Mortality Improvements at Advanced Ages in the United States, Progress Masked By Age Misreporting

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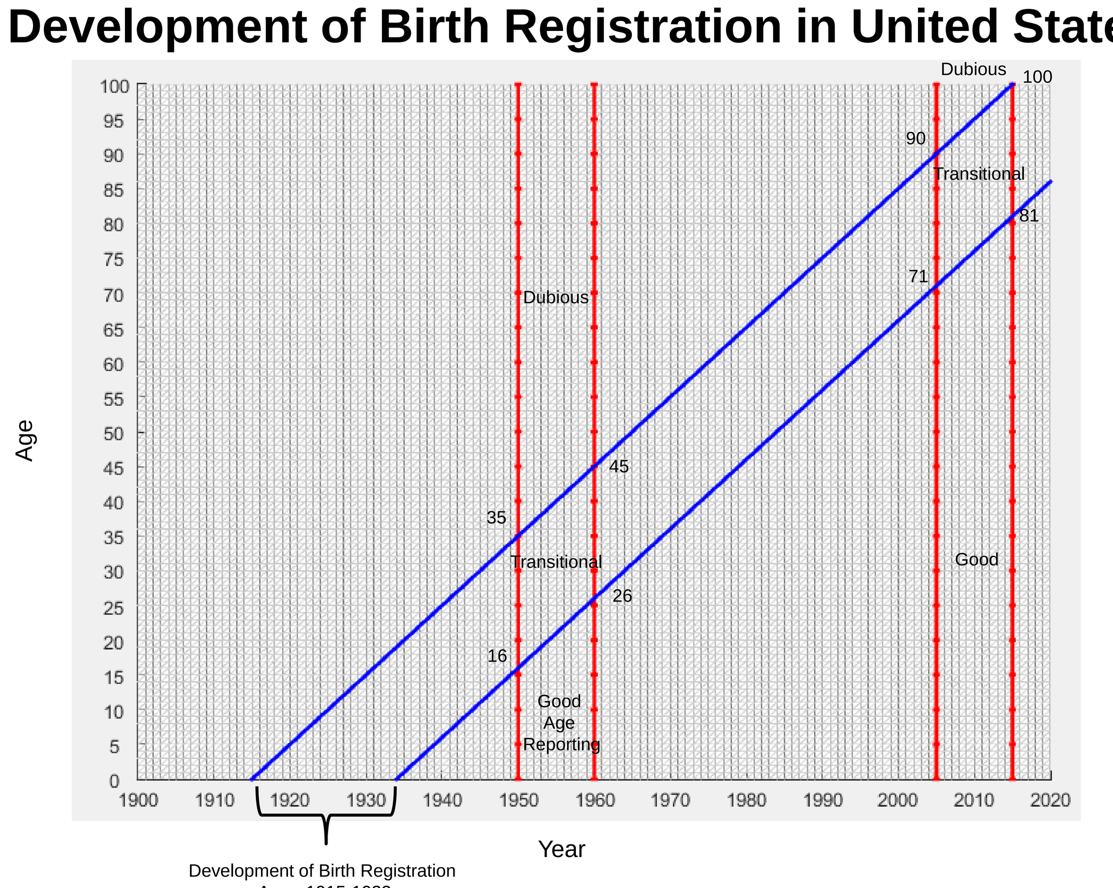
Objective To produce adjusted death rates for the United States at advanced ages for the 1950s and re-estimate mortality progress made by the U.S. over the last decades.

