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Southampton Statistical Sciences Research Institute

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Sex Differentials In Mortality In Nineteenth-Century England And Wales

Andrew Hinde

Abstract

This paper examines sex differentials in mortality in England in the 1860s, focusing on the impact of particular causes of death. I first decompose the sex differential in the expectation of life at birth by age, showing that regional variation in the sex differential is principally due to mortality at ages five years and above, with females enjoying a fairly consistent advantage over males in infancy and early childhood. The impact of causes of death is then studied, using death registration data from the Registrar General of England and Wales for the 1860s. The analysis first focuses on 11 Registration Divisions of England and Wales. Mortality was most favourable to females in London, and least favourable to females in parts of the Midlands. The causes of death which have most impact on the sex differential are pulmonary tuberculosis (or phthisis), 'other violent deaths' and deaths associated with childbirth. In particular, the overall sex differential is sensitive to the relative mortality of males and females from pulmonary tuberculosis. These results are illustrated by an analysis of eight smaller areas of England and Wales which have distinctive occupational and economic characteristics. One conclusion of the analysis is that the overall sex differential in mortality was often as responsive to the nature of the mortality environment which men faced as to the experience of women. The tendency of previous work to view the sex differential through the lens of 'excess female mortality' has obscured this point.

Sex differentials in mortality in nineteenth-century England and Wales

Andrew Hinde

Southampton Statistical Sciences Research Institute

University of Southampton

SOUTHAMPTON

SO17 1BJ

England

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KEY WORDS: *mortality, historical demography, sex differentials, life expectancy, registration data, decomposition, England and Wales*

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Introduction

Sex differentials in mortality are important indicators of the ways in which male and female roles and behaviour in a population differ, and of the relative status of males and females within a society. Although, for biological reasons, it seems that females naturally live slightly longer than males, cultural and behavioural variation have led to widely divergent differences between the expectations of life of males and females within human populations. In the twentieth century, for example, the difference between male and female expectations of life at birth increased slowly in favour of females in many western populations, partly due to the excess mortality of males from smoking-related diseases; more rapid divergence in the same direction was seen in many eastern European populations during the 1990s, and this again has been attributed largely to a rapid rise in health-destructive behaviour among men. Elsewhere in the world, the biologically-driven differential in favour of females has been reversed. In parts of the Indian sub-continent, for example, the low status of women is associated with their having higher mortality than males, especially in childhood and young adulthood. A recent study of mortality among Israeli Jews concluded that the low incidence of health-destructive behaviour among males coupled with relatively high mortality among females (partly for genetic reasons and partly because of their early life experiences) contributed to an unusually small sex differential.[1]

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[1] L. Staetsky and A. Hinde, 'Unusually small sex differentials in mortality of Israeli Jews: what does the structure of causes of death tell us? *Demographic Research* 20(2009), 209-52. http://www.demographic-research.org/volumes/vol20/11/20-11.pdf.

The existence of a female mortality advantage at all ages in European populations is a relatively recent phenomenon. An analysis of sex differentials in mortality since 1750 concluded that although males had died at a higher rate than females at ages under one year for as long as records allow us to observe the differential, female mortality was frequently higher than that of males at ages 5-19 years from as early as 1600 until well into the twentieth century.[2] E.A. Wrigley and his colleagues, using family reconstitution data from England observed that female mortality was higher than that of males in older childhood (that is, between ages 5 and 15 years) at various times during the seventeenth and eighteenth centuries, and that the female disadvantage increased after 1750 at ages 10-14 years. They attributed this to the increasing incidence of respiratory tuberculosis: the death rate for teenage girls from this cause was greater than that for boys, and respiratory tuberculosis was responsible for a high proportion of all teenage female deaths.[3] They also identified a consistently high ratio of female to male mortality at ages 25-44 years, some of which resulted from deaths associated with childbirth (as well as the continuing impact of

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[2] D. Tabutin and M. Willems, 'Differential mortality by sex from birth to adolesence: the historical experience of the west (1750-1930)', in United Nations Department of Economic and Social Affairs Population Division, *Too young to die: genes or gender?* New York, United Nations, 1998, 17-52. There is some dispute about when the higher mortality of girls and young women began. L. Henry, 'Mortalité des hommes et des femmes dans le passe', *Annales de Démographie Historique* (1987), 87-118 (translated and re-published as 'Men's and women's mortality in the past', *Population English Selection* 44 (1989), 177-201), suggests that it was only rarely present in European populations before the nineteenth century.

[3] E.A. Wrigley, R.S. Davies, J.E. Oeppen and R.S. Schofield, *English population history from family reconstitution 1580-1837*. Cambridge, Cambridge University Press, 1997, 298-300.

tuberculosis, to which women in the later stages of pregnancy were especially vulnerable).[4]

The fact that female mortality exceeded that of males at some ages did not mean that overall, females lived shorter lives than males, for female disadvantage occurred at ages where mortality rates were fairly low. At ages where mortality rates were high, notably at ages under 1 year and over 65 years, females had consistently lower mortality than males. By the middle of the nineteenth century, the expectation of life at birth in England and Wales was typically two or three years higher for females than males. It has been observed that in many European countries, the degree of female disadvantage accelerated during the nineteenth century, reaching a peak between 1880 and 1910.[5] However in England and Wales, female death rates were either constant or improving relative to male death rates at most ages over 15 years from the mid nineteenth century; between 1838 and 1854 female death rates exceeded those of males at ages 10-39 years, but by the first decade of the twentieth century they were higher than those of males only at ages 5-14 years.[6]

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[4] Wrigley, *et al.***,** *English population history*, 301-7, 317.

[5] Tabutin and Willems, 'Differential mortality', 26.

[6] S. Ryan Johansson, ' "Excess female mortality": constructing survival during development in Meiji Japan and Victorian England', in A. Digby and J. Stewart (eds) *Gender, health and welfare*. London, Routledge, 1996, 54-5; R. Woods and P.R.A. Hinde, 'Mortality in Victorian England: models and patterns', *Journal of Interdisciplinary History* 18(1987), 33.

Sex differentials in mortality in nineteenth-century England

In 2005, Kirsty McNay, Jane Humphries and Stephan Klasen reported an investigation into the determinants of what they saw as 'excess female mortality' in some regions of nineteenth-century England and Wales.[7] By 'excess female mortality' they meant effectively, a situation in which the mortality of females was higher, relative to that of males, than was the case in the country as a whole. Earlier, Gerry Kearns and Robert Woods and Nicola Shelton had shown that 'excess female mortality' was largely a rural phenomenon, and McNay and her colleagues confirmed this.[8] Mortality among females relative to that of males was highest within the reproductive ages, and lower at younger and older ages.[9]

The latter observation is consistent with several possible social and economic mechanisms. 'Excess female mortality' in the reproductive ages clearly suggests that maternal mortality might be one factor. However, it is generally accepted that it is neither the only, nor even the main, explanation. Deaths associated with childbirth cannot easily account for the observed regional variations, in that there is little evidence that maternal mortality (that is maternal deaths as a proportion of the number

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[7] K. McNay, J. Humphries and S. Klasen, 'Excess female mortality in nineteenth-century England and Wales: a regional analysis', *Social Science History* 29(2005), 649-81.

[8] G. Kearns, 'Le handicap urbain et le déclin de la mortalité en Angleterre et au Pays de Galles 1851-1900', *Annales de Démographie Historique* (1993), 93-5; R. Woods and N. Shelton, *An atlas of Victorian mortality*. Liverpool, Liverpool University Press, 1997.

[9] McNay, *et al.*, 'Excess female mortality', 654.

of births) varied greatly and systematically from place to place, and regional fertility variations also seem to have been insufficient.[10]

The biggest single cause of death in nineteenth-century England was phthisis, or tuberculosis of the lung. This disease tended to strike young adults, and, unusually, was more prevalent among women than men.[11] Almost 60 years ago, W.P.D. Logan noted that the mortality of women aged 15-24 years in England and Wales between 1848 and 1872 was higher than that of men, mainly due to deaths from infectious diseases, the most important of which was phthisis.[12] This female disadvantage was not confined to phthisis, but was characteristic of other infectious diseases which played an important role in the overall mortality profile in the nineteenth century. As Bernard Harris has argued, the overall sex differential in mortality reflects (in part) the importance of deaths from infectious diseases, and as mortality from infections declined as a proportion of all mortality, the female disadvantage diminished.[13]

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[10] Woods and Shelton, *Atlas*, 116 show that in the 1860s maternal mortality rates tended to be higher in Wales and urban areas of north-west England than elsewhere, but the geographical pattern is not very strong. It does become stronger later in the century, so that by the 1890s a clear divide opens up between a zone of high maternal mortality north and west of a line running from the Tees to the Severn estuary and a zone of lower maternal mortality to the south and east.

[11] This continued to be the case among teenage women in particular. As Tabutin and Willems, 'Differential mortality, 44, write: '[a]lmost everywhere in the Western world, girls and young women aged 5-19 years had at least a 29 per cent higher probability of dying from tuberculosis than their male counterparts'.

[12] W.P.D. Logan, 'Mortality in England and Wales from 1848 to 1947', *Population Studies* 4 (1950), 132-78.

[13] See B. Harris, 'Gender, health and welfare in England and Wales since industrialisation', in S. Wolcott and C. Hanes (eds) *Research in Economic History* 26. Bingley, Emerald Group, 2008, 157-204. According to Woods and Shelton, *Atlas*, 35, female death rates in the 1860s were generally higher than those of males for whooping cough, diphtheria and typhus, although the difference was not great.

Why were females more vulnerable than males to these diseases? Recently McNay and her colleagues have suggested that 'the sex- and age-specific nature of tuberculosis … may be endemic to the disease itself and females' inherent susceptibility to it'.[14] Another widely held account is that a lack of bargaining power in the home associated with a shortage of paid work for women led to women in many poor households having a much poorer diet than men, which lowered their resistance to infections.[15] In 1990 Michael Anderson argued that this was the underlying reason for the relatively high female mortality compared to that of males observed in poor agricultural areas, and regions dominated by mining and other heavy industry.[16] The impact of nutrition is considered to operate especially through pulmonary tuberculosis, or phthisis. In Anderson's words:

> '[m]uch of the excess, particularly in rural areas, was due to high levels of respiratory tuberculosis, and the pattern on a registration district and county basis reveals that poor agricultural areas, and districts with large unskilled working-class populations, were especially affected. This in turn suggests that

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[14] McNay *et al*., 'Excess female mortality', 668; see also R. Woods, *The demography of Victorian England and Wales*. Cambridge, Cambridge University Press, 2000, 317-8.

[15] McNay *et al*., 'Excess female mortality', 664; S. Ryan Johansson, 'Sex and death in Victorian England: an examination of age- and sex-specific death rates, 1840-1910', in M. Vicinius (ed.), *A widening sphere: changing roles of Victorian women*. London, Methuen, 1977, 174-8; Johansson, 'Excess female mortality', 54-7.

[16] M. Anderson, 'The social implications of demographic change', in F.M.L. Thompson (ed.) *The Cambridge social history of Britain, 1750-1950, vol. 2: people and their environment*. Cambridge, Cambridge University Press, 1990, 18-9.

> part of the responsibility lies with low levels of nutrition ... a by-product of a contemporary insistence on trying to keep the male "breadwinner" well fed even during hard times'.[17]

This nutrition-phthisis link may be deduced from 'reading sideways' the thesis of Thomas McKeown, who argued that the decline in mortality in general, and especially that from phthisis after 1850, was mainly attributable to improved nutrition.[18] If this was the case, it implies an association between nutritional status and death rates from phthisis. There is evidence that females, especially those in the age groups where female mortality from phthisis was most severe—and highest relative to that of males, were poorly nourished relative to males.[19] Therefore it seems plausible to argue that their elevated mortality was associated with their poor nutritional status.

However, a study of regional mortality patterns in nineteenth-century England reveals that there is no simple relationship between the degree of 'excess female

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[17] Anderson, 'Social implications', 19.

