Extension, Compression, and Beyond

A Unique Classification System for Mortality Evolution Patterns

- IAALS Colloquium, Barcelona, October, 24rth 2017
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Agenda
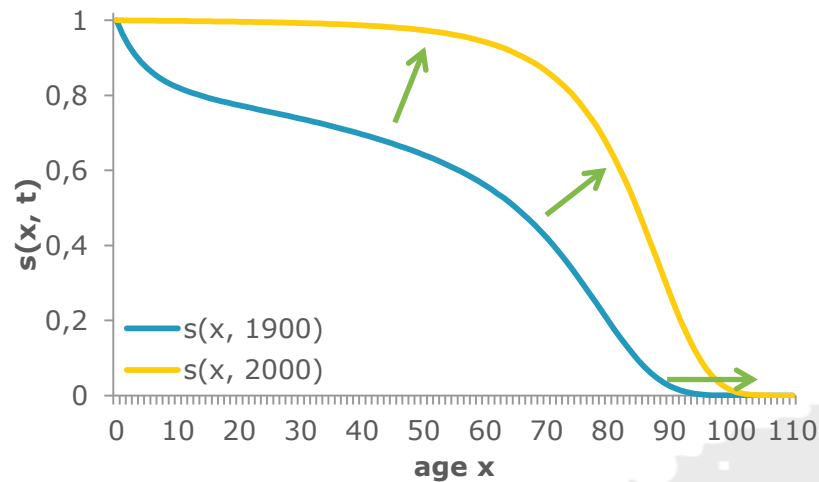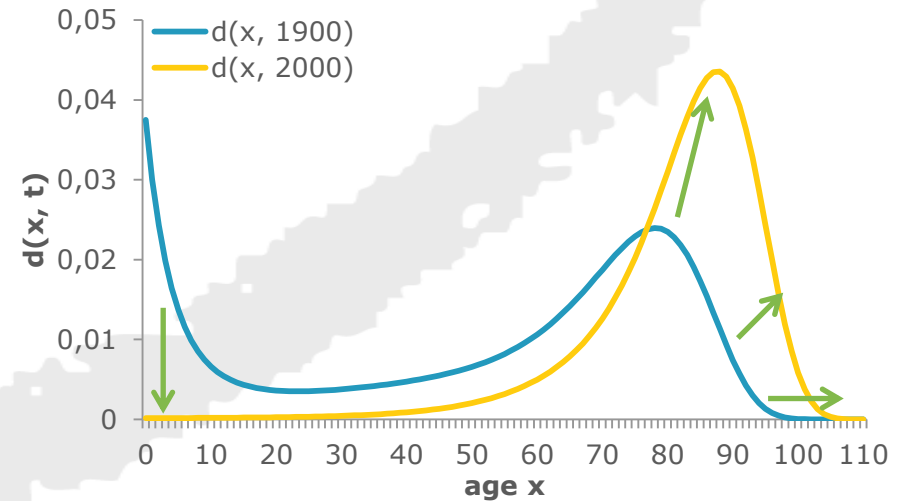
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Key question

- Life expectancy increases in many countries.

- But changes in life expectancy (and other typically used statistics) are only a **consequence of the underlying change of the age distribution of deaths**.

