

# Age Patterns of Mortality Improvement by Level of Life Expectancy at Birth with Applications to Mortality Projections

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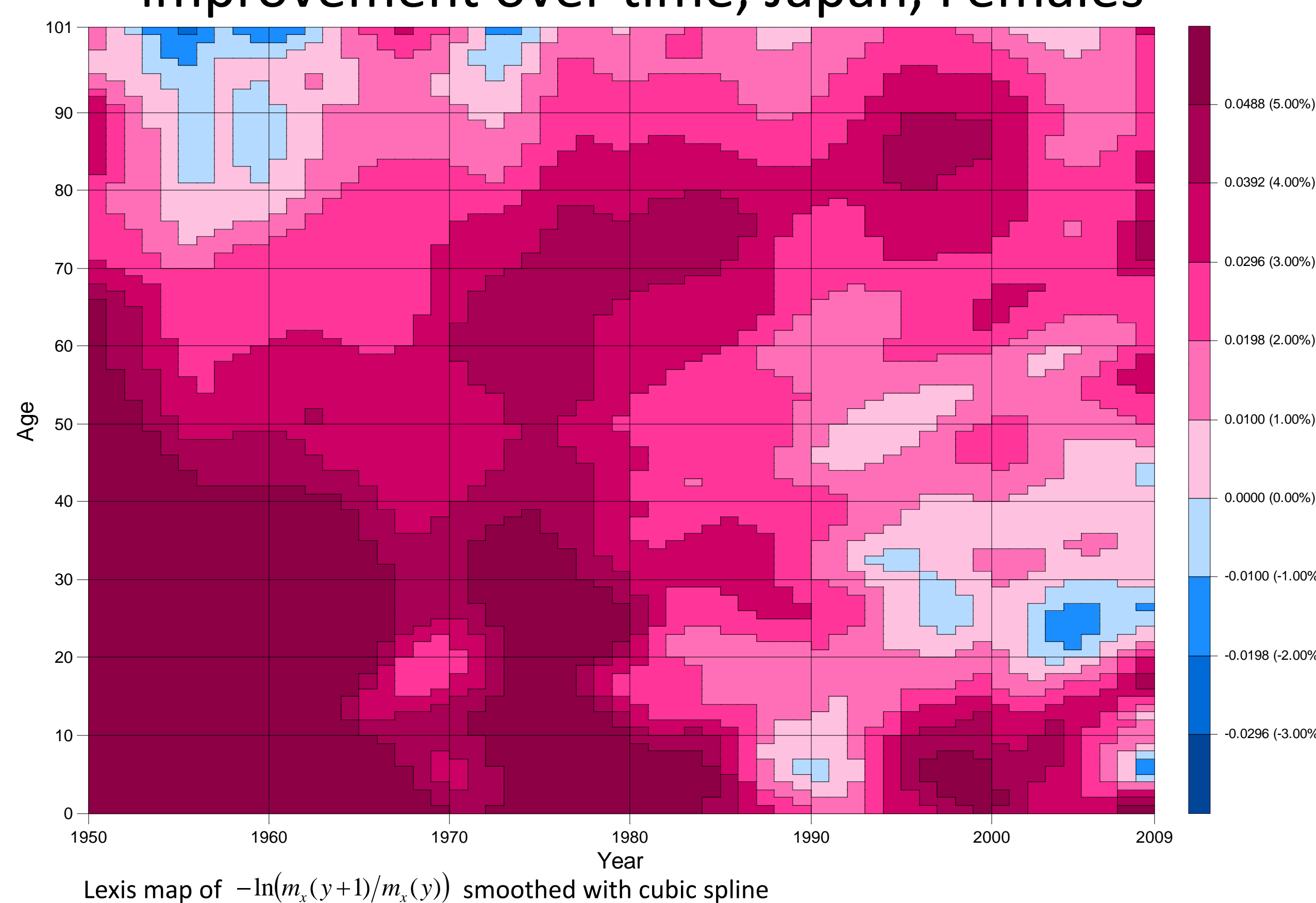
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**Abstract:** Mortality projections are often produced by a two-step procedure: first, projections of life expectancy at birth are prepared and, second, life tables consistent with the projected levels of life expectancy at birth are constructed. We propose a new method to construct projected life tables which incorporates typical age-specific patterns of mortality improvement. The patterns have been estimated from mortality dynamics of individual countries included in the Human Mortality Database. Such approach is important as it aids more accurate projections of future age patterns of human mortality.

