

The Remarkable, Accelerating Decline in Mortality at Older Ages and the Prospects for Further Improvement in Life Expectancy

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INTRODUCTION

As an outcome of steady increases in life expectancy in many developed countries, record life expectancy has been linearly rising since 1840 (1). During recent decades these increases were mainly due to decreasing mortality at advanced ages. It has been shown that survival chances of the elderly have considerably improved since the 1950s and especially since the 1970s (2–4). Having further improvements in life expectancy is therefore dependent on continued decreases in old-age mortality. Whereas those previous studies were based on data until 1990, we investigate here whether survival improvements continued also during the 1990s or whether we can observe a slowing down in improvements which could indicate that mortality rates are close to a biological minimum.

MATERIALS AND METHODS

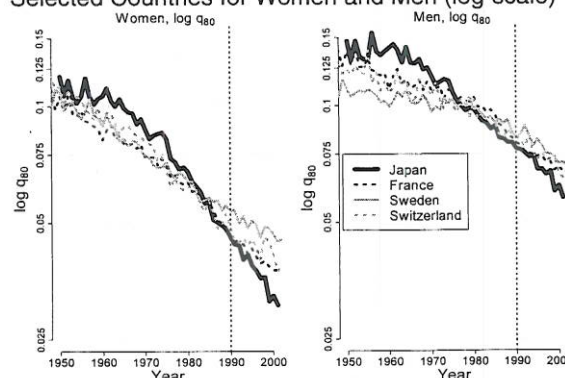
Our analysis is based on the "Kannisto-Thatcher Database on Old Age Mortality" which provides death counts and population estimates for more than 30 countries by age, birth year and current year for women and men aged 80 and older. We are analyzing survival improvements in this paper by plotting the logarithm of the probability of dying at age 80 for various countries over time. In addition we are calculating annual improvements in mortality following (4) which measures percentage reductions in mortality rates. To be able to make comparisons over time, across populations, and between sexes, we standardized the death rates using the Swedish population from 1950 to 2000. We restrict our analysis to France, Japan, Sweden, and Switzerland. They represent countries with high values of life expectancy. Detecting a deceleration of survival improvements in those countries could indicate that gains in life expectancy could be slowing down in the future.

RESULTS

Figure 1 shows the probability of dying at age 80 for women (left panel) and men (right panel) on a logarithmic scale from 1950 until 2000 separately for Japan, France, Sweden and Switzerland. Over time,

the jagged lines become more stable after the years 1970 which reflects that more and more people reached those ages. More importantly, death probabilities do not appear to be close to a biological minimum since they are continuously decreasing. Even after the year 1990, which provided the last year of available data for (2–4) and is marked by dotted horizontal reference lines, the general trend of continuous decreases in mortality persisted. Especially Japan gives evidence for rejecting the assumption that mortality rates hit a natural lower threshold. If this was the case, Japan should not show the steepest decline in mortality in recent years. Also the other three countries show a log-linear decline in mortality over time. The slope is, however, less steep in France, Sweden, and Switzerland than in Japan. These trends of log-linear decreases in mortality apply to women (left panel) and men (right panel) alike.

Figure 1: Probability of Dying at Age 80 (q_{80}) in Selected Countries for Women and Men (log-scale)



The absolute value of the slope for Japanese mortality in Figure 1 is increasing over time. This gives already some indication that survival improvements were accelerating over time. This can be better assessed using "Average Annual Improvements in Mortality" as outlined in Figure 2. There one can see for women in France, Japan, Sweden, and Switzerland combined for ages 80–84, 85–89, 90–94, and 95–99, how mortality improved in successive ten year periods. The first point of the black solid line indicates an average annual improvement in mortality of about 1.1% when

comparing the years 1950–59 with 1960–69. The next value refers to 1951–60 vs. 1961–70, etc.

Over time, one can recognize that mortality in all four analyzed age-groups fell at an increasing pace. Again, we are not able to detect any trend reversal during the most recent decade as indicated by the dotted vertical reference line. The last included values compare the period 1980–89 with 1990–99. We estimated for that last comparison that every year mortality dropped on average by more than three percent for women aged 80–84 in France, Japan, Sweden, and Switzerland and by about 2.5 percent for women between ages 85 and 89. Mortality of women aged 90–94 fell by 1.85 percent and the improvements for the oldest women in our analysis (aged 95–99) were about 1.25 percent annually on average.

