Uses of the Human Mortality Database for demographic estimation and forecasting at the United Nations

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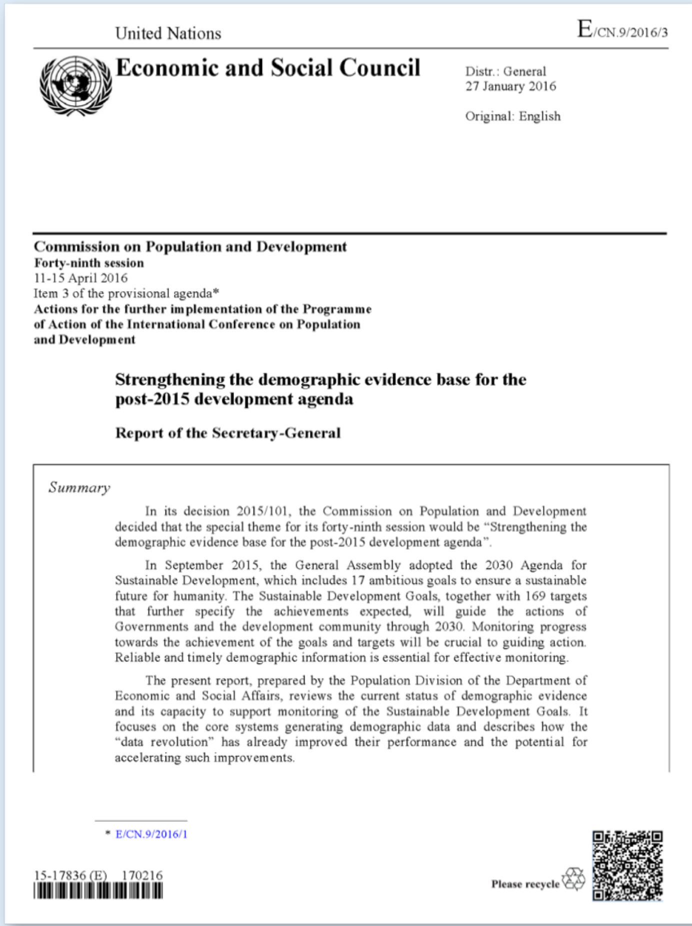
Background

- Population Division publishes estimates and projections by sex for all countries: population size and vital rates, 5x5 format (from July 1 to July 1) from 1950 to 2100
- World Population Prospects (WPP) series, revised every two years: since 1951 the UN has published 24 sets of population estimates and projections
- Used throughout UN system to provide the population base (denominators or multipliers); key input used for development planning, monitoring (MDGs and SDGs) and modeling (e.g., climate change)
- Latest: 2015 Revision, published in July 2015
- Upcoming: 2017 Revision, to be launched in June 2017

Recognition of HMD at the UN



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Commission on Population and Development
Forty-ninth session
11-15 April 2016
Item 3 of the provisional agenda*
Actions for the further implementation of the Programme of Action of the International Conference on Population and Development

Strengthening the demographic evidence base for the post-2015 development agenda

Report of the Secretary-General

Summary

In its decision 2015/101, the Commission on Population and Development decided that the special theme for its forty-ninth session would be "Strengthening the demographic evidence base for the post-2015 development agenda".

In September 2015, the General Assembly adopted the 2030 Agenda for Sustainable Development, which includes 17 ambitious goals to ensure a sustainable future for humanity. The Sustainable Development Goals, together with 169 targets that further specify the achievements expected, will guide the actions of Governments and the development community through 2030. Monitoring progress towards the achievement of the goals and targets will be crucial to guiding action. Reliable and timely demographic information is essential for effective monitoring.

The present report, prepared by the Population Division of the Department of Economic and Social Affairs, reviews the current status of demographic evidence and its capacity to support monitoring of the Sustainable Development Goals. It focuses on the core systems generating demographic data and describes how the "data revolution" has already improved their performance and the potential for accelerating such improvements.

* E/CN.9/2016/1

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Please recycle

Report of the Secretary-General prepared for the Commission on Population and Development in 2016:

The Human Mortality Database, created by the University of California at Berkeley and the Max Planck Institute for Demographic Research, contains time series of national life tables for 37 countries or areas having virtually complete vital statistics and census enumerations. It also contains data on registered deaths by age and sex, registered births and enumerated populations. A uniform method was used to construct the life tables, ensuring consistency over time and across countries. The database is accessible online and is the **best source on changing mortality patterns in developed countries**.

Overview

HMD is used at the United Nations to:

- Inform UN estimates for HMD countries
- Validate estimates for non-HMD countries
- Develop and test new models and methods
- Inform and calibrate projection models

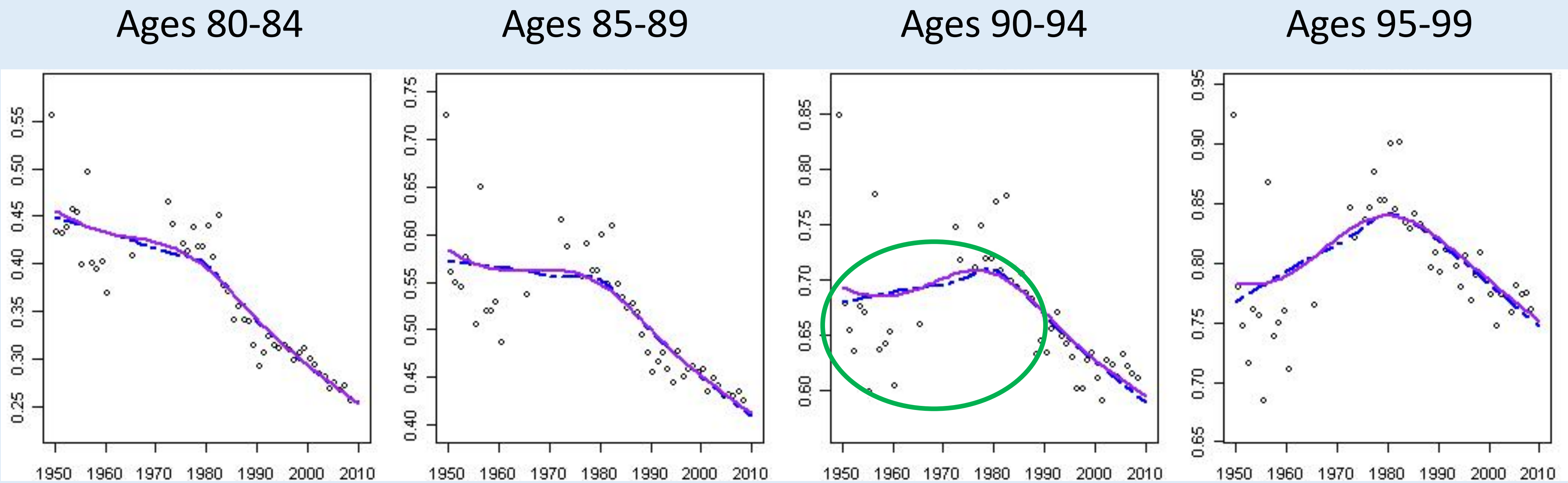
Inform estimates for HMD countries: World Population Prospects (WPP)

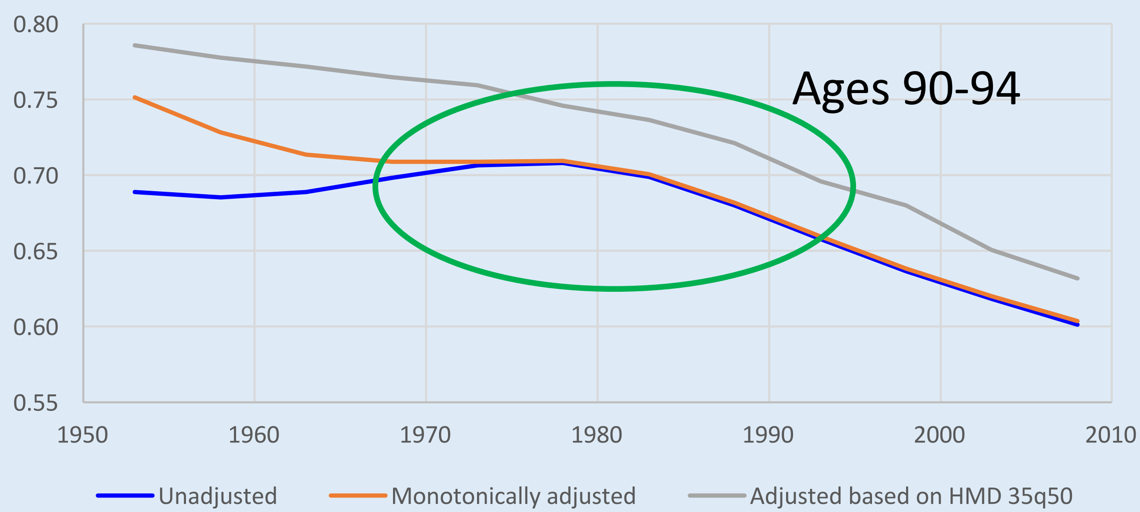
- Global coverage: 230 countries or areas (201 with at least 90,000 inhabitants in 2015)
- 1950-2015 = estimation period
- HMD population estimates by sex and 5-year age groups, and abridged period life tables inform WPP estimates of 5x5 population and mortality estimates (populations on 1 July, and rates from 1 July in year t to 1 July in year t+5)

Inform estimates for HMD countries: A couple of challenges

- For 13 countries or areas, HMD series start after 1950 (e.g., 1958 for Poland; 1959 for Belarus, Estonia, Latvia, Lithuania, Russia, Ukraine; 1960 for Luxembourg; 1970 for Taiwan, Province of China; 1981 for Greece; 1983 for Israel and Slovenia; 1990 for Germany)
- HMD data series not always updated for recent years
- WPP data series completed using other sources, which may reveal differences requiring adjustments (e.g., Israel for 1950-1980 above age 75, death rates show implausible trend and a low level of mortality)

Israel, women, q_x trends above age 80: National data for 1950-1980, HMD for 1980-2010