[18] T. McKeown, *The modern rise of population*. London, Edward Arnold, 1976. It has recently been asserted that the increasing average height of the population provides convincing evidence of the improving well-being of the population (where well-being is the net effect of nutrition and the demands placed upon people by work and disease) during the second half of the nineteenth century: see R. Floud, K. Wachter and A. Gregory, *Height, health and history: nutritional status in the United Kingdom, 1750-1980*. Cambridge, Cambridge University Press, 1990. On the dangers inherent in 'reading history sideways', see A. Thornton, *Reading history sideways: the fallacy and enduring impact of the developmental paradigm on family life*. Chicago, University of Chicago Press, 2005.

[19] For a recent study which demonstrates this, see S. Horrell, D. Meredith and D. Oxley, 'Measuring misery: body mass, ageing and gender inequality in Victorian London', *Explorations in Economic History* 46(2009), 93-119.

mortality' and the *level* of mortality from pulmonary tuberculosis. Woods and Shelton have shown that although there was excess female mortality from phthisis in many rural areas in the mid nineteenth century, the situation in urban areas—and in some rural areas where phthisis was most prevalent—was the other way round, with males suffering disproportionately.[20] Robert Woods's recent discussion of the reasons for the decline in phthisis mortality during the second half of the nineteenth century is somewhat sceptical of the role of improving nutrition, preferring the simpler explanation that 'the disease became less virulent'. However, he acknowledges that this does not mean that 'poor nutrition, overcrowded housing and poverty in general did not influence the outcome ... once the disease began to develop'.[21]

Finally, Samuel Preston has indicated that while females were disadvantaged by childbirth, males were disadvantaged by deaths from violence.[22] The effects of deaths from childbirth and deaths from violence offset one another. Both tended to occur prematurely, in that they predominantly affected young adults, and so potentially could have a substantial impact on the expectation of life.

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[20] Woods and Shelton, *Atlas*, 109; see also Woods, *Demography*, 332-5.

[21] Woods, *Demography*, 340. Since we are concerned in this paper with differential mortality from phthisis at a single point in time, this second point is perhaps more relevant than the issue of decreasing virulence. Stephen Kunitz, *The health of populations: general theories and particular realities*. Oxford, Oxford University Press, 2007, 196-7, disagrees with Woods about the major reason for the decline in mortality from tuberculosis, preferring an explanation based on less intense exposure to the disease and a decline in the severity of childhood disease in general. However, he is more emphatic than Woods in rejecting McKeown's nutritional account of the decline.

[22] S. Preston, *Mortality patterns in national populations, with special reference to recorded causes of death*, New York, Academic Press, 1976, 123-4.

The existing account of sex differentials in mortality in nineteenth-century England is, then, somewhat loose and unsatisfactory—a rather 'jerry-built' edifice constructed by bolting together several related observations. Historians have so far been unable to evaluate the validity of these ideas, though previous work has suggested that 'excess female mortality' is not mechanistically linked to the way in which economic opportunities for women develop during industrialisation.[23] One way in which we might be able better to understand the reasons for the sex differential in overall mortality is to study the relative impact of different causes of death. As Samuel Preston once wrote: '[i]gnoring causes of death in the study of mortality is somewhat akin to ignoring fecundity, exposure, contraceptive effectiveness and foetal wastage in the study of fertility'.[24] The principal aim of this paper, therefore, is to understand how different causes of death contributed to sex differentials in mortality in mid-nineteenth century England, and the extent to which their contributions varied from place to place.

Data and methods

The measurement of sex differentials in mortality. The existing discussion of sex differentials in mortality is hampered by being couched in terms of 'excess female mortality'. This is an ambiguous term. Some authors define 'excess female mortality'

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[23] See, for example, J. Humphries, ' "Bread and a pennyworth of treacle": excess female mortality in England in the 1840s', *Cambridge Journal of Economics* 15(1991), 451-73.

[24] Preston, *Mortality patterns*, 1-2.

as indicating female mortality higher than male mortality.[25] Yet this implies that the 'norm' is equality between the sexes, and it is not clear that this is the case. Many authors assert that the natural *direction* of any standard will be one of female advantage over males, but no kind of natural *level* has been agreed upon. Moreover, it is likely that if any 'natural' relationship between the levels of female and mortality can be discovered, it will vary with age (for example female mortality being naturally higher relative to that of males in the reproductive age groups).[26]

A more serious problem is that the use of the term 'excess female mortality' carries the implication that the sex differential in mortality is determined solely, or largely, by what is happening to women, and not by what is happening to men. At the end of their analysis of 'excess female mortality', McNay and her colleagues acknowledge this. They find that female mortality is low relative to that of males in Devon, Cornwall and South Wales, observe that the reason for these areas offering 'relatively benign settings' for women 'remains unclear', but suggest that it might be worth looking at 'men's roles and occupations and their impact on relative survival chances'.[27] Because of the problems with the term 'excess female mortality', I shall not use it in this paper, but simply describe the sex differential in mortality without reference to any implied 'standard' or 'normal' pattern.

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[25] Thus McNay *et al.*, 'Excess female mortality', 650: '[w]e note the difficulties that arise in conceptualizing and measuring a gender mortality gap and opt for the standard provided by the ratio of male to female death rates, taking ratios above one as indicating "excess" female mortality'.

[26] G.J. Stolnitz, 'A century of international mortality trends: II', *Population Studies* 10(1956), 17-42.

[27] McNay *et al.*, 'Excess female mortality', 675.

One obvious way to begin to address the relationship between social, economic and cultural factors and mortality differentials is to look at age-specific mortality rates. If a population manifests an unusual sex differential in mortality, how do the differentials at particular ages contribute to this? A second is to examine the contribution of various causes of death to the differential. There are issues, however, with the various measures of the differential between male and female mortality at different ages, and from different causes. McNay and her colleagues use the *ratio* between female and mortality rates at particular ages. If the aim of the research is to understand the factors determining the sex differential at particular ages this is fine.[28] However, if the aim of the research is to understand how different ages and causes of death contribute to the overall sex differential, it suffers from the problem that at ages where mortality is low, quite extreme ratios may be associated with very small differences between the sexes in the number of deaths, and hence with only a very small impact on the overall sex differential in mortality. For example, Sheila Ryan Johansson reports that during the 1850s in rural England, male mortality was only 64 per cent that of female at ages 15-19 years, and only 74 per cent that of female mortality at ages 25-34 years.[29] These are large relative differentials, but their impact on mortality over the whole age range was small, because death rates were generally low at these ages.

In this paper I measure the overall sex differential in mortality by comparing the difference in the expectation of life for males and females at various ages. I then

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[28] Tabutin and Willems, 'Differential mortality', 17-18 discuss various possible alternative measures before settling on the use of ratios.

[29] S. Ryan Johansson, 'Excess female mortality', 55.

decompose this difference first by age, and then by cause of death, in order to try to understand better the mechanisms determining the relative mortality of males and females. The technique I apply for the cause-specific decomposition has recently been developed by Hiram Beltrán Sánchez, Samuel Preston and Vladimir Canudas-Romo. [30] Although in the paper in which they described the method, it was applied to the study of changes in mortality differentials over time, here I use it to study the differential between males and females. The analysis is carried out for England and Wales as a whole, then for 11 regional Divisions, and finally for certain smaller regions which seem to have manifested particular sex-specific mortality patterns.[31]

Data. Data on the number of deaths by age, sex and cause were published by the Registrar General of England and Wales for the 1850s and 1860s.[32] The data are arranged on the basis of registration districts, of which there were more than 600 in the country. The Registrar General also provided, for each registration district, the average population exposed to risk within each age group in each decade.[33]

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[30] H. Beltrán Sánchez, S. Preston and V. Canudas-Romo, 'An integrated approach to cause-of-death analysis: cause-deleted life tables and decompositions of life expectancy', *Demographic Research* 19(2008), 1,323-50. http://www.demographic-research.org/volumes/vol19/35/19-35.pdf.

[31] For an earlier use of regional level data to analyse and illuminate the causes of sex differentials in mortality, see T. Eggerickx and D. Tabutin, 'La surmortalité des filles vers 1890 en Belgique: une approche régionale', *Population* 49(1990), 657-84.

[32] Unfortunately, from the 1870s onwards, deaths by age and cause are not subdivided by sex, and so are useless for our purposes.

[33] These data have been rendered machine readable by Robert Woods, and are available from the United Kingdom Data Archive at the University of Essex: see R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file]. Colchester, UK Data Archive [distributor], 1997, SN

Because death certificates were necessary for the legal disposal of a body, the death counts are believed to be largely correct, except for deaths at very young ages where there is evidence that in some cases neither birth nor death were registered.[34] However there are known to have been errors in the reporting of ages at death and causes of death. The effect of errors in age reporting can be reduced by the use of five and ten-year age groups for adults—the ages of children tended to be more accurately reported.[35] The biggest problems concern the reporting of causes of death. The first is that a considerable proportion of deaths were placed in the residual 'other causes' category. Woods and Shelton have considered this matter in detail, and shown that during the 1860s the percentage of deaths so classified was less than five per cent between ages 5 and 55 years but substantially greater at ages under 5 years (27 per cent) and over 55 years (22 per cent between ages 65 and 74 years, and over 50 per cent at ages 75 years and over).[36] They also found a higher proportion of deaths ascribed to 'other causes' in Wales than in England.[37]

Second, there is the failure to report both the external factor (e.g. a fall from a tree) and the internal morbid process (e.g. a brain haemorrhage caused by the fall)

3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

[34] Woods, *Demography*, 40-6.

[35] Moreover the most thorough study to date of age misreporting in nineteenth-century English demographic data concluded that it was not a major issue, at least from 1851 onwards: see R.D. Lee and D, Lam, 'Age distribution adjustments for English censuses, 1821 to 1931', *Population Studies* 37(1983), 445-64.

[36] Woods and Shelton, *Atlas*, 40.

[37] Woods and Shelton, *Atlas*, 44-6.

which led to death and the consequent unclear classification of death.[38] Third, there were known misdiagnoses, for example deaths from phthisis being classified as due to other lung complaints such as bronchitis.[39]

Having considered both these issues as well, Woods and Shelton conclude that 'the safest ground lies in England and for deaths occurring to those aged between 1 and 65 years'. In this paper we shall not be considering mortality at ages under 5 years. Moreover the main interest is on the impact of different causes of death on the expectation of life, and deaths at older ages have, individually, less impact on this than deaths at younger ages. Furthermore inadequacies in the reporting of causes of death are likely to have affected both males and females similarly, muting their effect on estimates of the sex *differential*. Therefore I believe that, despite their shortcomings, the cause of death data are useful for the examination of sex differentials in mortality at ages over five years.

Methods. The contribution of each age-group to the overall sex differential in mortality can be assessed using several methods. A recent review of these recommended the method published by the United Nations in 1985 on the basis that it is simple to understand and is related to most of the other methods.[40] If, for a given

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[38] K.C. Carter, 'Causes of disease and causes of death', *Continuity and Change* 12(1997), 189-98.

[39] A. Hardy, 'Death is the cure for all diseases: using the General Register Office causes of death statistics for 1837-1920', *Social History of Medicine* 7(1994), 490.

[40] P.K. Murthy, 'A comparison of different methods for the decomposition of changes in the expectation of life at birth and differentials in life expectancy at birth', *Demographic Research* 12(2005), 142, 162. www.demographic-research.org/Volumes/Vol12/7/12-7.pdf. The United Nations method is described in

registration district, the expectations of life for males and females at at age *x* years are denoted by the symbols e_x^m and e_x^f respectively, and the probabilities of survival to age *x* years by the symbols l_x^m and l_x^f respectively, then the contribution of age-group *x* to *x*+*n* years, ${}_nZ_x$, to the overall sex differential in the expectation of life at birth is given by the formula

$${}_nZ_x = 0.5(e_x^f - e_x^m)(l_x^f - l_x^m) - 0.5(e_{x+n}^f - e_{x+n}^m)(l_{x+n}^f - l_{x+n}^m),$$

where differentials in the overall expectation of life are expressed as females minus males. In other words the ${}_nZ_x$ s denote the contribution of mortality differential between ages *x* and *x*+*n* years to the quantity $e_0^f - e_0^m$.

