Forecasts of maximum age

Longevity 18 – 2023
Bayes Business School

Philip Gibbs

Work with Nikolay Zak

Has maximum human age been reached?

- “Gompertz” vs “plateau”
- Maximum reported age at death
- Compression or postponement
- Forecasts of maximum age
- Implications for Jeanne Calment

Longstanding demographic debate: “plateau” vs “Gompertz” at old ages

Latest contributions use the IDL database E.g.:

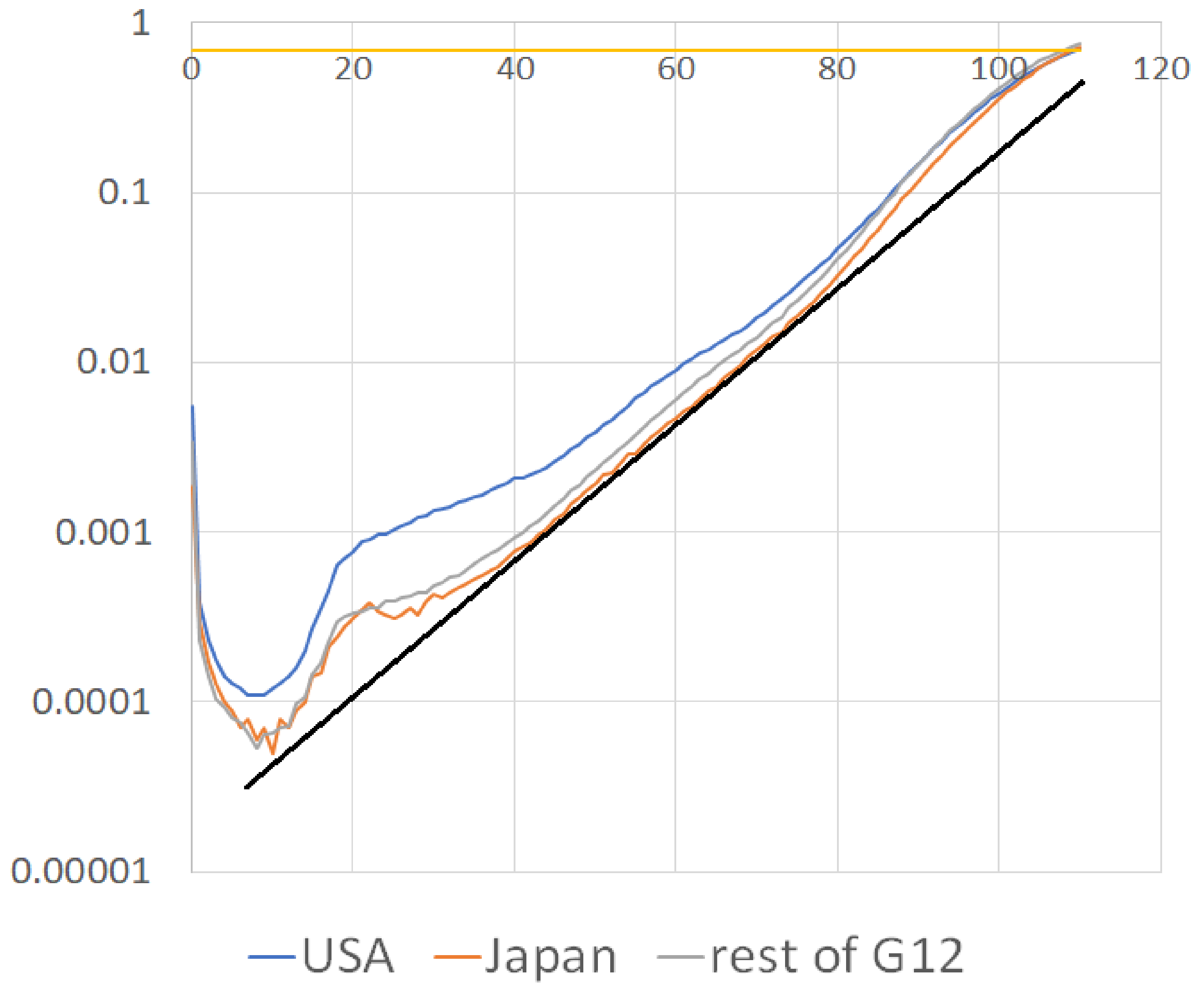
Vaupel (in Barbi et al, Science, Vol 360, 6396, pp.1459-1461 (2018)) sees a plateau at ages over 105 for Italy at 47.5% p.a. mortality.

but

Robine (in Dang et al, Demographic Research, Vol 48, pp.321-338 (2023)) found that in French data a Gompertz hazard model above age 105 was a better fit than a plateau.

Can newer data resolve this debate?

