One Hundred Years of US Racial Inequalities in Mortality: A Decomposition of the Distribution of Deaths by Age Group, 1900-1999

Introduction

To date, much of the social epidemiological literature has focused on identifying and explaining the differences in the central tendency of health indicators between subpopulations defined by social position. In this paper, I explore the use of a measure of the distribution of health in a total population (defined by nation-states), and the subpopulations that comprise it. I argue that inequalities in longevity within and between subpopulations, defined by social group status, will vary with epidemiological changes in the total population mortality regime (for example the transition from infectious disease mortality to chromic disease mortality as the leading cause of death). These inequalities in longevity are hypothesized to correspond with changes in the degree of within group variance at the population level from the beginning of one mortality regime through a transition to a second. I hypothesize that changes in mortality in specific age groups (associated with mortality regime changes) determine the changes in subpopulation and total population heterogeneity in the age of death. This theoretical model is empirically tested by decomposing the changes in the distribution of deaths by age in ten year periods from 1900 through to 2000 for US white and non-white men.

Demographers and public health researchers have studied the relationship between improvements in total population survival and total population living conditions over the last century, developing and critiquing The Demographic Transition Theory and The Epidemiological Transition Theory (Thompson 1946, Notestein 1950, Omran 1971, Caldwell 1976, Olshansky & Ault 1986, Coale & Watkins 1988, Horiuchi 1999, Greenhalgh 1990). At the same time, anthropologists and human ecologists have continued to study a related but historically broader literature on the evolution of the human life course (Carey 1997, Kaplan 1997). At the intersection of economics and medicine, specific technological innovations have been related to improved nutrition, taller stature and greater longevity (Fogel & Costa 1997), and among some sociologists, the social stratification of knowledge and innovations provides the "fundamental cause" for the social stratification of health (Link et al. 1998). This paper integrates and extends these theoretical frameworks to address more explicitly the patterns in health within total populations. I frame the discussion around phases of The Epidemiological Transition (Omran 1971, Horiuchi 1999). Specifically, these include: the age of receding pandemics in which infectious disease predominates trends; the age of degenerative and 'man-made' diseases in which chronic diseases predominate; and the slowing of aging and reverse transitions when reductions in disability and very-old age mortality are observed.

Variance or inequality in mortality is considered here in terms of the age at which death typically occurs in a population or subpoulation. For example, a period in which infant mortality is high (indicative of the age of receding pandemics), but chronic disease is becoming more prevalent (indicative of a mortality transition to degenerative and 'man-made' diseases) would have a wide a wider distribution of deaths than the period preceding it. For several decades, mathematical demographers and researchers interested in aging have examined the degree of variance in survivorship, or rectangularization of survival curves, using measures such as Keyfitz's *H-index*. Biodemographers have suggested recently that this literature might be related with the evolutionary literature on selection and survival (Tuljapurkar 1997). Moreover, economists have brought to attention the importance of addressing differences in the *distribution* of health when considering social inequalities in health, often linking it with the long history of similar analyses being done of income inequality (Gakidou et al. 2000). In this paper, I use the interquartile range of the distribution of deaths in the life table as an indicator of population and subpopulation inequality in mortality. Wilmoth & Horiuchi have advocated this measure over other potential indicators in light of its simplicity and interprability (Wilmoth & Horiuchi 1999).

Methods

The data come from the National Vital Statistics System for the US. Yearly, age-specific mortality rates were accessed in tabular form from the National Center for Health Statistics in the US Centers for Disease Control (2005b, 2005a). The US has consistently reported mortality rate from 1900-2000 by white and 'non-white' racial identity for men and women.

For the decomposition of the ten-year changes in the distribution of deaths by age, I use the method detailed by Wilmoth and Horiuchi (1999). The equations involved in this decomposition are described in the following equations (i.e. equations 1.1-1.5).