Although it is possible to extend the United Nations approach to encompass the decomposition of mortality by cause of death, in this paper the analysis by cause of death uses the recently-developed Beltrán-Sánchez, Preston and Canudas-Romo method. Beltrán-Sánchez and his colleagues have developed a set of formulae which

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United Nations, *World population trends: population development inter-relations and population policies* (1983 monitoring report, Vol. I, Population trends, ST/ESA/Ser. A/93). New York, United Nations Department of International Economic and Social Affairs, 1985, 193; see also United Nations, 'Sex differentials in life expectancy and mortality in developed countries: an analysis by age groups and causes of death from recent and historical data', *Population Bulletin of the United Nations* 65-107 (ST/ESA/Ser. N/25). New York, United Nations Department of Economic and Social Affairs, 1988.

attribute changes in life expectancy to various causes of death and examine the effect of removing deaths from a particular cause on life expectancy.[41]

Beltrán-Sánchez and his colleagues applied their method to all ages. However, for reasons which will become clear, here I restrict attention to the age range five years and over. Therefore rather than decomposing the differential in the expectation of life at birth, I decompose the differential in the expectation of life at age five years.

With this is mind, the key formula in the method can be written as follows: [42]

$$D_i^f(5) - D_i^m(5) = \sum_{x=5}^{\omega} \left({}_nL_{x,-i}^f - {}_nL_{x,-i}^m \right) \left(1 - \frac{{}_nL_{x,i}^f + {}_nL_{x,i}^m}{2n} \right) - \sum_{x=5}^{\omega} \left({}_nL_{x,i}^f - {}_nL_{x,i}^m \right) \left(\frac{{}_nL_{x,-i}^f + {}_nL_{x,-i}^m}{2n} \right).$$

$D_i^f(5)$ and $D_i^m(5)$ are the years of life gained at ages over five years by females and males respectively if cause of death *i* were eliminated. Thus $D_i^f(5) - D_i^m(5)$ is the number of years of life gained by females by eliminating cause *i* minus the number of years of life gained by males by eliminating cause *i*, which is simply the sex differential in the number of years of life lost to a particular cause of death. The quantity $D_i^f(5) - D_i^m(5)$ is equal to the sum of two terms. Consider the second of these: $\sum_{x=5}^{\omega} \left({}_nL_{x,i}^f - {}_nL_{x,i}^m \right) \left(\frac{{}_nL_{x,-i}^f + {}_nL_{x,-i}^m}{2n} \right)$. Here ${}_nL_{x,i}^f$ and ${}_nL_{x,i}^m$ are the numbers of person-years that would be lived between ages *x* and *x*+*n* in a situation where only cause *i* were operating, ${}_nL_{x,-i}^f$ and ${}_nL_{x,-i}^m$ are the numbers of person-years that would

[41] Beltrán Sánchez *et al.*, ‘An integrated approach’.

[42] Beltrán Sánchez *et al.*, ‘An integrated approach’, 5.

be lived between ages x and $x+n$ in a situation where all causes *except* cause i were operating, and the summation is over the age-range from exact age five years to the oldest age using age-groups of varying widths. Adapting the definition of Beltrán-Sánchez and his colleagues, this term represents the difference in the life expectancy at age five years between the two sexes due to the difference in sex-specific mortality from cause i. For convenience, I shall refer to this as the *direct* effect of mortality from cause i on the sex differential in mortality at ages over five years.

The first term in the formula for $D_i^f(5) - D_i^m(5)$,

$\sum_{x=5}^{\omega}\left({}_nL_{x,-i}^f - {}_nL_{x,-i}^m\right)\left(1-\frac{{}_nL_{x,i}^f + {}_nL_{x,i}^m}{2n}\right)$, measures the impact on mortality from other causes of death resulting from the elimination of cause i. Since people have to die of some cause or other, the elimination of one cause will change death rates from other causes, and this will modify the impact of eliminating cause i on the overall mortality regime. I shall refer to this as the *indirect* effect of eliminating cause i.

In the 1860s, the Registrar General published data on deaths by age and cause using 24 categories. Some of these were specific infectious diseases, such as smallpox and measles, whereas others were classified according to the part of the body afflicted (for example, 'diseases of the generative organs', or 'diseases of the lungs'). As well as the 24 categories, there was a residual category of 'other causes'.[43] In the 1860s, 18 per cent of all male deaths and 19 per cent of all female deaths were placed in this residual category. The proportion of deaths attributed to other causes was especially

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[43] Death rates by age and cause in England and Wales as a whole during the 1860s, using these categories, are presented for males and females in Woods and Shelton, *Atlas*, 34-5.

great among infants (34 and 35 per cent for males and females respectively), but at ages five years and over only 13 per cent of male deaths and 15 per cent of female deaths are assigned to the residual category.

Table 1 lists the categories into which the causes of death were divided, together with the percentage of deaths in each category at ages over five years in England and Wales as a whole in the 1860s. The most common single cause of death was phthisis, or pulmonary tuberculosis, which was responsible for 17 per cent and 18 per cent of deaths to males and females respectively.

In England and Wales in the 1860s about 2.5 per cent of deaths to women were the result of childbirth, and a higher proportion of deaths to males were the outcome of violence than were deaths to females (6.5 per cent compared with 1.5 per cent). Apart from childbirth and violence, the only other causes of death which seem to have affected one sex disproportionately were diseases of the kidneys (disadvantaging males) and cancer and diseases of the generative organs (disadvantaging females). These, however, tended to affect older people so that their impact on the overall sex differential in mortality is likely to have been small.

To apply the method of Beltrán-Sánchez, Preston and Canudas-Romo to the English data for the 1860s I start by creating a multiple-decrement life table covering the age range five years and over using the 25 categories of causes of death (24 named causes plus the residual category). Because of the way the data are presented by the Registrar General, I use age groups as follows: 5-9 years, 10-14 years 15-19 years, 20-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years and 85 years and over. To compute the ${}_nL^m_{x,i}$ and the ${}_nL^f_{x,i}$ requires an assumption about the distribution of deaths from each cause within each age group. Beltrán-

Table 1

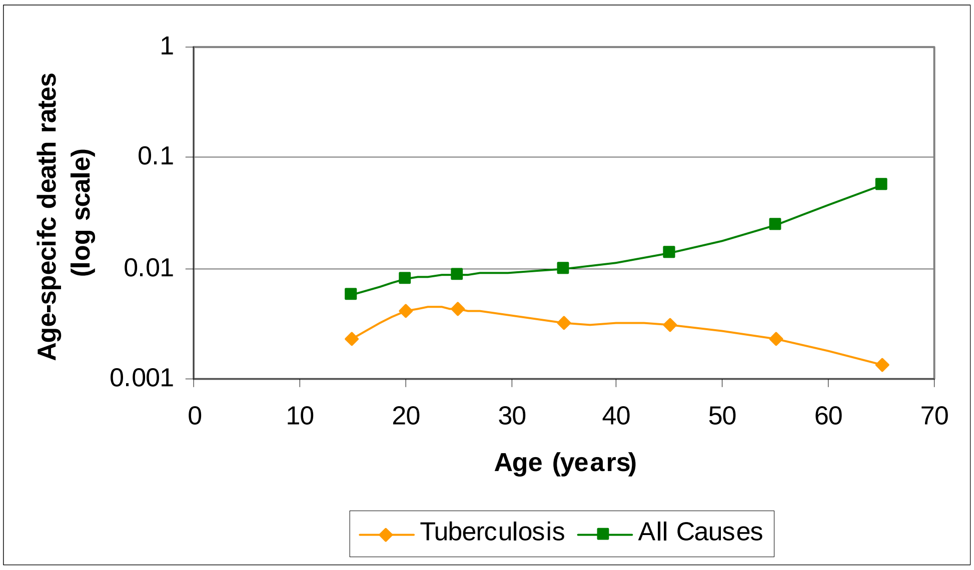
Distribution of deaths in England and Wales at ages over five years by cause, 1860s

Cause of death	Percentage of deaths	
	Males	Females
Smallpox	0.67	0.46
Measles	0.25	0.29
Scarlatina	2.62	2.65
Diphtheria	0.54	0.69
Whooping cough	0.12	0.17
Typhus	5.39	5.47
Diarrhoea and dysentery	1.38	1.59
Cholera	0.56	0.54
Other zymotic diseases	1.97	1.73
Cancer	1.80	4.02
Scrofula and tabes	1.07	0.92
Phthisis	17.31	18.21
Hydrocephalus	0.40	0.33
Diseases of the brain	11.08	10.37
Diseases of the heart; dropsy	9.33	10.33
Diseases of the lungs	15.06	13.35
Diseases of the stomach and liver	6.00	6.43
Diseases of the kidneys	3.01	1.32
Diseases of the generative organs	0.04	0.83
Diseases of the joints	0.63	0.48
Diseases of the skin	0.27	0.26
Childbirth; metria	0.00	2.48
Suicide	0.73	0.26
Other violent deaths	6.48	1.48
Other causes	13.30	15.33
Number of deaths	1,401,799	1,421,401

Source: R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file]. Colchester, UK Data Archive [distributor], 1997, SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

Figure 1

Age-specific death rates from tuberculosis and from all causes in England and Wales in the nineteenth century



Source. R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file]. Colchester, UK Data Archive [distributor], 1997, SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

Sánchez and his colleagues assumed that, within each age group, the force of decrement function from cause *i* was proportional to the force of decrement function from all causes combined. However, it is clear from an examination of the age pattern of mortality in nineteenth-century England and Wales from some cause of death categories that the assumption of a proportional force of mortality is unreasonable if we are using ten-year age groups. Compare the death rates from tuberculosis by age with death rates from all causes (Figure 1). At ages 25 years and over, the death rate from all causes is rising with age, whereas that from tuberculosis is falling. Given this, I used the assumption of a constant force of mortality from each cause within each age group.[44]

I now describe the calculation of the relevant life tables. The description below relates to females—analogous formulae are used for males. Let the constant force of mortality for females in the age group *x* to *x*+*n* years from cause *i* be ${}_n\mu^f_{x,i}$. I estimate this force by dividing the average number of deaths of females from that cause reported in a year by the Registrar General from by the female population exposed to risk. I then set the radix of the life table, l_5, to be 1.0, and calculate the proportions surviving at subsequent ages 10, 15, 20, 25, 35, 45, 55, 65, 75 and 85 years if only cause *i* were operating using the formula

$$l^f_{x+n,i} = l^f_{x,i} e^{-n\,{}_n\mu^f_{x,i}}$$

[44] S. Preston, P. Heuveline and M. Guillot, *Demography: measuring and modelling population processes.* Oxford, Blackwell, 2001, 82.

where $l^f_{x,i}$ is the proportion of females who survive to exact age *x*, and *n* is the width of the age group. The key quantity ${}_nL^f_{x,i}$ for causes other than the residual category is then estimated using the formula

$$ {}_nL^f_{x,i} = \frac{l^f_{x,i}[1-\exp(-n\,{}_n\mu^f_{x,i})]}{{}_n\mu^f_{x,i}}. $$

Following Beltran-Sanchez and his colleagues, I then estimate ${}_nL^f_{x,k}$, the person-years lived in a life table in which only the residual cause of death, *k*, were operating, using the formula:

$$ {}_nL^f_{x,k} = \frac{{}_nL^f_x}{\prod_{i=1}^{k-1} {}_nL^f_{x,i}} n^{k-1}, $$

in which ${}_nL^f_x$ relates to the all-causes female life table. Finally, the quantity ${}_nL^f_{x,-i}$ is obtained using the formula

$$ {}_nL^f_{x,-i} = \frac{{}_nL^f_x}{{}_nL^f_{x,i}} n, $$

for all causes $i = 1, \ldots, k$.

The contribution of different age groups to sex differentials in mortality

In nineteenth-century England, females could expect to live longer than males. For example, according to English Life Table 3, which represented mortality in the period 1838-1854, the expectation of life at birth for males was 39.9 years and that for females was 41.9 years, a differential of 2.0 years.[45] By the first decade of the

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45 Woods and Hinde, 'Mortality in Victorian England', 33.

twentieth century the expectations of life at birth for males and females had risen to 48.5 and 52.4 years respectively, and the differential had almost doubled to 3.9 years.[46]

Table 2 summarises the situation in the 1860s in England and Wales as a whole and in the 11 Divisions into which the country was divided for the purposes of administering vital registration.[47] The overall sex differential in the expectation of life at birth was 2.8 years, but this masked substantial regional variation. Relative to males, females in London were doing best of all, though they were doing well in other parts of southern England too. They were doing less well in the northern counties, and least well of all in the north Midland counties of Leicestershire, Rutland, Lincolnshire, Derbyshire and Nottinghamshire.

