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## Mortality inequalities: Scotland versus England and Wales

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## ABSTRACT

This paper is an observational study of particular historical trends in mortality inequality within Great Britain, comparing England and Wales with Scotland for the period 1925–2005. The inequalities in mortality within Great Britain have become more apparent over time. Growing inequality in premature mortality in Britain affected young Scottish men most severely after 1995. It would appear that something dramatic happened to the Scottish population in early 1970s which accelerated these broad and very important mortality differentials within Great Britain. The divergence in mortality within Great Britain is notable in successive male cohorts and to a lesser extent in women.

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## 1. Introduction

There have been numerous studies of inequalities in health between various population sub-groups within Britain. Several studies have highlighted growing health inequalities between regions and between Britain's constituent nations (Dorling, 1997; Mitchell et al., 2000; Townsend et al., 1988; Walsh et al., 2008). The existence of a widening 'North–South' divide in health (Shaw et al., 1999) within Britain is acknowledged and is thought to reflect a wider social and economic divide, a divide which is currently still widening rapidly (Bajekal et al., 2013; Barr et al., 2012; Thomas et al., 2010). The general trend is that the north of England and Scotland have experienced, and continue to experience, worse health outcomes than areas in the south of England (Hacking et al., 2011; Townsend et al., 1988).

This study explores the north/south health divide through a comparison of historical trends in mortality between Scotland, and England and Wales. Previous work has mapped historical spatial patterns of mortality in Britain (Dorling, 1997). Dorling asserted that 'between 1950 and 1985 the standard mortality rate for Scotland, relative to England and Wales as 100, never fell below 111 or rose above 112' (Dorling, 1997, p. 27) suggesting a consistent and persistent Scottish disadvantage. In this study we build upon

previous work by investigating and visualising historical trends in mortality for Scotland, relative to England and Wales. Our analysis tracks changes in relative differences in mortality within Britain over time. We highlight when differences in mortality between Scotland, and England and Wales began to alter, for which specific groups of the populations, and at which ages. We present analyses separately for men and women. This reflects the consistently longer life expectancy for women, relative to men, within Britain as in developed countries worldwide (Kruger and Nesse, 2004; Rigby and Dorling, 2007). Within the United Kingdom (UK) the gap in life expectancy between men and women is greatest in Scotland (Gjonca et al., 2005) a gap of around 5 years.

The next section discusses the data and methods used, explaining in detail the utility of considering mortality differentials using Lexis diagrams. We then show our results from applying the Lexis method, pinpointing the beginning of the current divergence in mortality rates within Britain and charting the subsequent development. Finally, we discuss the results, their implications and possible links to key historical events and developments throughout the study period.

## 2. Methods

The data used were derived from the Human Mortality Database (HMD). The HMD has a full methods protocol available detailing how the data were constructed (see Wilmoth et al.,

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2007). The data consist of annual death rates for England and Wales and Scotland by single year of age and sex. The data cover the time period 1925–2005. Since the data captured mortality in the entire population, there was a very large sample size, allowing for fine grained analysis. The data for 2005, for example, included 2,456,109 Scottish men and 2,638,691 Scottish women, and 26,096,092 English and Welsh men and 27,142,483 English and Welsh women. The total sample size for the study is 58,333,375, which is the count of people in 2005 alone.

Data analysis was undertaken using the statistical software R. Two types of analysis were undertaken. First, rate ratios for mortality in Scotland relative to England and Wales were calculated. Second, Lexis diagrams were constructed (Lexis, 1875). The Lexis diagrams were drawn using the Lexis map software, following the approach taken by Rigby and Dorling (2007) in their study of temporal trends in gender differences in mortality. The Lexis diagram, (or Lexis map), is 'one of the most useful technical devices of demography' (Alho and Spencer, 2005, p. 17). However, any reader unfamiliar with a Lexis diagram will need some orientation.

The horizontal axis on the Lexis diagrams (Figs. 1–4) represents time. In this case it shows the study period, from 1925 to 2005. The vertical axis represents age, from age 0 to age 90+. This combination of 81 years (columns), by 91 age groups (row) creates a matrix of 7371 cells. In Figs. 1 and 2 (for England & Wales and Scotland respectively), each cell is then shaded by the mortality rate for that age group, in that year (darker shading indicating lower mortality rate, lighter shading indicating higher mortality rate). The resulting diagram summarises a complex three dimensional distribution; mortality, by age and time (Gjonca et al., 2005, p. 11). In Figs. 3 and 4 (for women and men respectively), each cell is shaded by the mortality rate ratio (the age and time specific rate in Scotland divided by that in England and Wales); lighter shading denoting higher mortality rates in Scotland as against England and Wales. So, Figs. 1 and 2 map mortality rates for populations by single year of age and time, and Figs. 3 and 4 map the ratio of those age specific rates between Scotland, and England and Wales, over time. Diagrams show results for men and women separately.