Period mortality (mx) curve for G12 countries 2019 from life tables



G12 force of mortality curve weighted by population at age, to 110 years

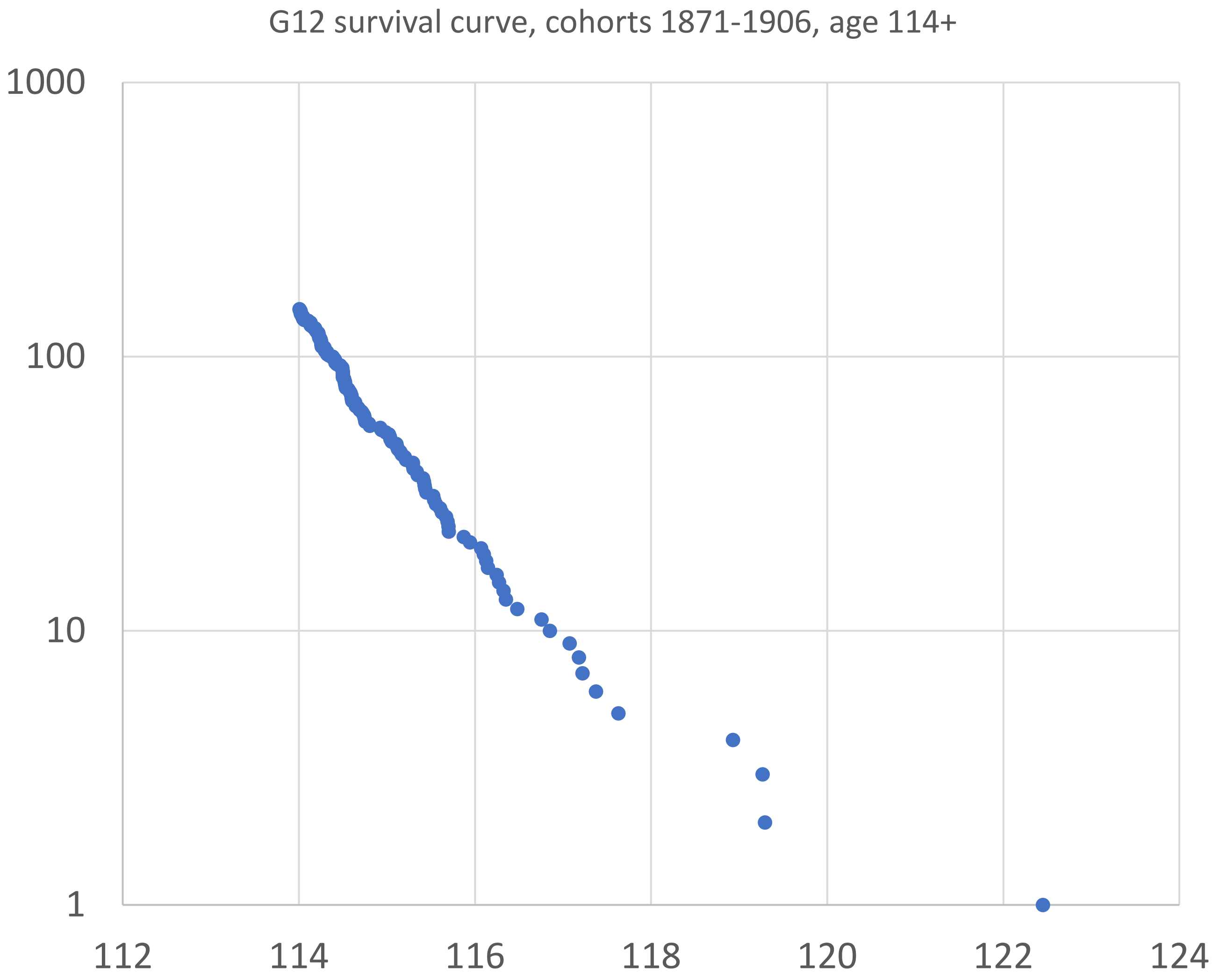
Data source: HMD at mortality.org

Gompertz law would be a straight line. Plateau would be flat line.

There are some deviations including a deceleration at highest ages

No mortality plateau is apparent but has crossed 50% pa mortality

Aim to extend mortality curve beyond 110 using supercentenarian counts



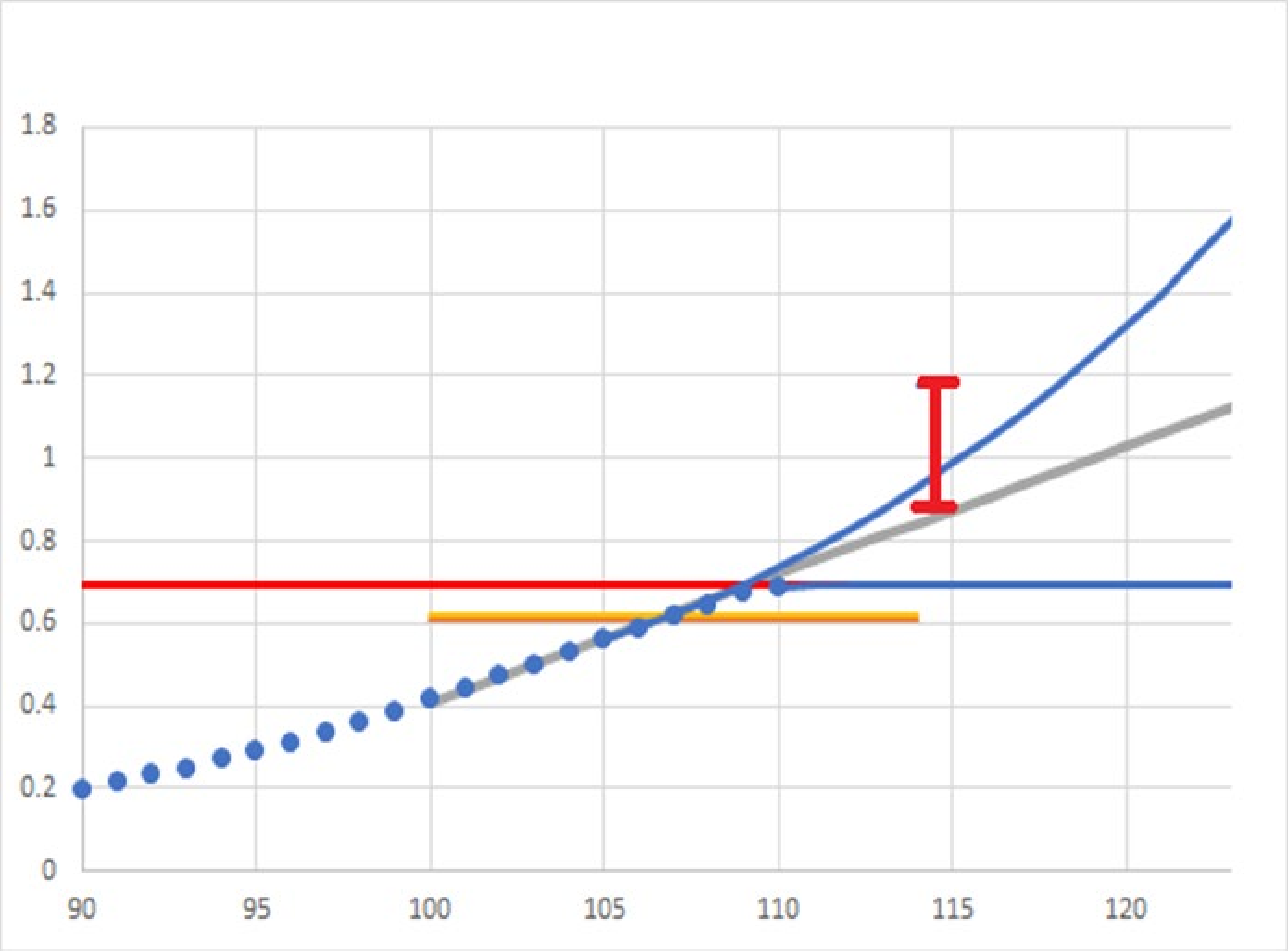
Survival curve for validated past supercentenarians. They have high quality results for age 114+ years (GRG, LongeviQuest, ESO, LAS etc.)

112+	>586
113+	>302
114+	149
115+	53
116+	20
117+	9
118+	4

mx(114) = 1.03 (force of mortality)
+/- 0.15
(64% mortality p.a.)