Table 3 shows the result of performing the decomposition by age for England and Wales and the 11 Divisions during the 1860s. In the country as a whole, more than half the differential in the expectation of life at birth is accounted for by higher mortality for males in infancy and early childhood. Differential infant mortality alone is worth about one and a half extra years of life for women compared with men, a

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[46] Woods and Hinde, 'Mortality in Victorian England', 33.

[47] The 11 Divisions other than London, Yorkshire, and Wales and Monmouthshire (the composition of which is self-evident) were made up as follows: south-eastern counties – Surrey, Kent, Sussex, Hampshire and Berkshire; south Midland counties – Middlesex, Hertfordshire, Buckinghamshire, Oxfordshire, Northamptonshire, Huntingdonshire, Bedfordshire and Cambridgeshire; south-western counties – Wiltshire, Dorset, Devon, Cornwall and Somerset; eastern counties – Essex, Suffolk and Norfolk; west Midland counties – Gloucestershire, Herefordshire, Shropshire, Staffordshire, Worcestershire and Warwickshire; north Midland counties – Leicestershire, Rutland, Lincolnshire, Derbyshire and Nottinghamshire; north-western counties – Cheshire and Lancashire; and northern counties – Cumberland, Westmorland, Durham and Northumberland.

Table 2

Expectation of life at birth for males and females, 1860s: England and Wales and 11 Registration Divisions

Division	Expectation of life at birth (years)		
	Males	Females	Difference (females minus males)
England and Wales	39.5	42.3	2.8
London	35.4	39.6	4.2
South-eastern counties	44.0	47.0	3.0
South Midland counties	43.5	45.7	2.2
South-western counties	44.1	47.1	3.0
Eastern counties	44.4	46.2	1.8
West Midland counties	40.5	43.4	2.9
North Midland counties	43.1	44.3	1.2
North-western counties	34.0	36.7	2.7
Yorkshire	37.6	40.1	2.5
Northern counties	39.5	41.4	1.9
Wales and Monmouthshire	41.1	44.0	2.9

Source: R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file]. Colchester, UK Data Archive [distributor], 1997, SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

figure which is similar in all 11 Divisions. Regional variations in the overall male-female mortality differential owe almost nothing to sex differentials at ages under five years. In London, for example, where the overall differential is largest, mortality at ages under five years contributes 1.55 extra years for females. By contrast, in the north Midland counties, where, overall, females do least well relative to males, the female advantage at ages under five years is actually *greater* than that in London, adding an extra 1.85 years to the lives of women compared with men.

The north Midland counties is the only region where females have higher overall mortality than males at ages over five years, and female mortality is consistently higher than that of males from ages 10 to 44 years. There are other parts of the country where the female expectation of life at age five years is only fractionally higher than that of males: the eastern counties (where, as in the north Midland counties, female mortality is higher than that of males from ages 10-44 years), the south Midland counties, Yorkshire and the northern counties. Elsewhere, however, in southern England, the west Midland counties, Wales and Monmouthshire and, above all, in London, females retain an advantage over males at ages over five years. In London, the north-western counties and Wales and Monmouthshire, for example, female mortality is lower than that of males in every age group from 5-9 years to 75 years and over.

To look at patterns by age, it is clear that mortality is slightly lower for females than for males at ages 5-9 years, but that at ages 10-14 years there is no overall female advantage. At ages 15-19 years female mortality is higher than that of males in most divisions, the effect being to add more than 0.25 years to the expectation of life of

Table 3 Contribution (in years) of various age groups to the sex differential in the expectation of life at birth, 1860s: England and Wales and 11 Registration Divisions

Age group (years)	England and Wales	London	SE counties	S Midland counties	SW counties	E counties	W Midland counties	N Midland counties	NW counties	York-shire	N counties	Wales and Mon-mouth-shire
0	1.47	1.28	1.39	1.69	1.40	1.52	1.53	1.71	1.42	1.69	1.34	1.27
1	0.16	0.24	0.20	0.13	0.18	0.18	0.14	0.10	0.13	0.18	0.13	0.11
2-4	0.00	0.03	0.07	-0.01	0.00	0.02	-0.03	0.04	-0.03	0.05	-0.04	-0.10
5-9	0.07	0.08	0.04	0.02	0.04	0.03	0.07	0.05	0.13	0.08	0.02	0.08
10-14	0.00	0.03	-0.07	-0.09	-0.05	-0.14	0.01	-0.08	0.05	0.00	0.09	0.07
15-19	-0.07	0.09	-0.18	-0.28	-0.14	-0.25	-0.07	-0.29	0.03	-0.13	0.02	0.08
20-24	0.06	0.22	0.04	-0.05	0.09	-0.04	0.01	-0.14	0.06	-0.04	-0.03	0.25
25-34	0.04	0.37	0.25	-0.04	0.22	-0.13	0.02	-0.45	0.02	-0.20	-0.25	0.05
35-44	0.21	0.53	0.34	0.14	0.29	-0.02	0.18	-0.15	0.19	0.07	-0.03	0.09
45-54	0.34	0.55	0.38	0.28	0.40	0.14	0.40	0.10	0.27	0.28	0.24	0.29
55-64	0.27	0.41	0.28	0.21	0.32	0.20	0.33	0.12	0.21	0.27	0.23	0.29
65-74	0.17	0.23	0.13	0.14	0.19	0.22	0.19	0.11	0.13	0.15	0.19	0.27
75-84	0.06	0.07	0.07	0.06	0.05	0.09	0.07	0.03	0.05	0.05	0.06	0.12
85 and over	0.02	0.01	0.03	0.02	0.03	0.03	0.02	0.01	0.02	0.02	0.03	0.03
All ages	2.79	4.16	2.96	2.23	3.00	1.84	2.86	1.18	2.67	2.46	1.97	2.92
0-4	1.63	1.55	1.66	1.81	1.58	1.72	1.64	1.85	1.52	1.92	1.43	1.28
5 and over	1.16	2.61	1.30	0.52	1.42	0.12	1.22	-0.67	1.15	0.54	0.54	1.64

Source: R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file]. Colchester, UK Data Archive [distributor], 1997, SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

Notes: Negative numbers mean that mortality is lower in that age group for males than females, and thus acts to offset the female advantage at other age groups. The age groups used in this table are those according to which the data were tabulated by the Registrar General, save that I have combined the single years of age 2, 3 and 4 years into one age group.

males relative to females in the south Midland counties, the eastern counties and the north Midland counties. Between ages 20 and 44 years there are intriguing regional variations in the sex differential. For example, in the prime childbearing ages of 25-34 years, females in London and southern England retain a substantial advantage over males, contributing 0.37 years to the overall expectation of life in London, 0.25 years in the south-eastern counties and 0.22 years in the south-western counties. By contrast in the north Midland counties female mortality is considerably higher than males in this age group (the impact being to subtract 0.45 years from the overall expectation of life of females relative to males), and the same is true of the northern counties and Yorkshire, if not to quite the same extent.

At ages above 45 years female advantage reasserts itself throughout the country. There are differences in the degree of female advantage in the age group 45-54 years, with the now familiar pattern of females doing relatively best in London and relatively worst in the north Midland counties and the eastern counties. However, as age increases these regional variations diminish.

Contribution of different causes of death

I now turn to examine the contribution of different causes of death to the overall sex differential in mortality. The interpretation of the results is illustrated by considering England and Wales as a whole (Table 4). I present the values of the terms in the equation for $D_i^f(5) - D_i^m(5)$ in reverse order, that is for each cause *i* Table 4 gives first the decomposition of the difference in the life expectancy at age five years between the two sexes by cause (the direct effect), and then the impact on mortality from other causes of death resulting from the elimination of the cause (the indirect effect), and then the values of $D_i^f(5) - D_i^m(5)$ itself. The sex differential in the expectation of life at age five years, e_5, in England and Wales during the 1860s was just under 1.6 years (e_5 was 49.8 years for males and 51.4 years for females). The contributions of each cause to this are given in the first column of Table 4. The first nine rows relate to infectious diseases, and reveal that these made very little contribution, mainly because mortality from these diseases was largely confined to infants and young children.[48] The biggest single contributor to the sex differential in e_5 was deaths from violence. This cause alone led to a female advantage of 1.19 years. Just under half of this (0.58 years) was offset by deaths associated with childbirth. Of the remaining causes, substantial female advantage resulted from diseases of the brain, lungs and kidneys, part of which was offset by the differential mortality from cancer, which favoured males.

A surprising result is the small impact of phthisis on the sex differential in e_5, given its large share in the overall number of deaths. However, this does not mean that the *elimination* of phthisis would have a small effect on the sex differential in e_5. Phthisis itself contributes very little to the sex differential in the expectation of life at birth because there is little difference between males and females in death rates from phthisis (in fact the age-specific death rates from phthisis are, overall, marginally higher for females than males, so the figure in column 2 is negative at -0.08 years). If phthisis were to be eliminated, then those (many) people who formerly died of phthisis would be subject to mortality from other causes, most of which are more

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[48] Of the 1,018,802 deaths in England and Wales during the 1860s attributed to infectious diseases (smallpox, measles, scarlatina, diphtheria, whooping cough, typhus, diarrhoea and dysentery, cholera and other zymotic diseases), 636,531 or 62.5 per cent were to infants and children aged under five years.

Table 4

Contribution of different causes of death to differential in expectation of life at age five years, e_5: England and Wales, 1860s

Cause of death	Contribution to sex differential in e_5, expressed as e_5 (females) minus e_5 (males)	Effect of removing cause on differential mortality by sex from other causes of death	Sex differential in gain in e_5 as a result of removing cause, $D_i^f(5) - D_i^m(5)$
Smallpox	0.05	0.00	-0.05
Measles	-0.01	0.00	0.01
Scarlatina	-0.01	0.03	0.04
Diphtheria	-0.04	0.01	0.05
Whooping cough	-0.02	0.00	0.02
Typhus	0.01	0.08	0.07
Diarrhoea and dysentery	-0.01	0.03	0.04
Cholera	0.01	-0.01	0.00
Other zymotic diseasesa	0.07	0.03	-0.04
Cancer	-0.36	0.08	0.44
Scrofula and tabes	0.04	0.01	-0.03
Phthisis	-0.08	0.29	0.37
Hydrocaphalus	0.02	0.00	-0.02
Diseases of the brain	0.32	0.21	-0.11
Diseases of the heart and dropsy	-0.01	0.23	0.24
Diseases of the lungs	0.57	0.22	-0.33
Diseases of the stomach and liver	0.02	0.13	0.11
Diseases of the kidneys	0.29	0.04	-0.25
Diseases of the generative organs	-0.15	0.01	0.16
Diseases of the joints	0.04	0.01	-0.03
Diseases of the skin	0.01	0.01	-0.00
Childbirth and metria	-0.58	0.02	0.60
Suicide	0.10	0.01	-0.09
Other violent deaths	1.19	0.03	-1.16
Other causes	0.11	0.43	0.32
All causes	1.59		

favourable to females compared with males than is phthisis. Therefore although the direct effect of phthisis mortality on the sex differential is small, the indirect effect of eliminating phthisis is much more substantial, and is worth 0.29 years of life more for females than males.[49] Adding the direct and indirect effects together means that, overall, females would gain an extra 0.37 years of life more than males from the elimination of phthisis (0.08 years because we have eliminated a cause which disadvantages females, and 0.29 years because those who formerly died of phthisis would now die from causes which disadvantage males). The same effect is seen, though to a lesser extent, for diseases of the heart and dropsy. By contrast, consider diseases of the lungs. Mortality from diseases of the lungs at ages above five years is heavier among males than females. The direct effect of this differential in mortality from diseases of the lungs is to reduce males' expectation of life at age five years by 0.57 years compared with that of females. However, if diseases of the lungs were eliminated, males would not gain 0.57 years of life more than females. In fact, they would gain only 0.33 years, because those who formerly died from diseases of the lungs would now die from other causes which also tend to disadvantage males—though not to the same extent as diseases of the lungs. This offsets some of the gain to males from eliminating diseases of the lungs. A similar situation is observed for diseases of the brain.