**Problem:** To account for temporal changes in patterns of mortality improvement in mortality projections

Evidence of change in pattern of mortality improvement over time, Japan, Females



**Solution:** To estimate patterns of mortality improvement by level of life expectancy at birth and extrapolate them to higher levels of life expectancy at birth

**Definition of mortality improvement pattern,  $\rho_x$**

$$\ln m_x(t_2) = \ln m_x(t_1) - k(t_1)\rho_x(t_1) \quad (1)$$

$m_x(t_1)$  - death rates in  $[t_1, t_1+5]$

$m_x(t_2)$  - death rates in  $[t_2, t_2+5]$

$\rho_x$  - normalized pattern of mortality improvement,  $\sum \rho_x = 1$

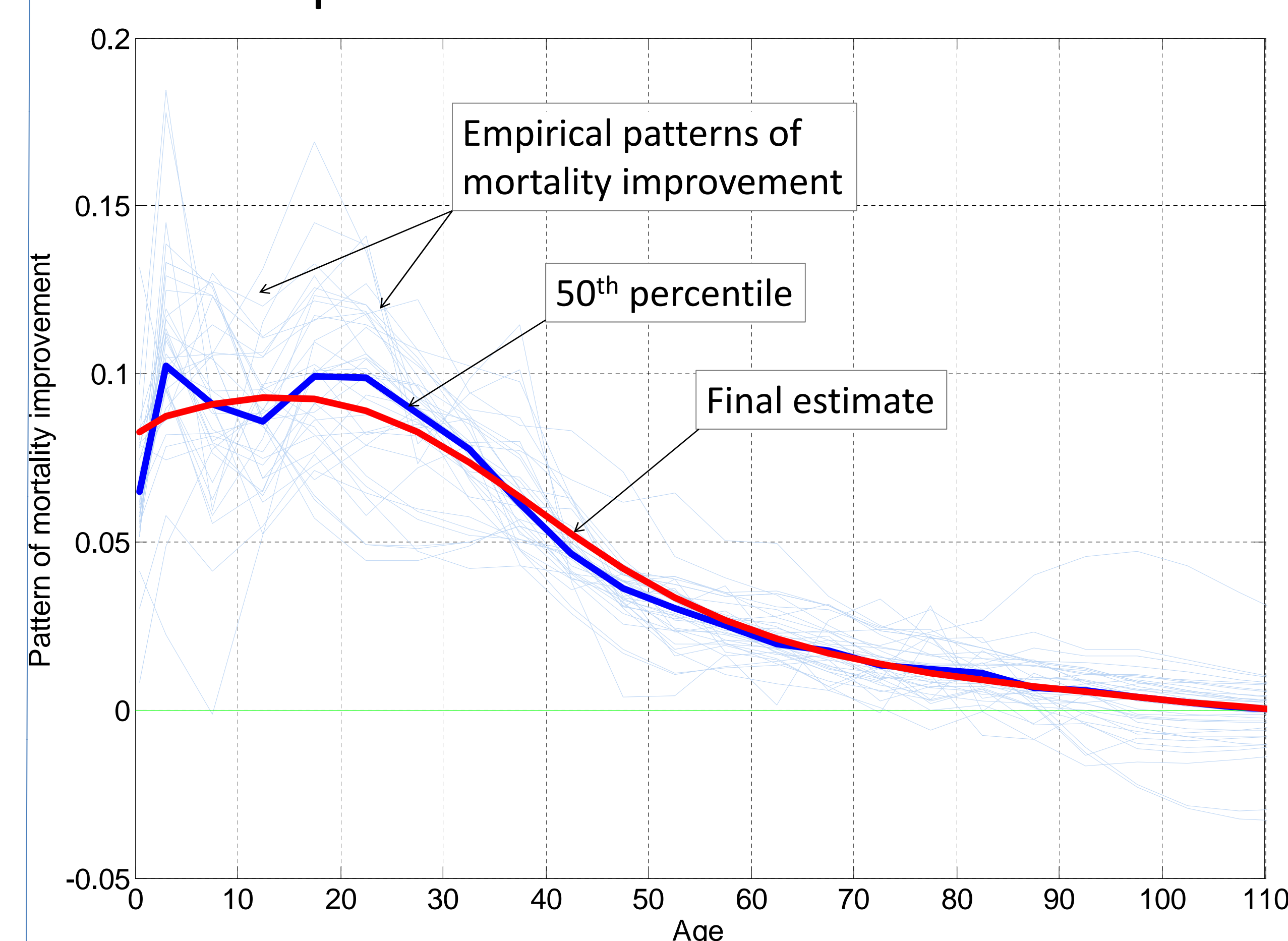
$k$  - level of mortality reduction, overall rate of progress in reducing mortality rates obtained by summing age-specific rates of progress

$$k \cdot 100\% = 100\% \cdot \sum_x (\ln m_x(t_1) - \ln m_x(t_2)) \cong \sum_x \left(1 - \frac{m_x(t_2)}{m_x(t_1)}\right) \cdot 100\%$$

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**Example of estimation** of pattern of mortality improvement level for  $e_0 = 65-70$ , females

- Datasets #1 & #2: life tables with  $e_0 = 65 \pm 2$  and  $e_0 = 70 \pm 2$  years of age (source: HMD)
- Compute  $\rho_x$  with Equ. (1) from mortality transitions within a single country
- Compute 50<sup>th</sup> percentile and smooth with cubic spline