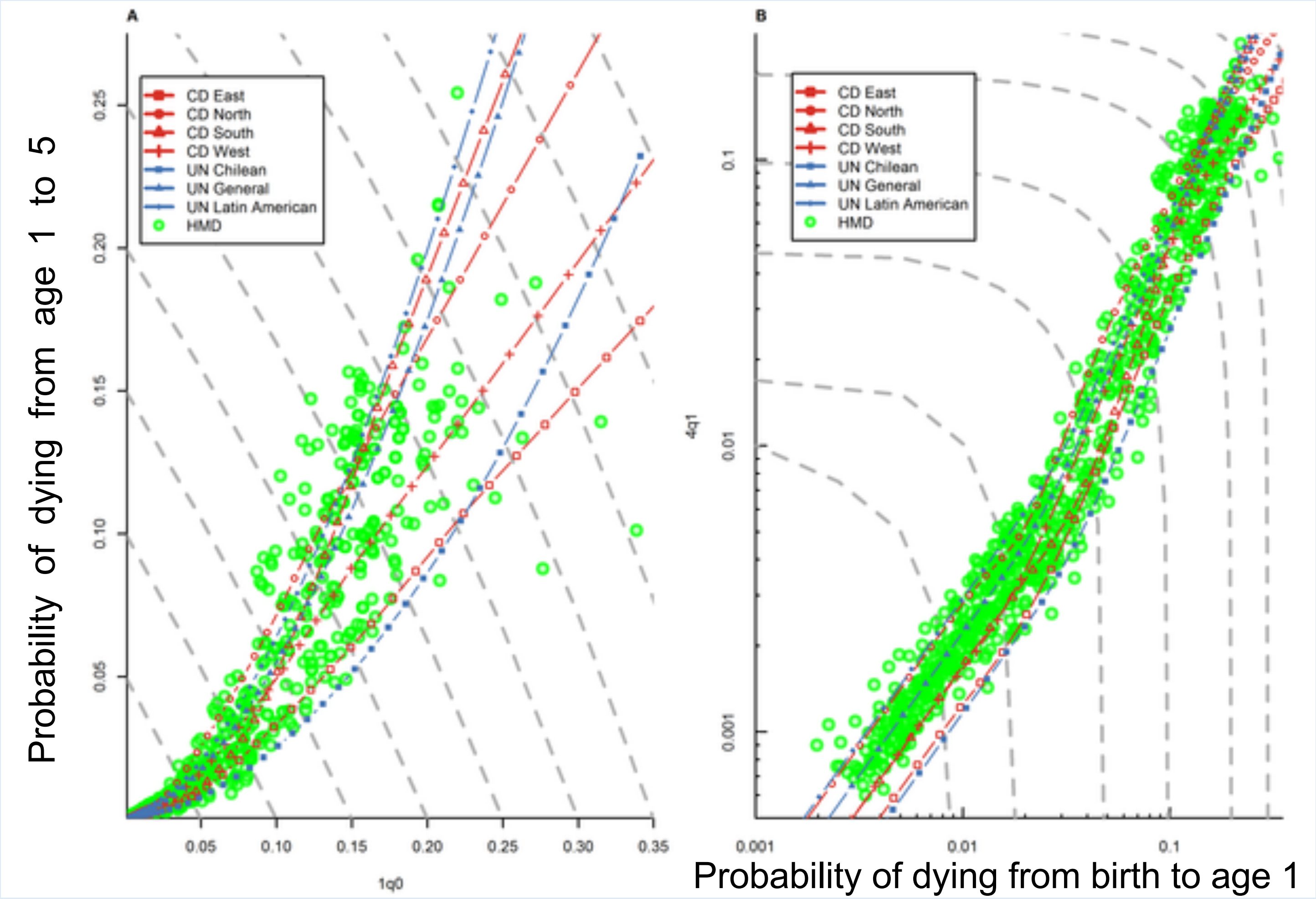


Source: United Nations, unpublished

Validate estimates for non-HMD countries

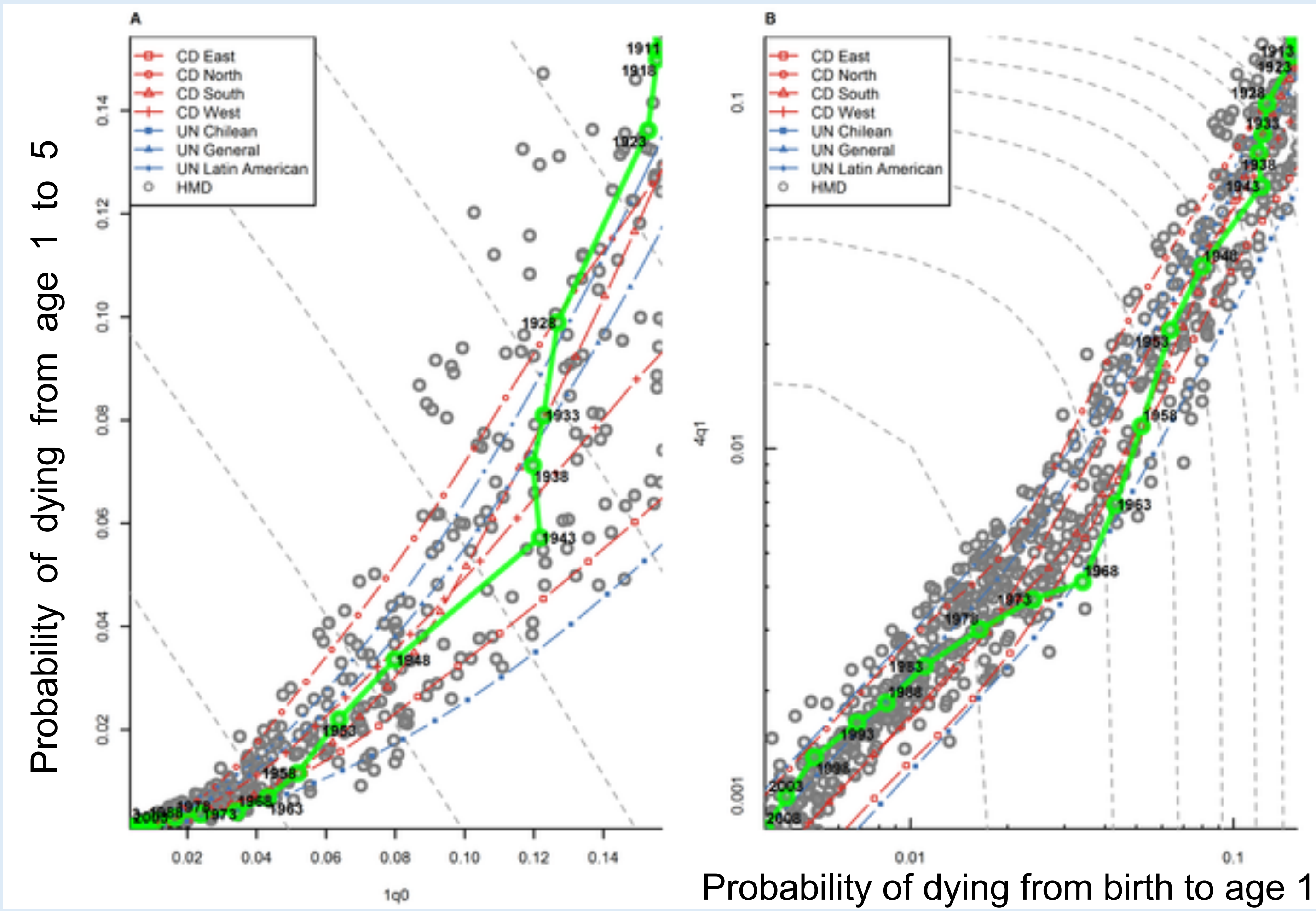
- Evaluate using key relationships:
  $_{1}q_{0}$ vs. $_{4}q_{1}$ $_{5}q_{0}$ vs. $_{45}q_{15}$ $_{45}q_{15}$ vs. e_{60}
- Compare observed values to historical patterns, using HMD supplemented by DSS data
- Assess plausibility of age patterns and trends over time
- Validate and/or adjust estimates using general methods and/or specialized models: smoothing, parametric models (Gompertz, etc.), empirical models (model life tables, relational models)

