The Age-Pattern of Sex Differences in Mortality Improvement

Benjamin Seligman, Gabi Greenberg, Shripad Tuljapurkar

1 Introduction

Sex differences in life expectancy and mortality change have been a topic of ongoing interest. While female life expectancy exceeds that of males in most populations, among developed countries since the 1970s the increase in life expectancy over time has accelerated for males, resulting in rapid catch-up and a narrowing in the differential. A compelling explanation for this has been hypothesized to be the effects of tobacco use, which declined for males over this period, as compared with some increase among females [1,2]. However, while Preston and Wang noted cohort effects in the male-female mortality differential [3] and were able to correct for them in forecasts by incorporating cohort smoking histories [4], the signature of tobacco among causes of death and the age pattern of these changes have not been thoroughly explored.

We set out to understand the age-pattern of improvement in life expectancy among males and females since the 1970s and to assess the contribution of tobacco-related mortality change to this improvement.

2 Methods

The decomposition of change in life expectancy over time into different components has previously been addressed by Demetrius [5], Keyfitz [6], Pollard [7], Goldman and Lord [8], and Vaupel [9]. Taking advantage of entropy of the life table, defined as:

$$\frac{-1}{e_0}\sum_{0}^{\infty} l_x ln(l_x)$$

We can interpret $\frac{-1}{e_0} l_x ln(l_x)$ as the elasticity of life expectancy to mortality change at age x. Then, given a proportional change in mortality rates at age x ϵ_x, the absolute change in life expectancy is:

$$\Delta e_0 = \epsilon_x l_x ln(l_x)$$

To investigate the age-pattern of mortality change, we multiply the age- and sex-specific elasticities by the proportional change in mortality rates (for specific causes of death, as a proportion of all-cause mortality) and take the male-female difference. To make our results more interpretable, we did not divide the age-specific entropies/elasticities by e_0, allowing multiplication by a proportional change in mortality rates to yield the change in absolute years of life expectancy.

Sex-specific life tables for the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) were taken from the Human Mortality Database (HMD) [10]. Analysis of Germany was limited to the regions that comprised the former West Germany, while national populations for the UK and France were used out of the available options. Data were taken from 1950 onward (1956 for West Germany).

To construct survival probabilities and life expectancies, mortality in the first year of life was estimated using formulae for males, females, and both sexes combined as appropriate [11, 12]. Observed life expectancy at birth, e_0, was generated in two fashions: one set was taken directly from HMD life tables, the other set was generated by summing the probability of mortality at each age x, q_x, across all ages x. The q_x values were taken from the HMD life tables or, for the first year of life, calculated using the formulae described below. These two approaches yield identical life expectancies.

To calculate the probability of death from birth to age one, ${}_1q_0$, given the infant mortality rate m0, we use the formulae previously described by Preston [11,12] for males, females, and combined sexes as appropriate. To get this probability of death, the formula is:

$$q_0 = \frac{{}_1m_0}{(1 + {}_1m_0(1 - {}_1a_0))}$$

Here ${}_1a_0$ (with ${}_1m_0 < 0.107$), the average number of years lived by those who died before age 1, is estimated by:

$$\text{combined sexes: } {}_1a_0 = 0.07 + 1.7 * {}_1m_0$$
$$\text{males: } {}_1a_0 = 0.045 + 2.684 * {}_1m_0$$
$$\text{females: } {}_1a_0 = 0.053 + 2.800 * {}_1m_0$$

We show results in this abstract for several specific causes of death in the United States: lung cancer, which should be highly influenced by smoking; liver disease, which should not be influenced by smoking; and ischemic heart disease (IHD), which should be intermediate. Data on cause-specific mortality for liver disease and IHD were available from 1970 to 2011 in the CDC WONDER database [13–15], while data on lung cancer were from the World Health Organization from 1970 to 2010 [16].

3 Preliminary Results

Figure 1 shows the the differences in male versus female age-specific contributions to changes in period life expectancy since 1950 among the G7 countries. Among the Western members of the G7, between 1970 and 1985 there is a change in the age-pattern of male-female differences in increase in life expectancy. Specifically, in middle to later ages, the rate of mortality improvement swings from being notably higher for women to being notably higher for men. This suggests that the particular causes of death that underlie the acceleration in mortality improvement for men should primarily cause death between 40 and 80.