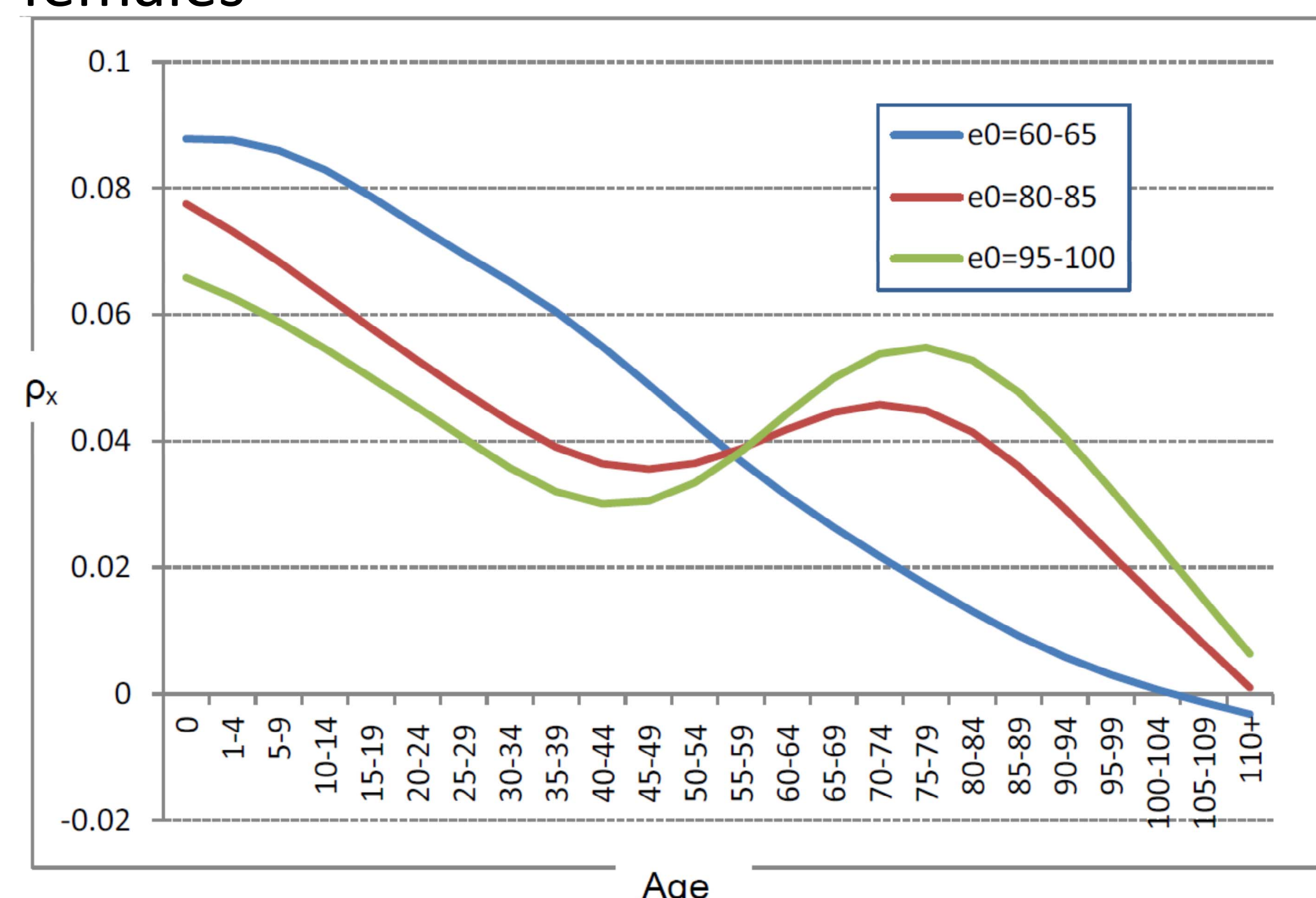


**Extrapolating** of patterns of mortality improvements to the higher levels of life expectancy at birth: ordinary least square regressions fitted to each of the age groups of the  $\rho_x$  matrix