Compare 3 models: mild Gompertz > 105, plateau > 110, linear > 100

G12 mx cohorts 1871 to 1906



782,000 centenarians in G12 cohort 1871-1906

149 survived to age 114+ (LQ/GRG)

Therefore average mx is 0.612 +/- 0.006 between 100 and 114

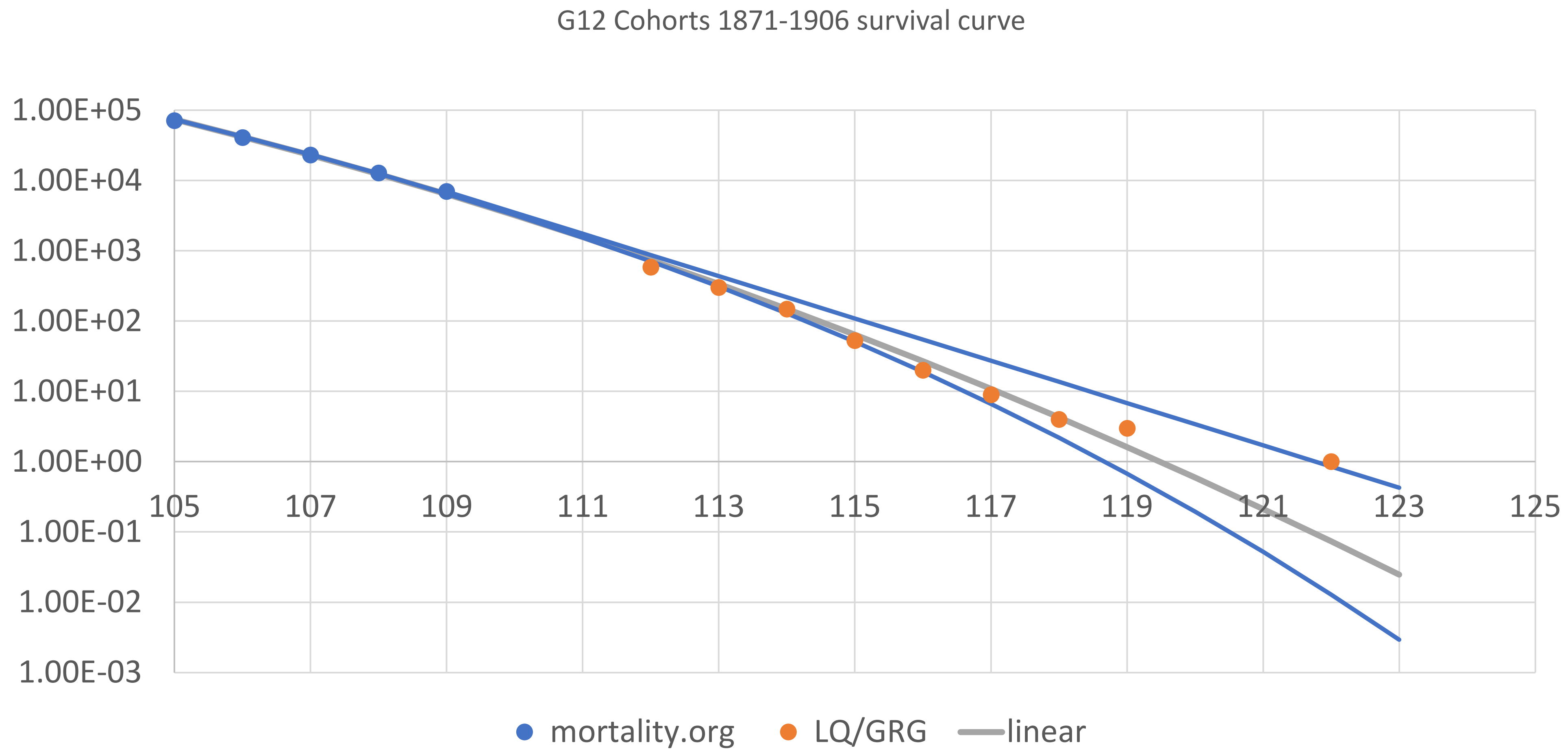
A linear increase of mx after age 100 is a good fit.

mx(age) = M+gT
T = age-100 > 0
M = mx(100) = 0.410
g = 0.031

This implies slow deceleration vs Gompertz, but no plateau

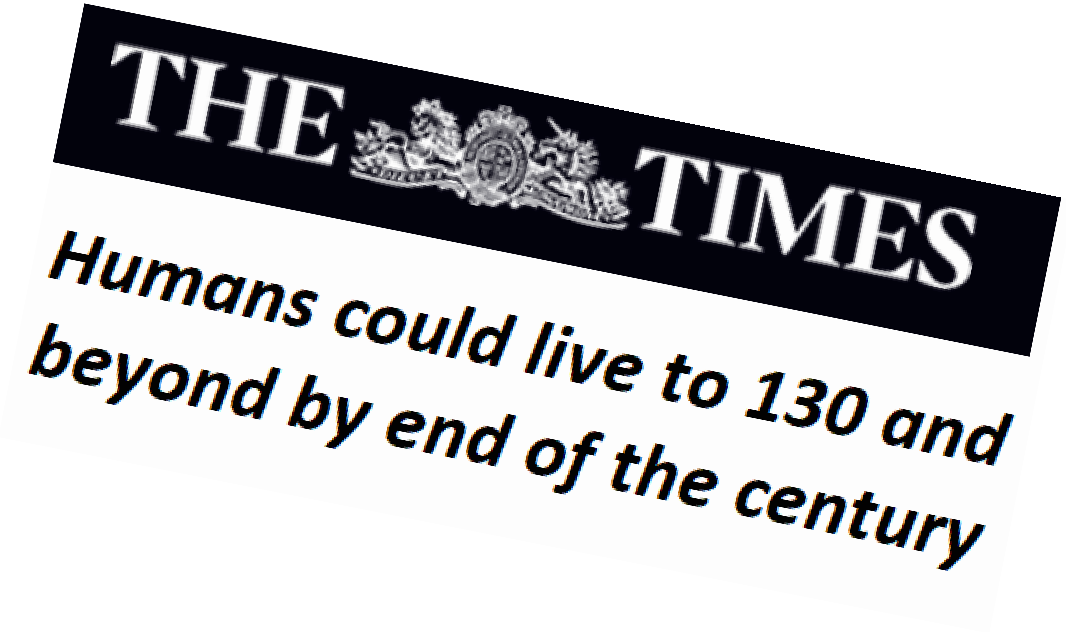
Linear mx model vs G12 population counts from mortality.org and LQ/GRG.

It is much better to match models to survival curves (or cumulative hazard) than mortality.



The linear mx model is a perfect match to survivor curve data from 100 to 118 years