Infant and child mortality: HMD data and model life tables



Source: Guillot, M., *et al*. (2012), *PLoS Med 9(8).*

Infant and child mortality: Spain, 1908-2009

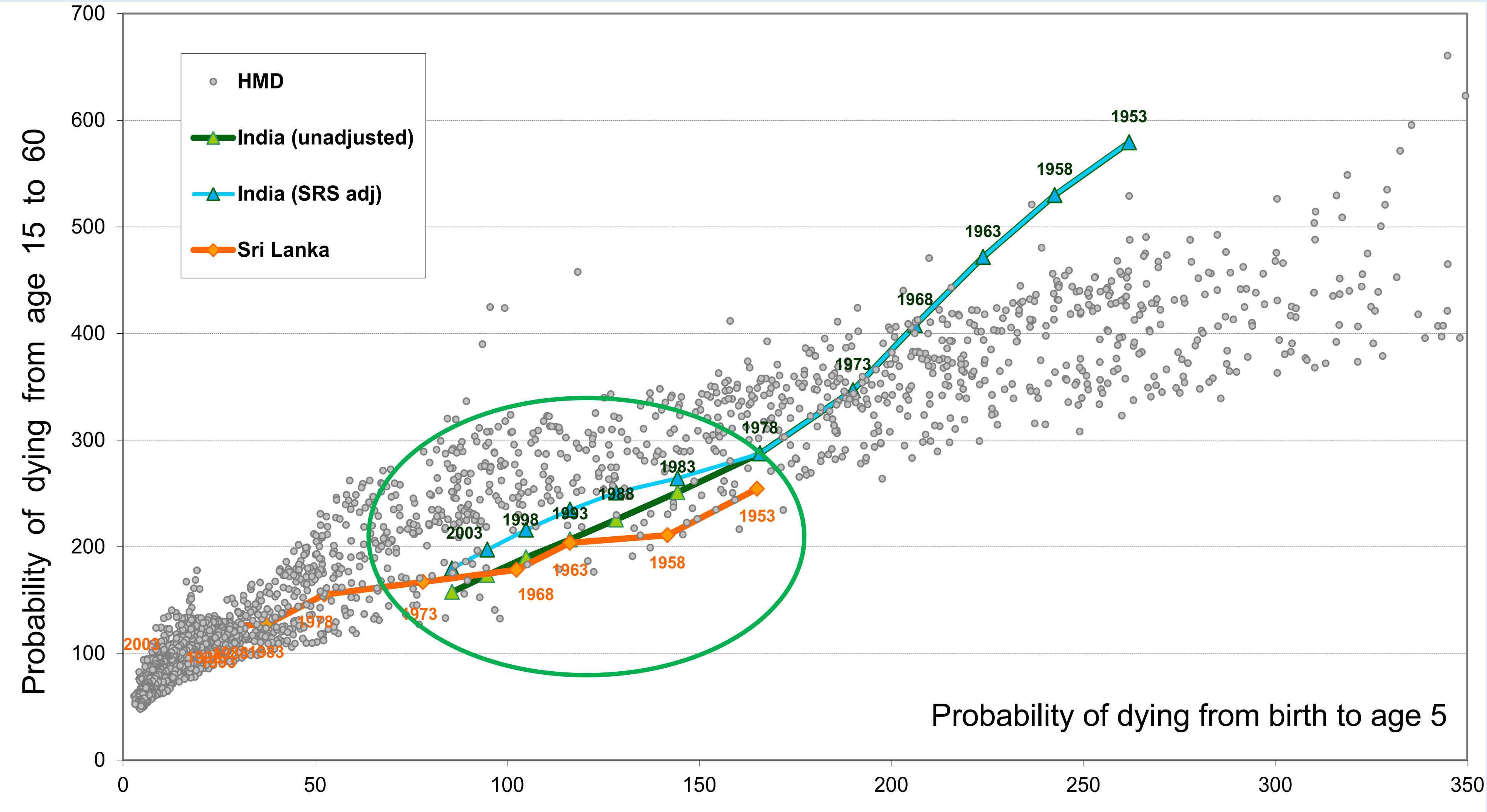


Source: Guillot, M., *et al*. (2012), *PLoS Med 9(8).*

Infant and child mortality: Distinctive pattern in the Sahel

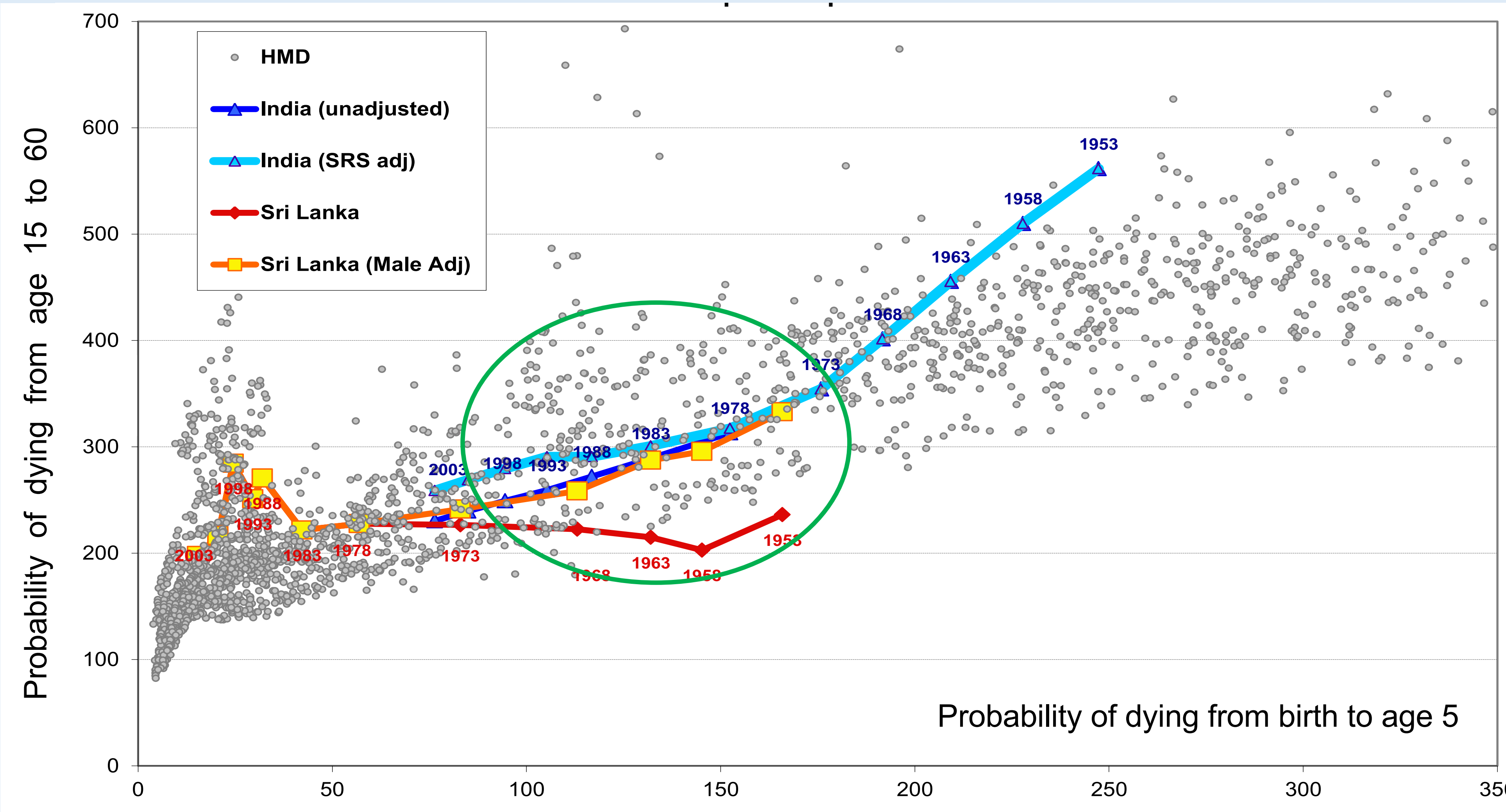
Source: United Nations (IGME), unpublished.

Child and adult mortality: India and Sri Lanka, women



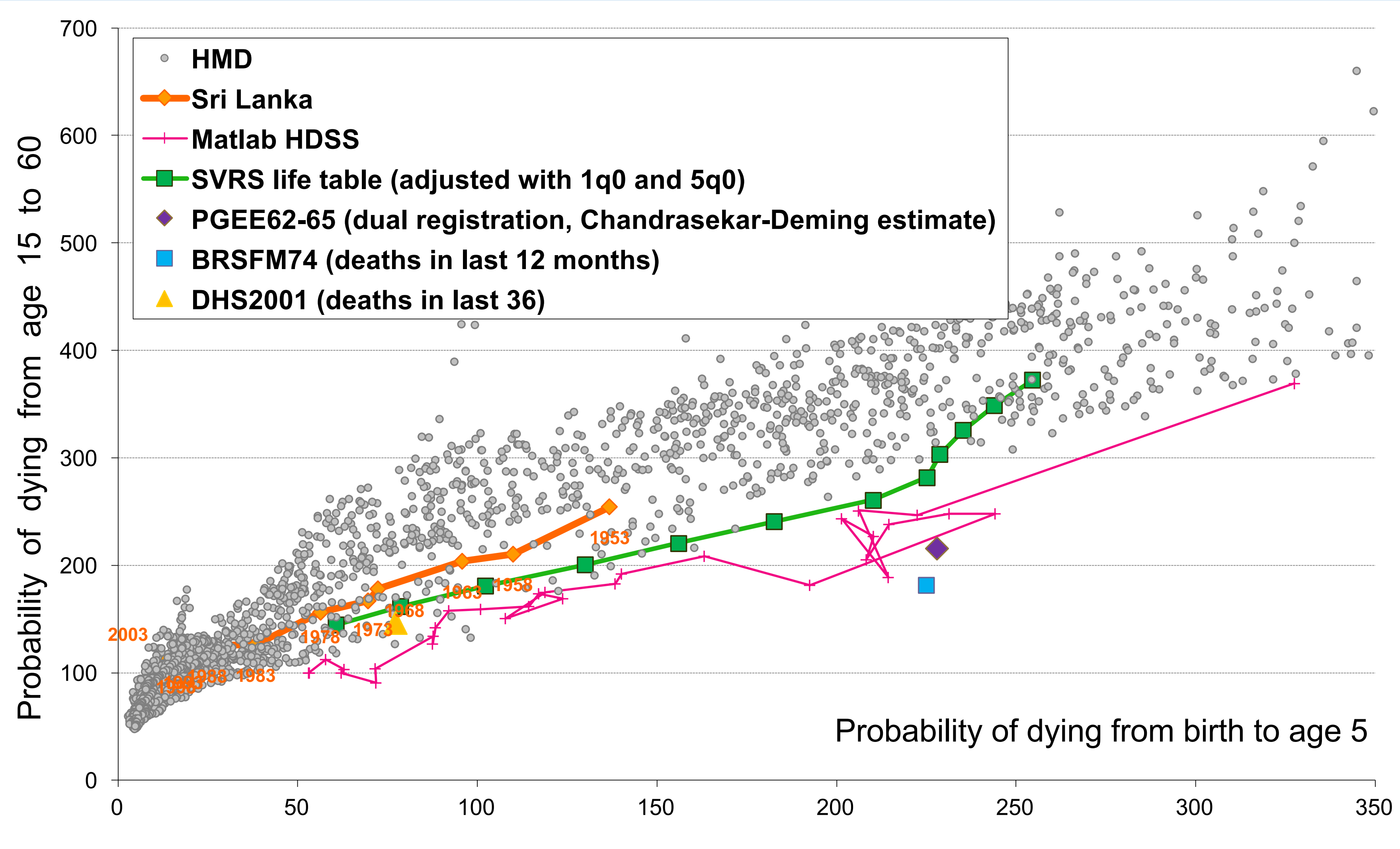
Source: Gerland (2014), *Asian Population Studies* 10(3):1-30.

Child and adult mortality: India and Sri Lanka, men



Source: Gerland (2014), *Asian Population Studies* 10(3):1-30.

Child and adult mortality: Bangladesh, women



Source: Unpublished UN analysis.

