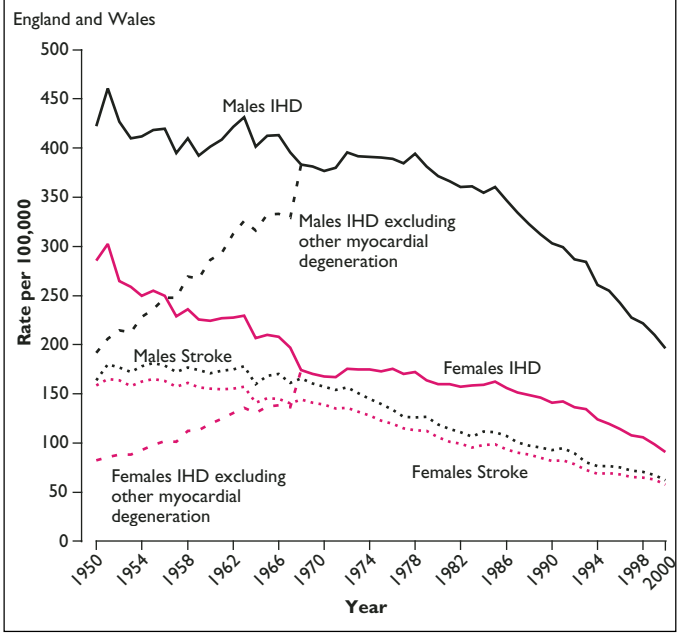
Ischaemic Heart Disease and Stroke 1950–2000

At the end of the Twentieth Century, ischaemic heart disease (IHD) and stroke together accounted for 30 per cent of deaths in England and Wales. Stroke accounts for fewer deaths than IHD. The occurrence of stroke is strongly related to blood pressure, and can be caused by either a blockage in the blood vessels in the brain (ischaemic stroke or cerebral infarct), or by a leakage of blood into the brain (haemorrhagic stroke or cerebral haemorrhage). IHD is caused by the obstruction of coronary artery blood flow by atherosclerosis. In about 20 per cent of cases, the first manifestation of the disease is sudden death.[36]

A detailed analysis of cardiovascular mortality trends can be found in *The Health of Adult Britain*.[37] In this article, we have examined trends from 1950 onwards. Figure 8 shows that stroke mortality rates have been declining since the 1960s. Trends in IHD depend on the selection of ICD codes for ICD-6 and ICD-7. If both 420 (Arteriosclerotic heart disease, including coronary disease) and 422 (Other myocardial degeneration) are used, then the pattern was one of decline, from 1950 onwards. However, if 422 is excluded then rates showed a substantial rise between 1950 and 1967, with a peak in the early 1970s and subsequent decline. It is likely that 'other myocardial degeneration' does include some deaths that were due to ischaemic heart disease. However, it is not possible to separate these out from other deaths in this category which were not. The interpretation of trends in IHD before 1968 is therefore problematic, and very much depends on the codes used to define the condition.

Other analysis of data from the 1930s onwards shows that IHD mortality rates increased then fell, whereas stroke mortality has fallen consistently. This is at odds with the fact that IHD and stroke share many of the same risk factors, for example cigarette smoking and increased levels of cholesterol. It has been proposed that this difference may be due to the fact that the term stroke covers the two major sub-types described above. Data from autopsy studies have been used to obtain ratios of cerebral infarct to cerebral haemorrhage over time and therefore trends for the two sub-types.[38] This showed that cerebral infarct trends were similar to IHD, but cerebral haemorrhage trends were not. This suggests that the causes of cerebral infarct and IHD are similar. Early-life exposures could be more important in cerebral haemorrhage.[38]

Figure 8 **Age-standardised ischaemic heart disease (IHD) and stroke mortality by, sex, 1950–2000**



Cancer in the Twentieth Century

Cancer has been known as a disease for thousands of years, for example there are pictures on the walls in Egyptian tombs showing people with tumours.[39] The Second Registrar General's Report, from 1838, contained the number of deaths from 'Carcinoma' and 'Tumour' by area of England.[40] These data for cancer, however, are highly unreliable and subject to doctor or certifier bias. ICD codes for cancer by site can only be used from the Second Revision of the ICD for breast cancer and from the Fifth Revision for most others. This is because these were the first occasions when separate codes were assigned to most of the common cancer sites.