Forecasts of maximum human lifespan


THE TIMES

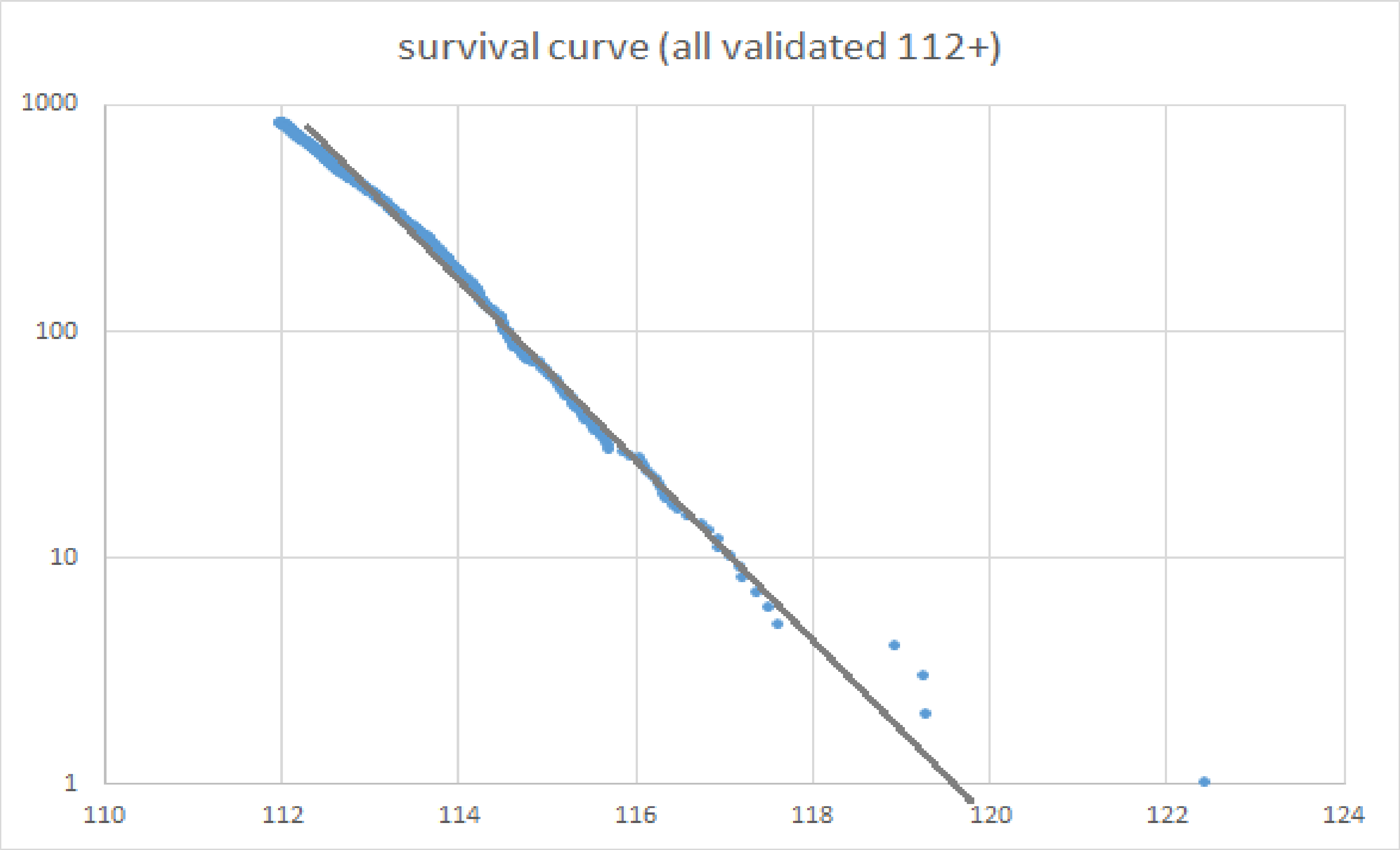
Humans could live to 130 and beyond by end of the century

A number of recent studies widely reported in the media have concluded that by 2100 the eMRAD could be 125, 130, 150 or even 180 years.

Define: Maximum Reported Age at Death is the oldest all time validated human age.

Actual Maximum Reported Age at Death (MRAD) is not a useful statistic

Use the expected Maximum Reported Age at Death (eMRAD) by fitting a line to the survival curve to find the age where one survivor is expected.



eMRAD Aug 2023 is

119.6 years

Kane Tanaka was 3 months younger

Jeanne Calment was 3 years older

eMRAD has low sensitivity to errors

Source: LongeviQuest/GRG list of oldest verified people of all time at 10th Aug 2023

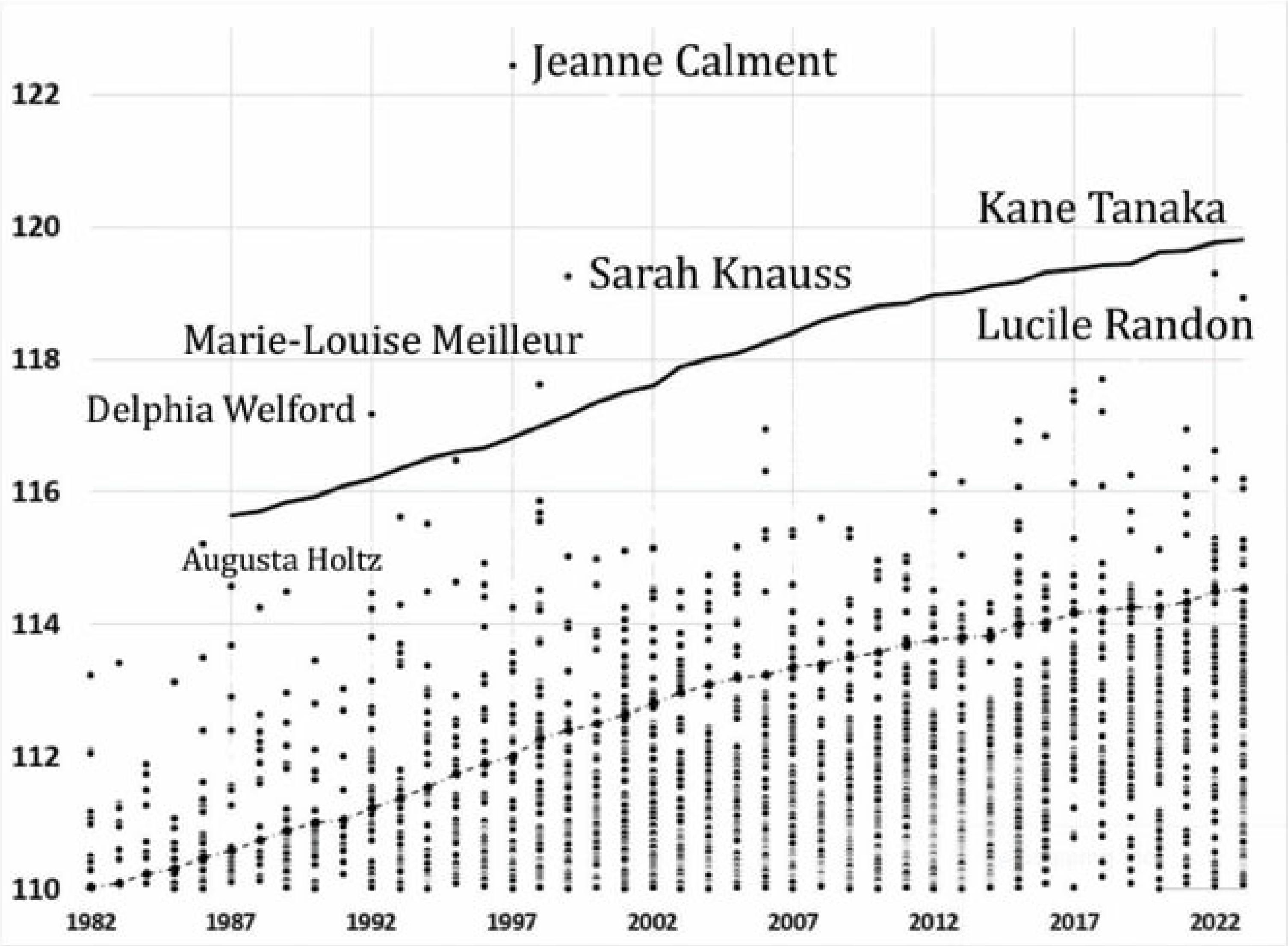


Fig. 1. Jeanne Calment versus eMRAD. The dots represent the ages of the supercentenarians validated by GRG as having died in the given year. Dashed line represents the age of the 100th oldest person validated up to the given year (see supplementary text).