Develop and test new models and methods

- Models of age patterns: model life tables, relational models
- Indirect estimation: intercensal survival, variable r method
- Vital registration data for non-HMD countries: extending the HMD toolkit

New model life table system: Log-quadratic model developed using HMD data

$$\log(m_x) = a_x + b_x h + c_x h^2 + v_x k + \varepsilon_x$$

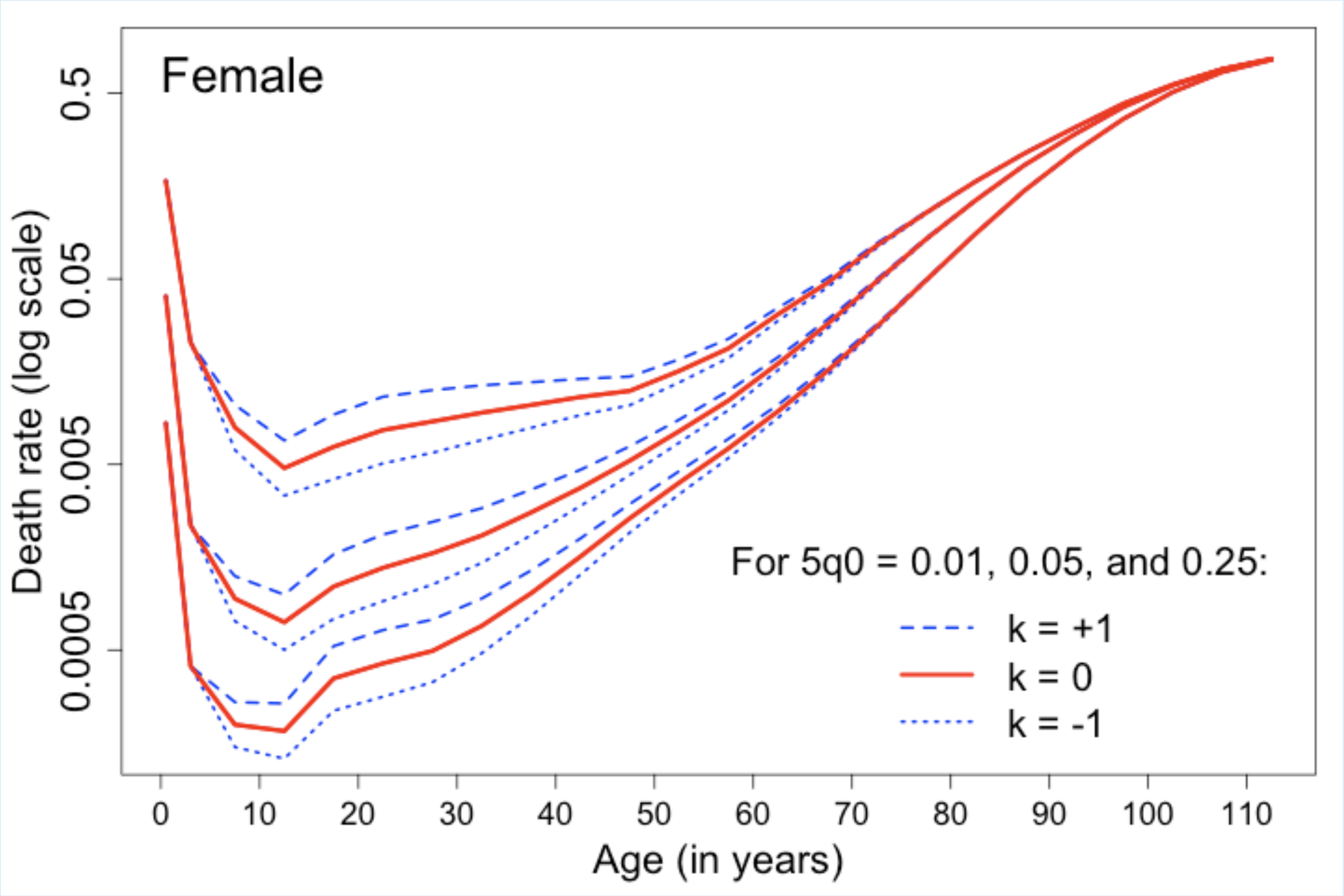
Thus, there two entry parameters:

- $h = \log({}_5q_0)$ reflects the level of child mortality
- k reflects the level of excess adult mortality and is chosen to match ${}_{45}q_{15}$ or other global measure of adult mortality (if available)

Source: Wilmoth, J., *et al*. (2012), *Population Studies* 66(1):1-28.

Log-Quadratic Model: Age Patterns

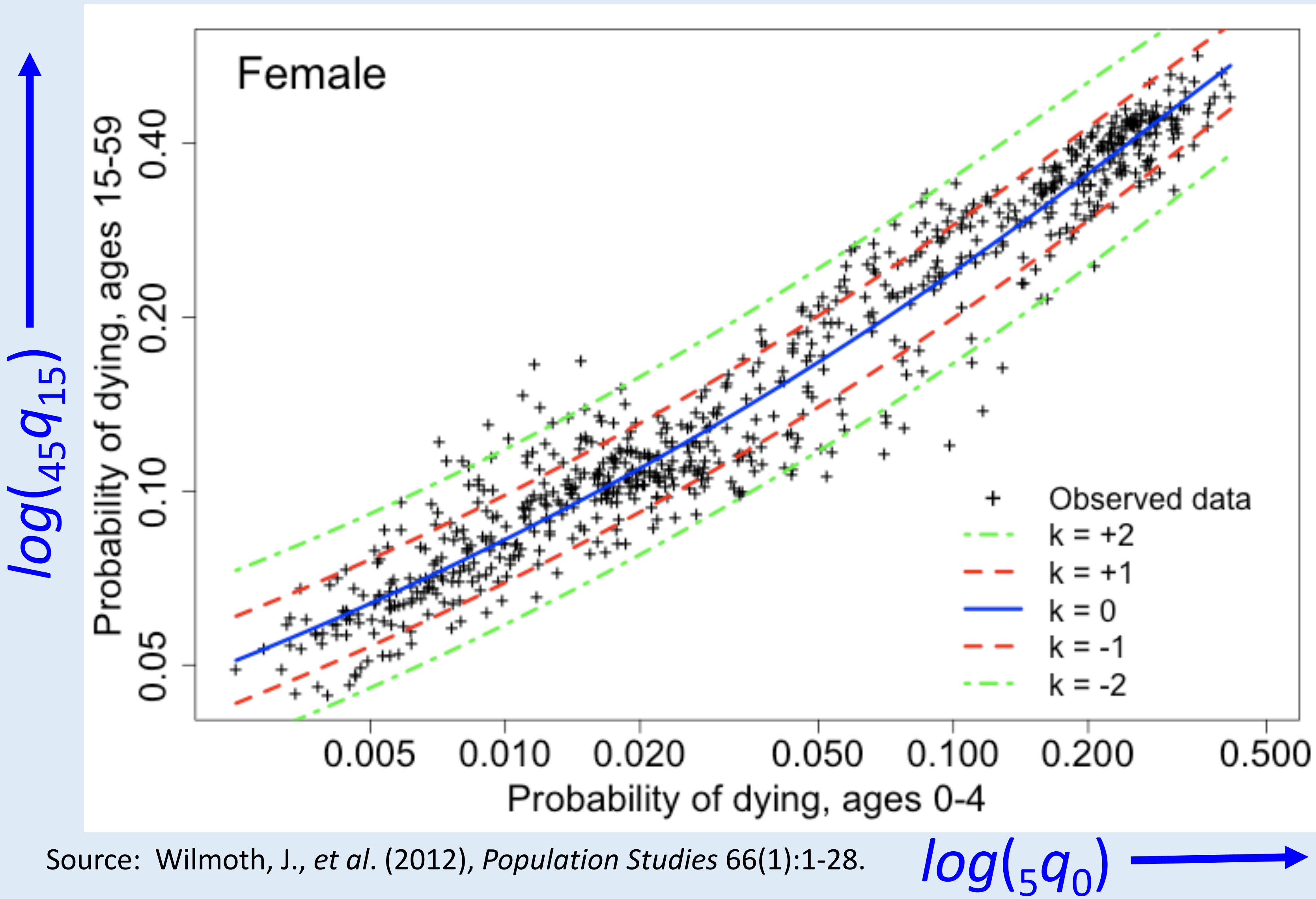
$$\log(m_x) = a_x + b_x h + c_x h^2 + v_x k$$



Source: Wilmoth, J., *et al*. (2012), *Population Studies* 66(1):1-28.