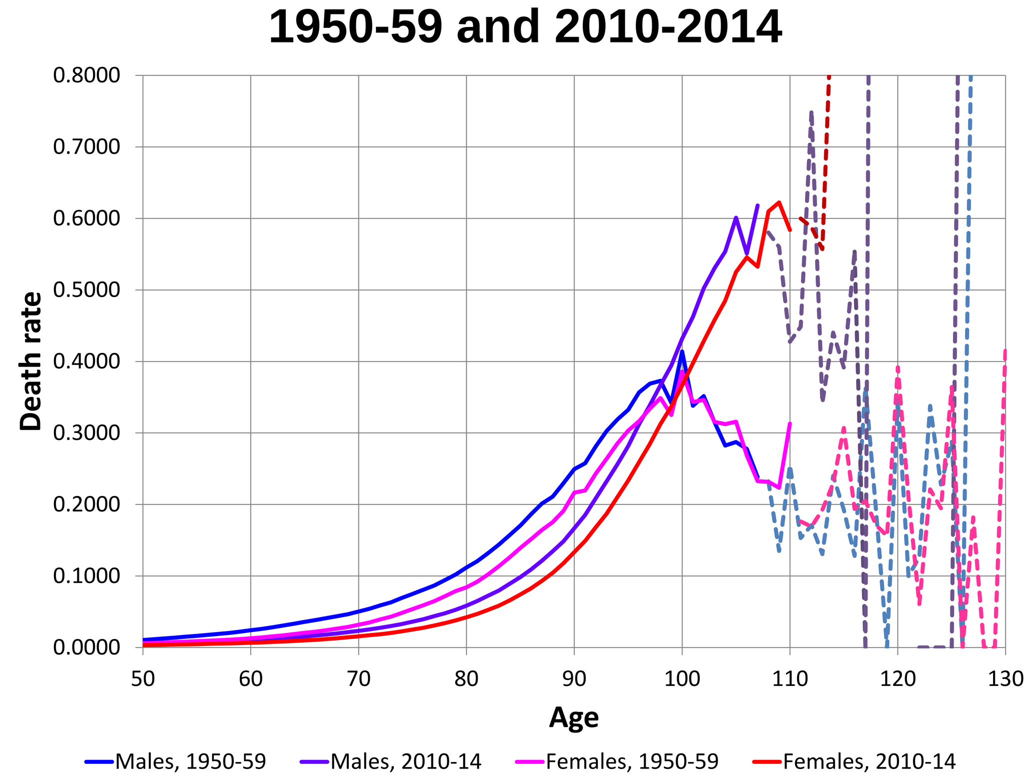
In the 1950s, mortality estimates at ages younger than 40 are expected to be of good quality as they are based on death records with valid birth certificates. Above this age, mortality estimates of dubious quality as information on dates of births is increasingly incomplete. In the period, 2005-2014, complete birth registration is available for more cohorts and data of good quality are expected up to roughly age 50.

Development of Birth Registration in United States



In the 1950s, U.S. death rates decline after age 100 undoubtedly reflecting presence of severe age misreporting in the U.S. data on deaths from vital registration. In 2010-2014, no such decline is observed due to improvements in data quality.

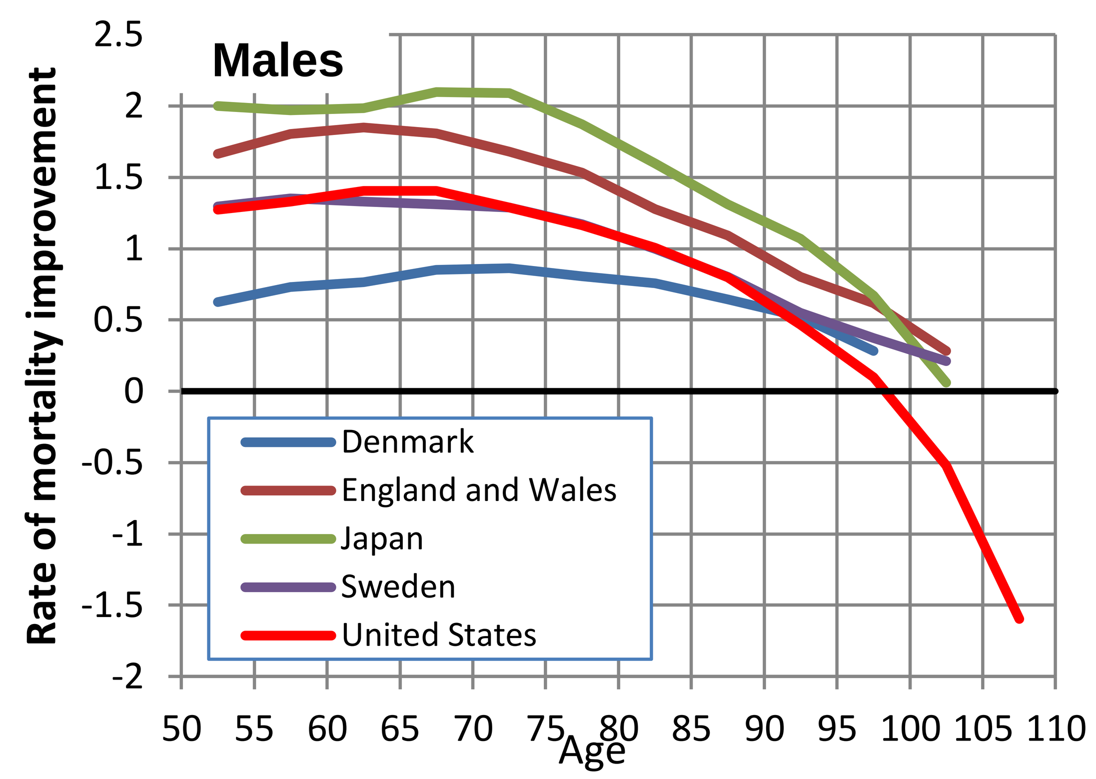
Direct U.S. mortality estimates in 1950-59 and 2010-2014