eMRAD has been increasing at about one year per decade. If it continues this trend it will reach 127 years by 2100, in line with the more conservative forecasts based on plateau models.

finding max age in terms of number of cohort centenarians

$$mx(age) = M + gT$$ (linear mx model)

T = age-100 > 0

M = mx(100) = 0.410

g = 0.031

C = cumulative population of cohort centenarians

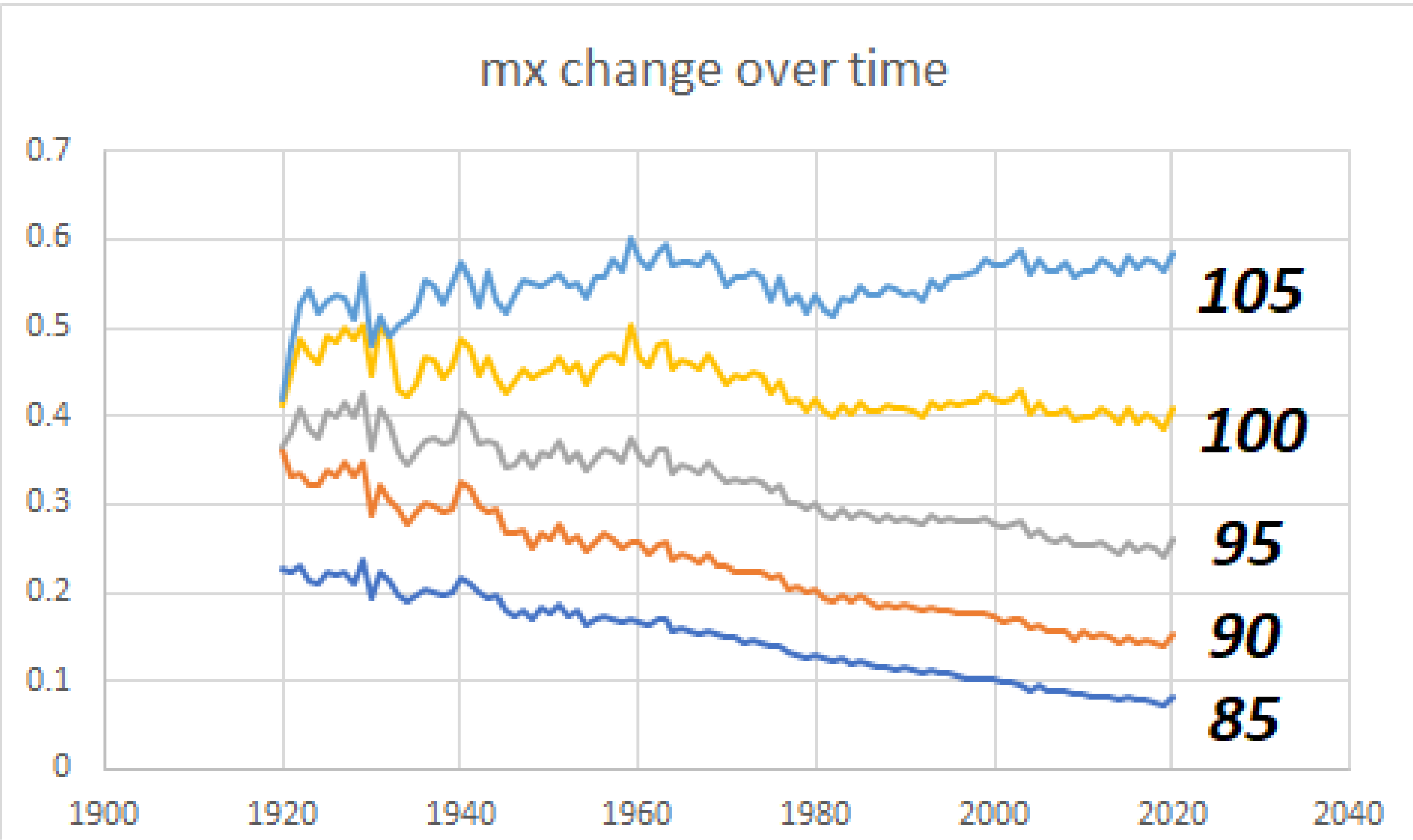
$$P(T+100) = C\, e^{-MT-gT^2/2} = 1$$

$$\text{eMRAD} = 100.5 + \frac{\sqrt{2g\ln(C)+M^2}-M}{g}$$

To forecast eMRAD in G12 we need a forecast for C and a forecast for how mx may change for ages over 100 years in G12

Compression or postponement?

How will mortality rates over age 100 change?