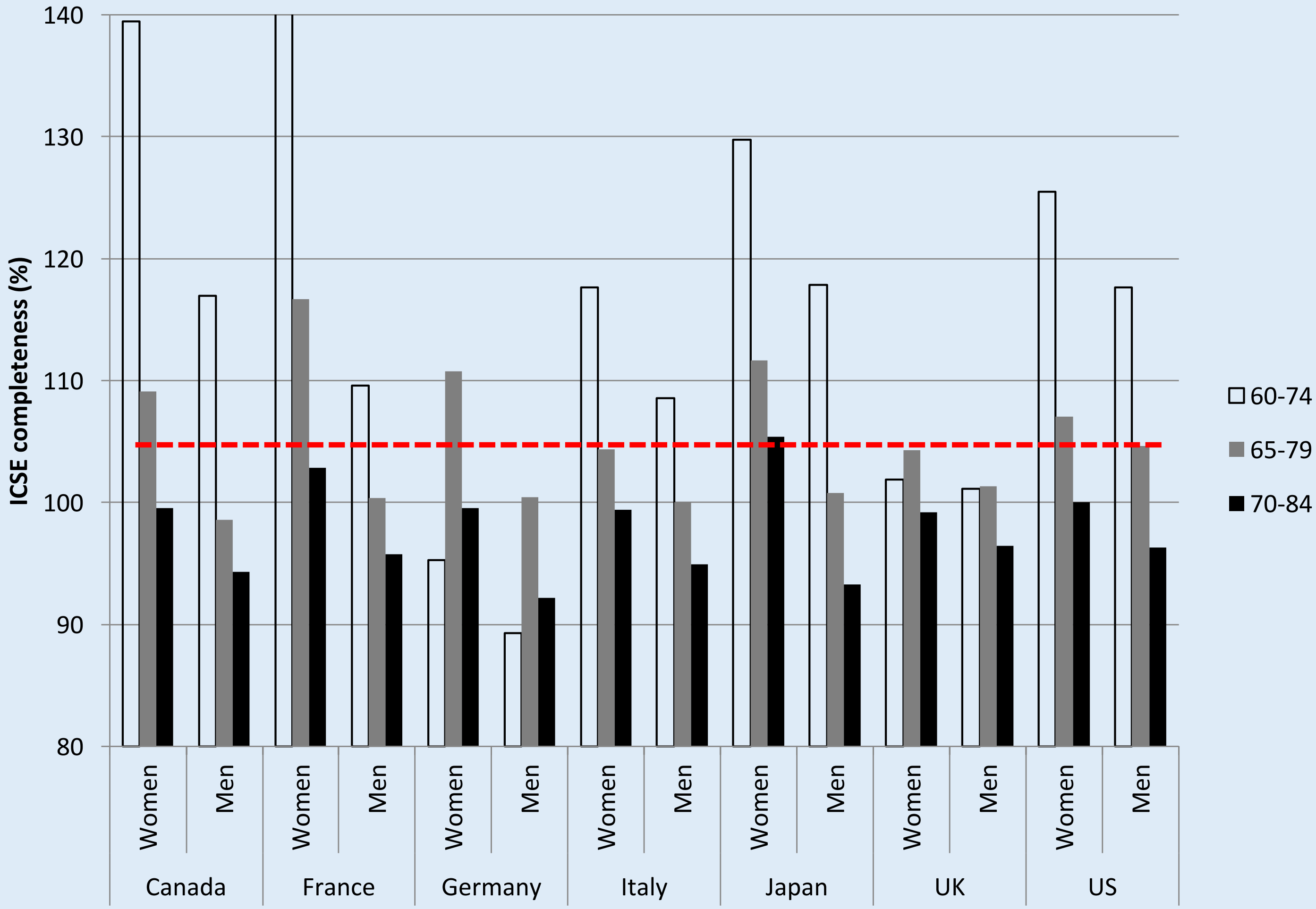
Child and Adult Mortality

Historical Data (HMD) + Log-Quadratic



Source: Wilmoth, J., *et al*. (2012), *Population Studies* 66(1):1-28.

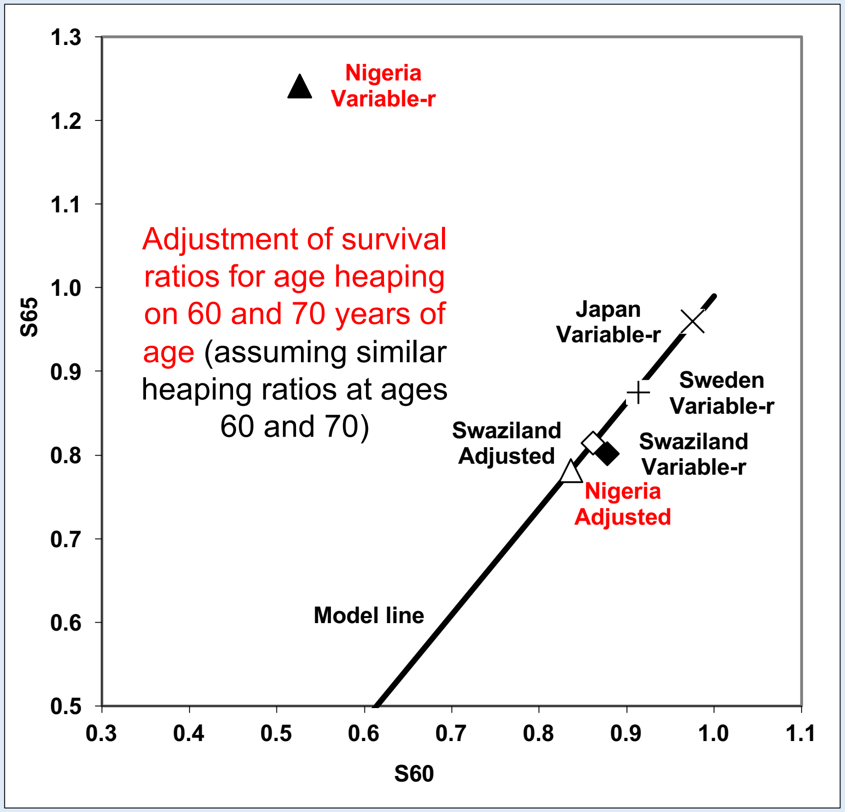
Test intercensal survival method: Completeness of death registration, G7countries, 2000-2010, using HMD data



Source: Li, N. and P. Gerland (2016), Expert Group Meeting on “Methodology and lessons learned to evaluate the completeness and quality of vital statistics data from civil registration”, United Nations, New York, 21-22 October.

Test variable-r method

Variable-r and adjusted survival ratios of females for selected countries



Estimates of $_{15}q_{60}$ based on applying the extended Gompertz model to the adjusted L_x

	Period	Males	Females
Japan	2000-2005	0.214	0.099
Sweden	1960-1965	0.370	0.292
Nigeria	1991-2006	0.356	0.479
Swaziland	1997-2007	0.624	0.419

Source: Li, N. and P. Gerland (2013), XXVII IUSSP International Population Conference, Busan, Rep. of Korea.

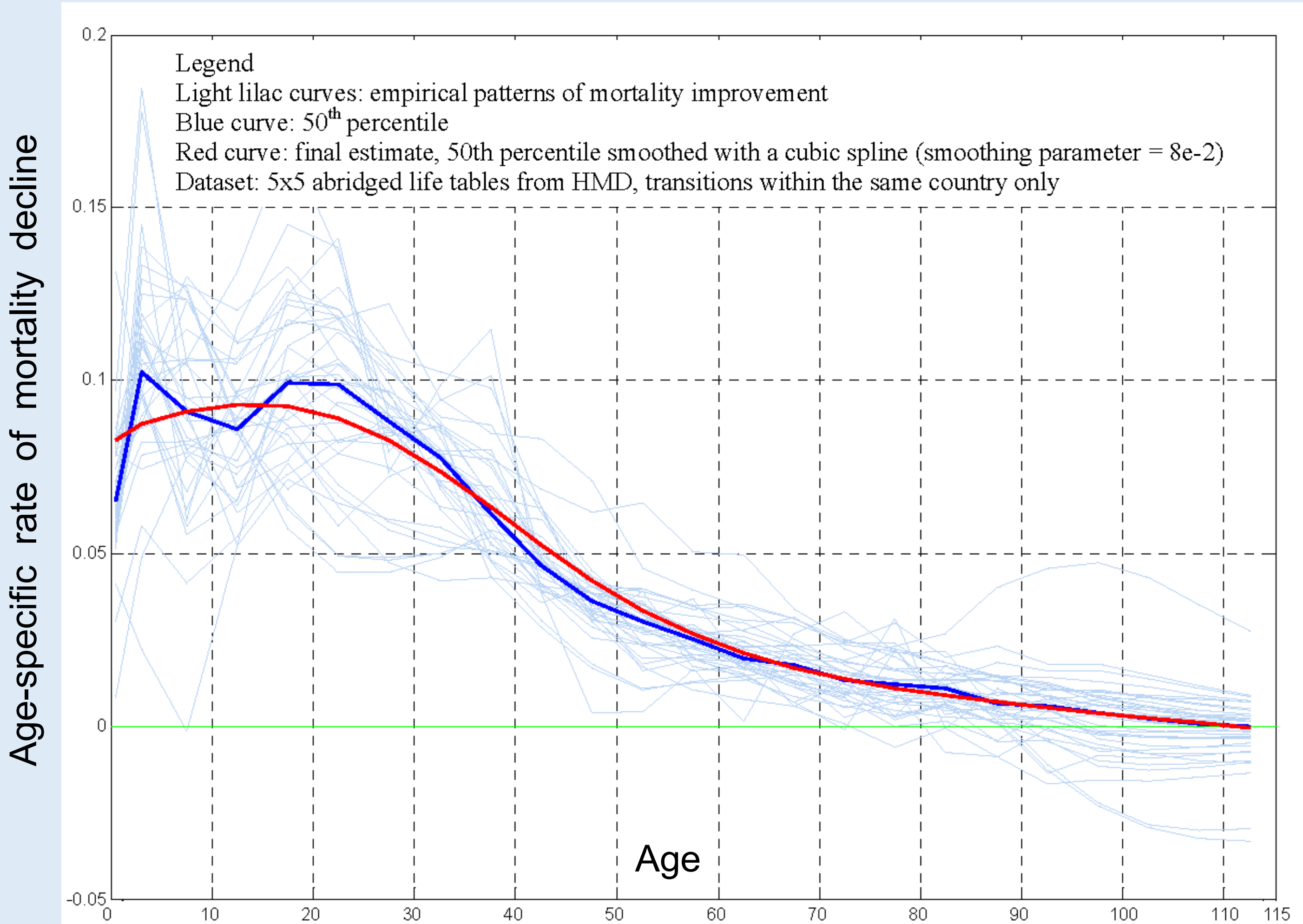
Vital registration data for non-HMD countries: extending the HMD toolkit

1. Collect death counts and population estimates
2. Review and standardize for differences in concepts and definitions
3. Evaluate completeness and adjust data (ages 5+), if needed
4. Use UN (IGME) estimates of $_{1}q_{0}$ and $_{5}q_{0}$
5. Compute life tables and interpolate/extrapolate, as needed, across age and time
6. Smooth/adjust old age mortality rates, as needed, to ensure plausible patterns over age, sex and time

Inform and calibrate projection models

- Age pattern of mortality: how to specify age-specific rates of change?
- Probabilistic projections of e_0: estimation and assumptions

