# Using the Equivalent Construction to Estimate Complete Life tables for the Developing Countries Mortality Database (DCMD)

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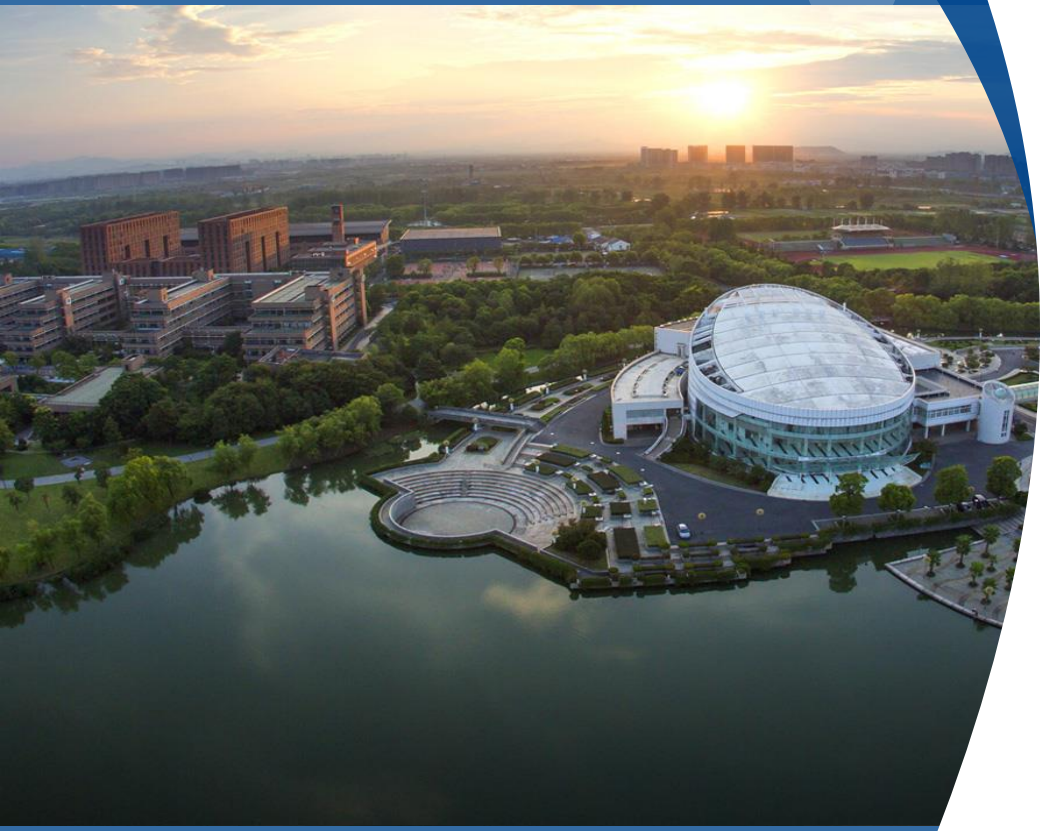