Survival curve of Swedish females 1900 and 2000

Deaths curve of Swedish females 1900 and 2000

- Key question: **How does the shape of these curves change over time?**

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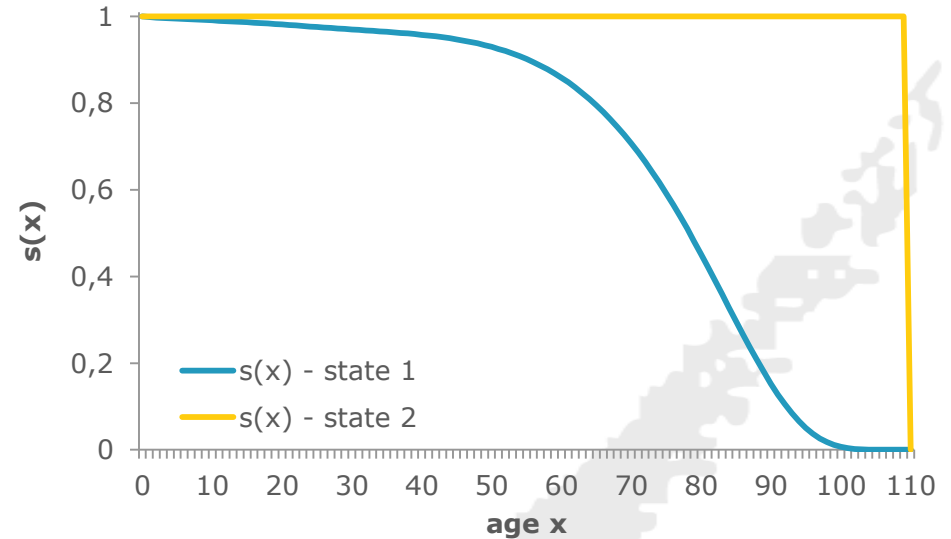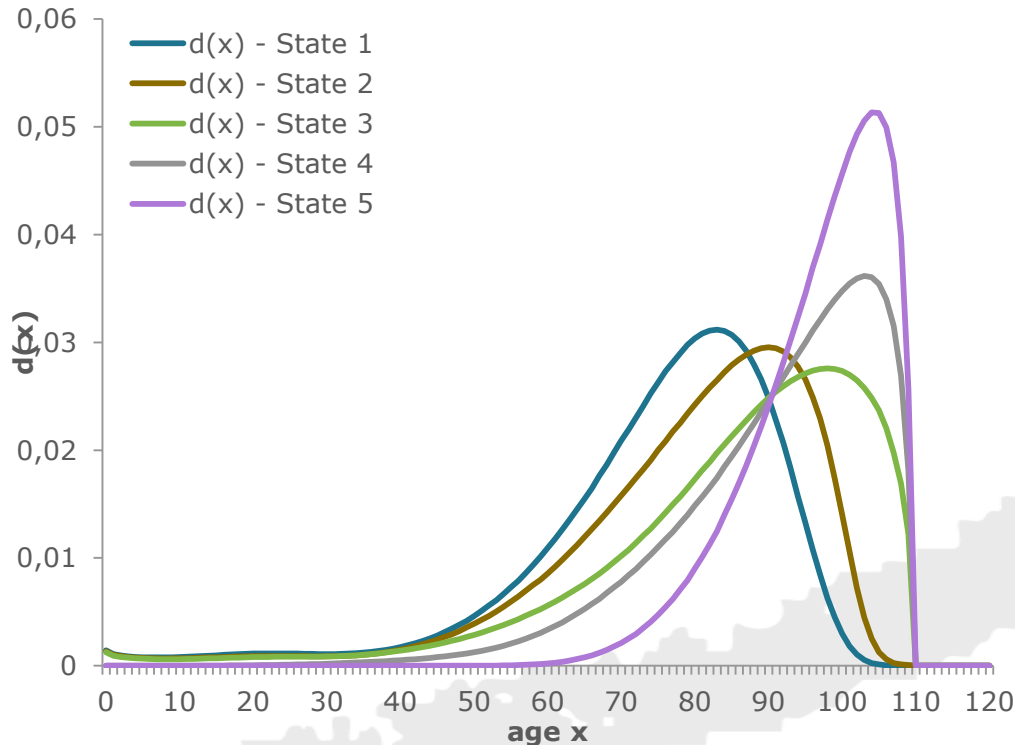# Classification of mortality evolutions in the past
Shortcomings

- There is a variety of literature on the question how the age distribution of deaths changes over time and we have identified some shortcomings there.

- In what follows, we discuss examples for four shortcomings:

  - Different notions for certain observations have been established (e.g. compression, extension, rectangularization, etc.) but sometimes these **scenarios were defined imprecisely**.

  - Some of these scenarios were supposed to be **mutually exclusive** but there are counterexamples.

  - Several often used **statistics are insufficient or even misleading**.

  - Often effects caused by the **choice of a certain age range** under observation were not considered.

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Classification of mortality evolutions in the past
Shortcomings

- **Imprecise scenario definitions:**

  - E.g., **rectangularization** is defined by a final state.