Figure 2 shows the specific contributions of liver disease, ischemic heart disease, and lung cancer to the male-female difference in mortality improvement. In the case of liver disease, the pattern of males improvement minus female improvement is not clear and consistent. By contrast, for lung cancer there is a clear signal of increased contributions to male life expectancy over female life expectancy beginning in the 1970s roughly between ages 40 and 80. For IHD, although the scale is quite different, there is again not a strong pattern of differences between men and women over time.

4 Discussion

This preliminary analysis shows clearly the age-pattern of mortality improvement that has led to male life expectancy catching up to that of women. Notably, in the Western countries of the G7, this began between the 1970s and mid-1980s for among people in their 40s to their 80s. With regard to the role of tobacco, lung cancer, which is heavily influenced by tobacco use, showed greater contributions to male life expetancy than female in the age groups expected, whereas liver disease, which is less influenced, does not. However, IHD, which was the main cause of mortality decline among both sexes and is substantially influenced by tobacco, does not show a clear sex-specific pattern.

Further work will more closely explore IHD and other smoking-related illnesses and the age patterns of their contributions to male and female life expectancy. We will also broaden this analysis to include other countries. Finally, Japan has an age pattern of sex differences in life expectancy improvement that is different from the Western G7 countries. This may also be a topic explored in more detail.