[49] The indirect impact of different causes of death on sex differentials in mortality was recognised by Harris, 'Gender, health and welfare', 180-92; and by McNay *et al.*, 'Excess female mortality', 671-2 although they were unable to quantify its impact.

Regional variations in sex differentials by cause

Table 5 shows the contribution of each of the 25 causes of death to the sex differential in the expectation of life at age five years for the 11 divisions of England and Wales.[50] It is perhaps easiest to read this table first by cause of death, and then by comparing the patterns across the divisions.

Infectious diseases, in general, contribute little to the sex differential in mortality. Although death rates from smallpox consistently offer a female advantage (positive numbers in Table 5 denote lower mortality for females), and diphtheria a female disadvantage, the effects of both are very small. The most substantial female disadvantage arises from deaths associated with childbirth (between about half and three quarters of a year's life is lost to females relative to males from this cause), cancer, and diseases of the generative organs. On the other hand, a consistent and substantial male disadvantage arises due to deaths from violence (other than suicide). This ranges from 0.89 years of life in London to 1.81 years in the northern counties and more than two years in Wales. Males also suffer consistently higher death rates than females from diseases of the brain, lungs and kidneys, the combined effect of these three causes in most regions being to reduce males' expectation of life at age five years by more than a year relative to that of females.

The most intriguing individual cause of death is phthisis. Earlier, it was noted that, at the national level, the impact of deaths from phthisis on the sex differential in the expectation of life at age five years was modest (a female advantage of 0.08

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[50] Woods and Shelton, *Atlas*, 36-7, present death rates by age, sex and cause for the London Division, but not for the other 10 divisions.

Table 5

Contribution of different causes of death to sex differential in expectation of life at age five years, e_5, expressed as e_5 (females) minus e_5 (males): 11 Registration Divisions of England and Wales, 1860s

Cause of death	London	SE	S Mid-land	SW	E	W Mid-land	N Mid-land	NW	York-shire	N	Wales and Mon.
Smallpox	0.09	0.07	0.07	0.04	0.06	0.06	0.02	0.04	0.03	0.04	0.07
Measles	0.00	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	0.00	-0.01	-0.02	-0.01
Scarlatina	-0.01	0.00	-0.01	-0.01	-0.01	-0.02	-0.01	0.02	-0.01	-0.07	-0.04
Diphtheria	-0.03	-0.07	-0.04	-0.03	-0.11	-0.05	-0.05	-0.02	-0.03	-0.03	-0.05
Whooping cough	-0.03	-0.03	0.01	-0.03	-0.02	-0.02	0.01	0.00	-0.02	-0.02	-0.01
Typhus	0.12	-0.05	-0.14	-0.06	-0.09	0.01	-0.13	0.12	-0.01	-0.01	0.06
Diarrhoea and dysentery	0.02	0.03	-0.03	0.01	-0.03	-0.02	-0.04	-0.02	-0.04	-0.03	0.00
Cholera	0.01	0.01	0.01	0.02	0.01	0.00	0.02	0.02	0.02	0.00	-0.02
Other zymotic diseases	0.10	0.09	0.09	0.07	0.07	0.09	0.04	0.06	0.06	0.02	0.07
Cancer	-0.41	-0.43	-0.37	-0.34	-0.52	-0.39	-0.37	-0.27	-0.36	-0.30	-0.20
Scrofula and tabes	0.05	0.01	0.00	0.06	0.00	0.03	0.03	0.08	0.04	0.06	0.11
Phthisis	1.36	0.12	-0.46	-0.08	-0.71	-0.15	-1.34	-0.14	-0.53	-0.75	-0.39
Hydrocephalus	0.02	0.00	0.01	0.02	0.02	0.01	0.02	0.03	0.02	0.01	0.03
Diseases of the brain	0.52	0.28	0.39	0.34	0.22	0.37	0.21	0.28	0.28	0.23	0.24
Diseases of the heart; dropsy	0.20	0.16	-0.10	-0.04	0.01	-0.04	-0.25	-0.06	-0.08	0.03	-0.13
Diseases of the lungs	0.76	0.56	0.43	0.67	0.44	0.67	0.39	0.53	0.60	0.38	0.81
Diseases of the stomach and liver	0.03	0.02	0.00	0.09	-0.01	0.02	-0.04	0.02	-0.02	-0.05	0.11
Diseases of the kidneys	0.37	0.35	0.28	0.32	0.35	0.29	0.28	0.22	0.25	0.19	0.22
Diseases of the generative organs	-0.18	-0.17	-0.16	-0.14	-0.20	-0.16	-0.18	-0.11	-0.13	-0.14	-0.09
Diseases of the joints	0.06	0.03	0.03	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.03
Diseases of the skin	0.02	0.00	0.01	0.01	0.01	0.00	-0.01	0.01	0.00	0.00	0.00
Childbirth and metria	-0.46	-0.53	-0.58	-0.56	-0.58	-0.60	-0.55	-0.56	-0.62	-0.70	-0.74
Suicide	0.12	0.15	0.10	0.09	0.10	0.09	0.10	0.09	0.07	0.08	0.04
Other violent deaths	0.89	0.93	0.95	1.26	0.97	1.28	0.98	1.19	1.13	1.81	2.06
Other causes	0.15	0.16	0.07	0.10	0.18	0.16	-0.06	0.13	0.13	-0.02	-0.01
All causes	3.79	1.65	0.55	1.84	0.17	1.68	-0.89	1.71	0.77	0.76	2.53

years). However, this national figure masks great regional variations. In London, at one extreme, phthisis is worth 1.36 additional years of life for females; at the other extreme, in the north Midland counties, it results in a male advantage of 1.34 years. Despite its small impact at the national level, the sex differential in mortality from phthisis is the most important cause of death contributor to regional variations in the relative mortality of males and females at ages above five years. Where females are substantially disadvantaged by mortality from phthisis, as in the north Midland counties, the eastern counties, the northern counties and Yorkshire, the overall female advantage is small (or even reversed); where there is no great female advantage in phthisis mortality, as in the south-eastern, south-western, west Midland and north-western counties, the overall female advantage amounts to between 1.5 and 2 more years of life than males; where phthisis death rates are lower for females than for males, as in London, the overall female advantage is almost four additional years of life. The only partial exception to this pattern is Wales and Monmouthshire, where the overall female advantage is inflated by the impact of deaths from violence.

Deaths from violence were proportionately most numerous among men in Wales and Monmouthshire and the northern counties, where they comprised 9.4 per cent and 9.8 per cent respectively of all deaths to males aged over five years, compared with corresponding figures of 1.3 per cent and 1.6 per cent respectively among females. The national figures were 6.5 per cent and 1.5 per cent (Table 1). Accidental deaths to coal miners were mainly responsible. Table 6 shows the proportion of all deaths to males and females which were classified as ‘other violent deaths’ in the 17 registration districts in England and Wales in which more than one third of males aged 20 years and over were working in the mining sector in 1861.[51] The high proportion of deaths from 'other violent' causes among males in coal mining districts stands out. In nine of the ten coal mining districts among the 17 this proportion exceeded 10 per cent, and in six it was more than 15 per cent, with the highest proportion in the district of Easington on the coast of north-east England at 19.8 per cent. Among females, however, deaths from violence in these districts were only slightly higher than the national average of 1.5 per cent (Table 4). Abnormally high mortality from accidental deaths was, then, a feature of coal mining areas, and to a much lesser extent, tin mining districts. It was absent from those areas where other forms of mining were common (such as lead mining or stone quarrying). Indeed, in lead mining districts, such as Alston and Reeth, in the upland areas of northern England, deaths from violence among both males and females were *less* common than was the case nationally, despite more than half the adult males being employed in mining.

Table 7 shows the sex differential in gain in the expectation of life at age five years as a result of eliminating different causes of death, $D_i^f(5) - D_i^m(5)$, for the 11 divisions of England and Wales. For most causes of death, the values in this table reflect those in Table 5 quite closely. For diseases of the heart and dropsy, diseases of the brain and diseases of the lungs, the pattern already described for England and Wales as a whole is reflected for most regions. More noticeable than in the national

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[51] Registration districts had an average population of about 33,000 in the 1860s. The occupational data are taken from the 1861 census of population. These have been made available in an electronic format by David Alan Gatley of Staffordshire University: see D.A. Gatley, 'Computerising the 1861 census abstracts and vital registration statistics', *Local Population Studies* 58(1997), 37-47.

figures is the effect of eliminating ‘other causes’ of death. These undiagnosed causes principally affect older people (more than half of all deaths in the country as whole which were ascribed to ‘other causes’ were to persons aged 75 years and over). There is no great difference between the death rates for the two sexes from these other causes, but if they were to be eliminated, then those (many) older people whose deaths are currently put down to ‘other causes’ would have to die from one of the 24 ‘named’ causes, and mortality at older ages among the latter favours females. The result is that in most divisions, females gain between 0.25 and 0.5 years of life more than males from the elimination of these causes (more than this in Wales and Monmouthshire), but that most of this gain is indirect, arising from the substitution of deaths from ‘other causes’ for deaths from more ‘female friendly’ causes.

Regional patterns in the changes resulting from eliminating deaths from phthisis reflect the contribution of deaths from phthisis to the sex differential in e_5, with the additional effect (already mentioned) that outside London females make additional indirect gains from its elimination because, on average, other causes of death favour females more than phthisis. In London, as we have already seen, phthisis deaths disadvantage males to the extent of 1.36 years of life, but since other causes also disadvantage males, males do not gain 1.36 years of life more than females from the elimination of phthisis: rather they gain about 0.9 years of life.

The results reported in this section show that, so far as regional *variability* in the sex differential in mortality is concerned, the two most important causes of death

Table 6 Deaths to males and females aged over 5 years classified as 'other violent deaths' in the 1860s: English and Welsh registration districts with over one in three adult males occupied in the mining sector

Registration district	Division	Main form of mining	Percentage of males aged over 20 occupied in mining sector in 1861	Deaths to males aged over 5 years in 1860s classified as 'other violent deaths'		Deaths to females aged over 5 years in 1860s classified as 'other violent deaths'	
				Number	Percentage of all deaths to males over 5 years	Number	Percentage of all deaths to females over 5 years
Alston	N counties	Lead	58.2	17	4.0	2	0.5
Redruth	SW counties	Tin	52.6	303	8.9	40	1.1
Reeth	N counties	Lead	52.5	20	4.7	0	0.0
Houghton-le-Spring	N counties	Coal	49.8	213	15.4	39	2.8
Weardale	N counties	Lead	48.7	79	6.9	4	0.3
Easington	N counties	Coal	48.3	328	19.8	28	1.9
Chester-le-Street	N counties	Coal	47.9	333	17.9	34	1.9
Merthyr Tydfil	Wales and Mon.	Coal	42.2	1,318	18.2	110	1.9
Auckland	N counties	Coal	41.4	434	13.1	45	1.4
Wigan	NW counties	Coal	39.5	1,181	16.7	147	2.2
Helston	SW counties	Tin	39.0	150	8.3	17	0.9
St Austell	SW counties	China clay	37.8	100	5.3	23	1.1
Crickhowell	Wales and Mon.	Coal	36.3	136	9.0	18	1.3
Bedwelty	Wales and Mon.	Coal	36.3	618	17.5	52	1.9
Durham	N counties	Coal	35.8	517	11.6	65	1.5
Chesterfield	N Midland counties	Coal	34.7	486	11.8	65	1.7
Caernarvon	Wales and Mon.	Stone	34.2	229	8.6	32	1.2

Sources. Database prepared by David Alan Gatley of Staffordshire University: see D.A. Gatley, 'Computerising the 1861 census abstracts and vital registration statistics', *Local Population Studies* 58(1997), 37-47; R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file] (Colchester, UK Data Archive [distributor], 1997), SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