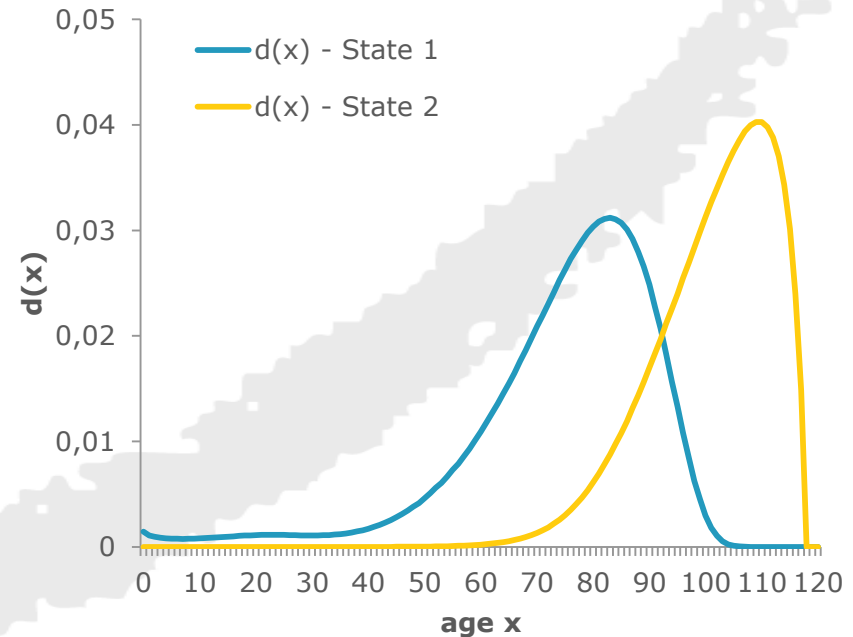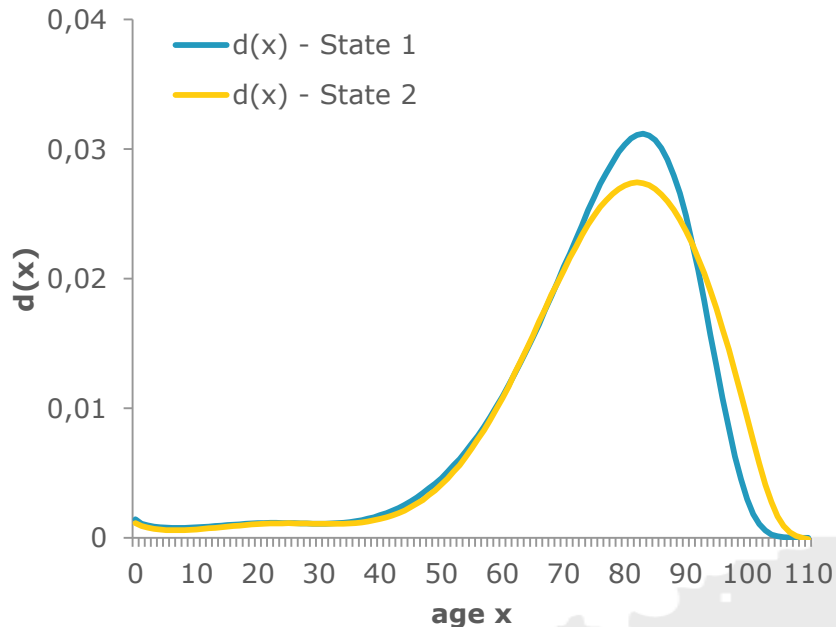Rectangularization: Present state (blue line) and final state (yellow line)

Overall rectangularization, but two different evolutions between State 1 and 3 and State 3 and 5, respectively.

Classification of mortality evolutions in the past
Shortcomings

- **Exclusiveness of scenarios:**

  - E.g., **compression** and **shifting mortality** are assumed to be opposing scenarios.

Neither compression nor shifting mortality prevail.

Compression and shifting mortality coexist.