Figure 2: Average Annual Improvements in Mortality in Successive Ten Year Periods for Women in 5-Year-Age-Groups for France, Japan, Sweden and Switzerland Combined

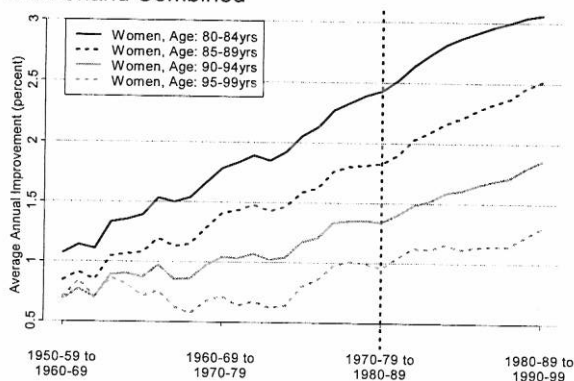
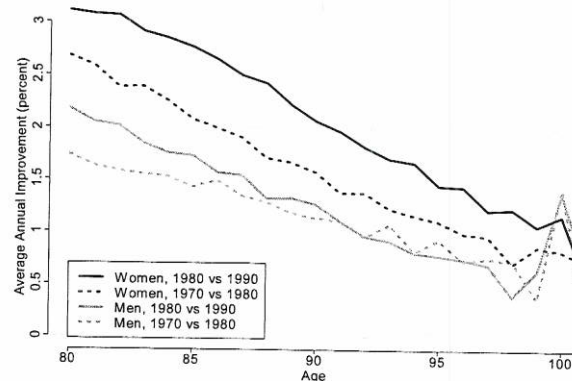


Figure 3 shows the results of average annual improvements in mortality for women and men by single year of age. Women's improvements are plotted in black, whereas the improvements of men are plotted in grey. Dotted lines refer to a comparison of the 1970s with the 1980s; solid lines compare the 1980s with the 1990s.

One can recognize that with increasing age improvements in mortality are becoming smaller – a finding which could be already concluded from Figure 2. Across all observed ages, the average annual improvements in mortality are larger for women than for men. By comparing the dotted with the solid lines, which is equivalent to a comparison of the 1970s/80s with the 1980s/90s, it is observable that mortality improvements were accelerating for women across all ages. At age 80, for instance, mortality dropped by about 2.6% annually for women between the 1970s and the 1980s. Ten years later, respectively, average annual improvements were larger than 3.1%. For men, improvements are visible until age 90. Men's mortality at age 80 dropped by about 1.7% between the 1970s and the 1980s and by roughly 2.2% between the 1980s and 1990s. After age 90 annual improvements remained relatively constant during the 1980s vs. the 1990s in comparison to the 1970s/80s.

At age 90, average annual improvements were 1.1% during both analyzed time periods.

Figure 3: Average Annual Improvements in Old-Age Mortality for Women by Single Year of Age for France, Japan, Sweden and Switzerland Combined



Our results have shown that mortality at the highest ages in four countries with relatively high life expectancy still continued since the 1990, the last year in which many analyses of old-age mortality are based. Mortality is still decreasing in a linear fashion on the log-scale in France, Japan, Sweden, and Switzerland. We found that average annual improvements accelerated for women over time across the age range of 80 to 99 years. Men displayed an increased pace in mortality improvements for octogenarians and a constant pattern for nonagenarians.

If mortality rates are close to a lower natural threshold one could expect that improvements in mortality rates should decelerate in countries with relatively high life expectancy such as France, Japan, Sweden, and Switzerland. In the light of our results the prospects for future gains in life expectancy are, therefore, promising since we did not find a deceleration in survival improvements in the four analyzed countries France, Japan, Sweden, and Switzerland. On the contrary: although women have lower mortality than men at all observed ages, their mortality dropped at an even faster pace than male mortality.

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