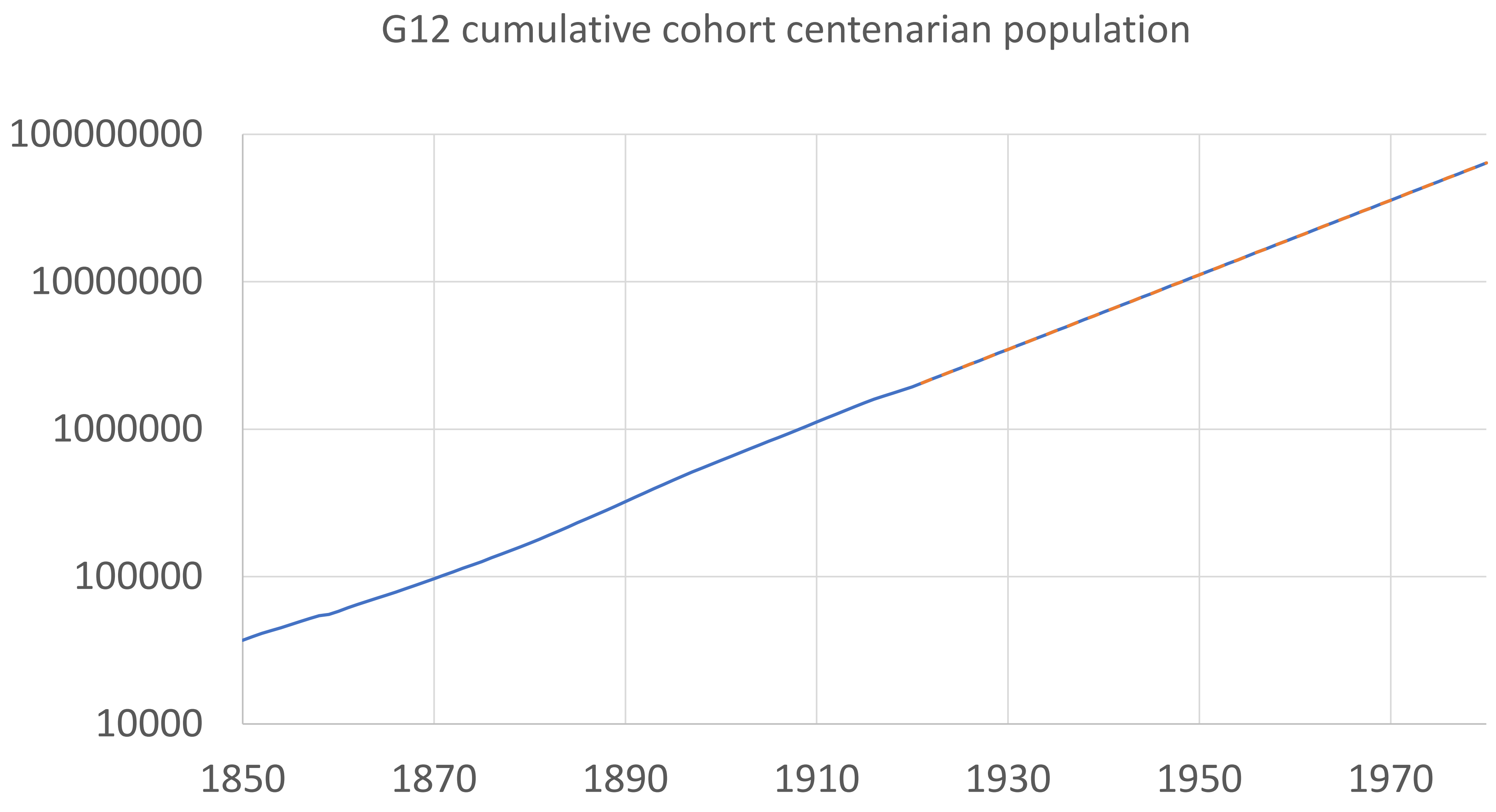


Period mortality rates change with time, but there has been very little change at age 100 for the last 40 years in G12

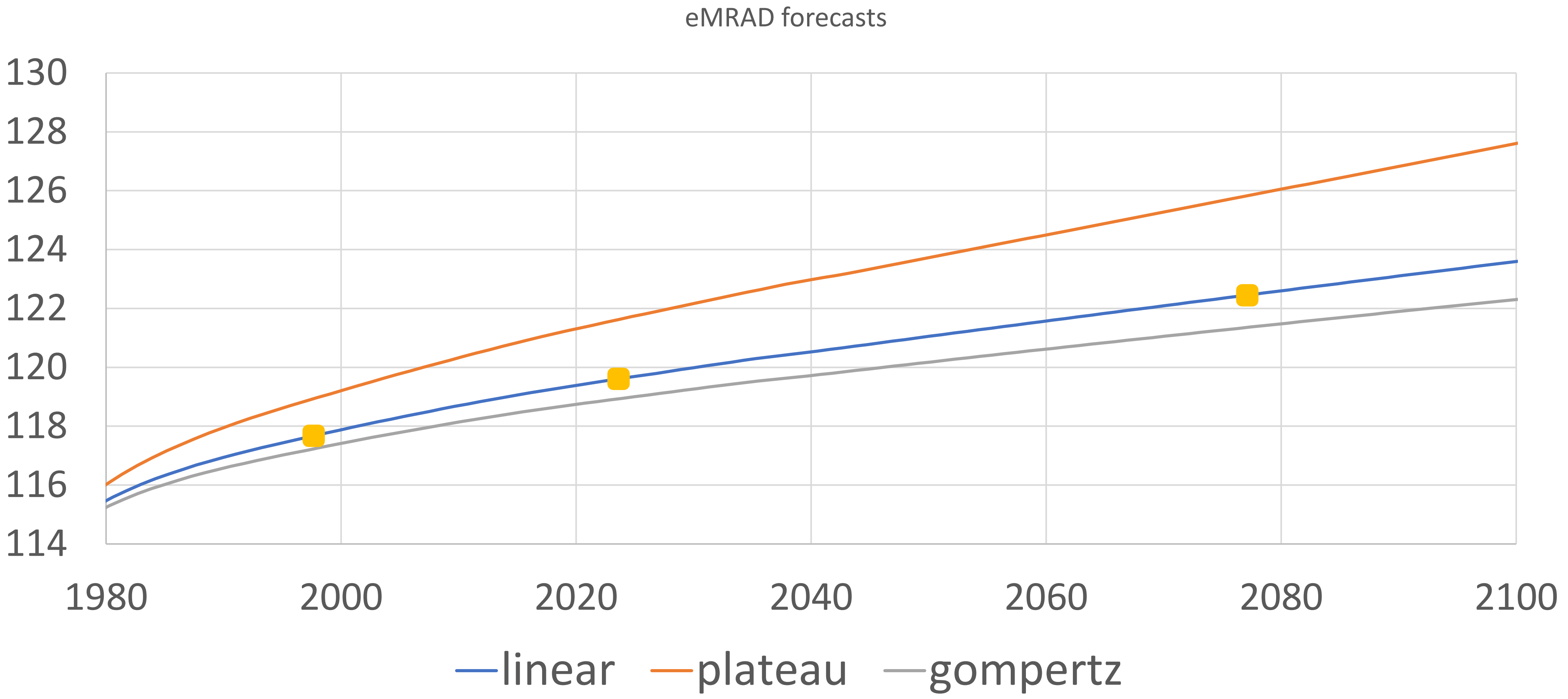
Take future static mx after age 100 as a working assumption. Actual mx will be unpredictable.

Cumulative cohort centenarian population doubles every 12 years

Take this as a working assumption backed by UN projections



G12 eMRAD forecast from a static linear mx model with cumulative centenarian population doubling every 12 years



The linear mx model projection is lower than forecasts that assume a mortality plateau

Was Jeanne Calment Authentic?

The centenarian population before Calment was too small by a factor of 200 for her reported age at death using today's mortality rates and a linear mx model.

It would be 20 times for the plateau model and 1000 times for Gompertz.

"*statistically improbable is not the same thing as statistically impossible*"

The linear mx model and the authenticity of Jeanne Calment are statistically incompatible

But the alternative plateau model that barely supports Calment is strongly incompatible with present day supercentenarian counts from LongeviQuest and GRG.