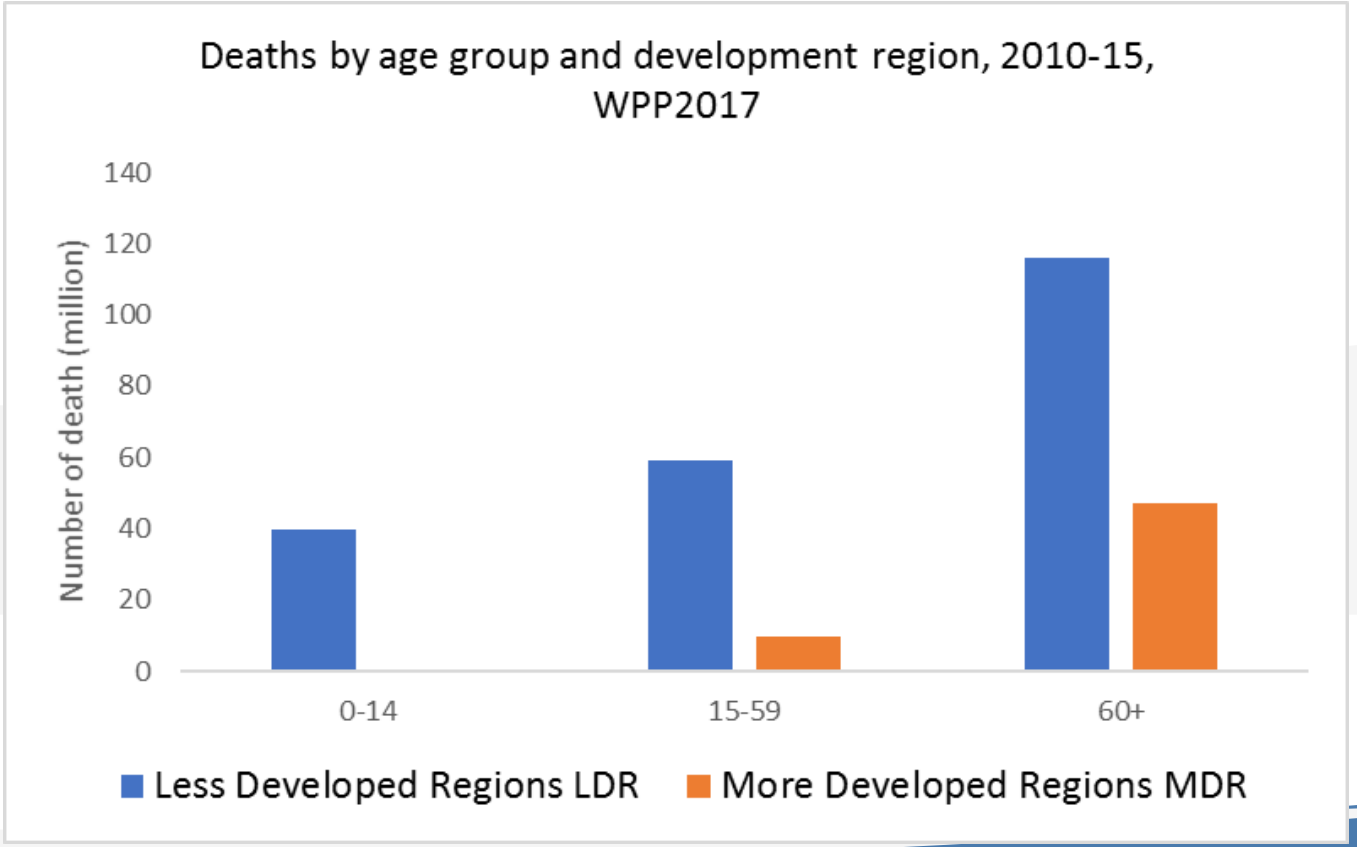
# CONTENT

# Part 1

# An introduction to DCMD

# The problem: the biggest number of death is the least reliable.

- The biggest number, D(60+) of LDR（Less Developed Region), is estimated using model life tables. Other numbers of death are obtained from registrations and surveys.

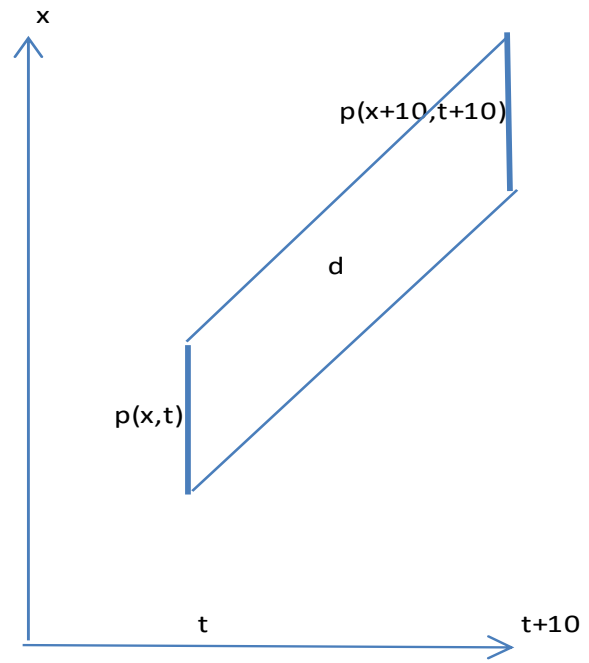


# The problem: the biggest number of death is the least reliable.

- This reality indicates that improving the estimates of old-age mortality (${}_{15}q_{60}$) for individual developing countries is not enough, and that establishing a life-table database for all developing countries, which utilizes the improved estimations of old-age mortality, is necessary.

# What can we do?

- Use census population to estimate old-age deaths between two censuses.
- Use child mortality (Mc, UNICEF), adult mortality (Ma, IHME), old-age mortality (Mo, Census Method) and the three-input-parameter model life table to provide life tables for developing countries.




*The result is the Developing Countries Mortality Database (DCMD), available at www.lifetables.org.