Although all-cause mortality fell over the past century for both males and females, cancer mortality did not. Therefore deaths from cancer accounted for an increasing proportion of all deaths as the century progressed. Cancer accounted for 25 per cent of all deaths in England and Wales in 2000, in contrast to around 15 per cent in 1950. Increases in the number of deaths recorded as cancer in the early part of the century were probably due to progress in clinical diagnosis or fashions in coding, but since the 1950s the increasing proportion of all deaths attributed to cancer is due to the declines seen in other diseases, for example circulatory diseases, but not in cancer. Figure 9 shows age-standardised mortality rates by sex and major cancer site for England and Wales from 1940 to 2000.

Lung cancer 1940–2000

Lung cancer was a relatively rare disease at the beginning of the Twentieth Century and did not have its own ICD code until 1940. At the end of the Twentieth Century it was the most common cause of death from cancer in the world, killing around 900,000 people every year.[41] The link between lung cancer and smoking was discovered at the beginning of the 1950s[42] and it is now estimated that tobacco smoking causes around 90 per cent of cases.[43] Other recognised risk factors for lung cancer include passive smoking; occupational exposures, especially to asbestos; and radon exposure.[43]

Mortality in males rose steeply from 1940 to the mid-1970s when it peaked at 110 deaths per 100,000 but has since fallen by almost half. Mortality in females, however, showed a four-fold increase from 1940 to 1990, peaking at about 30 deaths per 100,000 in 1991, and has since very gradually declined. Mortality rates at the end of the century were approaching those of breast cancer.

The latency period for lung cancers attributable to smoking is at least 20 years, and thus smoking patterns affect the pattern of mortality at least 20 years later. The differing take-up and cessation of smoking in men and women can be clearly seen by the timing of the peaks in mortality. Men took up smoking during the First World War.[44] Earlier in the century fewer women smoked, they started to smoke later in life than men, tended to smoke less, and used brands of cigarettes containing less tar.[45] Smoking only became popular among women during the Second World War,[44] and thus the peak in female mortality occurred later.[46]

Women have also been slower to give up smoking than men.[47] The impact on smoking patterns of measures designed to persuade people to give up, or not start, smoking, such as banning of TV advertising of cigarettes in 1965 and the introduction of a 'National No Smoking Day' in 1984 may have influenced smoking patterns and thus mortality figures.

Breast cancer 1940–2000

Breast cancer is the most common cause of death from cancer in women throughout the world[41] and accounts for a quarter of all malignancies in females.[45] From the early 1950s it has had the highest mortality rate of all cancers in women but there has been a decline in mortality from a peak in 1988. This has been suggested to mainly result from better treatment, including the use of tamoxifen, but also, to a lesser extent, from screening.[48,49]

The major recognised risk factors for breast cancer include age (four in five women diagnosed with breast cancer are over 50), family history of breast cancer, hormones, age at menarche and previous radiotherapy.[50] Age at first birth is also important, with risk of developing breast cancer being raised for women who remain childless, or who have their first birth late in their reproductive period, although the trends in these factors do not predict breast cancer trends particularly well.[51]