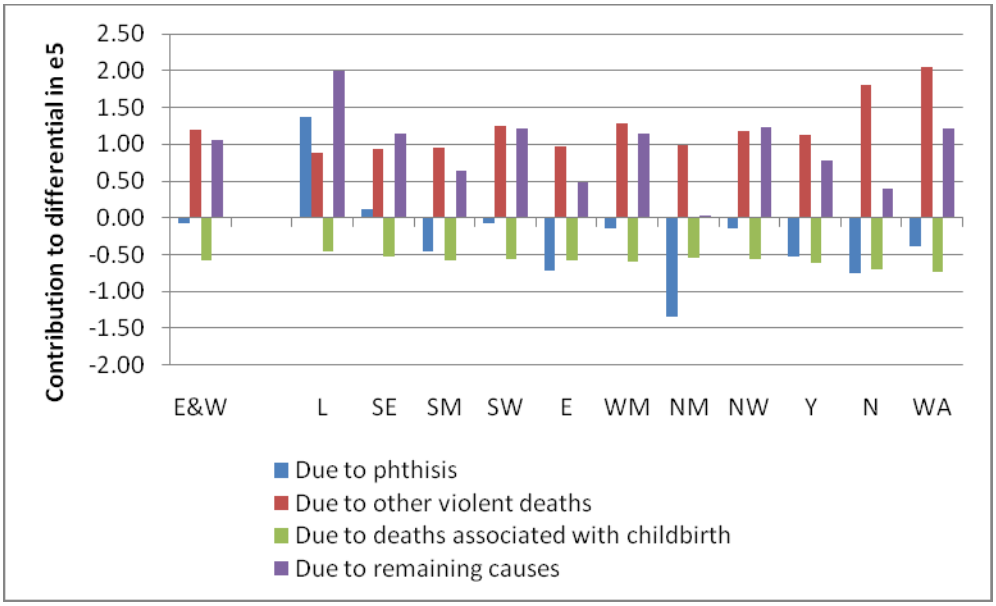
Table 7

Sex differential in gain in expectation of life at age five years as a result of eliminating different causes of death, $D_i^f(5) - D_i^m(5)$: 11 Registration Divisions of England and Wales, 1860s

Cause of death	London	SE	S Mid-land	SW	E	W Mid-land	N Mid-land	NW	York-shire	N	Wales and Mon.
Smallpox	-0.07	-0.06	-0.06	-0.03	-0.06	-0.05	-0.02	-0.03	-0.03	-0.03	-0.06
Measles	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.00	0.02	0.02	0.02
Scarlatina	0.08	0.03	0.02	0.03	0.02	0.04	0.00	0.02	0.02	0.08	0.07
Diphtheria	0.04	0.08	0.04	0.04	0.11	0.06	0.05	0.02	0.03	0.04	0.06
Whooping cough	0.03	0.03	-0.01	0.03	0.02	0.02	-0.01	0.00	0.02	0.02	0.01
Typhus	0.06	0.12	0.18	0.13	0.11	0.06	0.11	0.00	0.06	0.06	0.05
Diarrhoea and dysentery	0.03	0.00	0.06	0.01	0.05	0.05	0.04	0.06	0.07	0.06	0.03
Cholera	0.03	0.00	-0.01	-0.01	-0.01	0.00	-0.02	-0.01	-0.01	0.01	0.04
Other zymotic diseases	-0.03	-0.06	-0.07	-0.04	-0.06	-0.05	-0.04	-0.03	-0.04	0.00	-0.03
Cancer	0.58	0.51	0.43	0.42	0.58	0.47	0.38	0.33	0.42	0.35	0.27
Scrofula and tabes	-0.02	0.01	0.01	-0.04	0.01	-0.01	-0.03	-0.06	-0.04	-0.05	-0.09
Phthisis	-0.90	0.14	0.64	0.38	0.88	0.41	1.42	0.47	0.76	0.99	0.91
Hydrocephalus	-0.02	0.00	-0.01	-0.02	-0.02	0.00	-0.02	-0.02	-0.02	-0.01	-0.02
Diseases of the brain	-0.06	-0.05	-0.26	-0.12	-0.10	-0.15	-0.22	-0.08	-0.13	-0.09	-0.03
Diseases of the heart; dropsy	0.20	0.08	0.26	0.31	0.11	0.30	0.29	0.27	0.25	0.13	0.37
Diseases of the lungs	-0.03	-0.35	-0.32	-0.47	-0.34	-0.42	-0.43	-0.17	-0.43	-0.25	-0.59
Diseases of the stomach and liver	0.22	0.12	0.08	0.04	0.07	0.13	0.03	0.12	0.13	0.14	0.02
Diseases of the kidneys	-0.27	-0.31	-0.26	-0.29	-0.34	-0.25	-0.29	-0.18	-0.23	-0.17	-0.18
Diseases of the generative organs	0.20	0.18	0.17	0.15	0.21	0.17	0.18	0.11	0.14	0.15	0.09
Diseases of the joints	-0.05	-0.03	-0.03	-0.03	-0.02	-0.03	-0.04	-0.03	-0.03	-0.03	-0.02
Diseases of the skin	0.00	0.00	-0.01	0.00	-0.01	0.00	0.01	0.00	0.01	0.01	0.01
Childbirth and metria	0.50	0.55	0.59	0.58	0.58	0.62	0.55	0.59	0.64	0.71	0.78
Suicide	-0.10	-0.14	-0.10	-0.08	-0.10	-0.08	-0.10	-0.08	-0.07	-0.07	-0.04
Other violent deaths	-0.79	-0.90	-0.95	-1.22	-0.97	-1.24	-1.01	-1.15	-1.12	-1.83	-2.03
Other causes	0.34	0.18	0.23	0.40	0.11	0.31	0.23	0.30	0.28	0.44	0.92

Figure 2

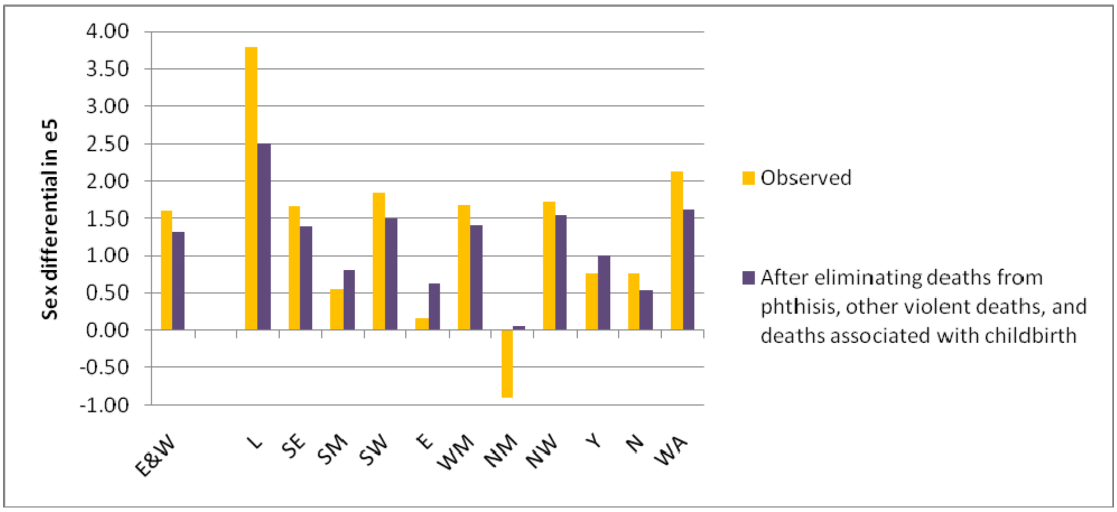
Contribution of deaths from phthisis, 'other violent' deaths, deaths associated with childbirth and deaths from remaining causes to overall sex differential in expectation of life at age 5 years: England and Wales and 11 registration divisions, 1860s



Note. Expectations of life are expressed as e_5 (females) minus e_5 (males). E&W – England and Wales, L – London, SE – south-eastern counties, SM - south Midland counties, SW – south-western counties, E – eastern counties, WM – west Midland counties, NM – north Midland counties, NW – north-western counties, Y – Yorkshire, N – northern counties, WA – Wales and Monmouthshire.

Figure 3

Comparison of observed sex differential in the expectation of life at age five years with that which would be expected if deaths from phthisis, 'other violent deaths' and deaths associated with childbirth were eliminated: 11 Registration Divisions of England and Wales, 1860s.



Note. Expectations of life are expressed as e_5 (females) minus e_5 (males). E&W – England and Wales, L – London, SE – south-eastern counties, SM - south Midland counties, SW – south-western counties, E – eastern counties, WM – west Midland counties, NM – north Midland counties, NW – north-western counties, Y – Yorkshire, N – northern counties, WA – Wales and Monmouthshire.

are phthisis and ‘other violent deaths’. Deaths associated with childbirth, while also important, vary rather less from region to region. Figure 2 summarises the contribution of these three causes of death to the observed sex difference in e_5 in England and Wales as a whole and in each division. Figure 3 compares the actual regional sex differences in e_5 with those that would obtain were deaths from phthisis, ‘other violent deaths’ and deaths associated with childbirth to be eliminated. The rank ordering of the regions with respect to the difference remains roughly the same, but the inter-regional differentials diminish, the range between the most ‘female-friendly’ and least ‘female-friendly’ division falling from 4.7 years to 2.5 years.

Sex differentials in mortality in particular types of area

To illustrate how the cause-specific components of sex differentials in mortality at ages over five years combine I have applied the method of Beltrán-Sánchez and his colleagues to eight smaller areas. Seven of these have been chosen because, on the basis of previous research, their economic characteristics suggested that sex differentials in mortality should take a specific form. Three of these areas are expected to manifest female disadvantage: a low wage agricultural area in Suffolk, a manufacturing area in the west Midlands, and a coal mining area in Durham, all of which are characterised by low rates of female employment.[52] Three of the areas, on

[52] In the Suffolk area in 1861, the number of males employed in agriculture, expressed as a percentage of the number of males aged 20 years and over, was 68 per cent. In the west Midlands region, the corresponding figure for males employed in manufacturing was 44 per cent; in the Durham region, the corresponding figure for males employed in mining was 42 per cent. In all of these regions, female employment was rare. As a percentage of women aged over 20 years, the number of females employed (excluding domestic servants) was 20 per cent in the Suffolk region, 18 per cent in the west Midlands region and 13 per cent in the mining region.

the other hand, have high rates of female employment: a middle class area on the south coast of England where a large number of women were employed as domestic servants; an area in Lancashire where women were employed in large numbers in factory work; and an agricultural area in Bedfordshire where women were employed in their own homes in lace-making.[53] As a comparator, a high wage agricultural area in the north of England was also analysed.[54] Finally, in view of the importance of phthisis as a cause of death, we selected a region in the west of Wales which was notorious for high death rates from this cause—a 'phthisis pool', in which the disease continued to cause many deaths even after it had declined in most other parts of the country.[55] Among persons aged over five years, deaths from phthisis formed 28 per cent of all male deaths and 23 per cent of all female deaths in this region (compared with 17 and 18 per cent respectively in England and Wales as a whole).

Table 8 presents the sex differential in the expectation of life at age five years in each of these areas, and the decomposition of this according to the 25 causes of death distinguished by the Registrar General (the direct effect). Consider first those

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For the data on which these calculations are based, see Gatley, 'Computerising the 1861 census abstracts'.

[53] As a percentage of women aged over 20 years, the number of females employed (excluding domestic servants) was 48 per cent in the Lancashire region and 60 per cent in the Bedfordshire region. Male employment in the Bedfordshire region was largely in agriculture, whereas that in Lancashire was more mixed. In the south coast region, the number of women employed in domestic service was 27 per cent of the number of women aged 20 years and over.

[54] This area was mainly in the West Riding of Yorkshire (with a small part in the North Riding). The number of males employed in agriculture was 49 per cent of the number aged 20 years and over. Female employment was more common than in the low wage agricultural region in Suffolk.

[55] Woods, *Demography*, 335-6.

areas where female disadvantage might have been expected on the basis of previous research. The low wage agricultural area in Suffolk conforms to this picture, with a female expectation of life at age five years of 52.8 years compared to 55.5 years for males. The main contributor to female disadvantage in this region was phthisis, which along was responsible for 1.7 years of the differential in e_5. Relatively high mortality from phthisis for females is also a feature of the high wage agricultural area in Yorkshire, and of the area of female by-employment in Bedfordshire. It seems to be a general feature of agricultural regions of England, and confirms the pattern described by Michael Anderson.[56] In Bedfordshire, the availability of female employment may well have attenuated the female disadvantage, but did not eliminate it.