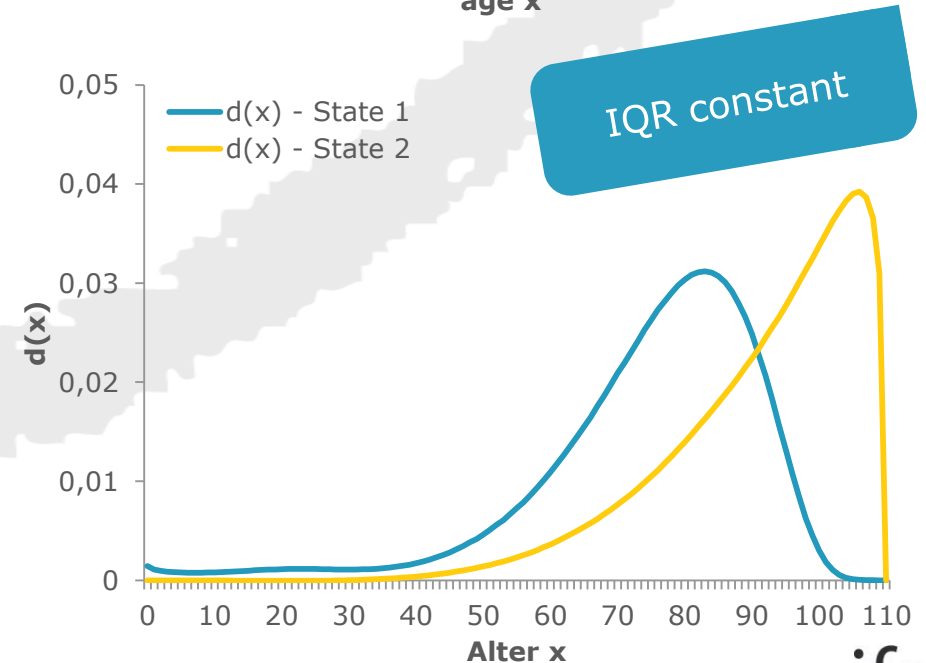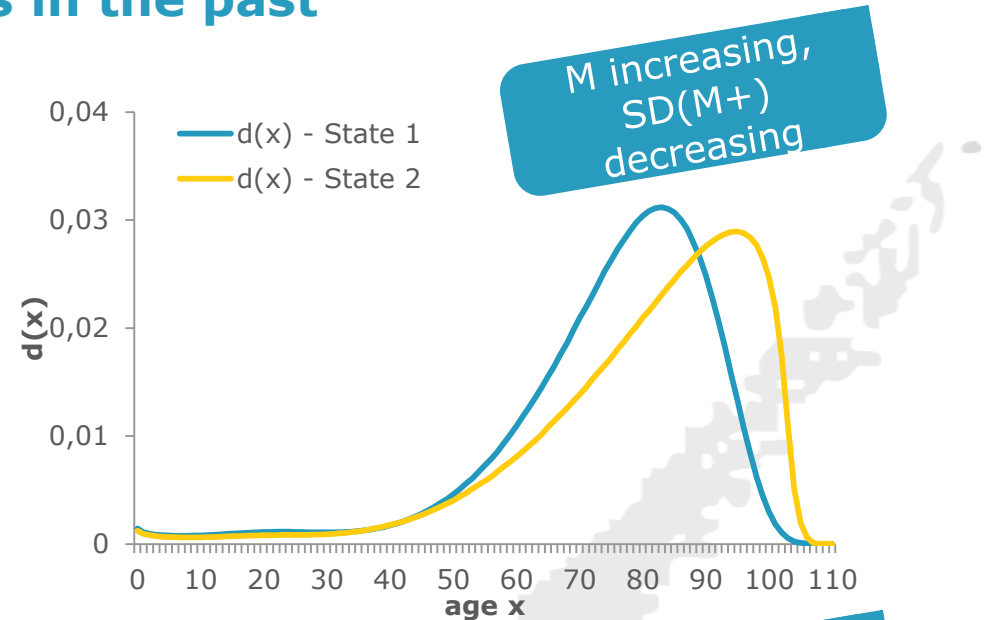Extension, Compression, and Beyond

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Classification of mortality evolutions in the past

Shortcomings

- **Insufficient or misleading statistics:**

  - Example 1: compression cannot always be detected by an exclusive analysis of **M and SD(M+).**

  - Example 2: compression cannot always be detected with **IQR.**

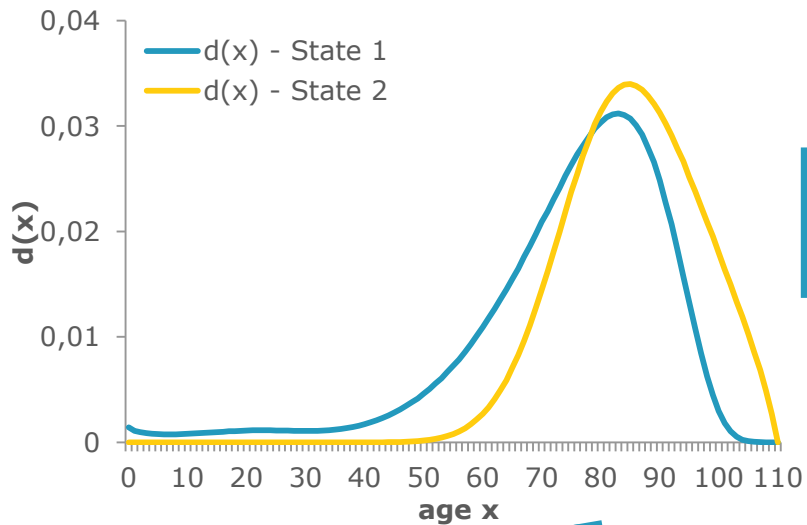M increasing, SD(M+) decreasing

IQR constant

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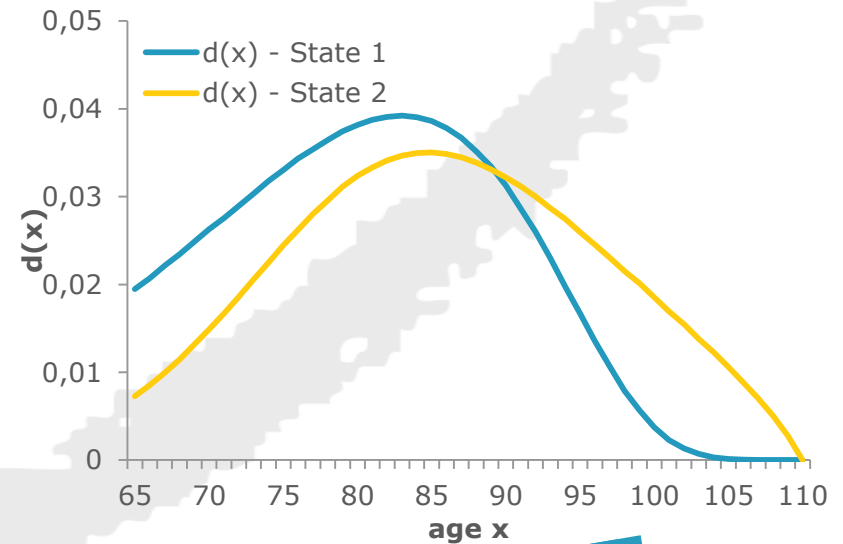# Classification of mortality evolutions in the past
Shortcomings

- The choice of the **age range matters:**

  - The age range should be chosen depending on the question at hand.

$$s(65)=1$$

Compression into the higher ages

No compr. within the higher ages

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A new classification framework
Requirements

In light of these shortcomings of previous approaches, a new classification system should…

- … uniquely categorize every material change in mortality patterns,
- … allow for mixed scenarios,
- … be applicable to different age ranges,
- … build on statistics that can be feasibly calculated and easily interpreted,
- … be extendable by additional components if needed.

Our new approach:

- We use the deaths curve as basis for the framework.
- We define 4 characteristics of the deaths curve for a unique classification of observed mortality evolutions.

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A new classification framework