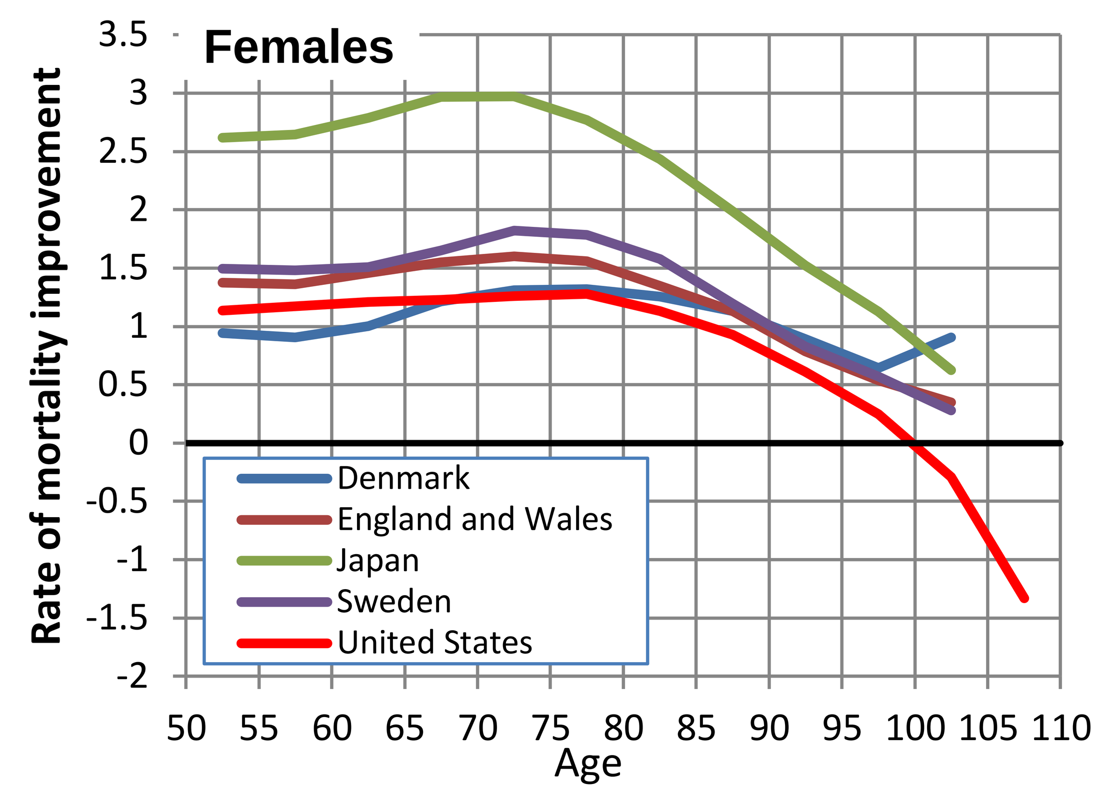


Direct estimates of deaths (no smoothing, adjustments or extrapolations).
Death rates based on less than 100 deaths are shown with dotted lines.

Direct estimates of rates of mortality improvement show that the U.S. progress was the lowest at the highest ages, and after age 95 the U.S. death rates were even increasing. These estimates, however, cannot be taken at face value as they are biased by age misreporting:

Direct estimates of rates of mortality improvement, 1950-1959 to 2005-2014



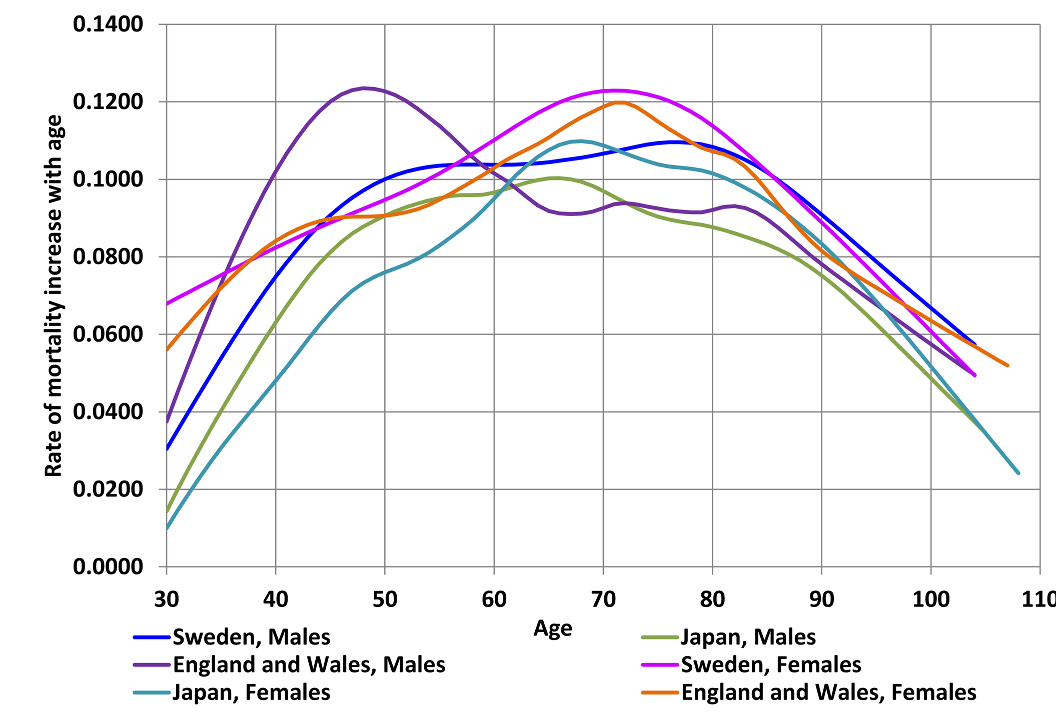


How to correct for age misreporting at advanced ages? Common approaches are: 1) extrapolations of death rates based on a mortality model, possibly with additional constraints on shape and level of mortality curve e.g. Coale and Kisker (1990); 2) selecting age pattern of mortality and assuming that aggregate mortality rate for age X and above and age-specific population growth rates above X are not affected by age misreporting (e.g. Horiuchi and Coale (1982), Elo and Preston (1994), Ediev (2016)).

Unconstrained extrapolation is based on the following assumptions: 1) mortality estimates are accurate below some age *X* and incorrect above it, and 2) death rates above *X* can be produced by extrapolation of death rates based on a mortality model fitted to ages with accurate data.

Choosing mortality model for extrapolation. If death rates are believed to be flawed significantly as early as age 50, mortality model selected for extrapolation must be able to reproduce bell-shaped pattern of rates of mortality increase with age. Commonly used mortality models to depict death rates at older ages (Gompertz, Coale-Kisker, Kannisto, gamma-Gompertz) are not able to reproduce a bell-shaped pattern as rate of mortality increase with age is either constant or declining in these models.

Empirical patterns of rates of mortality increase with age, $k_x = \ln(m_{x+1}/m_x)$, 1950-59

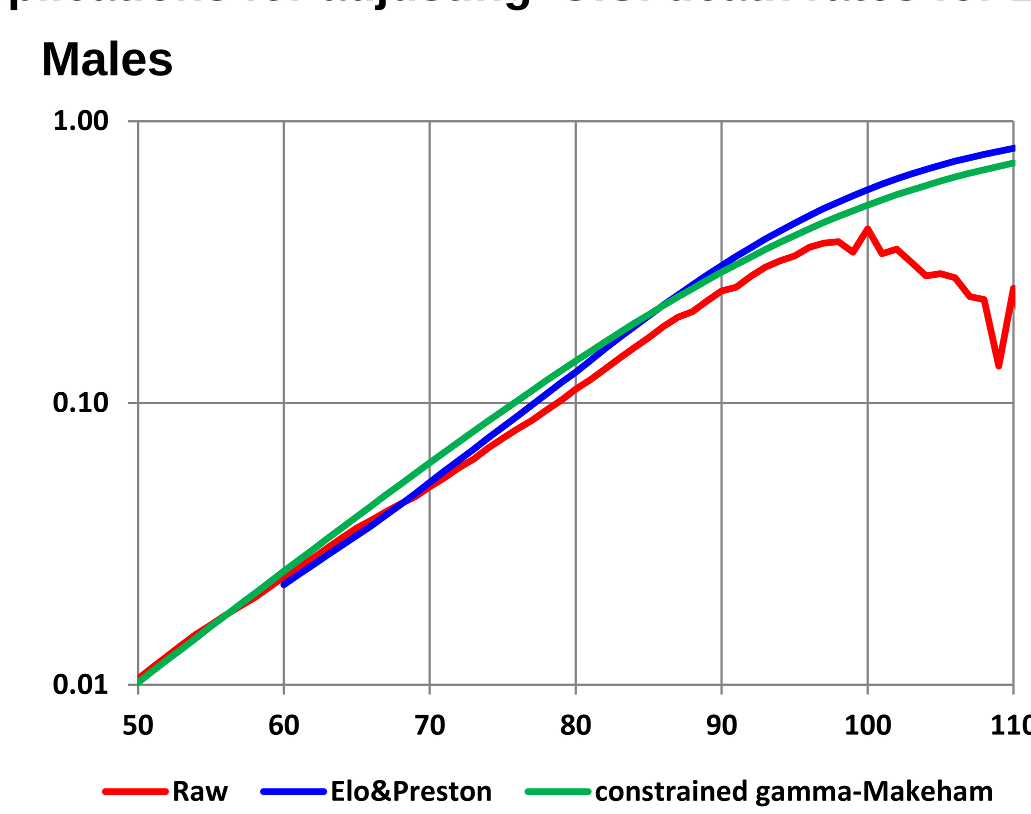


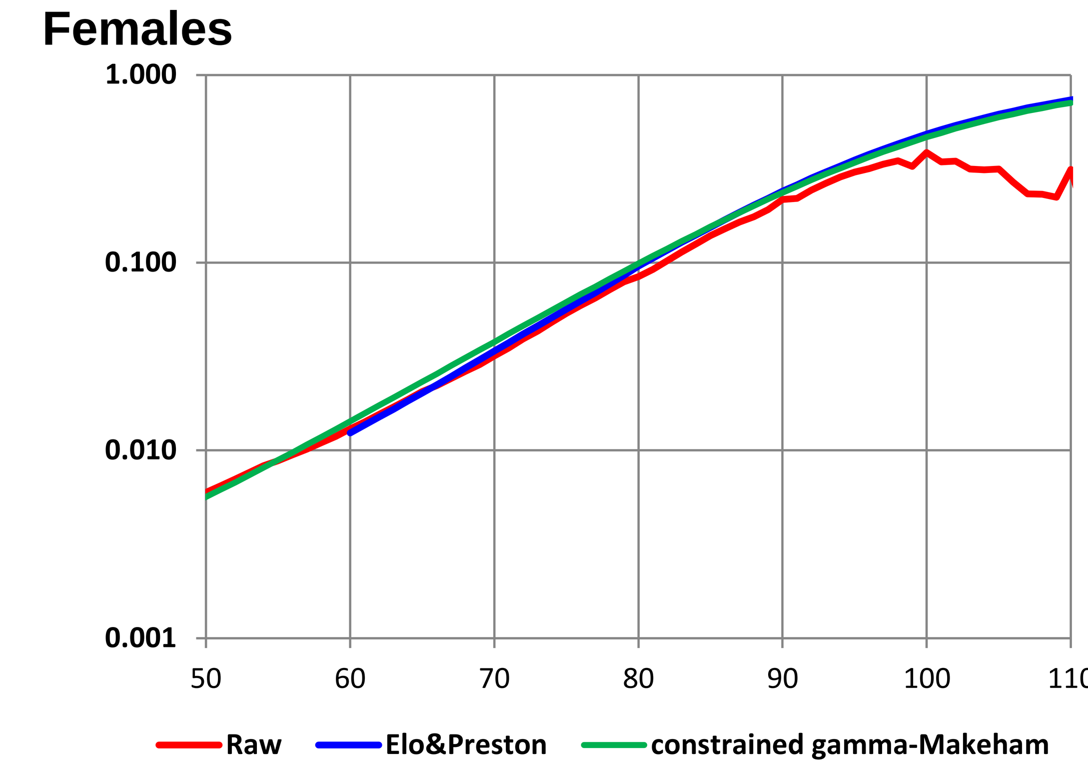
The gamma-Makeham model $\mu(x) = \dfrac{ae^{bx}}{1+\sigma^2 \dfrac{a}{b}(e^{bx}-1)} + c$

is, perhaps, the simplest model that is flexible enough to reproduce the above patterns. **Testing on Swedish data**, 1950-59, shows that gamma-Makeham model delivers promising but **unstable** results. Extrapolation based on fit to death rates at ages 40-49 and, especially, 35-84 overshoots the empirical death rates at ages 80 and older. To ensure more robust extrapolation we decided to constrain gamma-Makeham model to m(110) > 0.7 and *k(110)* < 0.03. Hereafter, **constrained gamma-Makeham model.**

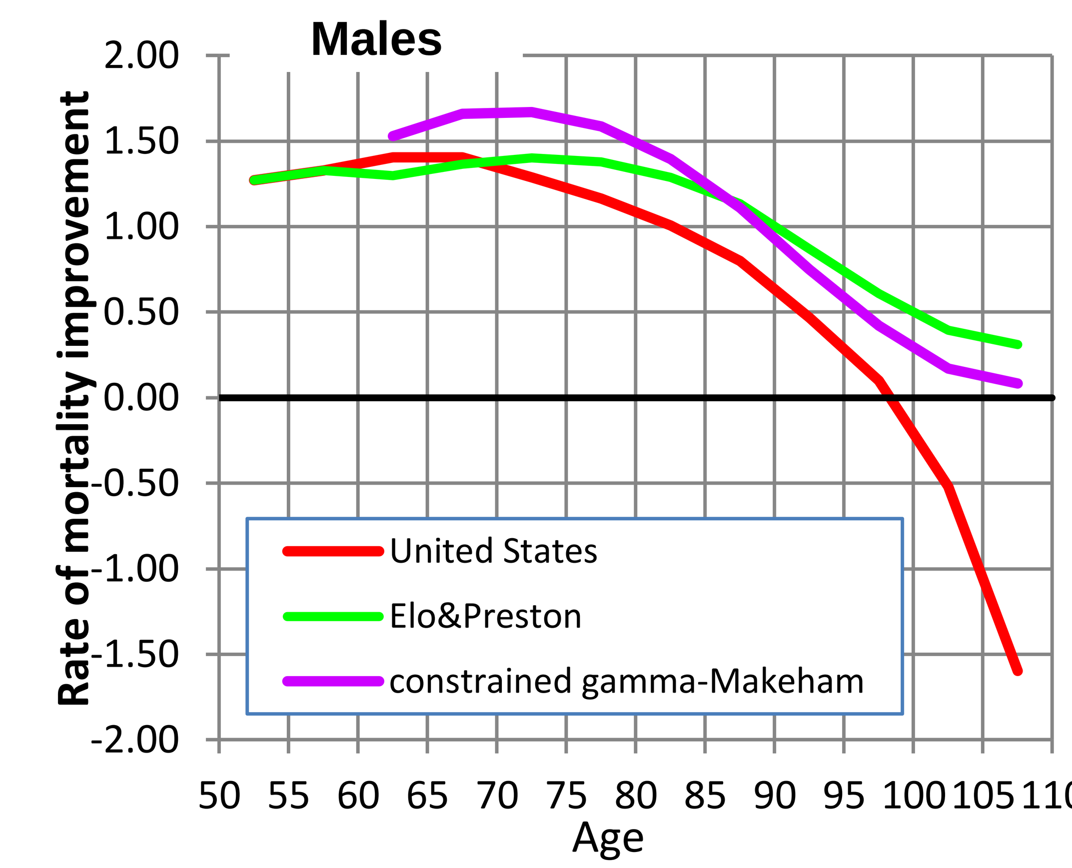
For testing the second approach, we extended the method of Elo and Preston to single ages and used extended North Coale-Demeny model life tables to model age pattern of mortality. Hereafter, **Elo & Preston extended method**. We further assumed that observed US population growth rates above age 60 are correct.

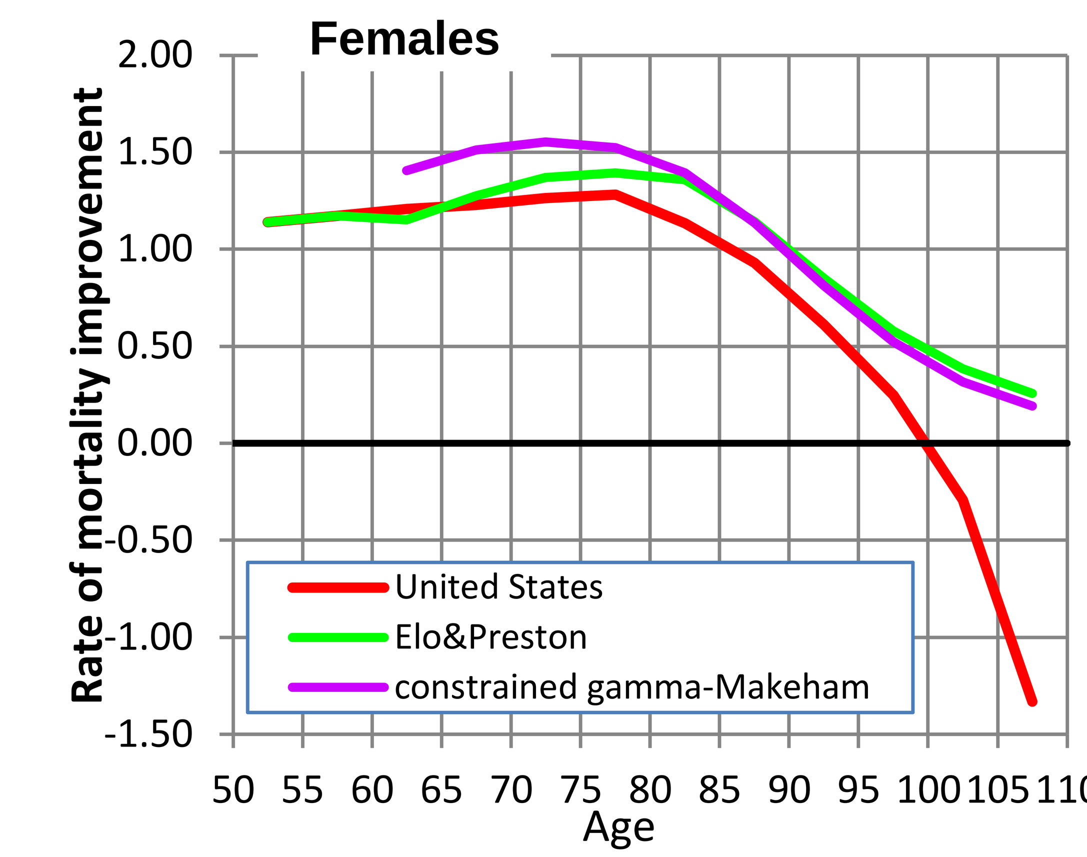
Applications for adjusting U.S. death rates for 1950-59





Results: adjusted rates of mortality improvement





Conclusions

- Age misreporting biases rates of mortality improvement downwards, leading, in severe cases, to spurious increases in mortality;

Conclusions (cont.)

- Adjusting U.S. death rates for age misreporting results in higher than observed estimates of rates of mortality improvement;
- Adjusted mortality improvement rates are comparable with the improvements observed in other high-longevity countries;
- Producing correct mortality forecasts requires adjustment of death rates for age misreporting. Without adjustment , future gains in longevity will be biased downwards as well.

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