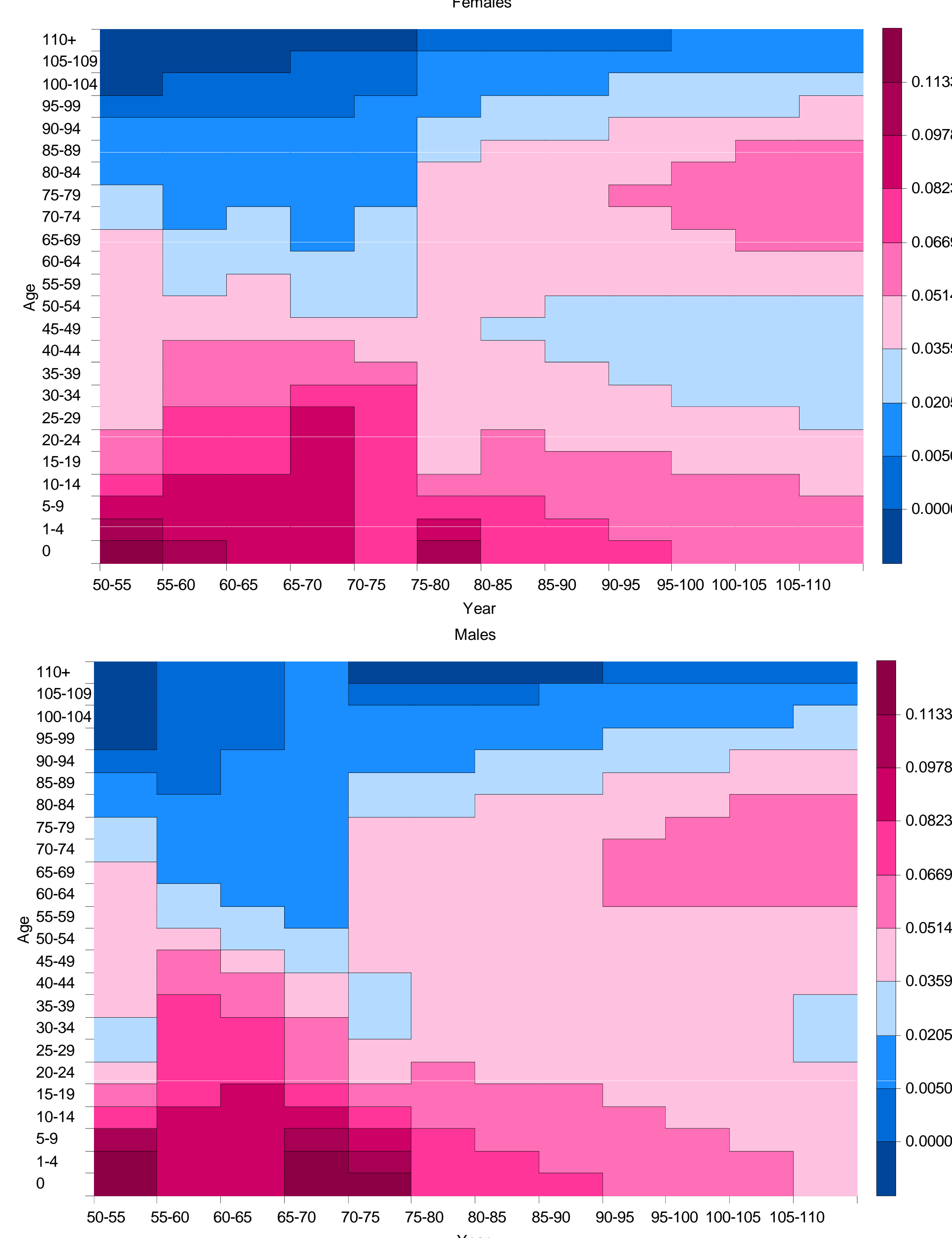
**Preparing mortality projection:**

- 1) prepare projection of  $e_0$
- 2) Select  $\rho_x$  based on the current  $e_0$
- 3) Apply Equ. (1) to the current schedule of death rates to get  $m_x$  for the next period

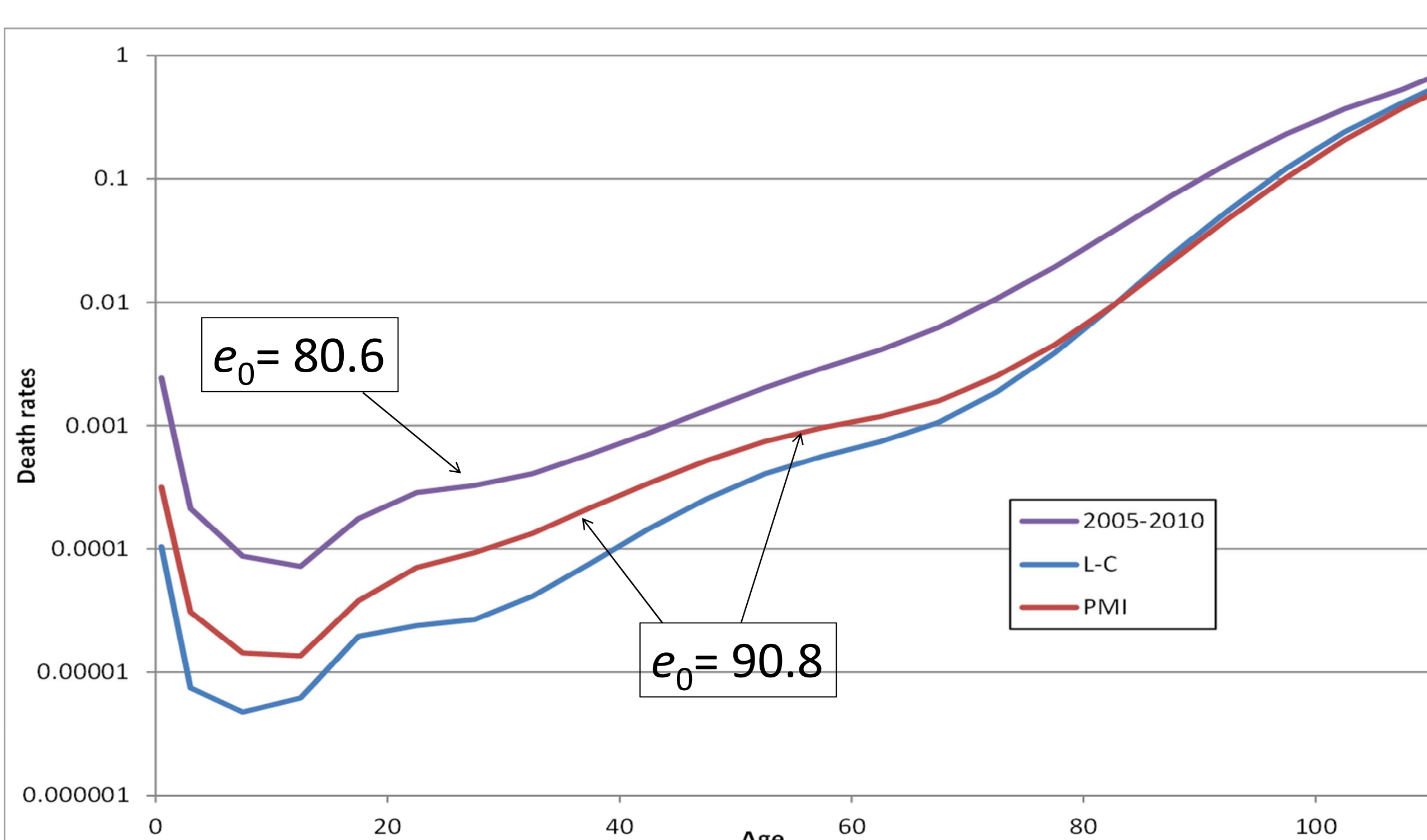
**Results:** Estimated and extrapolated patterns of mortality improvement for selected levels of life expectancy at birth, females