References

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5 Figures

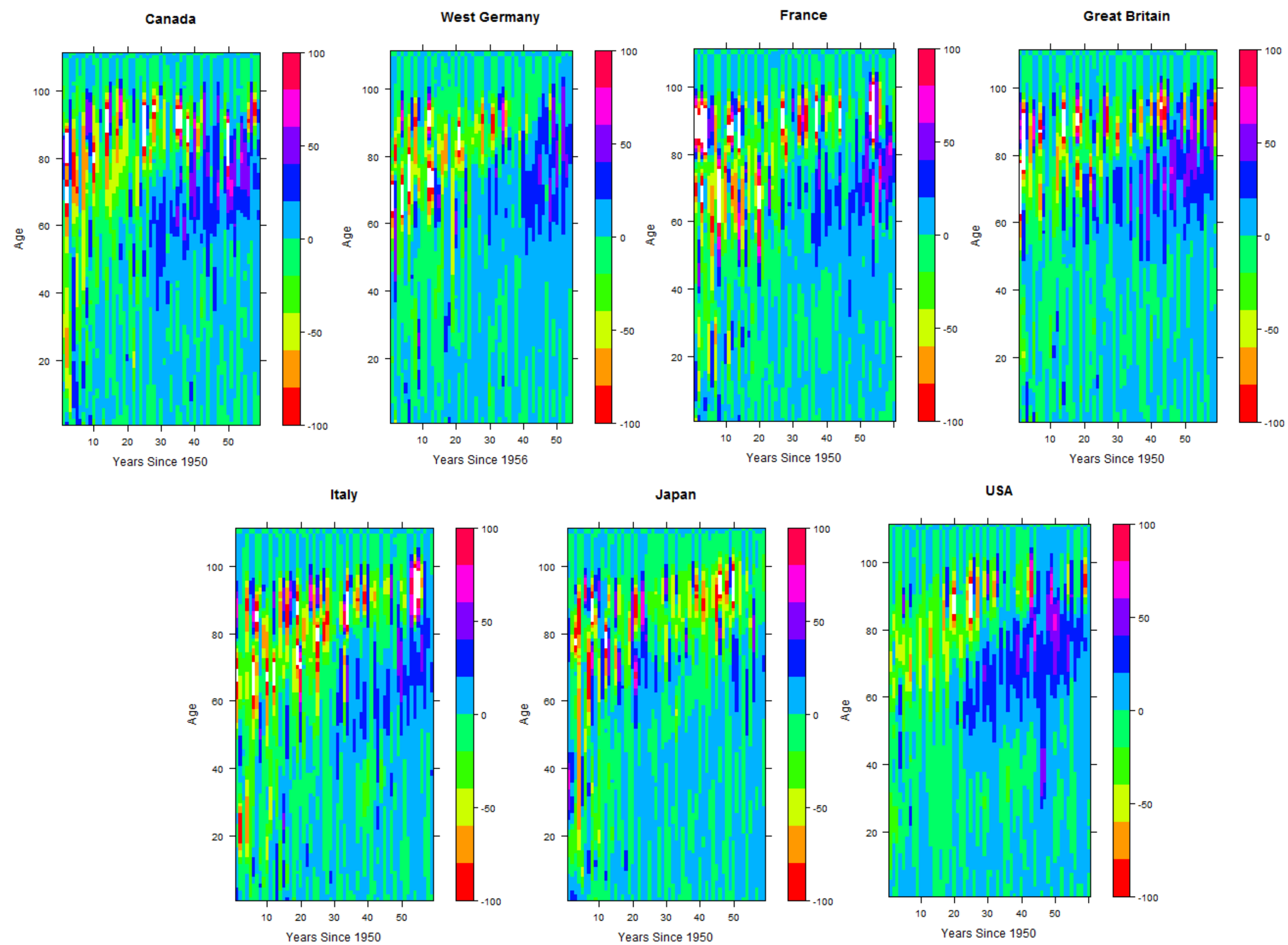
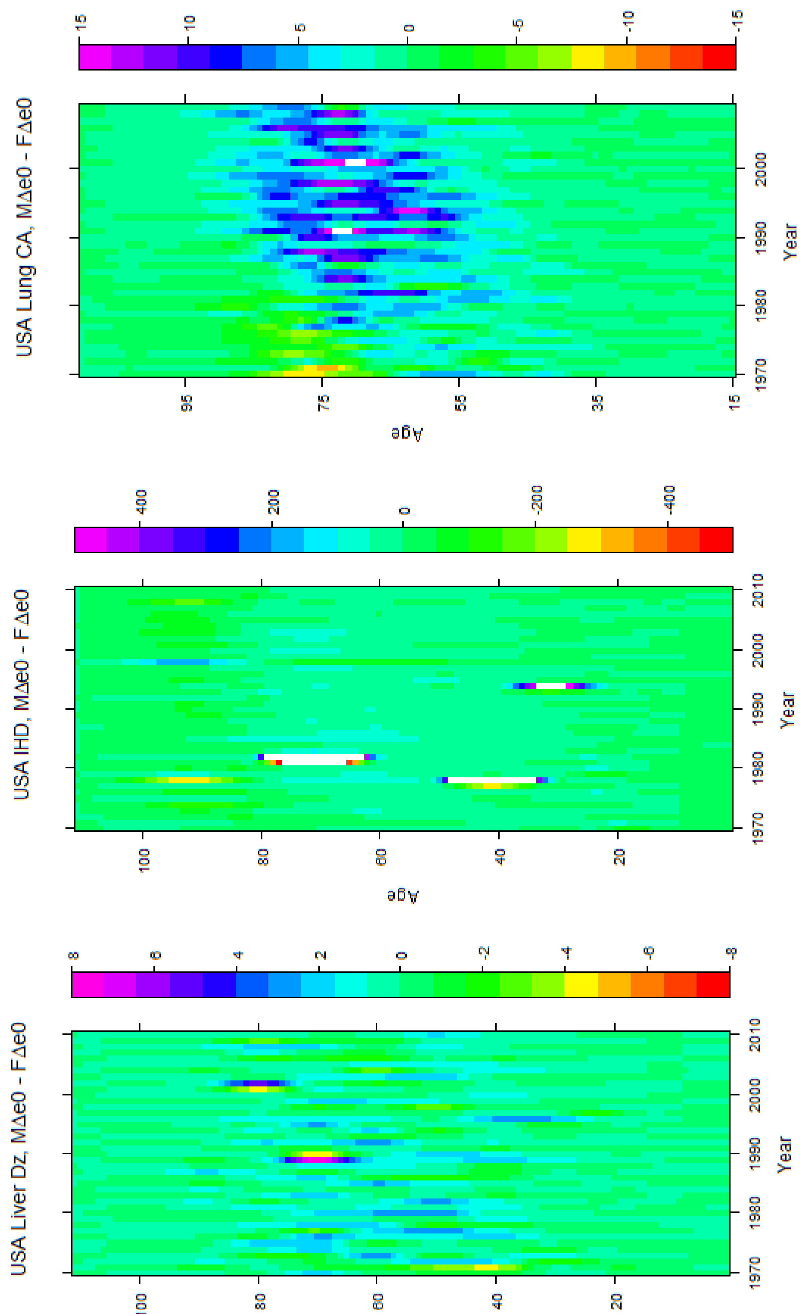

Canada
West Germany
France
Great Britain
Italy
Japan
USA
Age
Years Since 1950
Years Since 1956
100
80
60
40
20
10
30
50
0
-50
-100

Figure 1:



USA Liver Dz, MΔe0 - FΔe0
USA IHD, MΔe0 - FΔe0
USA Lung CA, MΔe0 - FΔe0
Age
Year

Figure 2: