Mortality Pattern at Adult and Older Ages

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5th HMD Symposium

14.05.2019

MAX-PLANCK-INSTITUT
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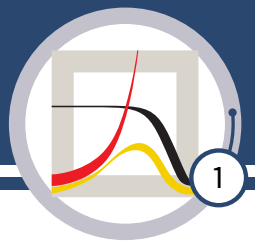
Life-table for Life Expectancy



- Life tables summarize mortality information
- Constant-hazard assumption in the open-ended age group
- Huge portion of the population surviving to this age

Handling censoring adequately: gamma-Gompertz-Makeham model

Gompertz Baseline

- Force of mortality for an individual:

Gompertz $\mu_G(x) = ae^{bx}$

Gompertz-Makeham $\mu_{GM}(x) = ae^{bx} + c$

- Frailty:

Gamma-Gompertz $\mu_{\Gamma G}(x \mid z) = zae^{bx}$,

Gamma-Gompertz-Makeham $\mu_{\Gamma GM}(x \mid z) = zae^{bx} + c$,

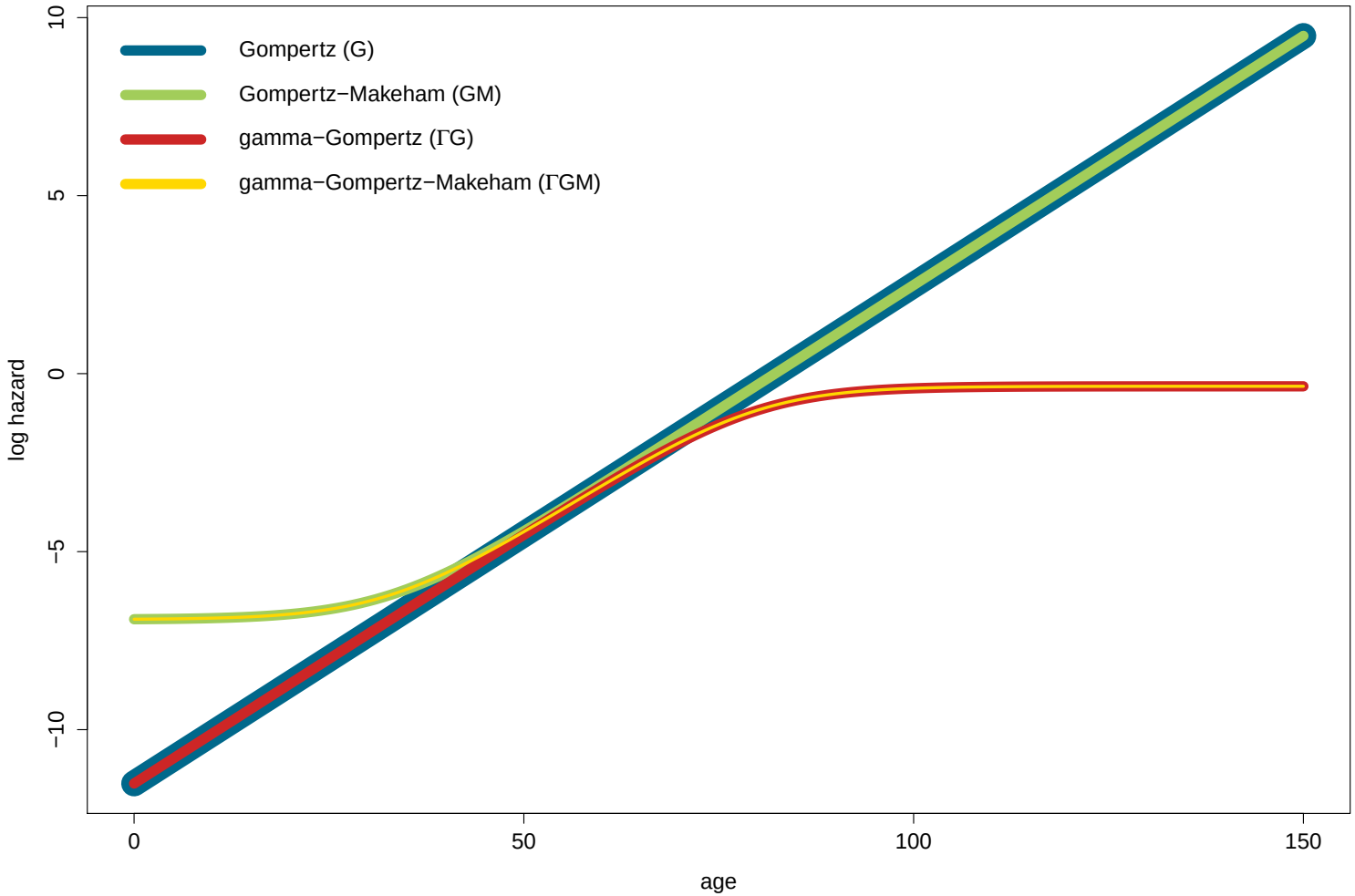
$Z \sim \Gamma(1/\gamma, 1/\gamma), E(Z) = 1, CV^2(Z) = \gamma$

- Force of mortality for the population:

$$\mu_{\Gamma G}(x) = \frac{ae^{bx}}{1+\frac{a\gamma}{b}(e^{bx}-1)} \qquad \mu_{\Gamma GM}(x) = \frac{ae^{bx}}{1+\frac{a\gamma}{b}(e^{bx}-1)} + c\,.$$

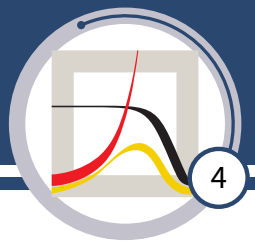
[Gompertz, 1825, Makeham, 1860, Vaupel et al., 1979]

Hazards with Gompertz Baseline



Parameter values: a=0.00001, b=0.14, c=0.001, γ=0.2

Why the gamma-Gompertz-Makeham model

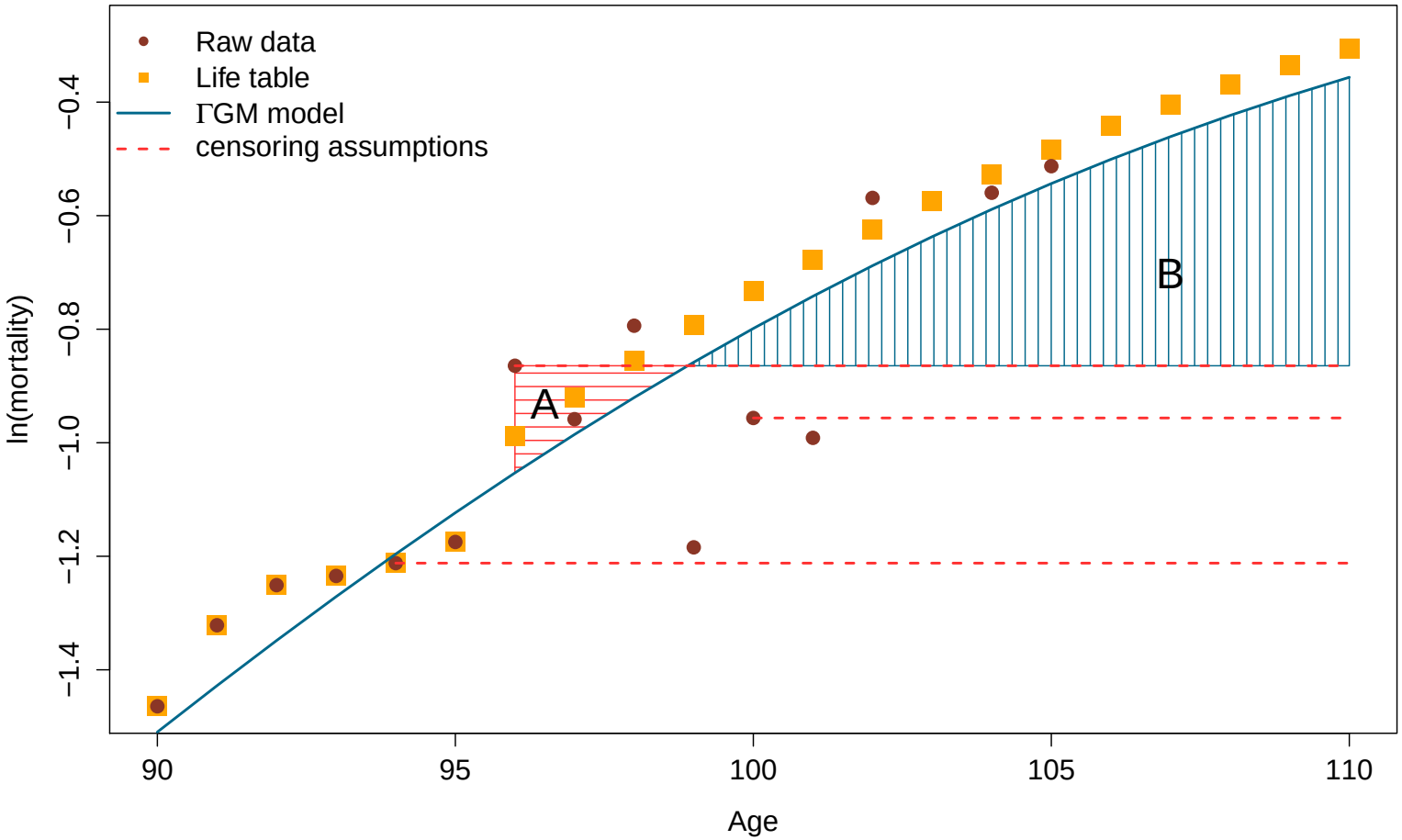


- Captures both excess mortality at young-adult ages and the deceleration of death rates at older ages
- the model is able to capture both an infinitely increasing risk of death and an S-shaped pattern
- qualitatively similar to the Kannisto model applied by the largest high-quality mortality databases
  Kannisto model:
  $\mu_K(x) = \frac{ae^{b(x-x0)}}{1+ae^{b(x-x0)}}$

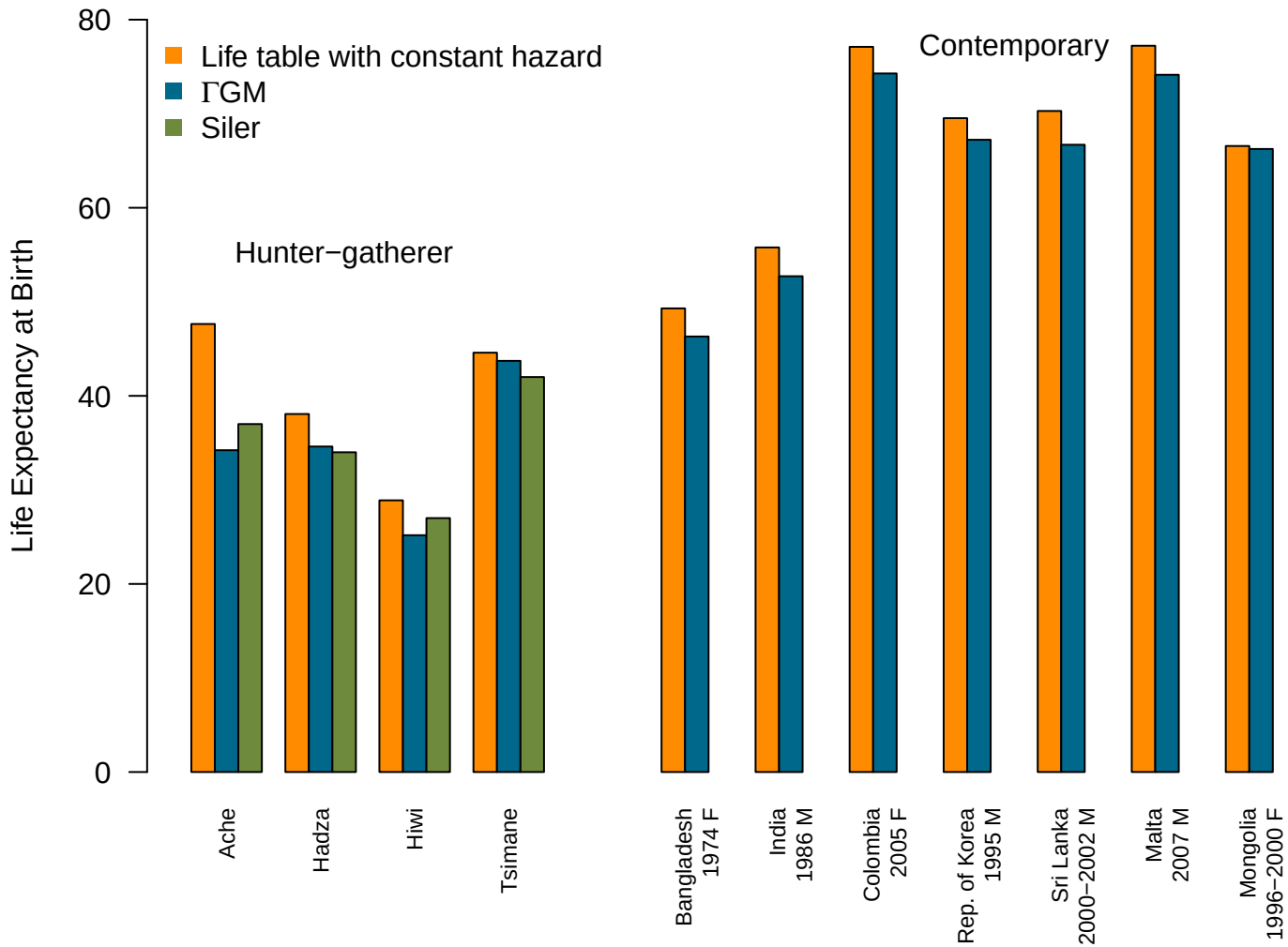
Advantages over Kannisto

- unobserved heterogeneity - frailty (parameter gamma)
- flexibility of capturing Gompertz whereas Kannisto always predicts mortality plateau
- the magnitude of the plateau is not restricted to 1
- Makeham term - less sensitive to the starting age of analysis.
- can be fitted over wider age range
- expansion of abridged (grouped) life-table values to (non-)integer ages.
- tails of the distribution, good fit
- parameters are easily interpreted, clear demographic meaning, input for further calculations

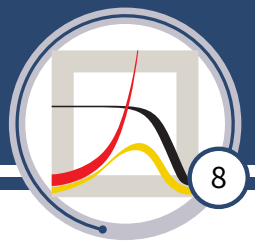
Censoring assumption



Reconstructed Life Expectancy

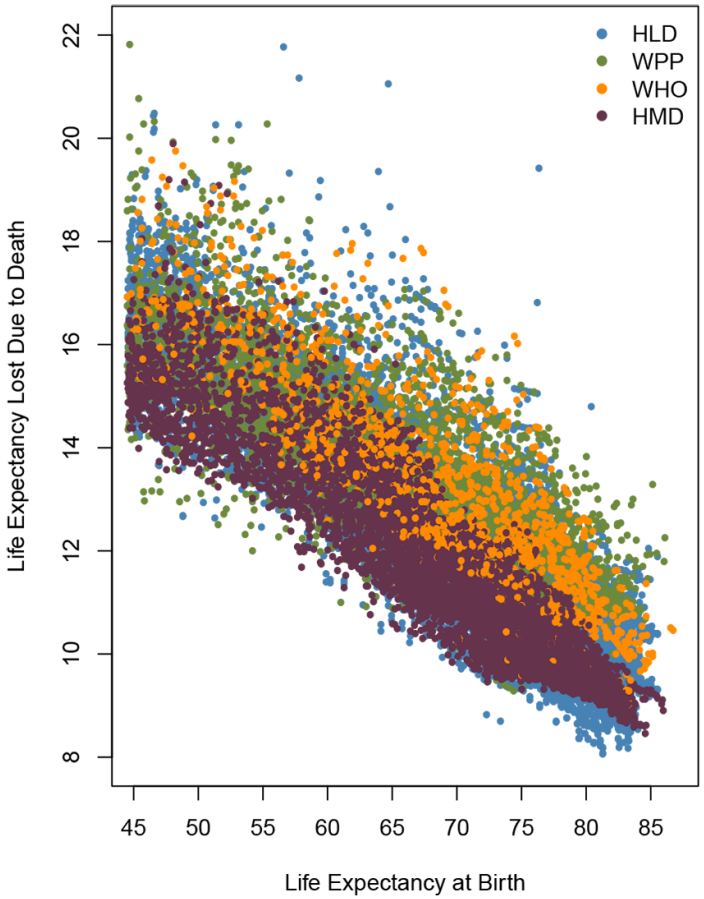


Life Expectancy Reconstruction



- Life-table Databases
  - Human Mortality Database (HMD)
  - Human Life-table Database (HLD)
  - Global Health Observatory Data Repository (WHO)
  - World Population Prospects (WPP)
  - Database published by Eurostat
- HMD, WHO, WPP use cubic splines smoothing + Kannisto model
- method protocols do not give clear justification

Lifespan Inequality Measures



Thank you! nemeth@demogr.mpg.de

References

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