The great strength of Lexis diagrams is that they enable identification of age, period and cohort effects. Age effects are apparent as horizontal lines of similar grey scale shading; if everyone in a particular age group has a similar mortality rate, or rate ratio, the shading for that age group will be similar. Cohort effects are apparent as diagonally upwardly sloping lines of similar shading (as people age over time). Period effects are shown as vertical columns of a similar grey scale shade; if mortality rates or rate ratios are similar within time points, the shading for that time will be similar. Lexis diagrams are designed to enable 'contour' shading, so that distinctions between 'areas' with similar rates can be highlighted. These are the grey lines that appear to emphasise the differences between 'clumps' of combinations of age and year with similar mortality rates or rate ratios.

### 3. Results

The most striking pattern in Figs. 1 and 2 is the darkening shade, indicating falling Age Specific Death Ratios ASDRs, as you move from left to right (i.e. from the past to the present), particularly at younger ages. This shows the gradual decline in mortality rate over time; population health has improved, particularly for children and young adults. Generally speaking the increasing risk of mortality with age is also very clear; the shading gets lighter towards the top of both Figs. 1 and 2. A good illustration of the power of Lexis diagrams is in how they allow

the viewer to visualise the impact of the Second World War on mortality rates. For men (Figs. 1b and 2b), there is a dramatic lightening of the shade for those aged about 18–28, in the years labelled World War II. The contrast between the figures for men and women is also striking. Women's greater longevity is clearly shown by the persistence of darker shading at greater ages (compare Fig. 1a and b). However, the change over time (i.e. from left to right) is also very different. For women from about 1950 onwards much lower rates establish themselves, at a wider range of ages. This is shown by the growing (from left to right) expanse of the darkest shading.

Figs. 3 and 4, show that trends in *rate ratios* between Scotland, and England and Wales, are more complex than trends in mortality for each geographic entity. For both men and women, the most striking feature on the diagrams is the apparent impacts of World War II. Scotland fared relatively worse than England and Wales. Young women in Scotland died at an enhanced rate compared to women in England and Wales through to at least 1955 (Fig. 3). For men, the upwards and rightwards diagonal of pale shading, indicating higher mortality rates in Scotland, extends into the 1960s (Fig. 4). Children's mortality rates appear worse affected by wartime in Scotland as compared to England and Wales (indicated in both Figs. 3 and 4).

For men in particular, there are three more striking features not directly associated with war-time. First, there is an upwards and rightwards pale band for those aged 30–40 from 1925 up until at least aged 70–80 by 1975. This indicates that Scottish men born about 1885–1895 experienced a worsening of their mortality rate, relative to those in England and Wales. In some ways, Scotland's relatively worse mortality experience began a long time ago. Second, there is a very considerable upwards and rightwards pale diagonal, extending from those aged about 30 in the early 1970s, persisting through to 2005 (by which time, these men are aged 65). This denotes a cohort effect. Third, there is a very substantial pale shading feature ranging from ages 17 around 1992, continuing through to these people's mid 40s, and persisting from about the early 1990s right through to 2005. The figure shows that those men who were aged about 20 in 1995 had mortality rates 1.4 times greater than men in the rest of Britain. Those aged about 20 in 1995 were, of course, born about 1975, the same era as the start of the visible cohort effect on those aged about 30 in 1975 (their fathers' generation). Cohort effects for women are more subtle (Fig. 3), but also show a worsening over time since the 1970s.

A further feature in Figs. 3 and 4 is the concentration of darker shades in the under 20 year olds, post-1950. For these age groups in these years, the rate ratios less than 1 means that Scotland's mortality rates are lower than those in England and Wales. The pattern for males and females is similar, but more marked for girls and young women. There is a noticeable Scottish advantage in comparison to the rest of Britain for women under 20 years old between approximately 1965 and 2005. Scottish males aged up to 15 fare relatively well compared to their English and Welsh counterparts in the period following 1990. It is the sudden reversal of fortunes once males reach age 16 to 18 (perhaps linked to labour market entry, perhaps also to car driving) that is noteworthy.

The gradual slide from equality with England and Wales to elevated mortality in Scotland can be seen by looking at men aged 45. Starting at the bottom of the distribution in 1925 (rate ratio 1) and reaching the top of the distribution by the end of the period (rate ratio 1.35), working age males' relative mortality prospects have been gradually declining over time. This means that for every 100 men dying in England and Wales aged 45 in 2005; the equivalent is 135 men aged 45 dying in Scotland. This compares with equal numbers in both England and Wales and Scotland in 1925, for 45 year old men.

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