The life table *IQR* at time *t* is defined as the difference between the 25th and the 75th percentiles of the life table distribution of deaths such that:

$$IQR(t) = x_{75}(t) - x_{25}(t). \tag{0.1}$$

A change in the 'p'th percentile of the life table distribution of deaths between time 't_1' and 't_2' can be equated with the force of mortality as follows:

$$\begin{aligned}\Delta x_p(t_1,t_2) &= x_p(t_2) - x_p(t_1) \\ &= \int_{t_1}^{t_2}\int_0^{\infty} \frac{-\frac{\partial}{\partial t}\mu(x,t)}{\mu(x_p(t),t)} \cdot I_p(x,t)dxdt,\end{aligned} \tag{0.2}$$

where

$$I_p(x,t) = \begin{cases} 1 \text{ if } x < x_p(t) \\ 0 \text{ else} \end{cases}. \tag{0.3}$$

Using these relationships, the change in the *IQR* from between time 't_1' to 't_2' can be written as follows:

$$\begin{aligned} \Delta IQR(t_1,t_2) &= \Delta x_{75}(t_1,t_2) - \Delta x_{25}(t_1,t_2) \\ &= \int_{t_1}^{t_2}\int_{0}^{\infty} -\frac{\partial}{\partial t}\mu(x,t) \cdot \left[\frac{I_{75}(x,t)}{\mu(x_{75}(t),t)} - \frac{I_{25}(x,t)}{\mu(x_{25}(t),t)} \right] dxdt. \end{aligned} \tag{0.4}$$

In addition, the portion of the Δ*IQR* determined by the mortality change between time 't_1' to 't_2' in the age group from 'a' to 'b' as follows

$$= \int_{t_1}^{t_2}\int_{a}^{b} -\frac{\partial}{\partial t}\mu(x,t) \cdot \left[\frac{I_{75}(x,t)}{\mu(x_{75}(t),t)} - \frac{I_{25}(x,t)}{\mu(x_{25}(t),t)} \right] dxdt. \tag{0.5}$$

This last relationship allows me to decompose the changes in *IQR* from one time period to the next into changes in mortality reductions (or increases) in specific age groups. This is conducted for the periods 1900-1909; 1920-1929; 1950-1960; 1970-1980; and 1990-1999.