Details

number of deaths in the modal age at death d(M): concentration or diffusion

degree of inequality DoI: compression or decompression

upper bound of the death curve's support UB: extension or contraction

modal age at death M: right or left shift

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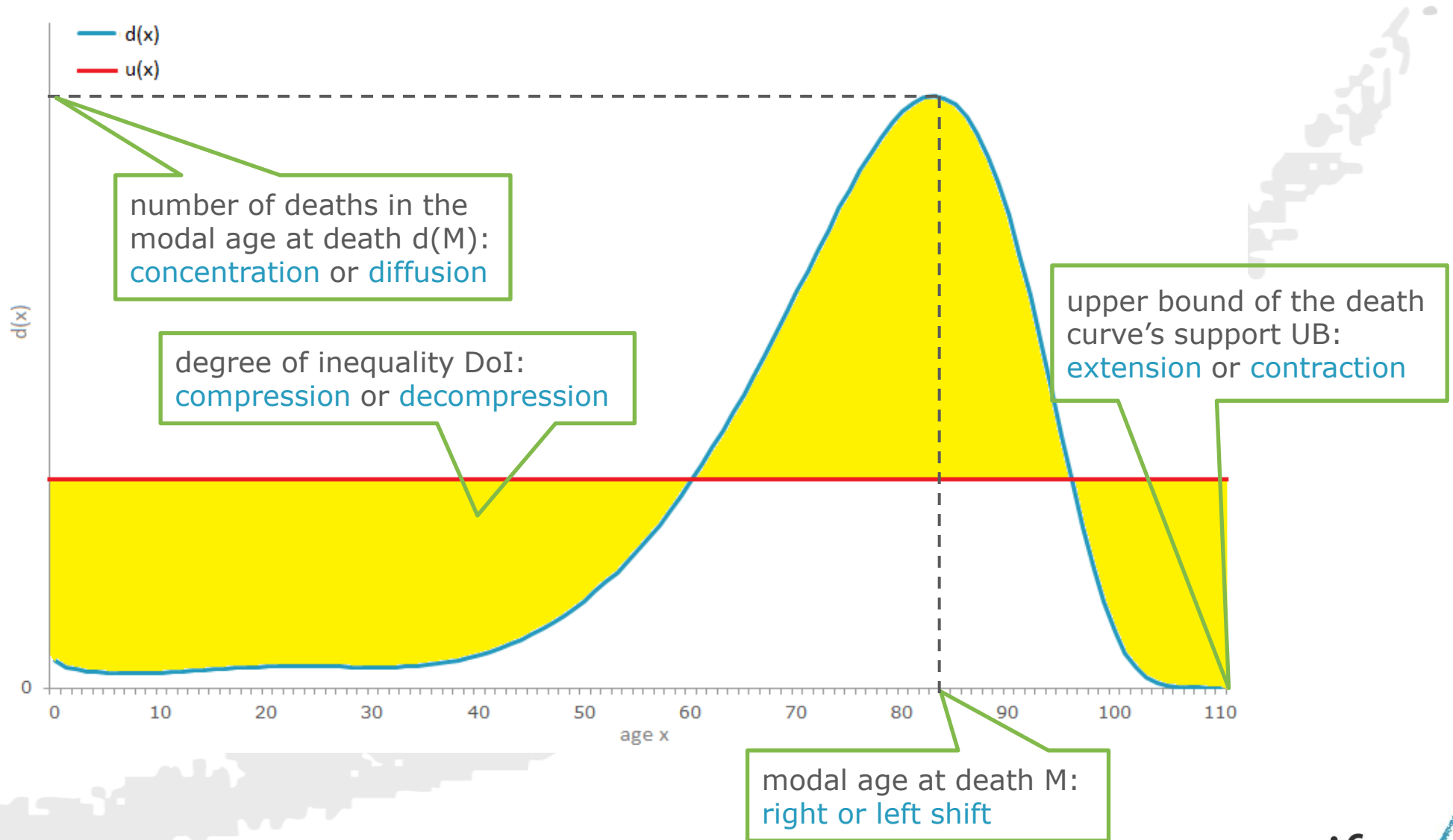
A new classification framework
Details

Each scenario is defined by a **4-dimensional vector** where each component can have three specifications:

| component	attainable states
M	right shift / neutral / left shift
UB	extension / neutral / contraction
DoI	compression / neutral / decompression
d(M)	concentration / neutral / diffusion

- This allows for $3^4=81$ different scenarios (some of which might not be relevant in practice)

- The framework satisfies the requirements:

  - Each observed mortality evolution can uniquely be classified in one of those scenarios.

  - Pure and mixed scenarios are included.

  - The framework can be applied to age ranges starting at any given age up to UB.

  - Feasible and easily interpretable statistics are used.

  - The framework is extendable by additional statistics if needed.