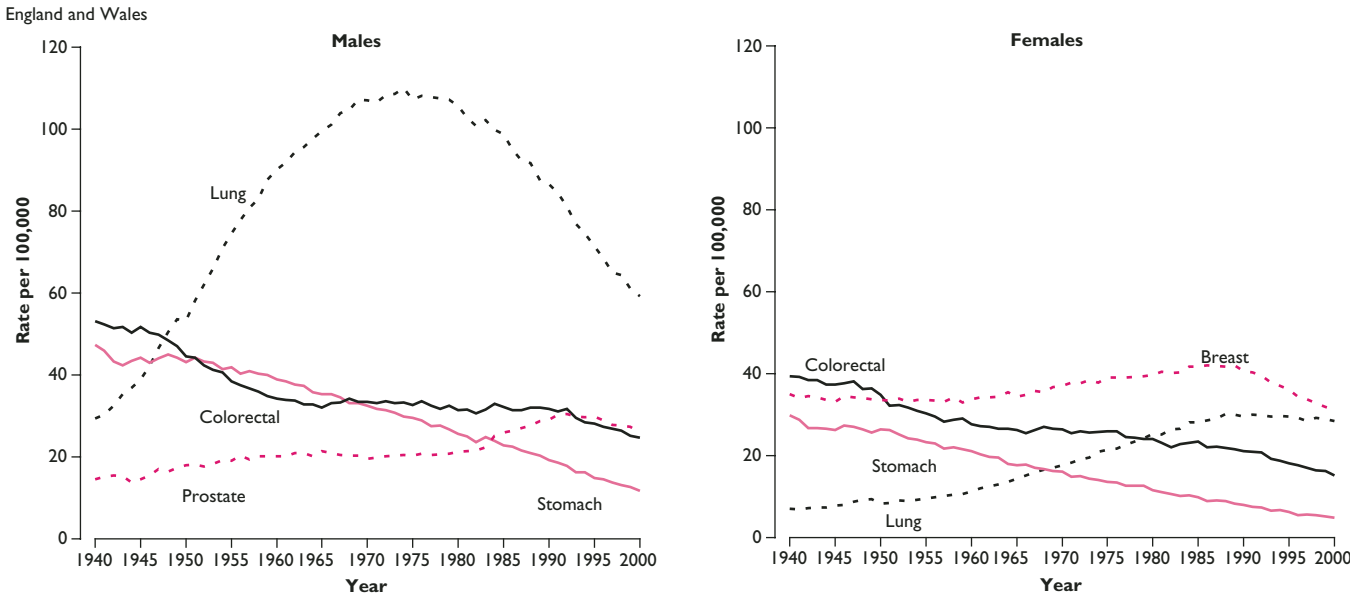
Breast cancer has good survival compared with lung cancer. Consequently it is not easy to make a direct link between the mortality rates presented in this article and trends in incidence. To interpret breast cancer mortality trends information on incidence and survival is also needed.

Prostate cancer 1940–2000

Prostate cancer is now the second most common cancer in men in England and Wales and killed over 8,000 men in 2000.[52] It has had its own ICD code since 1940, before which there were only codes for diseases of the prostate. Figure 9 shows that mortality from prostate cancer increased from 1940 to 1950 and remained stable at just over 20 per 100,000. It reached a peak in the early 1990s and declined from then.

The reasons for the decline in mortality are not clear. Prostate cancer incidence has been rising rapidly due to the widespread and increasing use of a diagnostic test (prostate specific antigen (PSA) testing), particularly in the early 1990s. Because of the lag between diagnosis of prostate cancer and death, we would only now expect to see any impact of this screening on mortality, whereas the decline appeared to be

Figure 9 **Age-standardised cancer mortality by sex and site, 1940–2000**



happening slowly throughout the 1990s. Research in the US has shown that prostate cancer screening does not appear to reduce mortality when compared with groups that have not been screened.[53] This backs up the view that PSA testing leads to cases of prostate cancer being diagnosed that would normally not show symptoms during life.[54]

The major risk factors for prostate cancer are age (prostate cancer has the steepest age curve of any disease); family history of the disease; occupational exposure to radioactive substances; and, in the USA, prostate cancer is more common in men of African descent,[55] although rates in Africa are among the lowest in the world. Ethnic origin is not available from routine mortality data in England and Wales, so it is not possible to analyse mortality by this factor.

Stomach Cancer 1940–2000

Stomach cancer has declined substantially since the 1950s. In 1940, it killed more men than lung and prostate cancer, and more women than lung cancer. By 2000 death rates from stomach cancer had declined by 75 per cent in men and nearly 85 per cent in women. This appears to be a reversal of trends in the first part of the century, when substantial increases were seen.[51]

The reasons for the early century rise are unclear, although there is likely to have been some element of improvements in diagnosis. The decline cannot be attributed to better survival, and improvements in diet and nutrition probably had only a limited effect. It has been suggested that early-life influences have an impact on adult mortality from stomach cancer.[56] Recently a link has been made between infection with *Helicobacter pylori* and stomach cancer.[57] This infection has been decreasing in successive cohorts born since the 1920s. This parallels the decline in stomach cancer mortality, although *H. pylori* infection has continued to decline while stomach cancer mortality has levelled off.[51] This could be related to a lag time between infection with *H.pylori* and development of stomach cancer, with infection in childhood increasing the risk of cancer in later life, but also suggests that a proportion of stomach cancers is not caused by infection with *H.pylori*.