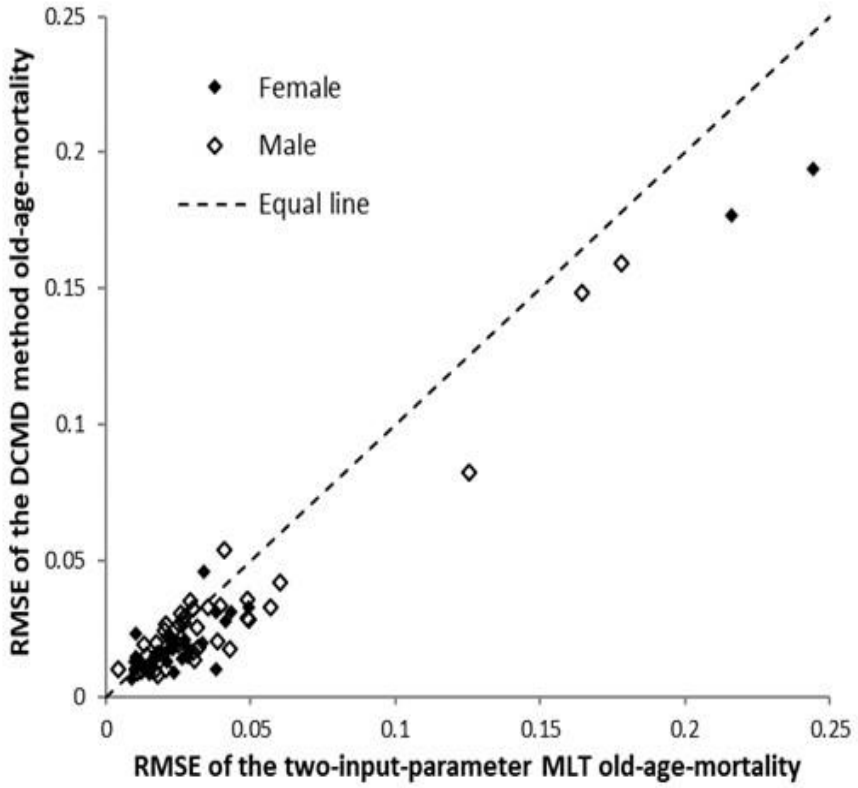
# Does the idea work?

- For all the countries in HMD after 1950 (or after World War II)

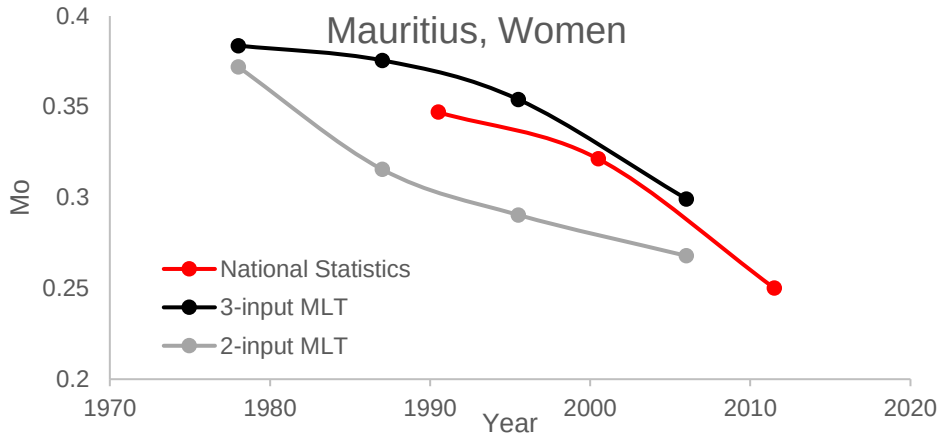
(1) We estimated old-age mortality using: Two-input-parameter MLT and child and adult mortality (previous methods).

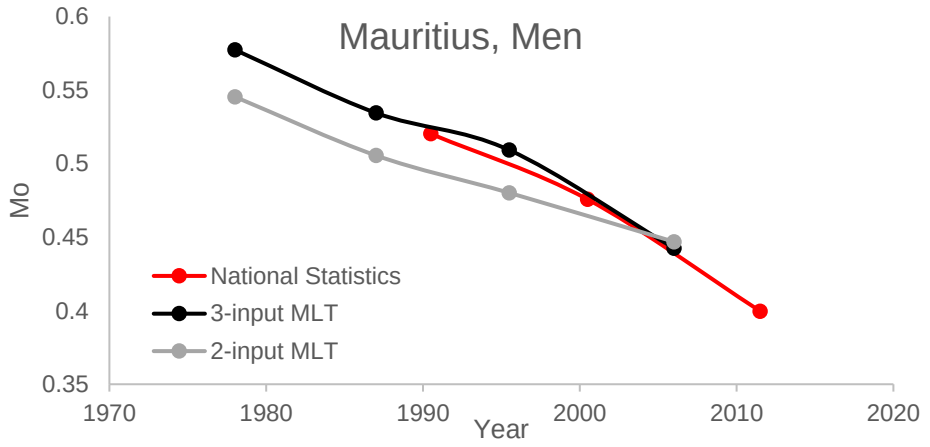
(2) We also estimated old-age mortality using: Three-input-parameter MLT and Child, adult and old-age mortality.

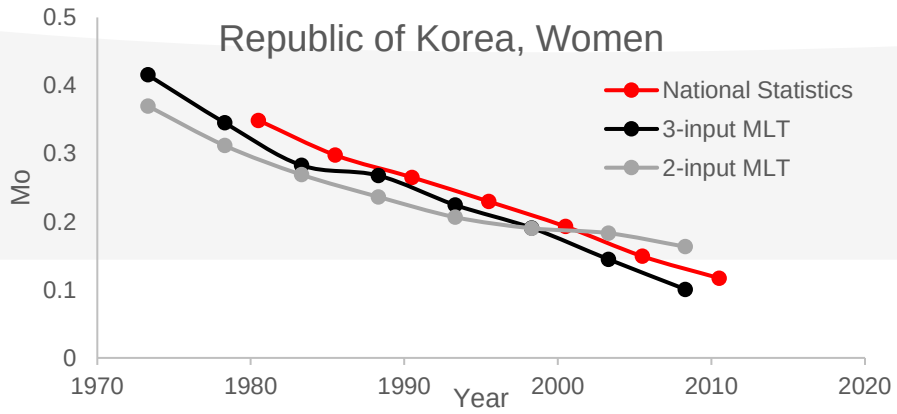
- The errors of (2) are lower than that of (1) for more than 70% countries.

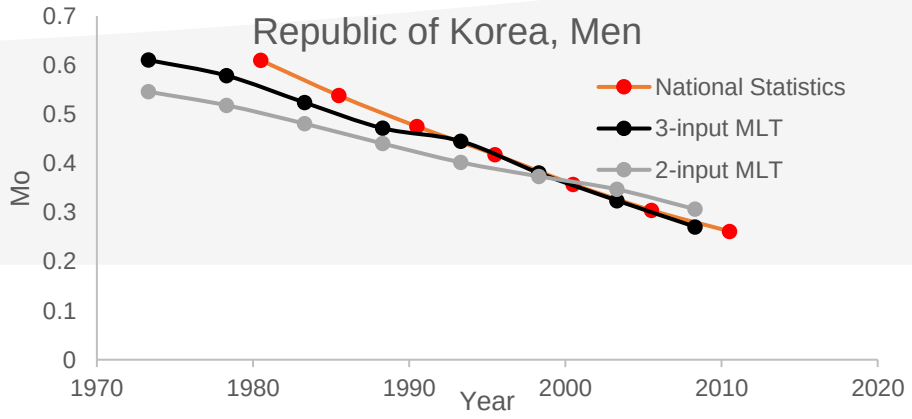


# How about developing countries?

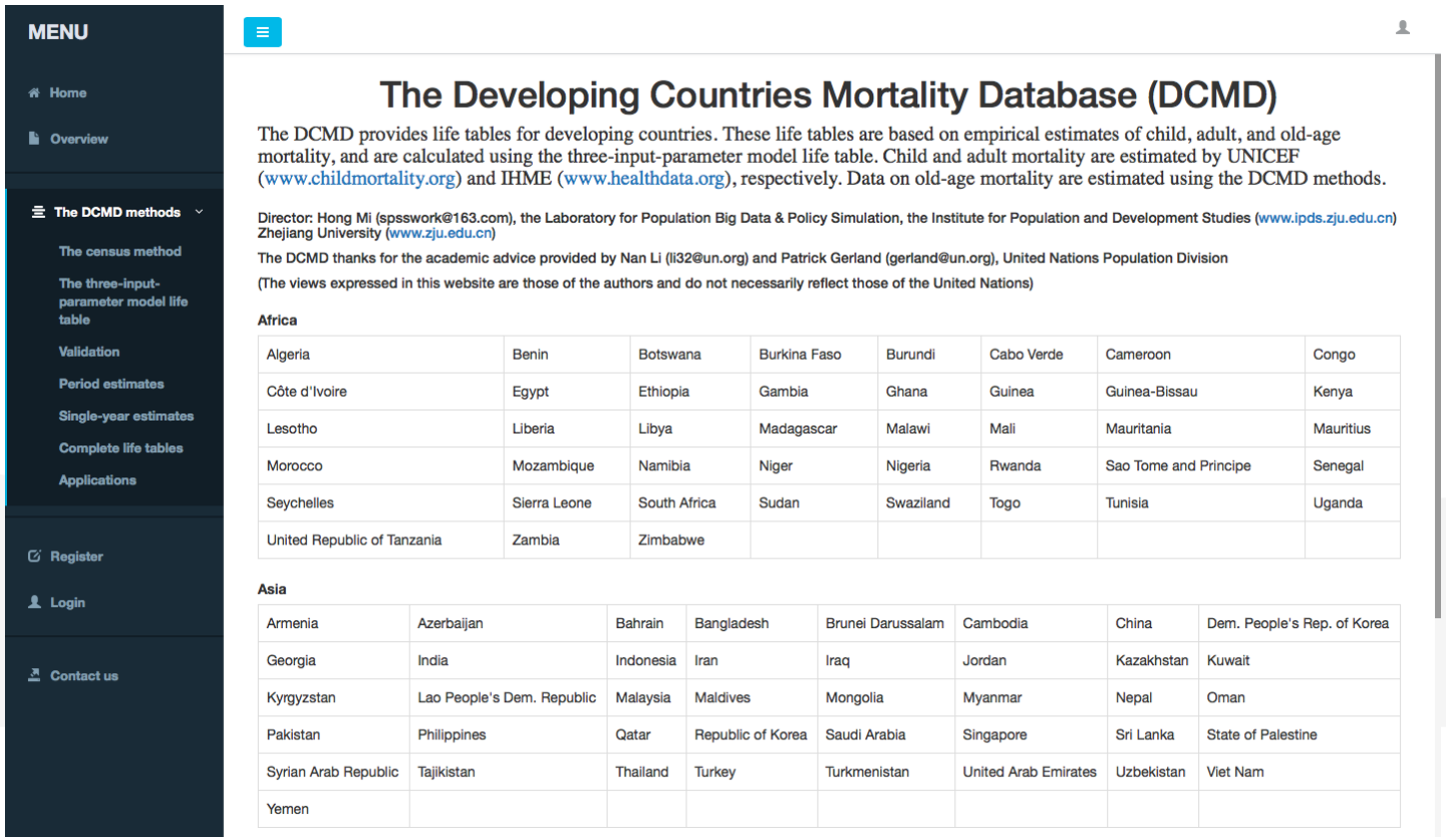


# The Developing Countries Mortality Database (DCMD)




- DCMD (www.lifetables.org) provides life tables for developing countries, using empirical estimates of child, adult, and old-age mortality, and the three-input-parameter model life table.
- The homepage of the website is divided into two parts, and the left side is a menu. And the main content is on the right side, which list 122 countries
- The 122 countries are divided into three categories by region, such as Africa, Asia and Latin America and the Caribbean, Oceania.

# Part 2

# How are the complete life tables estimated?

# How are the complete life tables estimated?

- When extending an abridged life table to a complete life table, there are two targets. The first is to preserve the age patterns of the original abridged life table, and the second target is to satisfy the smoothness of the functions of the complete life table.
- In a recent study (Li, 2019), an equivalent construction of life table is proposed.
  - The first step of this method is to reduce an observed unsmooth complete life table to a smooth abridged life table, which can use five-year, ten-year, or flexible age groups.
  - In the second step, the abridged life table is used as input to equivalently construct a complete life table, which refers to that, using the complete life table to compute an abridged life table, the result is identical to the original abridged life table for every life-table function at each age. If the equivalently constructed complete life table is not smooth enough, a construction-based graduation is used as the third step.

# Equivalent Construction

- The computational structure of a life table is analyzed. It chooses, for the reason of simplicity, the function of survivors at age $x$ ( $l_x$ ) and the function of person-years between ages $x$ and $x+n$ ( ${}_nL_x$ ) as the two independent life-table functions of an original abridged life table, as input, to construct a complete life table that is equivalent to the original abridged life table.

$$l_x = l_{x_a}, \quad x = x_a. \quad (1)$$

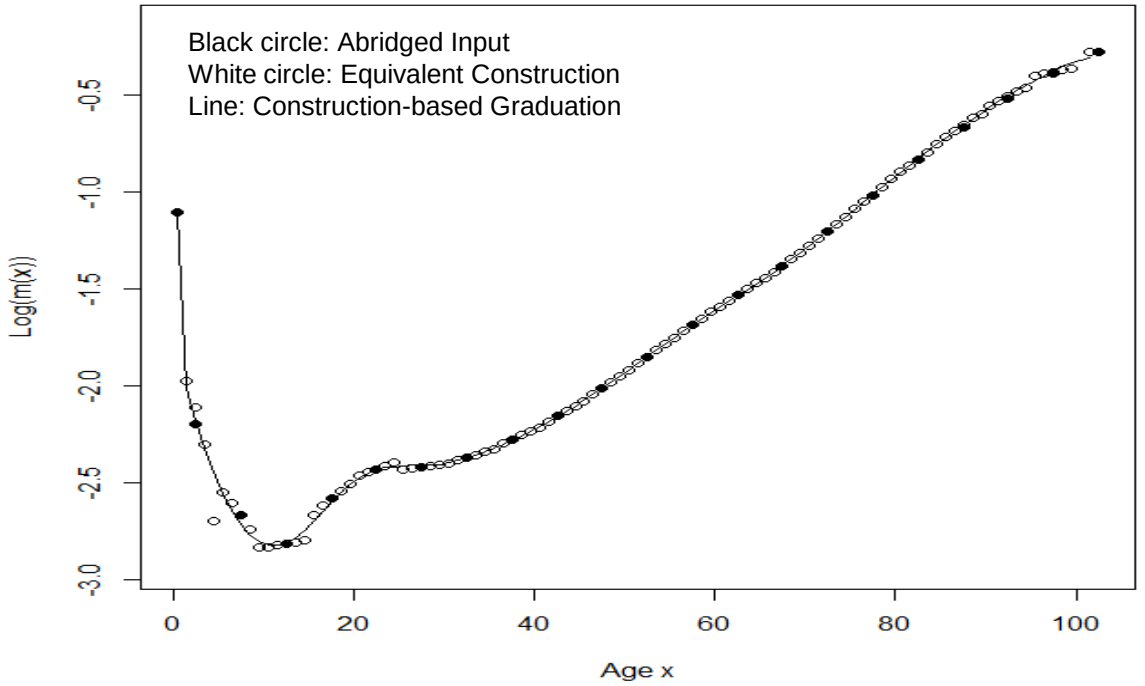
$${}_5L_{x_a} = \int_{x_a}^{x_a+5} l_y dy. \quad (2)$$

- How to determine the $l_y$ between $x_a$ and $x_{a+5}$?

The smoothest from minimizing $\int_{x_a}^{x_a+n} [\frac{d^2 l_x}{dx^2}]^2 dx$

# Construction-based graduation

- When some functions of the equivalently constructed complete life table are not smooth enough, especially at the boundaries of successive abridged age groups, a graduation (or smooth) could be applied to a life-table function, which is a construction-based graduation



# Average relative difference (Ard)

- **How big are the average relative difference (Ard) between the abridged and complete life tables?**

- An equivalently constructed complete life table is guaranteed to be equivalent to the original abridged life table. A life table of construction-based graduation is an adjustment on the equivalently constructed complete life table. We measure an adjustment using the average relative difference (Ard) between the life expectancies at ages 0, 15 and 60 years of the complete life tables of the equivalent construction and construction-based graduation.

$$Ard = 100 \cdot (|\frac{e_0^c - e_0^g}{e_0^c}| + |\frac{e_{15}^c - e_{15}^g}{e_{15}^c}| + |\frac{e_{60}^c - e_{60}^g}{e_{60}^c}|) / 3$$

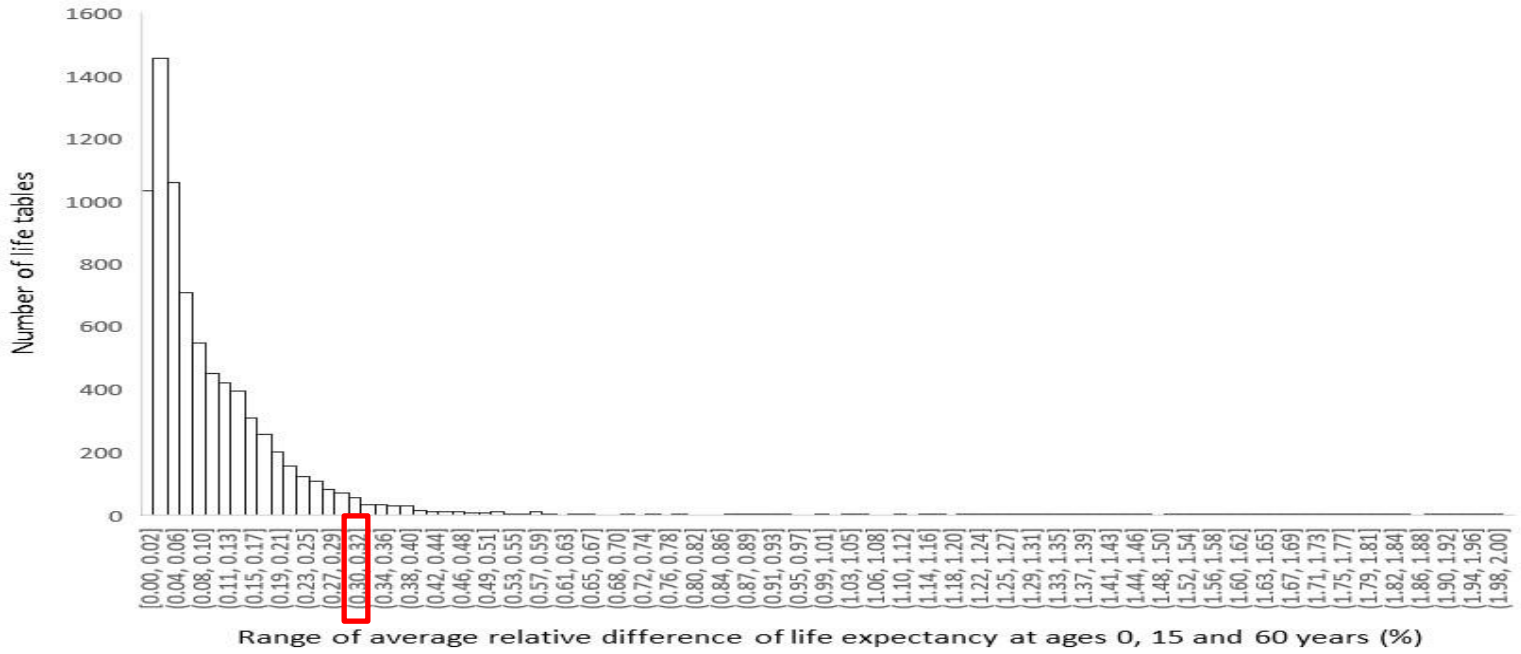
# Application

- The Developing Countries Mortality Database (DCMD, www.lifetables.org) provided abridged life tables that use five-year age group. But most population-related statistics and programs are using single-year age.

- We report an application of **equivalent construction**, which extends all DCMD abridged life tables to complete life tables. **In this application, the targets of preserving the age patterns of the abridged life table and satisfying the smoothness of the complete life table are reached simultaneously for more than 97% life tables in DCMD.**

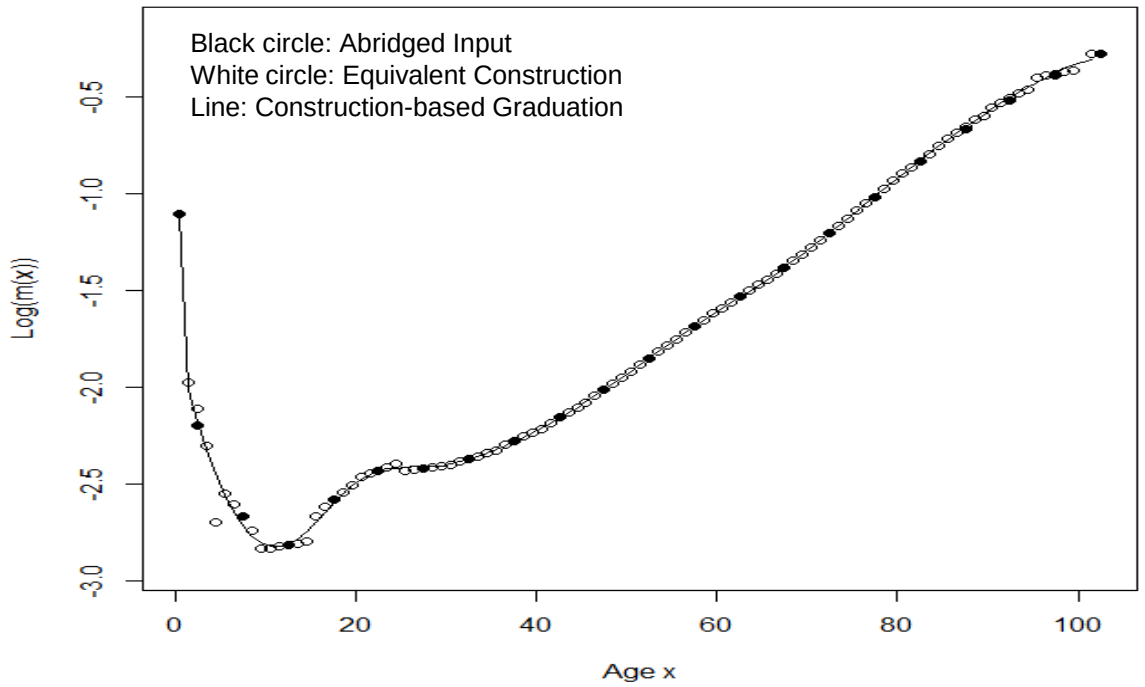
# Application

- **The Ard are smaller than 0.3% (Malawi men, 2001) for 97% of the 7712 life tables in DCMD.**
- 0.3% means about 0.3 years if the life expectancies are 100 years.



# Application

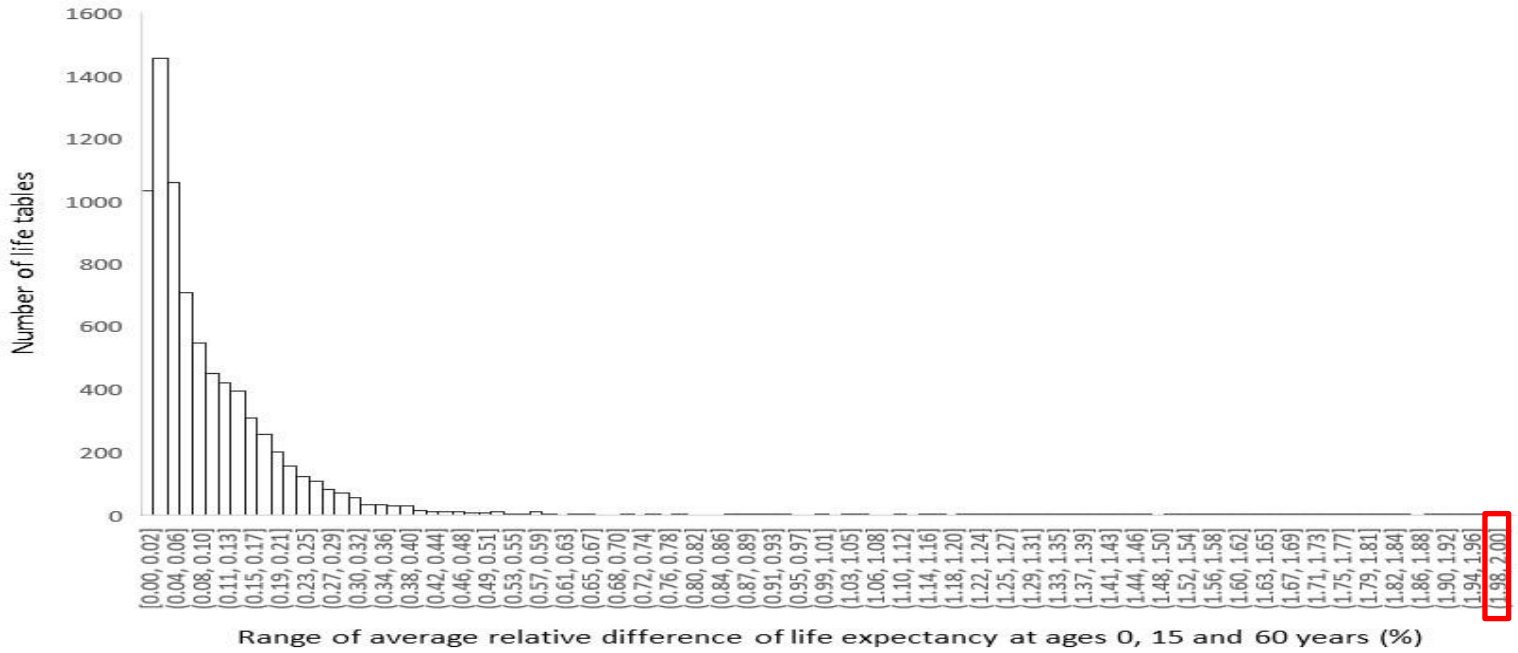
Figure 1. Logarithm of death rate by single-year and five-year age groups, Malawi men, year 2001




In Figure 1, the black circles represent the logarithms of death rate of the original abridged life table, the white circles stand for that of the equivalently constructed life table, and the line displays that of the construction-based graduation. The difference between the white circles and the line, is large at only one age and small at all other ages, leading to an Ard as small as 0.3%.

# Application

- **The biggest Ard: 2% (Rwanda women in 1994, in which an unprecedented genocide happened )**
- 2% means about 2 years if the life expectancies are 100 years



# Application

Figure 2. Logarithm of death rate by single-year and five-year age groups, Rwanda women, 1994.

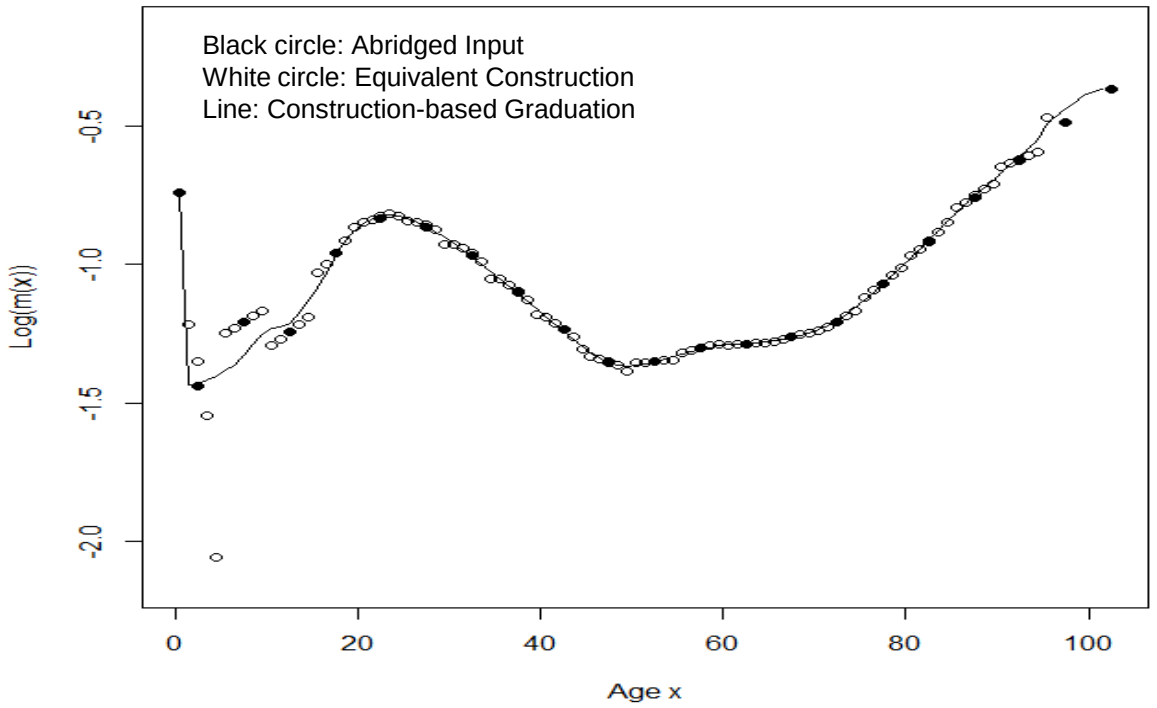



Figure 2 displays the logarithms of death rate by age of Rwanda women in 1994. Although the age pattern of death rate is extremely unusual, all black circles are still overlapped and in line with the white circles.

The adjustment is still small at most ages, but moderate at ages younger than 15 and extremely large at age 5 years, leading to an Ard as large as 2%.

# Thank You!

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