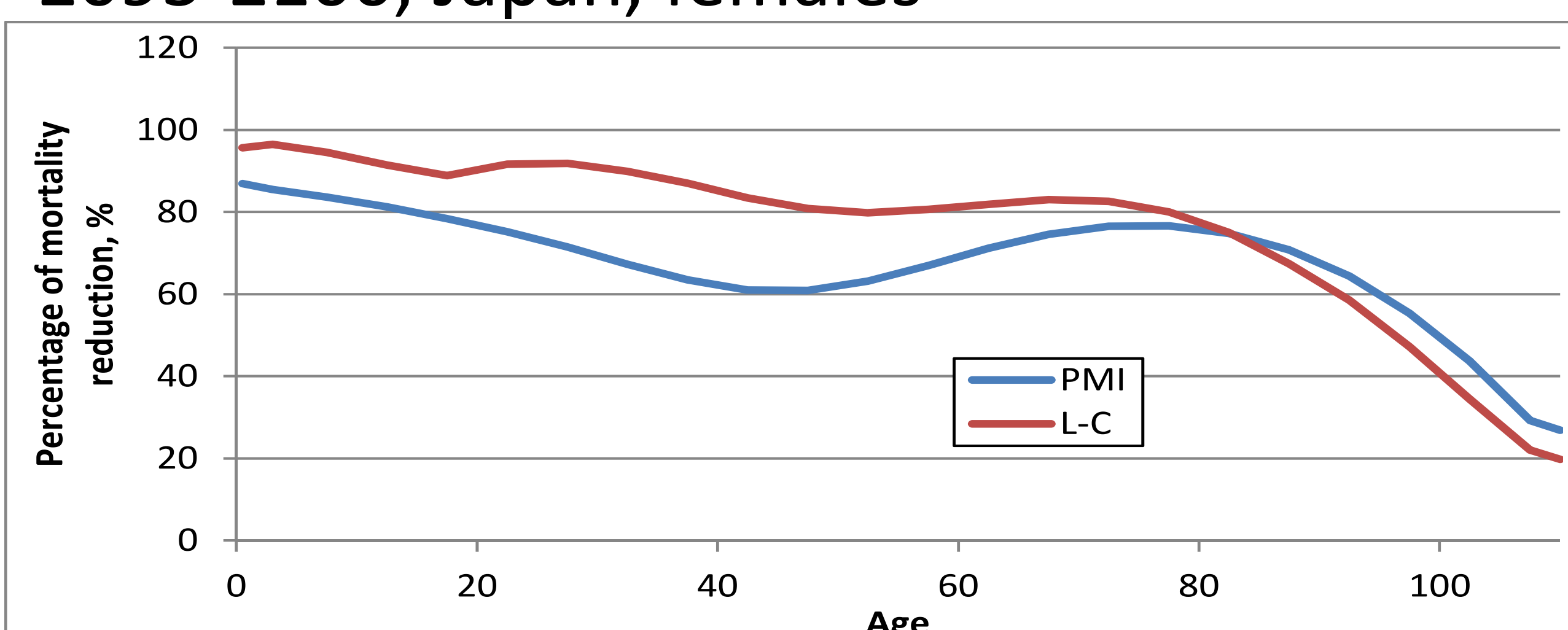
Patterns of mortality improvements by age and by level of life expectancy at birth