In the paper, we discuss different issues in estimating these statistics, e.g. how to estimate UB, and methods for the detection of trends

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A new classification framework
Application: UB for US females, starting age 10

- For each calendar year, we estimate the four statistics. This gives us four time series.

- Example: UB for US females

considerable **noise** in the data

unclear trends and trend changes
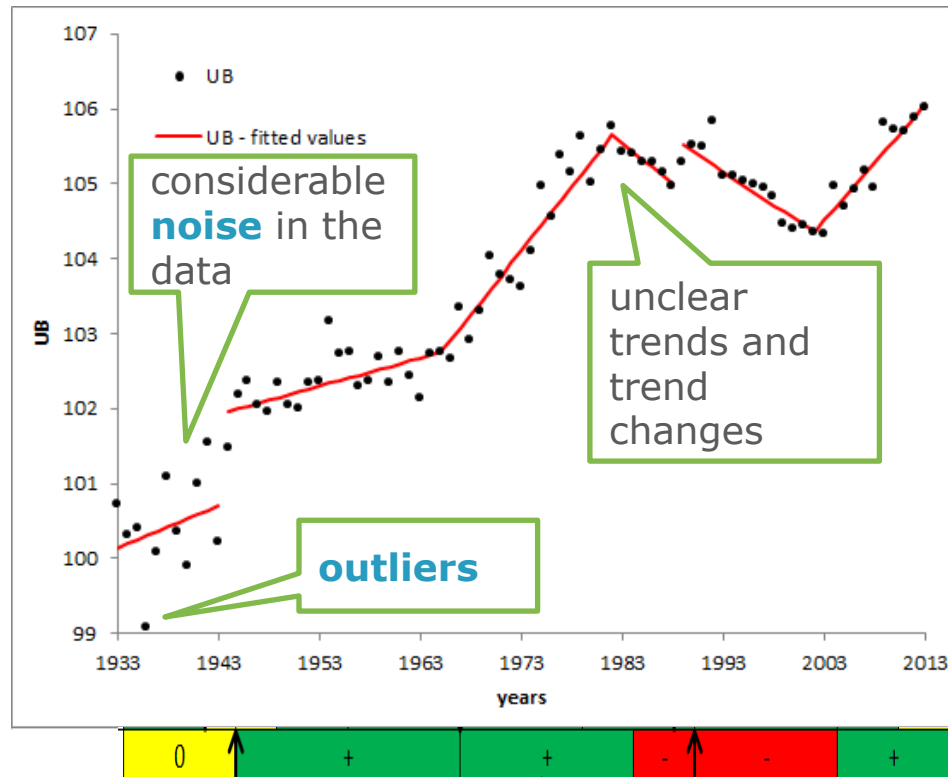
outliers

(Source: HMD and author's calculation)

- The time series for each statistic...

  - ... are "**noisy**" → We need to eliminate the noise.

  - ... have **outliers** → We need to eliminate the outliers.

  - ... in parts have **unclear trends** → We need a method to identify periods of stable trends.

- We fit a polygonal curve to the data and allow for **changes in slope with or without jumps**. Thus we achieve a decomposition of the time range into periods, where the time series follows a linear trend.

- For each period we detect whether a trend is **increasing**, **neutral**, or **decreasing** using a statistical test.

- This can be illustrated by a time bar.

A new classification framework

Application: The mortality evolution of US females

What does this mean for the classification framework?

We see that…

- … each component of the vector develops independently from the others (no redundant information).

- … there are mixed scenarios (rather the rule than an exception).

- … there are different scenarios for different age ranges (age range matters).

In the paper, we analyze this application in more detail and in Genz (2017) we analyze such patterns for several different countries.

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Summary

In the paper, we have…

- … identified **shortcomings** of previous approaches for classification of mortality scenarios,
- … derived **requirements** for a new framework,
- … identified 4 central **characteristics** of the deaths curve,
- … derived a **new classification framework** based on these characteristics, which
  - … builds on clear scenario definitions,
  - … provides a unique classification for each mortality evolution,
  - … allows for mixed scenarios,
  - … is applicable for different age ranges,
- … discussed **methods** we suggest for the determination of prevailing states, and
- … **applied the framework** to concrete data for US females.

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Thank you for your attention!

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References

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