Age-pattern of change: countries with recent data but no historical series

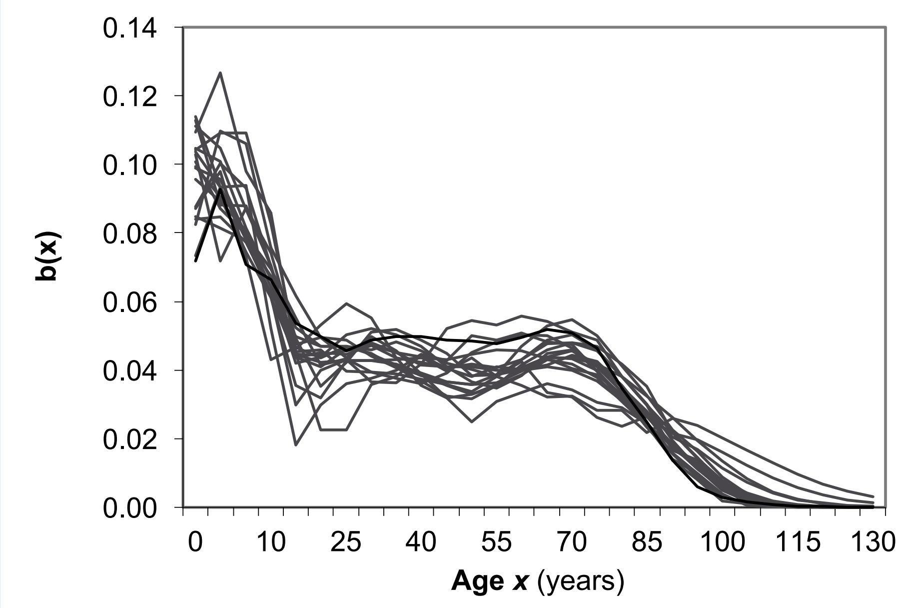


Example: Estimating the age pattern of mortality decline, for a given level of life expectancy at birth (65-70 years, women)

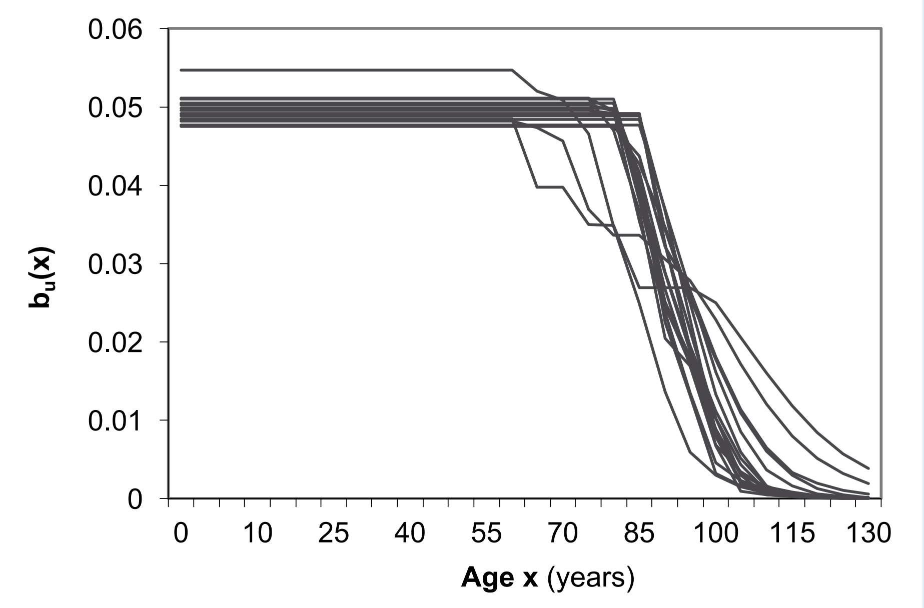
Source: Andreev, K., D. Gu and P. Gerland (2013), annual meeting of the Population Association of America, New Orleans, http://paa2013.princeton.edu/papers/132554.

Age-pattern of change: countries with historical data series

The Lee-Carter b(x) of the 20 low-mortality HMD populations based on 1950–2010 death rates



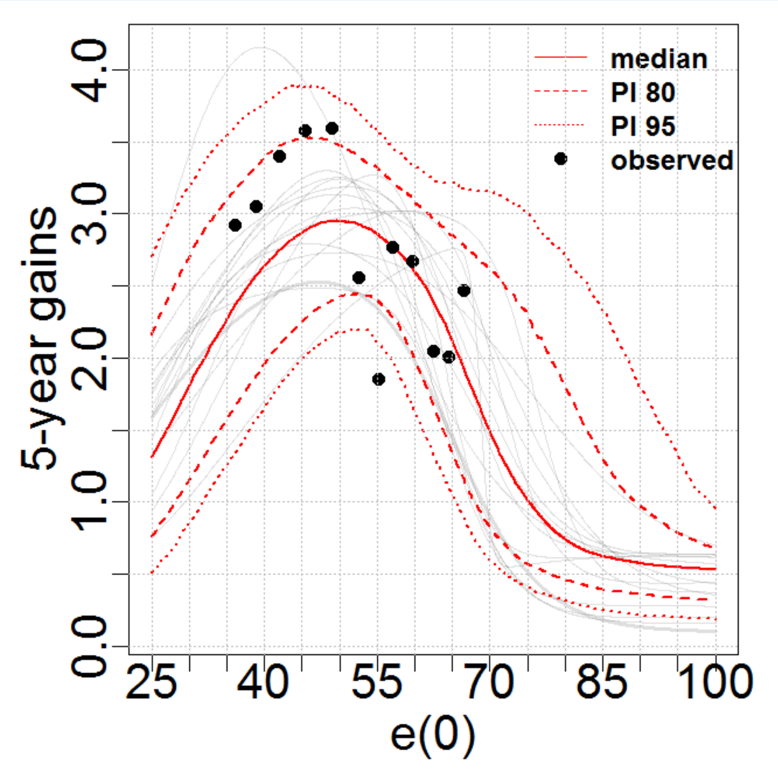
The ultimate b(x) of the 20 low-mortality HMD populations



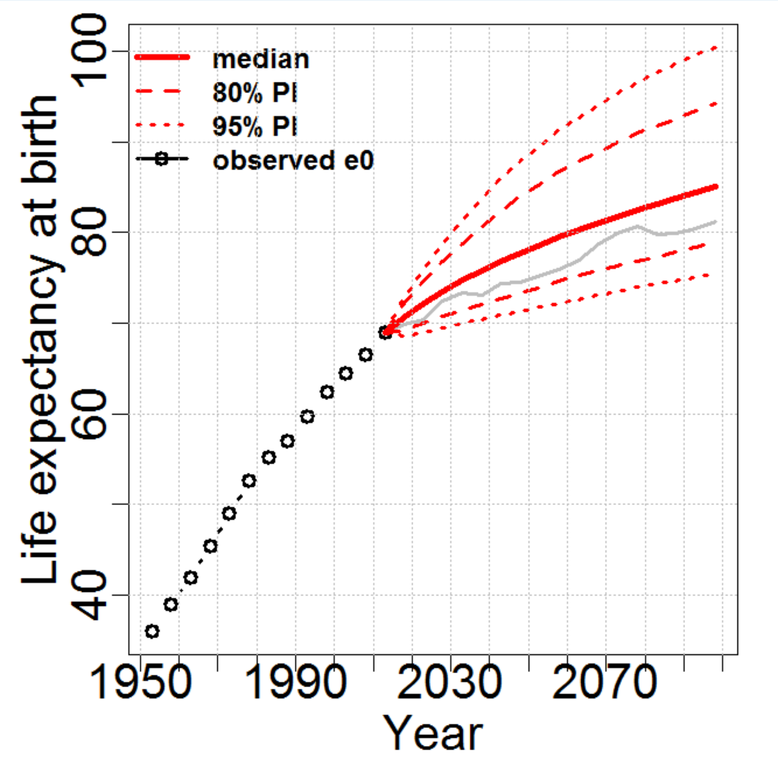
Source: Li, N., R. Lee and P. Gerland, (2013), *Demography* 50(6):2037–2051.

UN probabilistic projection: India, women, e_0

Double-logistic gain in e_0 function



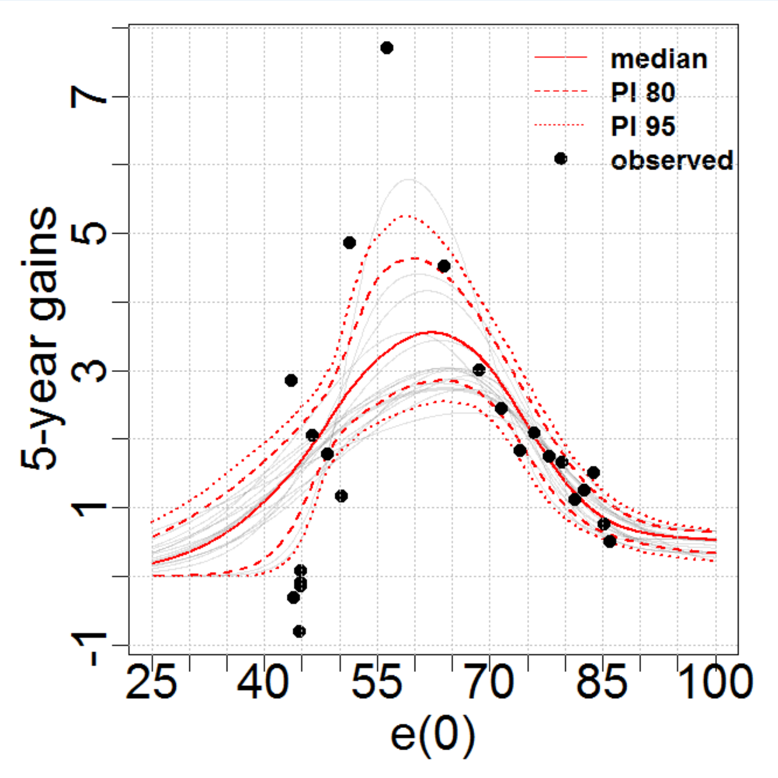
Probabilistic projections of e_0



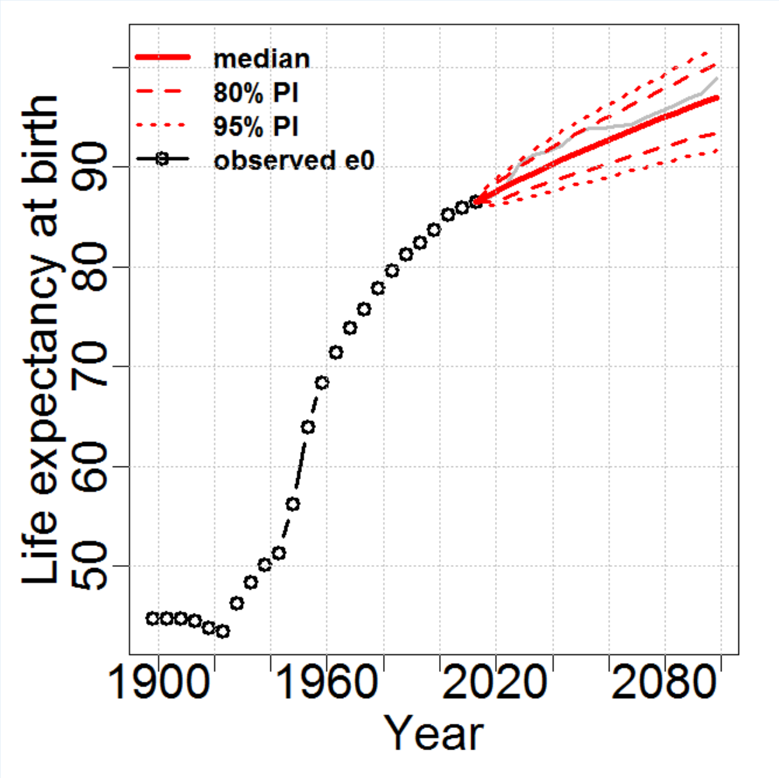
Source: United Nations (2015), WPP2015 online data, https://esa.un.org/unpd/wpp/Graphs/Probabilistic/EX/.

UN probabilistic projection: Japan, women, e_0

Double-logistic gain in e_0 function



Probabilistic projections of e_0



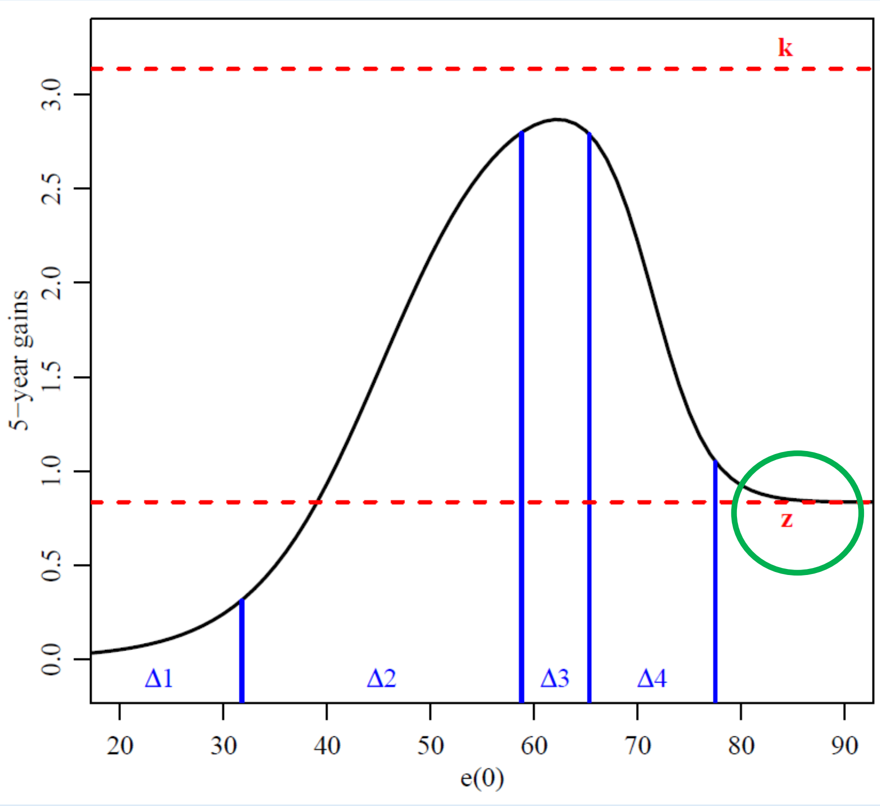
Source: United Nations (2015), WPP2015 online data, https://esa.un.org/unpd/wpp/Graphs/Probabilistic/EX/.

Estimating the model parameters

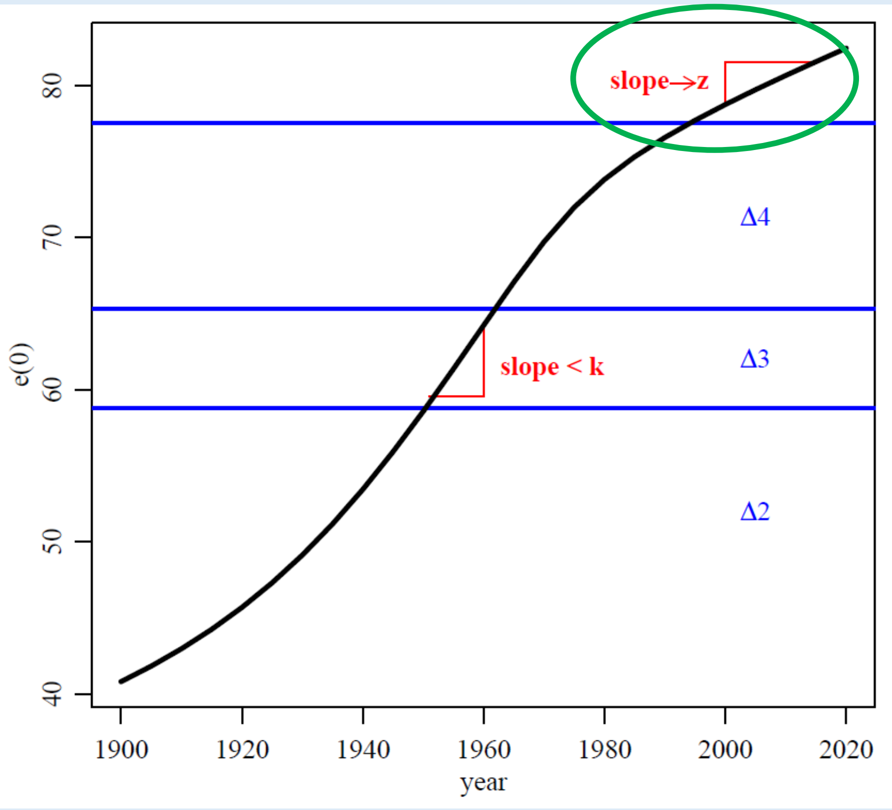
- All parameters except the long-run asymptote can be estimated using empirical data
- Estimated using observation pairs consisting of values of e_0 and of changes in e_0 (over 5 years)
- Estimated using UN data for 1950 and later, and HMD pre-1950 data

Sources: United Nations (2014), WPP2012: Methodology, ESA/P/WP.235.
Sevcikova, H., *et al*. (2015). *bayesLife: Bayesian Projection of Life Expectancy*, R Package and documentation.
United Nations (2015), *wpp2015: World Population Prospects 2015*, R Package and documentation.

How to determine the asymptotic limit to future gains in e_0?

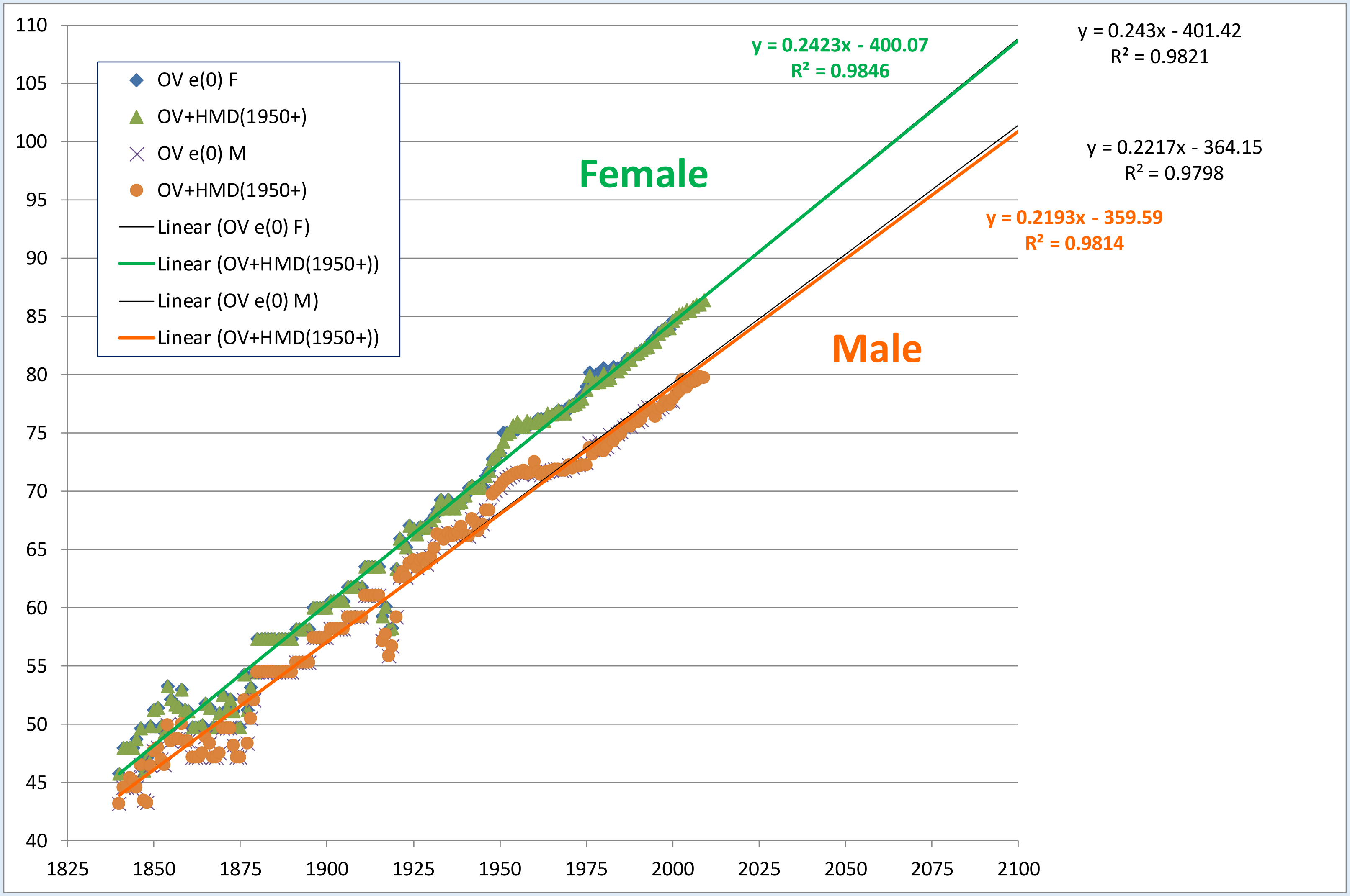


Double-logistic function used to model rate of change in life expectancy at birth



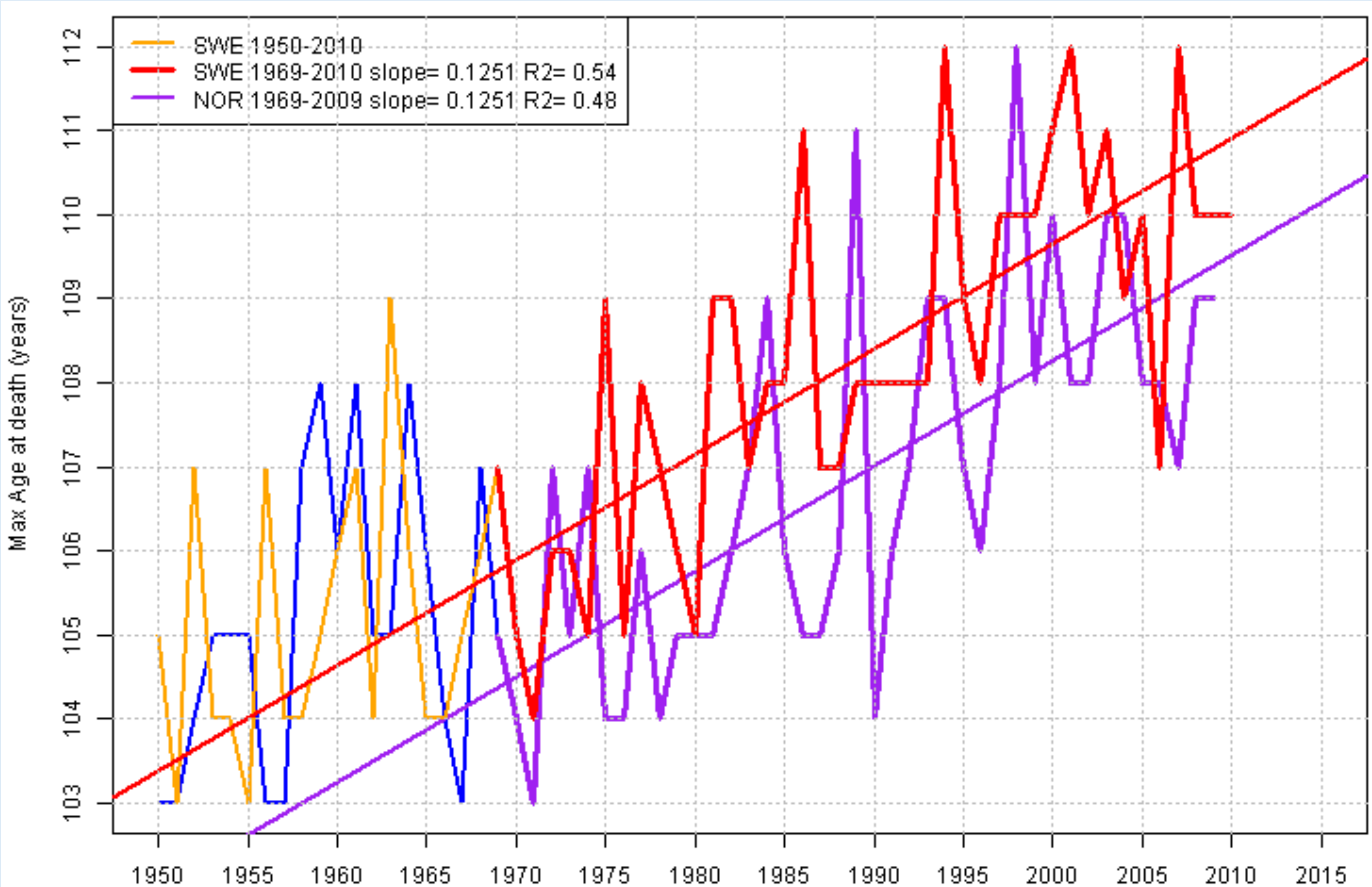
Trend in life expectancy at birth with slope determined by double-logistic function

First approach: Calibrate according to average gain in maximum e_0



Source: United Nations (2013), unpublished analysis based on Oeppen & Vaupel (2002) and HMD data.

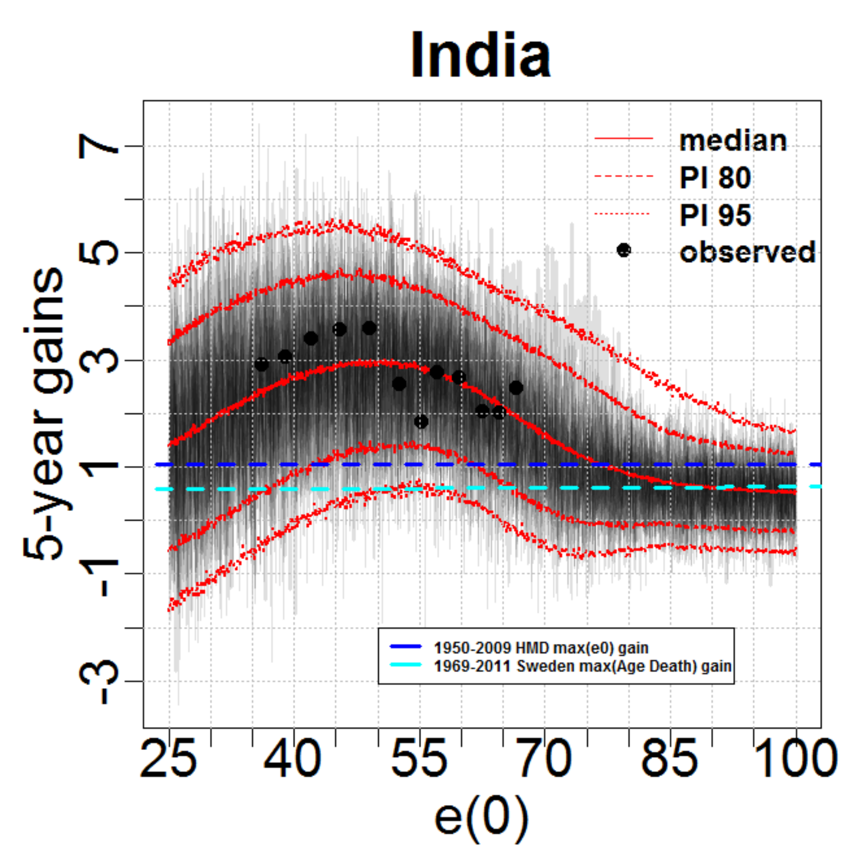
Second approach: Calibrate according to average gain in maximum life span

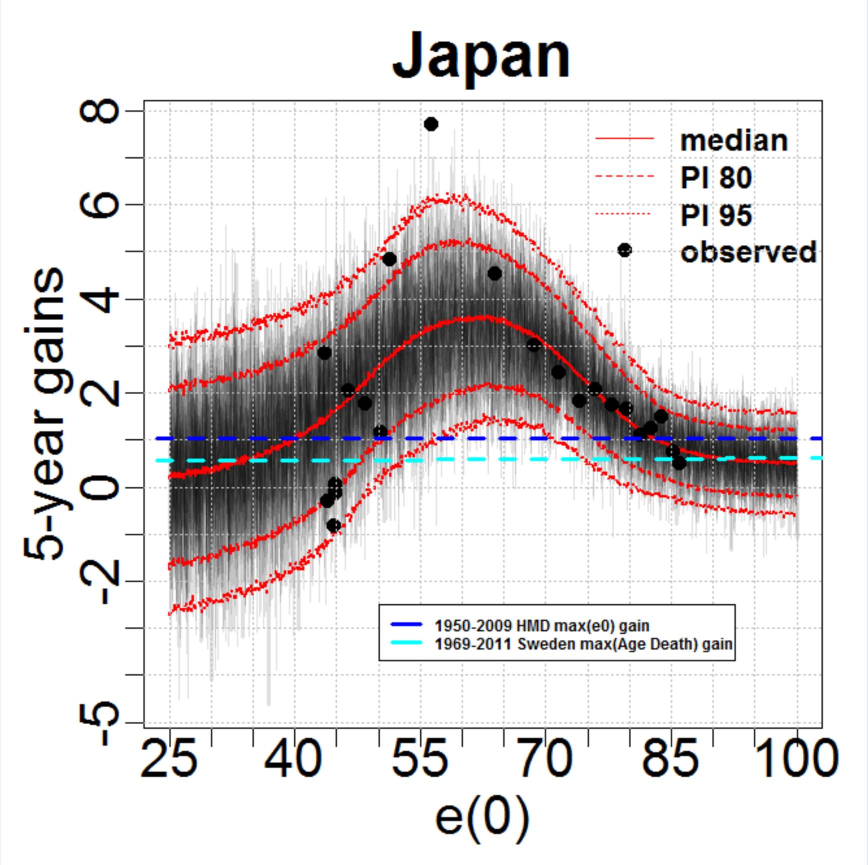


Source: United Nations (2013), unpublished analysis based on data from N. Ouellete.

Predictive distribution of change in e_0: India and Japan, women

Alternative assumption for asymptotic limit lies within band





Source: Unpublished graphs, prepared using *bayesLife*, *wpp2015* and online data (see previous two slides).

Acknowledgement

Many thanks to Patrick Gerland of the United Nations Population Division for his assistance in preparing this presentation