In 2018 Nikolay Zak disputed Jeanne Calment’s longevity

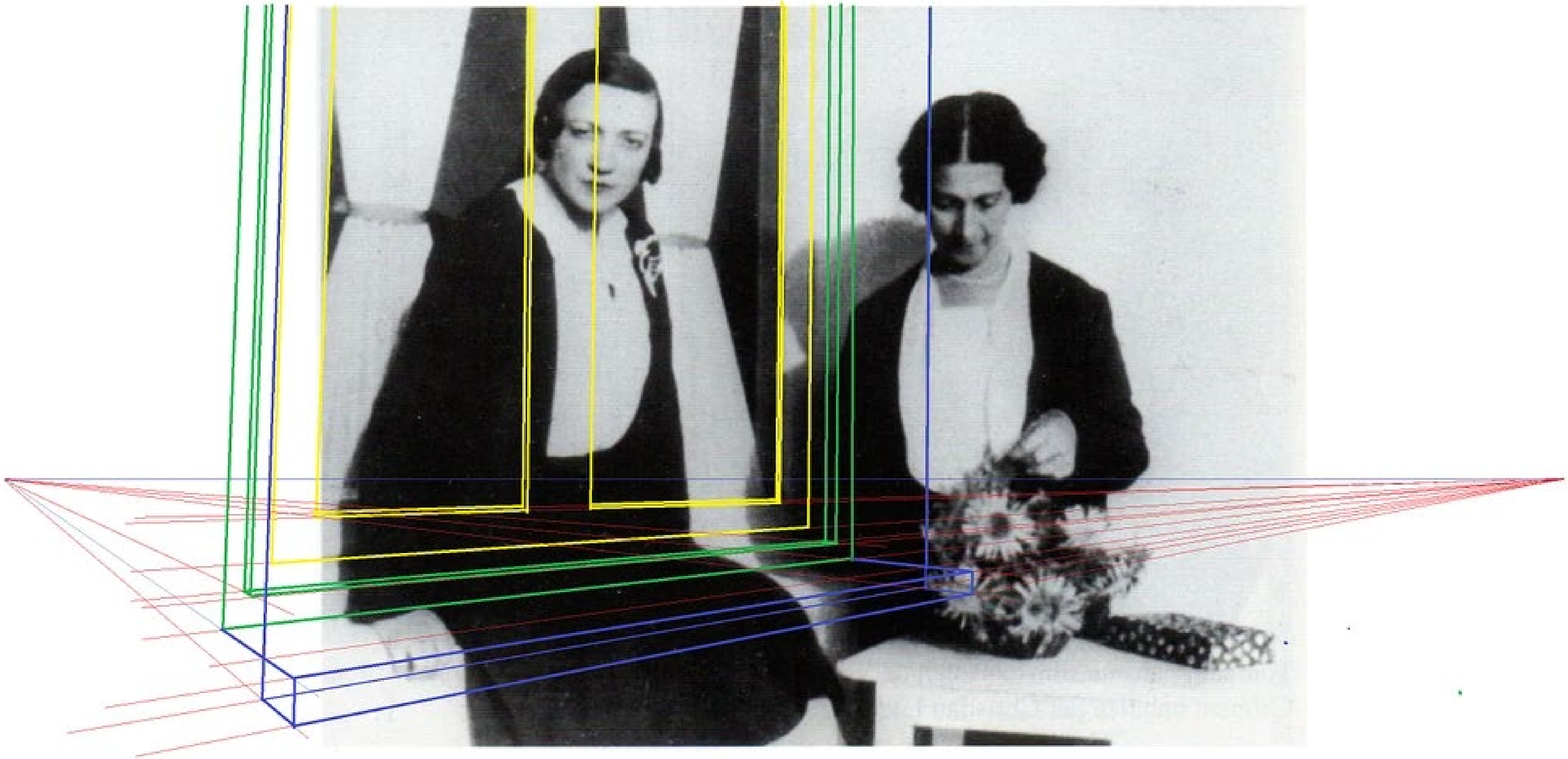
There were inconsistencies in her testimony.

She said that Frederick Mistal had been a friend of her “father,” then corrected in to “husband”

She said that she had been escorted to school by Marthe Fousson, but Fousson was too young

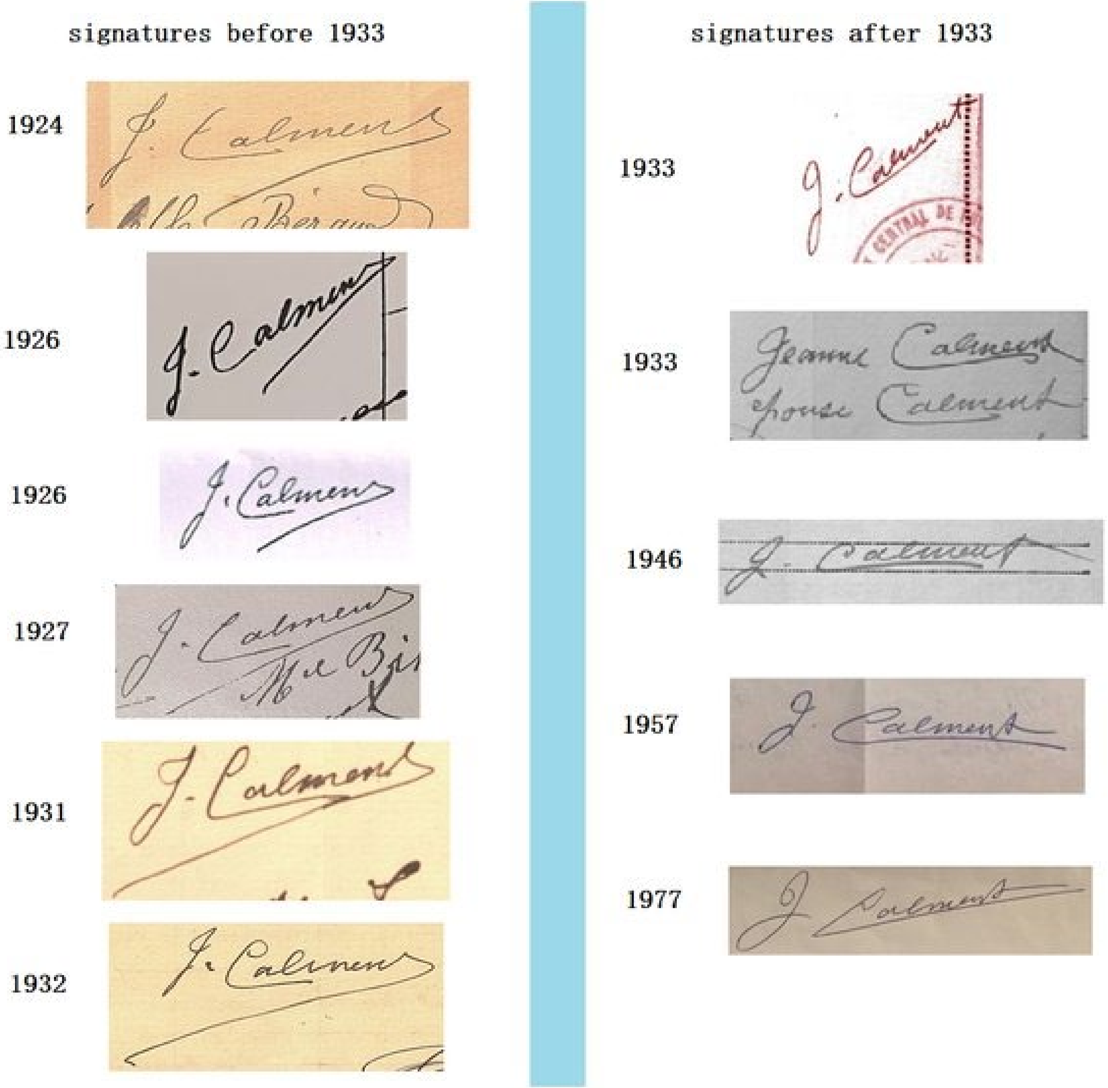
Could Mme Calment be really Jeanne’s daughter Yvonne who was believed to have died in 1934?