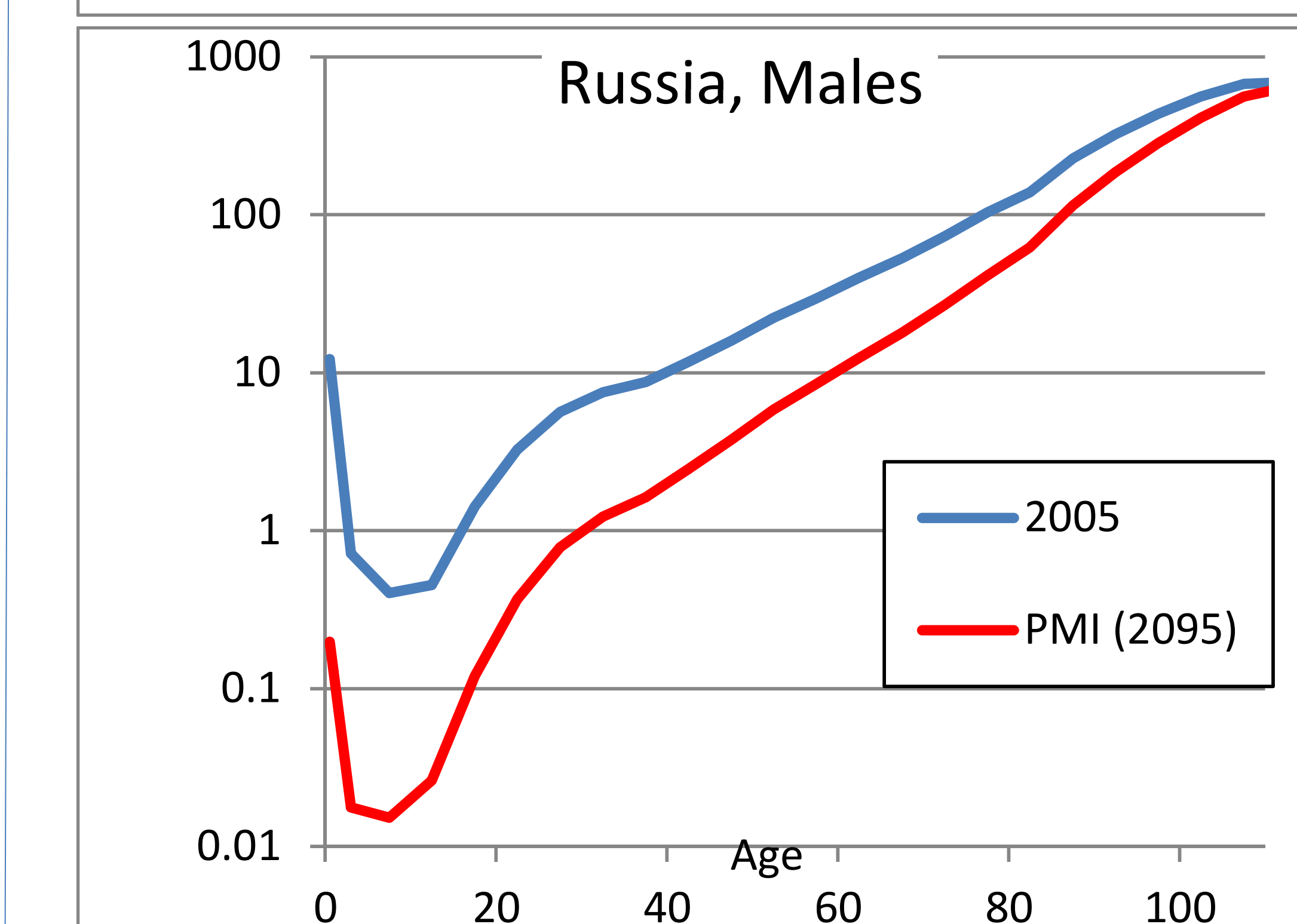
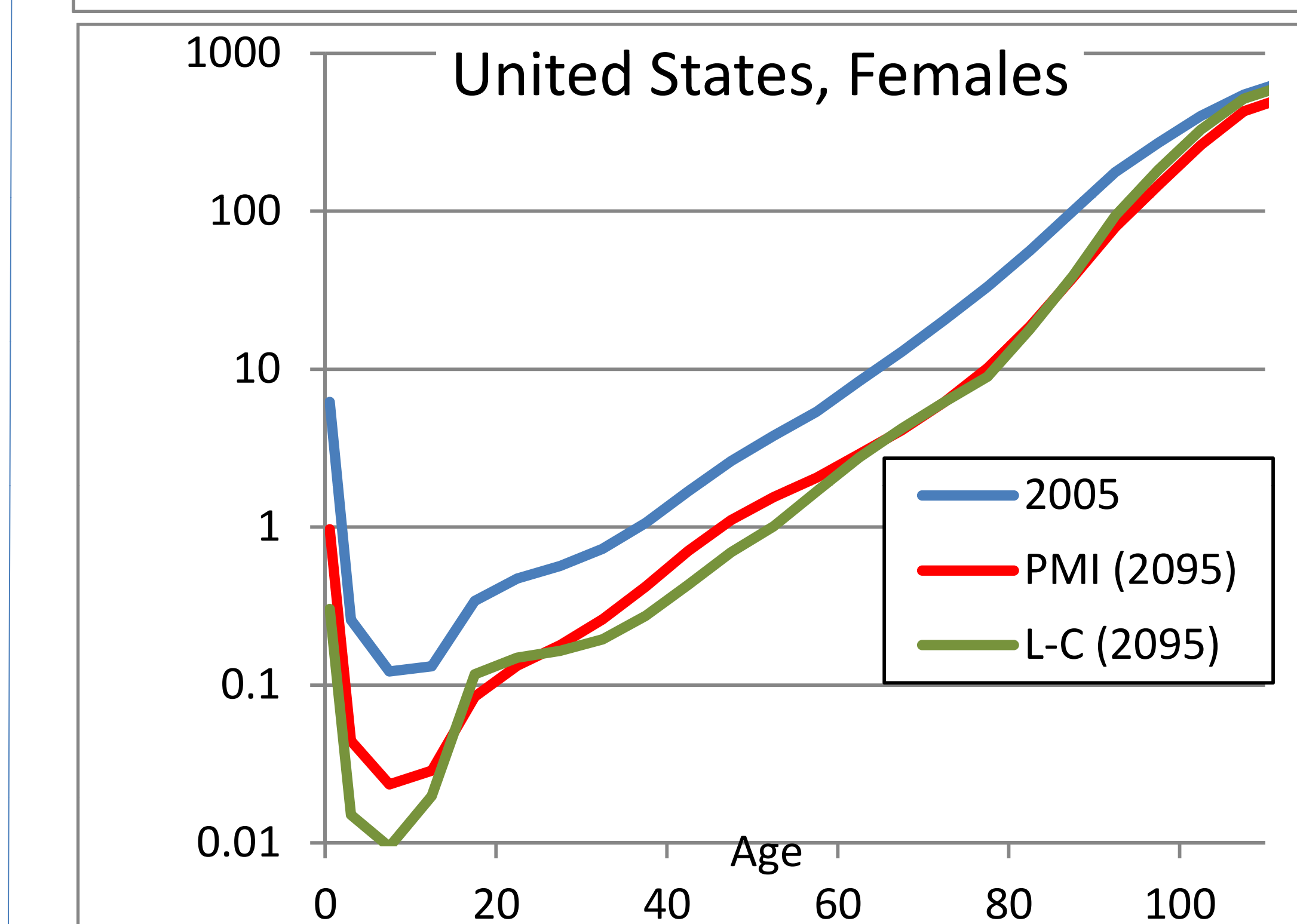
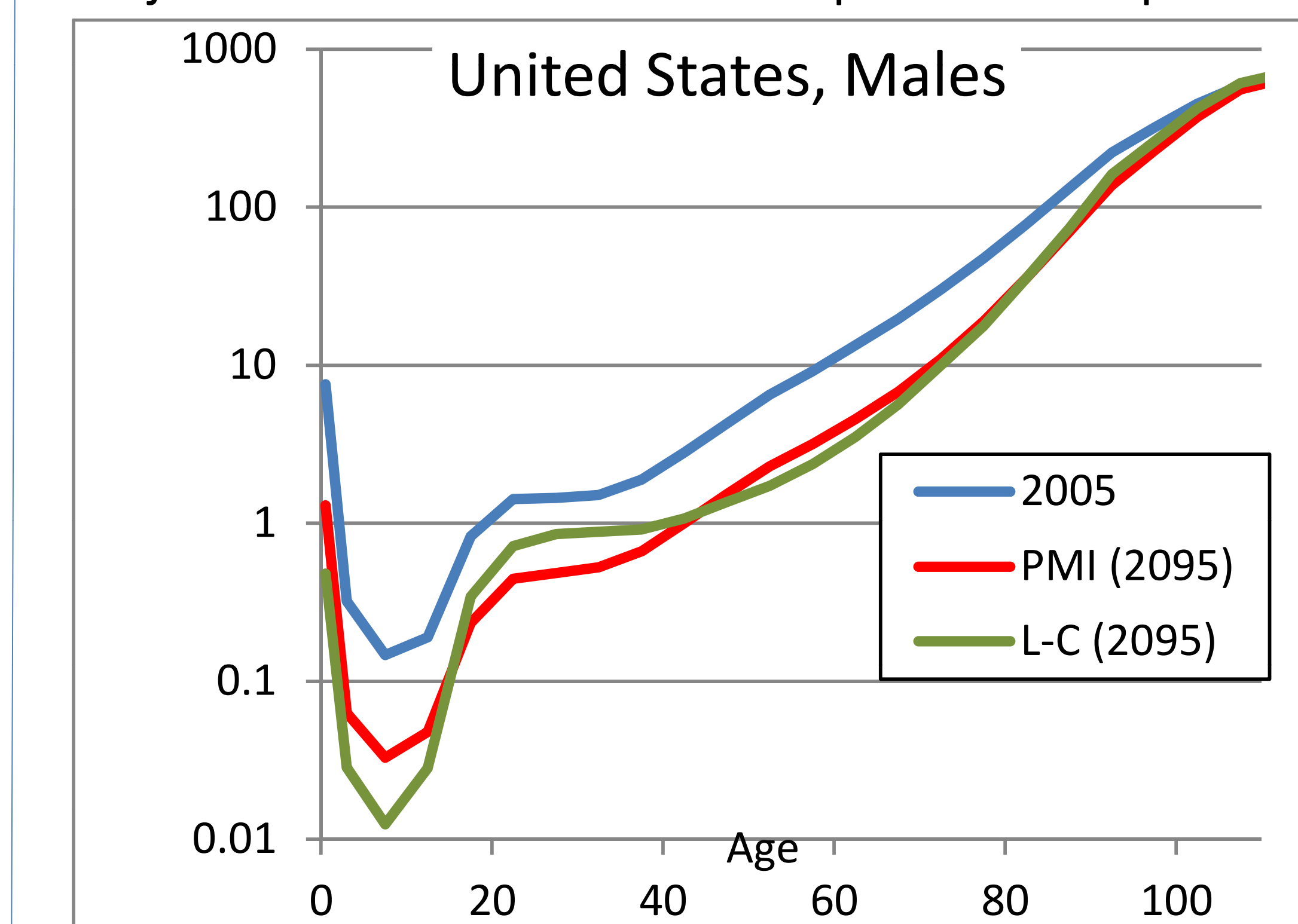
Changes in age pattern of mortality from 2005-2010 to 2095-2010 produced by using the estimated patterns of mortality improvements (PMI) and Lee-Carter (L-C) method constrained to  $e_0$ , Japan, females