Initial findings & Discussion

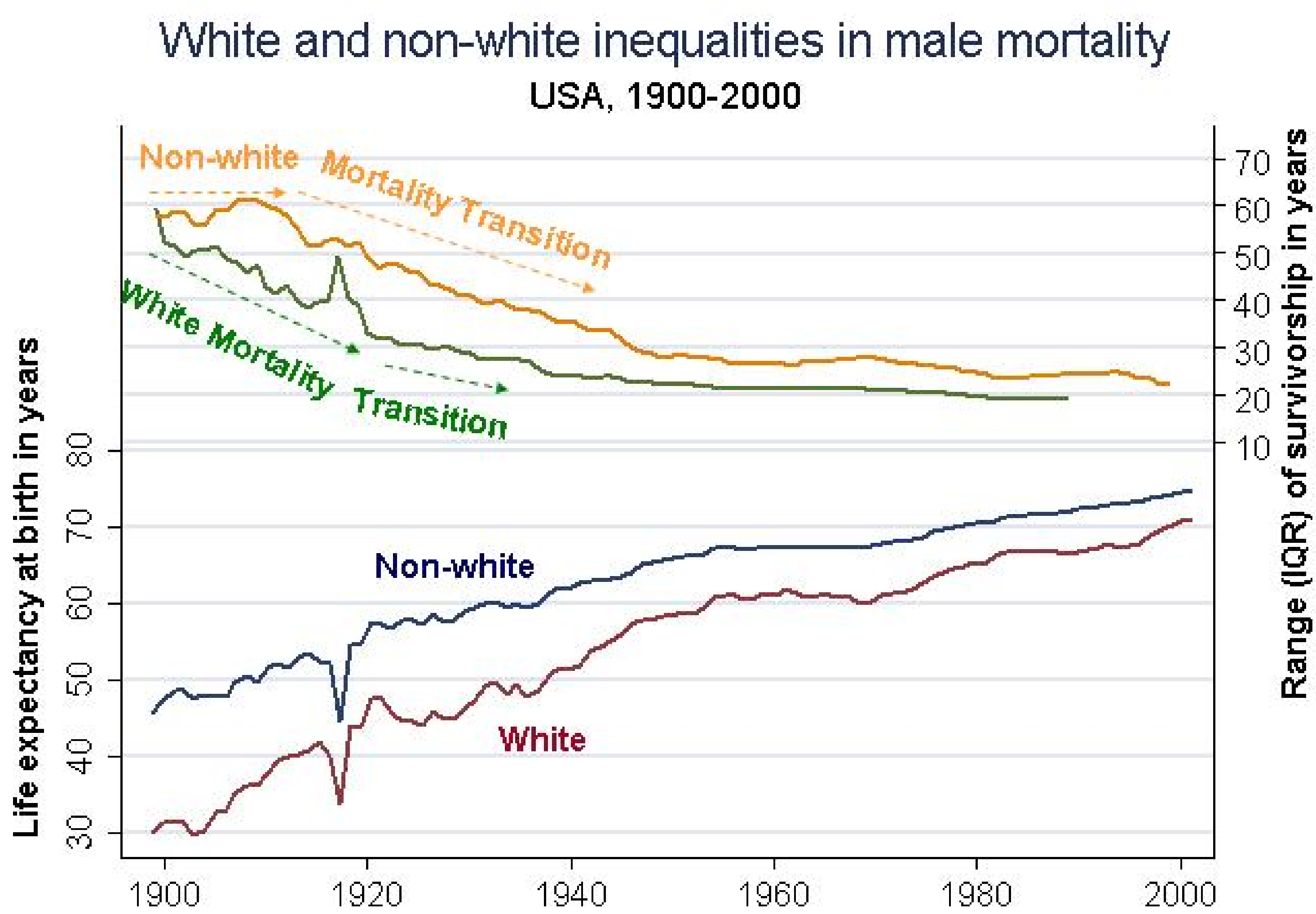
Table 1 depicts the yearly trends in life expectancy and the yearly trends in the *IQR* for white and non-white men. Three periods of widening and converging inequalities in life expectancy (a measure of central tendency) are observed which are consistent with mortality patterns suggested by the Epidemiological Transition Theory. These have occurred: 1) in the first several decades of the twentieth century; 2) during the period between 1960 and 1980; and 3) during the period between 1980 and 2000.

In addition, Table 1 depicts the changes in the *IQR* over the twentieth century. Consistent with the three periods identified above, there is widening and converging inequality in the distribution of death between 1900 and 1940, 1960 and 1980, and (if the trends for 'whites' are projected forward) 1900-2000. In these periods, there is an apparent increase in 'non-white' inequality in the distribution of death (as measured by the *IQR*) from the beginning to the middle of the period and then a decrease in the distributional inequality from the middle to the end.

It is noteworthy that the 1918 flu pandemic increased the variance in deaths such that the *IQR* was nearly as large as the *IQR* for non-whites in that year. This is likely due to the increase in child and infant deaths, which stand out from the trends in declining mortality in these age groups (likely leading to the decreases in the *IQR*) from the beginning to the end of the period.

It is expected that the decomposition of the changes in *IQR* during these age periods will indicate that decreases in the inequality are due to specific mortality changes. For the first period, these would be reductions in child and infant mortality and greater concentration of death in the middle and older ages. For the second period, it will involve reductions in midlife mortality (associated with chronic diseases) and a concentration of mortality in the older ages, and for the last period it will involve further expansion and rectangularization in the older ages (Manton et al. 1991).

This research offers a unique perspective on social inequalities in health by linking the Epidemiological Transition Theory to new methods for the studying of survival in aging populations.



Note: Data from the US National Center for Health Statistics, Centers for Disease Control.
(1918 dip caused by 1918 Influenza Pandemic)

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