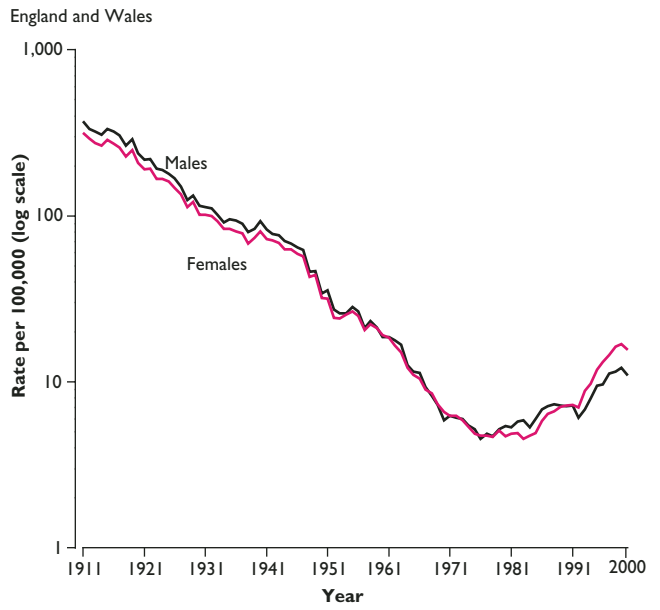
Ill-defined causes of mortality 1911–2000

Doctors are required to certify the cause of death to the best of their knowledge and belief. If the doctor cannot identify a disease which caused the death, the death is normally referred to the coroner for investigation. However, there have been some exceptions historically, for example a climate of greater acceptance of Sudden Infant Death Syndrome (SIDS) and 'old age' as 'natural causes' of death. These have been coded to the ICD chapter for symptoms, signs and ill-defined conditions (referred to here as ill-defined causes of mortality). Variations in rates for this chapter often reflect changes in diagnostic techniques, quality of investigation and certification, and classification of diseases rather than real changes in disease patterns. To an extent they can be used as an index of the quality of death certification. Figure 10 shows trends in mortality from ill-defined causes.

In 1911 ill-defined causes accounted for nearly 10 per cent of all deaths compared to 2.5 per cent in 2000. This compares to 0.4 per cent in 1976, the lowest proportion recorded. Rates started to rise from the 1980s, but the increase appeared to taper off in 2000. A system of 'medical enquiries' was used by the General Register Office in most years since 1881 until 1992.[58] These enquiries allowed the follow-up of deaths where the cause of death needed further explanation, thus allowing more deaths to be assigned to specific ICD codes, although most changes that resulted from medical enquiries were at the 4th digit level of ICD-9. They were stopped in 1993 when automatic cause coding was introduced, as it was not possible to generate the enquiries from the system or to deal with them in a timely way,[16] and because very few led to any significant change in the underlying cause of death. The cessation of this system therefore probably contributed only a small amount to the increase in the number of deaths coded to the ill-defined chapter of the ICD.

Rates do vary with age, with the highest rates being found in those aged 75 and over. They have been rising since the mid-1980s in this age group.[1] Deaths certified as due to 'old age' (ICD-9 797) are included in this chapter of the ICD. The current guidance on completing the Medical Certificate of Cause of Death gives the following guidance on the use of old age as a cause of death:

Figure 10 **Age-standardised mortality rates for ill-defined causes of mortality by sex, 1911–2000**



'Old age, senility – do not use 'old age' or 'senility' as the only cause of death in Part I unless a more specific cause of death cannot be given and the deceased was aged 70 or over'

The proportion of ill-defined deaths that were certified as due to 'old age' has increased from about 50 per cent in 1979 to over 90 per cent in 2000. Thus almost all the rise in mortality from ill-defined causes from the 1980s can be attributed to increases in the use of 'old age' or 'senility' (without mention of dementia) on death certificates. However, acceptance of 'old age' as a cause of death is likely to change following the independent public inquiry into the issues arising from the case of Harold Shipman.[59] A decline in mortality from ill-defined causes was seen in 2000, due to declines in the use by certifiers of 'old age' as a cause of death. This could signal the start of a change in attitude to the use of 'old age' on death certificates.