Yvonne and Jeanne sitting outside a window on the terrace at the Belvedere sanatorium in Leysin 1931. Who is ill – Yvonne or Jeanne?



https://www.youtube.com/watch?v=8TNrXdagQRM

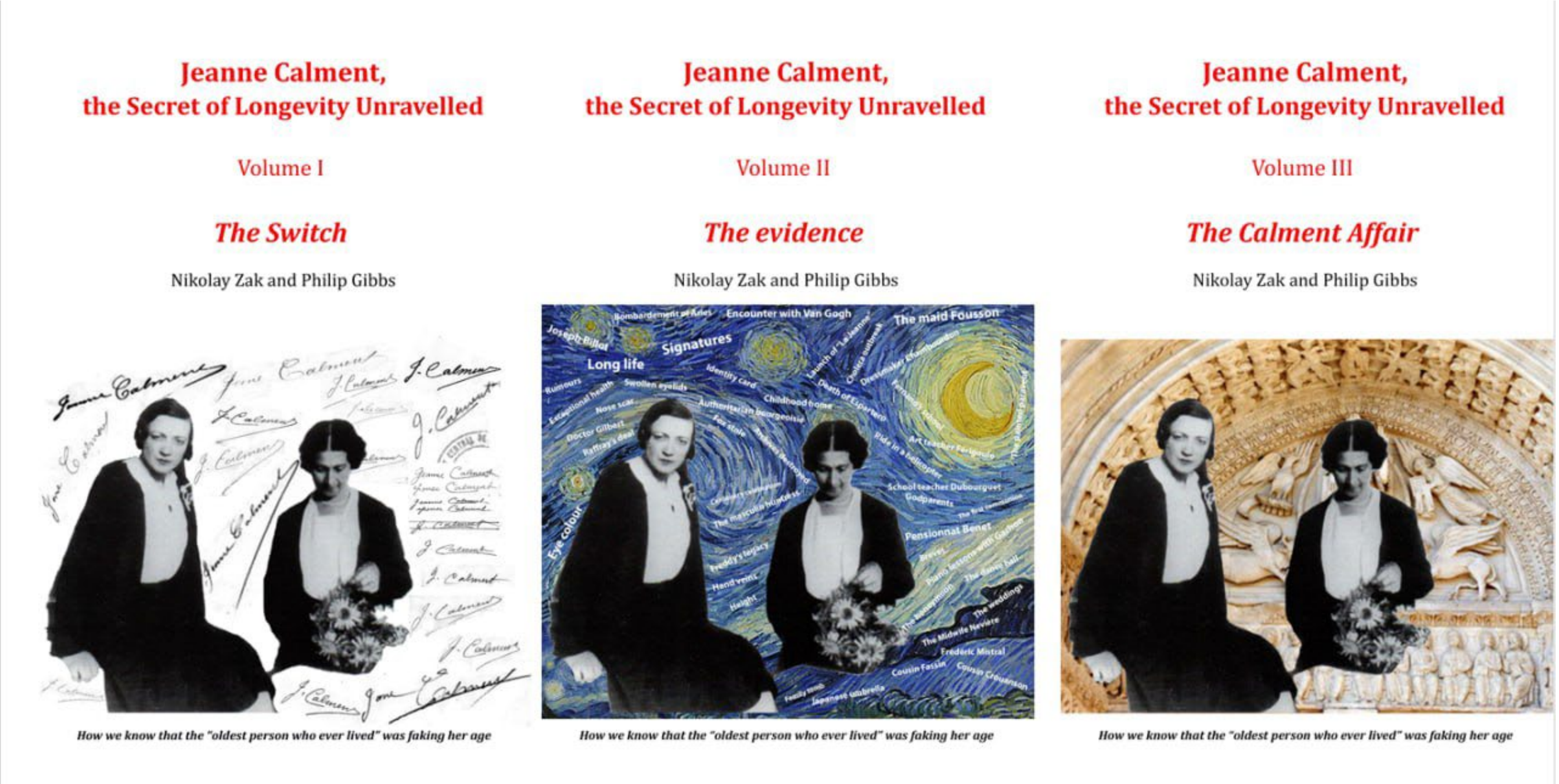
What happened next? Did Yvonne relapse and die in 1934 while Jeanne recovered and lived a further 66 years, or did Jeanne die while her daughter assumed her identity?



Jeanne Calment's signature was stable from 1924 to 1932, but in 1933 it changed inexplicably. This was too sudden to be natural evolution, and a decision to refresh her signature would be unthinkable given the importance of the legal and financial documents involved.

We conclude that Yvonne assumed her mother's identity in 1933 to avoid the stigma of her illness and to allow Yvonne's husband to renew his army leave. When Jeanne unexpectedly died a year later they had to tell a much bigger lie to avoid the scandalous legal consequences

Complete analysis of the evidence including an examination of Mme Calment’s recorded testimony and a Bayesian analysis is available in the book “**Jeanne Calment, the Secret of Longevity Unravelled**” (Zak and Gibbs)



On the authenticity of “the oldest human” Jeanne Calment, Zak, Gibbs, 2023
https://osf.io/preprints/socarxiv/jgmsc/
A Review of Longevity Validations up to May 2023, Gibbs, Zak, 2023
https://osf.io/preprints/socarxiv/hk7fb/

Does it matter?

Jeanne Calment is mentioned in over 3600 articles on Google Scholar.

A single outlying data point can be statistically significant if it is validated with high certainty.

“the annual risk of death after age 114 cannot rise much above 50% unless Jeanne Louise Calment’s rigorously documented lifespan of 122.45 years is fraudulent” - Jim Vaupel in Exceptional Lifespans (Springer, 2021)

“If claims of extreme-age plateaus in human mortality turned out to be generally illusory, much of the demographic modeling of the last two decades would have to be rethought.” – Barbi et al (2019)

So this question is important.

Future hopes and Questions

Improving statistics of mortality at extreme ages will help confirm or refute the linear mx model and show how it changes.

A DNA test on Jeanne Calment would resolve her authenticity to the satisfaction of all.

Supercentenarian validation groups such as LongeviQuest would benefit from sponsorship.

END