The other two traditional working class areas did not exhibit high female mortality relative to males overall. In the coal mining area of Durham, there was relatively high female mortality from phthisis, but this was compensated for by extremely high male mortality from accidental deaths. Deaths from 'other violent' causes in this area 'cost' males 2.5 years of life at ages over five years relative to females, and counterbalanced relatively high female mortality from other causes, notably phthisis and childbirth. A high rate of male mortality from 'other violent' deaths was also a feature of the west Midlands manufacturing area, but here the death rate from phthisis was roughly the same for males and females, so that overall females enjoyed about 1.8 *more* years of life than did males at ages over five years.

In the female factory work area in Lancashire, female and male mortality at ages over five years were almost the same overall, and sex differentials by individual

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[56] Anderson, 'Social implications', 19.

causes of death were muted. It is not clear from this analysis, therefore, that female employment in manufacturing necessarily reduced the female disadvantage in mortality. Women did relatively better in the west Midlands, where there was little work for them in factories, than in areas of Lancashire where there was a great deal.

The two areas where females did best relative to males were the middle class region on the south coast, where they enjoyed 3.3 years more life than did males at ages over five years, and the 'phthisis pool' in west Wales, where the differential in e_5 favoured females by 4.6 years. In both of these areas, death rates from phthisis were higher for males than females, and in the 'phthisis pool' the effect of this was to subtract a massive 3.0 years of life from males compared with females.[57] In the south coast area, females also benefited from low mortality associated with childbirth.

The three causes of death which most influenced the sex differential in e_5 in these eight areas were phthisis, deaths associated with childbirth and 'other violent deaths' (Figure 5). Deaths from 'other violent' causes disadvantaged males in all areas, but their effect was especially great in the coal mining area, and to a lesser extent in the manufacturing area of the west Midlands—which also had a substantial coal mining sector.[58] The impact of deaths associated with childbirth was to 'cost' women between 0.5 and 0.75 years of life compared with males in most areas. Areas

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[57] Thus the conjecture of McNay *et al.*, 'Excess female mortality', 668 that in areas which continued to harbour tuberculosis until the end of the nineteenth century 'tuberculosis may have been associated with [excess female mortality] independently of economic and social conditions' is true, though in what I suspect is the opposite direction to the way they had in mind.

[58] Males employed in mining as a percentage of all males aged 20 years and over were 25 per cent in Dudley, 22 per cent in Walsall, 16 per cent in West Bromwich and 16 per cent in Wolverhampton.

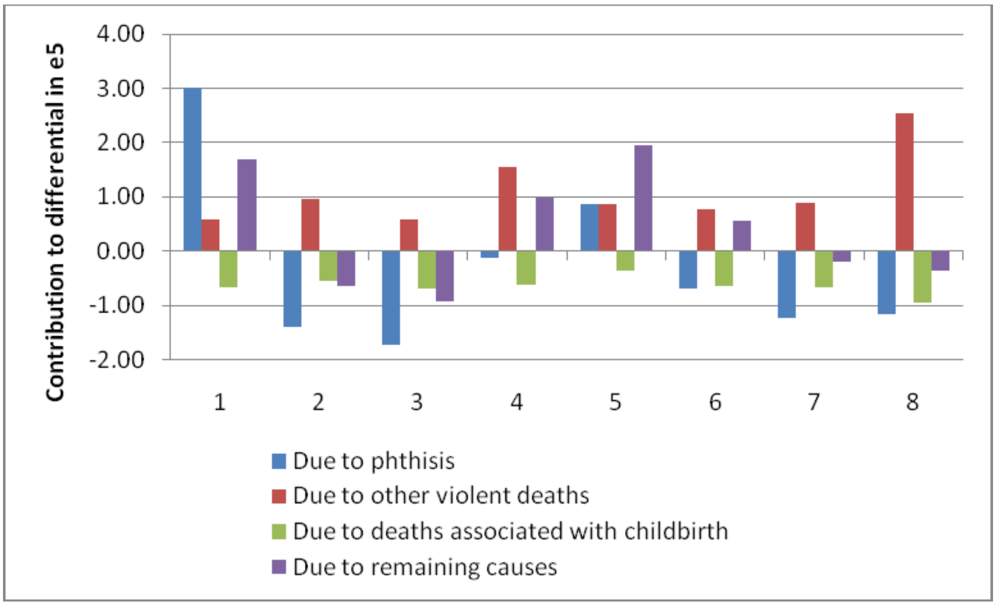
Table 8 Contribution of different causes of death to sex differential in expectation of life at age five years, e_5, expressed as e_5 (females) minus e_5 (males): selected types of region in England and Wales, 1860s

Cause of death	'Phthisis pool'	High wage agri-cultural	Low wage agri-cultural	Manu-facturing	South coast middle class	Female factory work	Female by-employ ment	Coal mining
Smallpox	0.09	0.07	0.06	0.07	0.10	0.01	0.09	0.05
Measles	0.00	-0.01	0.02	-0.01	-0.03	-0.01	0.00	-0.01
Scarlatina	-0.07	-0.21	0.14	0.01	0.05	-0.02	0.08	-0.14
Diphtheria	-0.09	-0.11	-0.21	-0.07	-0.10	-0.01	-0.04	-0.03
Whooping cough	-0.04	-0.03	-0.01	-0.01	-0.03	-0.02	-0.03	-0.02
Typhus	0.01	-0.17	-0.26	0.04	0.09	-0.07	-0.24	-0.06
Diarrhoea and dysentery	0.04	-0.01	0.05	-0.02	-0.01	-0.03	-0.09	-0.10
Cholera	0.01	0.01	0.02	0.01	0.01	0.02	-0.02	0.03
Other zymotic diseases	0.10	0.02	-0.00	0.10	0.14	0.09	0.09	-0.00
Cancer	0.03	-0.42	-0.53	-0.34	-0.43	-0.25	-0.35	-0.28
Scrofula and tabes	0.34	0.01	-0.06	0.04	0.04	0.11	-0.00	0.02
Phthisis	3.01	-1.41	-1.73	-0.12	0.87	-0.68	-1.24	-1.16
Hydrocephalus	-0.01	0.02	-0.01	0.02	0.01	0.02	0.05	0.02
Diseases of the brain	0.16	0.22	-0.17	0.12	0.63	0.16	0.15	0.16
Diseases of the heart; dropsy	-0.11	-0.42	-0.29	-0.02	0.29	-0.20	-0.31	-0.11
Diseases of the lungs	0.80	0.25	0.16	0.85	0.52	0.37	0.30	0.37
Diseases of the stomach and liver	0.31	-0.18	-0.19	-0.04	0.06	0.02	-0.11	-0.18
Diseases of the kidneys	0.19	0.25	0.48	0.22	0.35	0.24	0.31	0.17
Diseases of the generative organs	-0.02	-0.14	-0.19	-0.13	-0.16	-0.10	-0.14	-0.13
Diseases of the joints	0.01	0.04	0.05	0.03	0.09	0.06	0.00	0.01
Diseases of the skin	0.01	-0.02	0.03	0.01	0.01	0.01	0.02	-0.01
Childbirth and metria	-0.67	-0.54	-0.70	-0.62	-0.35	-0.64	-0.66	-0.96
Suicide	0.05	0.08	0.07	0.05	0.19	0.10	0.07	0.06
Other violent deaths	0.59	0.95	0.59	1.55	0.86	0.77	0.90	2.54
Other causes	-0.11	0.09	-0.07	0.09	0.13	0.07	-0.03	-0.17
All causes	4.61	-1.65	-2.77	1.80	3.34	0.02	-1.19	0.06

Notes. The regions in the table were composed of the following registration districts: 'phthisis pool' – Aberayron, Cardigan, Newcastle-in-Emlyn, Lampeter and Tregaron (total population of 71,182 in 1861); high wage agricultural – Easingwold, Great Ouseburn, Tadcaster, Wetherby and Wharfedale (total population of 85,377 in 1861); low wage agricultural – Bosmere, Cosford, Hoxne, Mildenhall and Thingoe (total population of 75,084 in 1861); manufacturing – Aston, Dudley, Walsall, West Bromwich and Wolverhampton (total population of 552,766 in 1861); south coast middle class – Brighton, Eastbourne, Lewes, Steyning and Worthing (total population of 173,897 in 1861); female factory work – Blackburn, Burnley, Chorley, Clitheroe and Preston (total population of 389,882 in 1861); female by-employment – Ampthill, Bedford, Leighton Buzzard, Luton, Woburn (total population of 119,369 in 1861); coal mining – Auckland, Chester-le-Street, Durham, Easington and Houghton-le-Spring (total population of 225,896 in 1861).

Figure 5

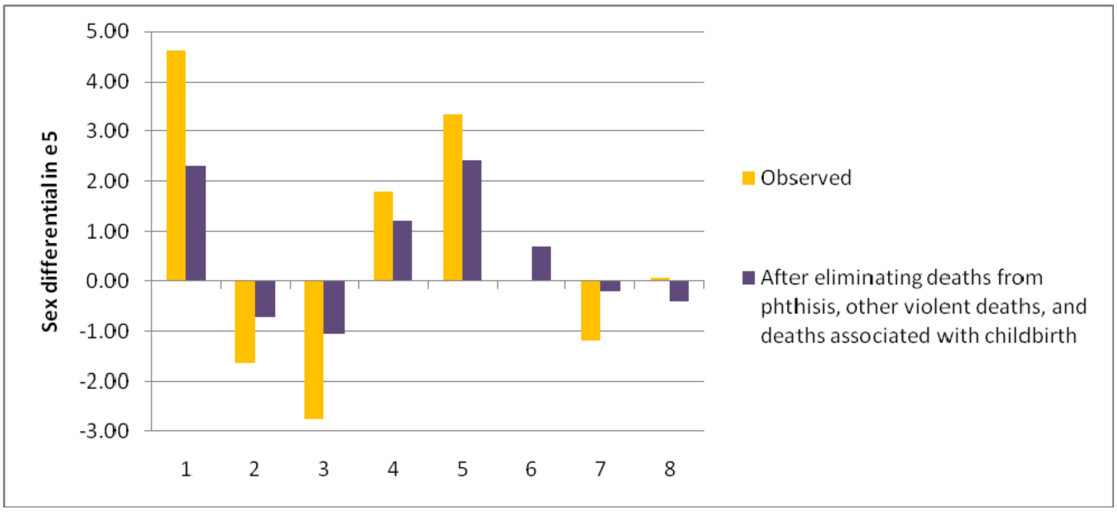
Contribution of deaths from phthisis, 'other violent' deaths, deaths associated with childbirth and deaths from remaining causes to overall sex differential in expectation of life at age 5 years: eight selected areas of England and Wales, 1860s



Note. Expectations of life are expressed as e_5 (females) minus e_5 (males). 1 – 'Phthisis pool', 2 - High wage agricultural (Yorkshire), 3 – Low wage agricultural (Suffolk), 4 – Manufacturing (west Midlands), 5 – south coast middle class (Sussex), 6 – female factory work (Lancashire), 7 – female by-employment (Bedfordshire), 8 – coal mining (Durham).

Figure 6

Comparison of observed sex differential in the expectation of life at age five years with that which would be expected if deaths from phthisis, 'other violent' deaths and deaths associated with childbirth were eliminated: eight selected areas of England and Wales, 1860s.



Note. Expectations of life are expressed as e_5 (females) minus e_5 (males). 1 – 'Phthisis pool', 2 - High wage agricultural (Yorkshire), 3 – Low wage agricultural (Suffolk), 4 – Manufacturing (west Midlands), 5 – south coast middle class (Sussex), 6 – female factory work (Lancashire), 7 – female by-employment (Bedfordshire), 8 – coal mining (Durham).

where childbirth had a greater or lesser impact than this were characterised by exceptionally high or low fertility. In the coal mining area of Durham, for example, the average women in the mid-nineteenth century had more than five children, and deaths associated with childbirth 'cost' women nearly a whole year of life compared with males.[59] By contrast, some of the lowest fertility rates in England were recorded in the south coast registration districts of Brighton and Steyning, where the impact of deaths associated with childbirth on the sex differential in e_5 was only about one third of a year of life.[60]

Figure 6 examines the effect of eliminating mortality from these three causes on the sex differential in e_5 in the eight areas. In each of the three agricultural areas, where females suffered mortality higher than that of males, the differential is reduced by more than 50 per cent, and in the three areas where female advantage is most marked, the elimination of these three causes reduces it substantially.