Deaths certified as due to unknown cause (ICD-9 799.9) formed around 6 per cent of all deaths from ill-defined causes in 2000. These were deaths where the coroner certified the cause of death as 'unascertained' following an inquest or deaths in the elderly with bronchopneumonia with a duration of over 1 year as the only condition mentioned on the death certificate. Since this is not acceptable as an underlying cause combination under international coding rules the cause of death is coded as unknown.

Sudden Infant Death Syndrome was introduced into the ICD in 1969. However, rates did not change suddenly. The gradual acceptance of SIDS as a 'natural cause' of death led to a corresponding rise in SIDS together with a decline in respiratory diseases.[60] However, rates of SIDS fell substantially from 1988 to 1992, with a more gradual decline to 1998.[61] SIDS deaths formed over 40 per cent of all deaths assigned to the ill-defined chapter in the early 1980s. By 2000 this had fallen to less than 2 per cent, partly due to declines in SIDS deaths, but also due to the rapid rise in the use of 'old age' as a cause of death.

Discussion

We have set out to illustrate the use of the *Twentieth Century Mortality* CD-ROM to analyse trends in mortality, both for all causes of death and by cause, using what is a very basic data set containing age, sex, cause and year of death. This has illustrated some of the problems that can be encountered in using these data. Care must be taken when analysing trends to take account of differences in understanding of disease processes (certification drift), terms and definitions as well as coding rules and ICD codes.

Many diseases have strong cohort as well as period patterns, for example lung cancer which is strongly affected by the timing of smoking take-up and cessation by different groups. It is therefore useful to analyse mortality by year of birth as well as by year of death to obtain a full picture of trends. A recent analysis by the Government Actuary's Department (GAD) showed that cohorts of men and women born between 1925 and 1945 appeared to have the greatest rates of mortality improvement.[62] In collaboration with GAD, we plan to analyse cohort trends in all-cause mortality and in mortality by cause in future work.

The analysis of trends at national level masks differences across the country, especially in mortality by social class and area.[63, 64]

Key points

- Infant mortality and childhood mortality have fallen most dramatically during the last 100 years. Infant mortality rates at the beginning of the century were nearly 30 times higher than those at the end. Childhood mortality rates were nearly 50 times higher in males and 65 times higher in females.
- Around 80 per cent of deaths occurred at ages over 65 in 2000 compared with around 20 per cent in 1901.
- Patterns of mortality by cause of death have changed throughout the century.
- Infectious diseases have declined to low levels, with the epidemics of the early part of the century no longer occurring.
- At the end of the century, deaths from all cancers combined formed around 25 per cent of all deaths in England and Wales, compared with 15 per cent 50 years previously and less than 5 per cent in 1901. This was because mortality from ischaemic heart disease and stroke declined substantially while mortality from cancer did not.
- There were increases in death rates from ill-defined causes from the 1980s to 1999, although these still formed a small proportion of all deaths in 2000 (2.5 per cent). This was due to the increasing certification of deaths as due to 'old age'.

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Annex 1 ICD codes used to examine trends by cause of death

ICD Revision	Start date	End date	Cause of death: Infectious diseases	All cancer	Endocrine system	Mental disorders	Nervous system	Respiratory system	Digestive system	Genito–urinary	Circulatory system system	Injury and poisoning
ICD-1*	1901	1910	==	==	==	==	==	==	==	==		==
ICD-2†	1911	1920	1–9, 11–25, 28–35,37–38, 62, 104A,105A, 106,107,112,164	39–46, 53, 74c, 129	26, 27, 36, 49–52, 74B, 88	56, 59, 68, 74A, 154A	60, 63, 66, 67, 69, 73,74D–76	10, 86–87, 89–98, 100	99, 101–103, 104B–H, 105B–H, 108–111, 113–118	119–128, 130–133	47, 64, 65, 72, 77–85, 189A	57–58, 153, 155–163, 165–186
ICD-3†	1921	1930	1–10, 12–42, 71, 72, 113–116, 121, 175	43–50, 65, 84(2), 137, 139	53–63	66, 68, 77, 84(1), 164(1)	70, 73, 75, 76, 82, 84(3)–86	11, 97–107, 109	108, 110–112 117–120,122–127	128–136, 138, 140–142	51, 74, 81, 83, 87–96, 205(1)	67, 163, 165–174, 176–199, 201–203
ICD-4†	1931	1939	1–10, 12–44, 79, 80, 119, 120, 177	45–55, 72	58–69	75, 76, 83, 84, 162a	78, 81, 82c, 85, 87b–89	11, 104–114, 115(3)	115(1)–(2), 115(4), 116–118,121–129	130–139	56, 82a–b, 87a, 90–97, 99–103, 200(1)	77, 163–176, 178–198
ICD-5†	1940	1949	1–32, 34–44a, 44c–d, 119, 120, 177	44b, 45–57, 74	60–66a, 66b(2)–71	77, 84, 162b	80–82, 83d–e, 85, 87b–89	33, 104–114, 115b–d	115a, 116–118 121–129	130–139	58, 83a–c, 87a, 90–97, 99–103, 200a(1)	66B(1), 78, 79, 163–176, 178–198
ICD-6	1950	1957	001–138, 571, 696, 697, 764	140–220, 222–239, 294	250–289, 772	300–326	340–361, 364, 366–398, 781	240, 241, 470–527	530–570, 572–587	590–637, 792	330–334, 400–454, 456–468, 782	242–245, 365, E800–E999
ICD-7	1958	1967	001–138, 571, 696, 764	140–220, 222–239, 294	250–289, 772	300–326	340–361, 364, 366–398, 744, 781	240, 241, 470–527	540–570 572–587	590–637, 792	330–334, 400–454, 456–468, 782	242, 245, 365, E800–E999
ICD-8	1968	1978	000–136	140–239	240–279	290–315	320–351, 354–389, 733, 781	460–519	444.2, 520–577	444.3, 580–629, 792	390–444.1, 444.4–589, 782	E800–E999
ICD-9	1979	2000	001–139	140–239	240–279	290–319	320–389	460–519	520–579	580–629	390–459	E800–E999

ICD Revision	Start date	End date	Cause of death: Symptoms signs and ill–defined conditions	Ischaemic heart disease	Stroke	Influenza	Tuberculosis	Lung cancer	Breast cancer	Prostate cancer	Stomach cancer	Colorectal cancer
ICD-1*	1901	1910	==	==	==	012.0	046.0–054.0	==	==	==	==	==
ICD-2†	1911	1920	70, 71, 142, 154B, 187–188A 189B–F	==	==	10	28–35	==	43	==	==	==
ICD-3†	1921	1930	79, 80, 151, 164(2), 204, 205(2)–(3)	==	==	11	31–37	==	47	==	==	==
ICD-4†	1931	1939	86, 98, 162b, 199, 200(2) –(3)	==	==	11	23–32	==	50	==	==	==
ICD-5†	1940	1949	86, 98, 162a, 162c, 199, 200a(2), 200b–c	==	==	33	13–22	47a,b	50	51b	46b	46c–d
ICD-6	1950	1957	455, 780, 783–791, 793–795	420, 422	330–334	480–483	001–019	162–163	170	177	151	153–154
ICD-7	1958	1967	455, 780, 783–791, 793–795	420, 422	330–334	480–483	001–019	162–163 excluding 162.2	170	177	151	153–154
ICD-8	1968	1978	780, 783–791, 793–795	410–414	430–438	470–474	010–019	162	174	185	151	153–154

* An unnumbered list was used in England and Wales rather than the International classification during this period.

† As amended for use in England and Wales.