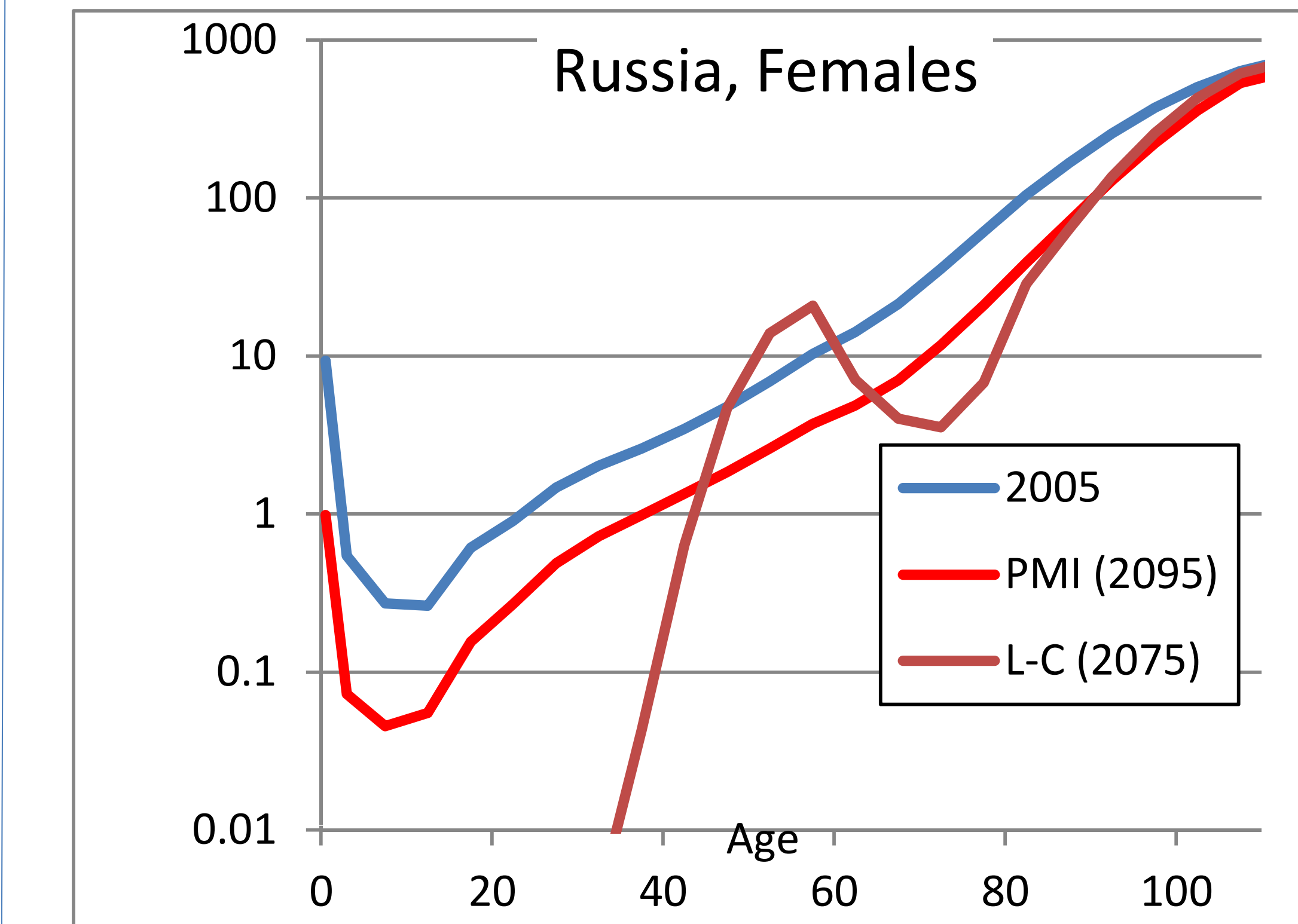
Reductions (%) in mortality from 2005-2010 to 2095-2100, Japan, females



Examples of changes in age pattern of mortality from 2005-2010 to 2095-2010  
Projections of  $e_0$ : 2010 World Population Prospects



\* No projection by the Lee-Carter model possible because of  $b_x$  est.



\* Projection by the Lee-Carter model is possible until 2075 only

**Conclusion:** the estimated age patterns of mortality improvement lead to construction of more plausible life tables in the mortality projections