Discussion and conclusion

This paper has applied a new method of evaluating the contribution of different causes of death to overall differentials in mortality. The major advantage of the approach of Beltran-Sanchez and his colleagues over previous approaches is its ability to distinguish between the value of the contribution of a particular cause of death to an overall mortality differential between two populations, and the effect on that overall differential of eliminating a particular cause of death. These two quantities are

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[59] Woods, *Demography*, plate *e*, 96-7.

[60] Woods, *Demography*, plates *e* and *f*, 96-7.

generally not the same, because the elimination of one cause of death changes the cause structure of mortality in general (that is, it increases the number of deaths from the remaining causes). Therefore a cause with a small *direct* contribution to an overall mortality differential can have a large *indirect* effect if it is eliminated, and *vice versa*. Both decomposition and cause elimination are required for a proper understanding of the impact of causes of death on differential mortality. Cause elimination alone does not distinguish between direct and indirect effects (to what extent is the effect due to the cause itself and to what extent due to the consequent re-organisation of the impact of other causes?). Decomposition, however, measures the direct effect of cause elimination.

Of course, the approach of Beltran-Sanchez and his colleagues still involves assumptions about what happens if a cause of death is eliminated. For example the distribution of the deaths which now have to be attributed to another cause will depend on the relationship between different morbid conditions. It has been suggested, for example, that infectious diseases in childhood can reduce resistance to tuberculosis in adulthood. Therefore if diseases such as measles and smallpox were eliminated, we might expect death rates from phthisis to fall as well.[61] These kinds of effects are not taken into account by the cause-elimination formulae of the method used in this paper. However, since both our evidence for, and our understanding of, these kinds of relationships between diseases is still grossly incomplete, any kind of approach which would incorporate them is still some way off.

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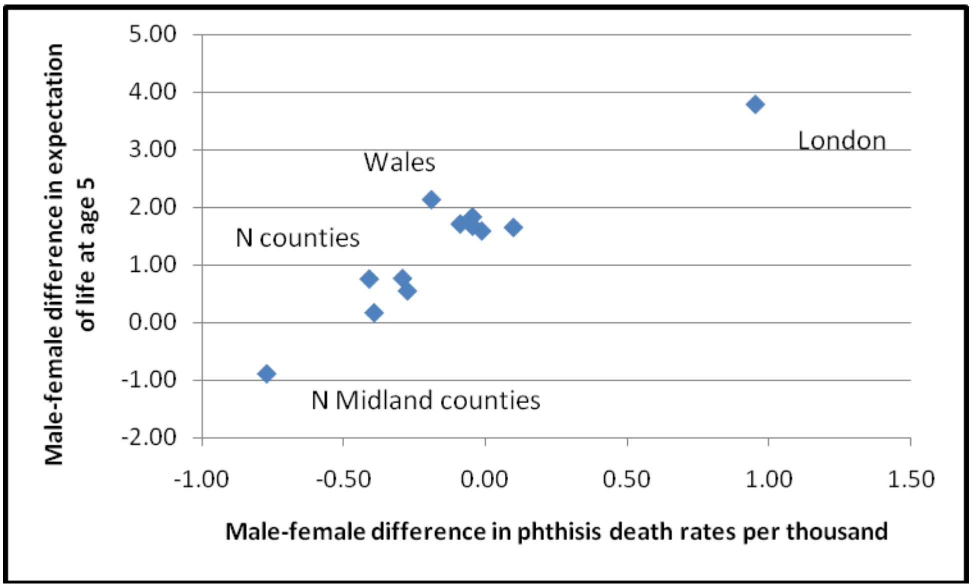
[61] See the discussion in Kunitz, *Health of Populations*, 193-4.

Figure 4

Relationship between sex differentials in expectation of life at age five years and in death rates from phthisis: 11 Registration Divisions of England and Wales, 1860s



Source. R. Woods, *Causes of death in England and Wales, 1851-60 to 1891-1900: the decennial supplements* [computer file] (Colchester, UK Data Archive [distributor], 1997), SN 3552. This is available from the UK Data Archive at the University of Essex (www.data-archive.ac.uk).

Note. The differences in both variables are expressed as female minus male.

Viewed using the perspective of causes of death, sex differentials in mortality in mid-nineteenth century England are most conveniently seen as the outcome of differential mortality from three distinct causes of death: pulmonary tuberculosis or phthisis, violent deaths, and deaths associated with childbirth, together with the differential mortality from the remaining causes of death.

Generally speaking, phthisis mortality disadvantaged females relative to males, but this was not universally the case. It was true in agricultural areas, in coal mining areas, and more generally in eastern England and what would now be described as the east Midlands. Overall sex differentials in mortality were partly a function of the prevalence of phthisis, but much more clearly of the extent to which phthisis mortality disadvantaged females. Where phthisis mortality disadvantaged females, the overall sex differential between female and male mortality, as measured by $e_5^f - e_5^m$, was small or even negative; where phthisis mortality disadvantaged males, $e_5^f - e_5^m$ was large. The closeness of the relationship between the male-female differential in phthisis mortality and in the expectation of life at age five years is revealed by Figure 4.[62] The position of two divisions of the country is particularly noteworthy. In London, the female advantage was far greater than in any other region mainly because, uniquely among the divisions, in London phthisis mortality was higher for males than females. Robert Woods has made the point that mortality in London had

[62] So far as the impact of phthisis mortality is concerned, then, the conclusion of the paper reflects that of Woods and Shelton, *Atlas*, 107-14, in which geographical variations sex differentials in phthisis mortality are presented and shown not to have any clear relationship with regional variations in the quality of life.

distinctive features.[63] Death rates in London were considerably lower than those in other major cities, such as Liverpool and Manchester. It is clear that this distinctiveness extended to the sex differential in mortality from phthisis.[64] The other division which stands out is the north Midland counties where the female disadvantage from phthisis was substantially greater than anywhere else in the country. Further investigation into the reasons for the pattern of phthisis mortality in this area would be useful.

The fact that phthisis mortality did not everywhere disadvantage females casts doubt on the hypothesis that female under-nutrition was mainly responsible for the high female death rates from this cause. Although the evidence from many rural areas in England is consistent with it, the evidence from manufacturing areas does not suggest that females in manufacturing areas where work for married women was in plentiful supply did better than those in areas where it was not. Moreover the under-nutrition account has to explain why in rural Wales it was young *men* who were considerably disadvantaged by phthisis mortality. Either the bargaining position of rural Welsh men in the home was greatly different from that of rural English men, or some other account of the sex differential in Wales is required.[65] The problem with the

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[63] Woods, *Demography*, 375-80.

[64] For a detailed analysis of sex differentials in mortality in London, comparing the decade 1851-1860 with 1901-1910, see G. Mooney, 'Shifting sex differentials in mortality during urban epidemiological transition: the case of Victorian London', *International Journal of Population Geography* 8 (2002), 17-47.

[65] As Woods and Shelton wrote: 'it is no simple matter to demonstrate the value' of the arguments put forward by Michael Anderson; excess female mortality 'was almost exclusively a rural phenomenon at mid-century, but not all rural districts experienced such excess' (Woods and Shelton, *Atlas*, 135, 138).

'bargaining' account of differential nutrition leading to different mortality levels for men and women might be the relationship between nutrition and mortality. In a recent paper, Sara Horrell and her colleagues have provided important new evidence to show that, in London the 1860s and 1870s, women—especially married women—were undernourished relative to men.[66] They base this conclusion on the analysis of data on the heights and weights of men and women incarcerated in Wandsworth House of Correction. Perhaps their most remarkable finding is that, unlike men, women tended to *gain* weight while they were in the House of Correction, despite being subject to hard labour and compelled to subsist on the meagre prison dietary, an observation which, in their words, 'points to a level of deprivation outside in the free world that is hard to comprehend'.[67] However, our results reveal that despite this, women enjoyed a considerable mortality advantage over men in London. If Horrell and her colleagues are correct about the relative nutritional status of males and females in London as a whole, it seems clear that the relative female nutritional deficiency did not translate into excess female mortality there. Indeed, the ages at which anthropometric indicators suggest that London women's position was worst relative to men (35-54 years) are precisely those ages contributing most to their mortality advantage (see Table 2 above). The attractiveness of the nutritional account has perhaps distracted attention from alternative arguments based on differential biological or physiological susceptibility to phthisis.[68]

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[66] Horrell *et al.*, 'Measuring misery'.

[67] Horrell *et al.*, 'Measuring misery', 111.

[68] In his recent review of the evidence relating the standard of living to mortality, Kunitz makes the additional point that 'the health of populations is responsive to many

Let us consider further the contrast between the 'phthisis pool' in Wales and the low wage agricultural area in Suffolk. [69] In the 'phthisis pool' area, the expectation of life of five-year old males was 4.6 years less than that of females, whereas in the Suffolk countryside it was 2.8 years greater, a 'difference in the differential' of 7.4 years. Of this 'difference in the differential', 4.7 years (64 per cent) was the result of the relative mortality of the sexes from phthisis. In the 'phthisis pool' area the male e_5 was 49.9 years, and the female e_5 was 54.5 years. In the Suffolk area the male and female e_5 values were 55.5 and 52.8 years respectively. The difference between the two areas in the level of male mortality was therefore considerably greater than the difference in female mortality. Characterising the sex differential in mortality in terms of 'excess female mortality' diverts attention from the impact of variable mortality for men. To return to the question posed by McNay and her colleagues as to why south Wales offered a 'relatively benign' setting for women, we can offer the answer that south Wales offered an especially hostile setting for men, who suffered relative to women from phthisis in the rural south-west of

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more factors … than are summarized by the measures conventionally used. Much depends on the context, epidemiological, sociopolitical, as well as economic' (Kunitz, *Health of populations*, 76).

[69] It is striking that when Robert Woods attempted to classify the registration districts of England and Wales into 16 categories on the basis of 'the composition of their disease environments', he placed most of the registration districts in these two areas in the same category—with heavy mortality from phthisis in an otherwise rather healthy environment (Woods, *Demography*, plate *o*, 96-7; and 341-4). Within this ostensibly similar disease environment are areas with sex differentials in mortality at both extremes of the range observed in England and Wales.

Wales, and from accidental deaths associated with coal mining in the Welsh valleys and Monmouthshire.[70]

The male-female mortality differential was influenced to a lesser extent by the level of male deaths from 'other violent causes'. Most of these deaths were accidental, and many of them were the result of accidents associated with employment. Coal mining areas stood out for their high rate of male deaths from this cause, which in a few localities formed almost one out of every five deaths to males aged over five years. The impact of high rates of deaths from violence was to increase the female mortality advantage relative to males. In Figure 4, this is reflected in a shifting upwards of the point for the relevant division, as in the case of the northern counties and Wales and Monmouthshire where male deaths from 'other violent causes' were most common. Deaths from violent causes invariably disadvantaged males, and the extent of the disadvantage was principally associated with the extent to which males were engaged in hazardous occupations, of which by far the most important (and dangerous) was coal mining.

Deaths associated with childbirth, of course, disadvantaged females, and variations in the death rates from this cause were closely associated with regional variations in fertility. There is little evidence of any systematic variation in the risk associated with each birth.

After accounting for mortality from these three causes of death, what remains? In England and Wales as a whole, an advantage amounting to just under 1.5 years of

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[70] McNay *et al.*, 'Excess female mortality', 675. The importance of 'factors that might have helped to raise male mortality' was also pointed out by Harris, 'Gender, health and welfare', 195.

life at age five years accrued to females. A similar advantage arose in many regions of the country, including southern England (except London) and most western areas. The advantage to females was higher in London (about 2.5 years), middle class areas of southern England, and areas where phthisis was especially prevalent among males. It was lower in agricultural areas (especially poor agricultural areas), and in eastern and northern areas of the country, being lowest of all in an area encompassing Derbyshire, Nottinghamshire, Leicestershire and Lincolnshire.