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Post-COVID-19 Mortality Trends

Controlling for excess mortality in individual-level data

Presentation at Longevity 19 Conference in Amsterdam

16 September 2024

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Introducing the speaker

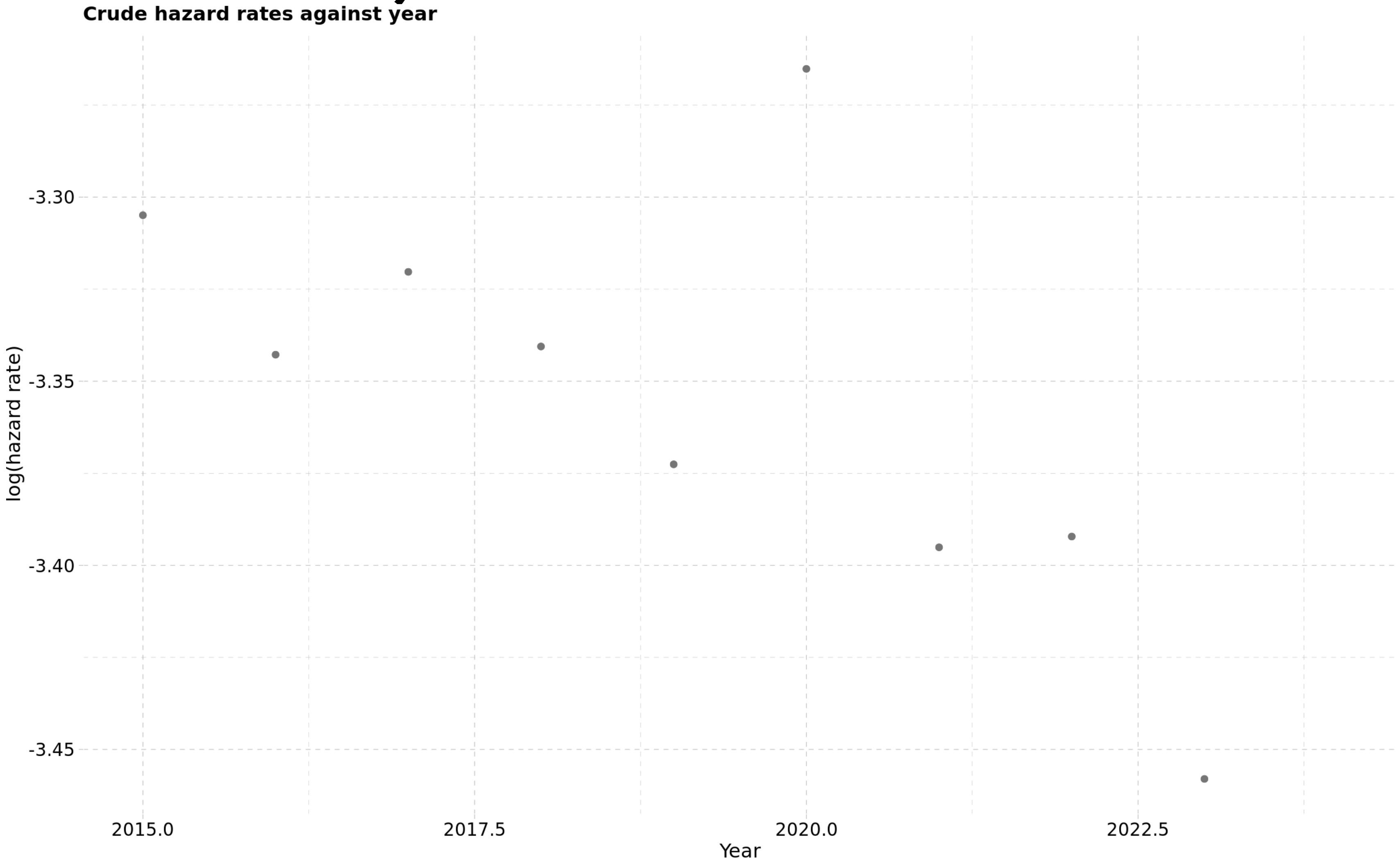
Kai Kaufhold – Life Reinsurer & Actuarial Consultant

- Life Reinsurance:
  - 1996 – Zurich Re (Cologne),
  - 2000 – Manulife Reinsurance, Toronto, from 2003: Cologne
- Since 2011: Ad Res Advanced Reinsurance Services GmbH
  - Quantitative analysis: mortality, persistency, disability, morbidity risks
  - CIA mortality projection scale, CIA pensioner tables, SAS life tables
  - Trainer for the experts, researcher, author

Agenda

- Motivation
- Data
- Model Specification
- Results
- Discussion

Crude mortality hazard over time



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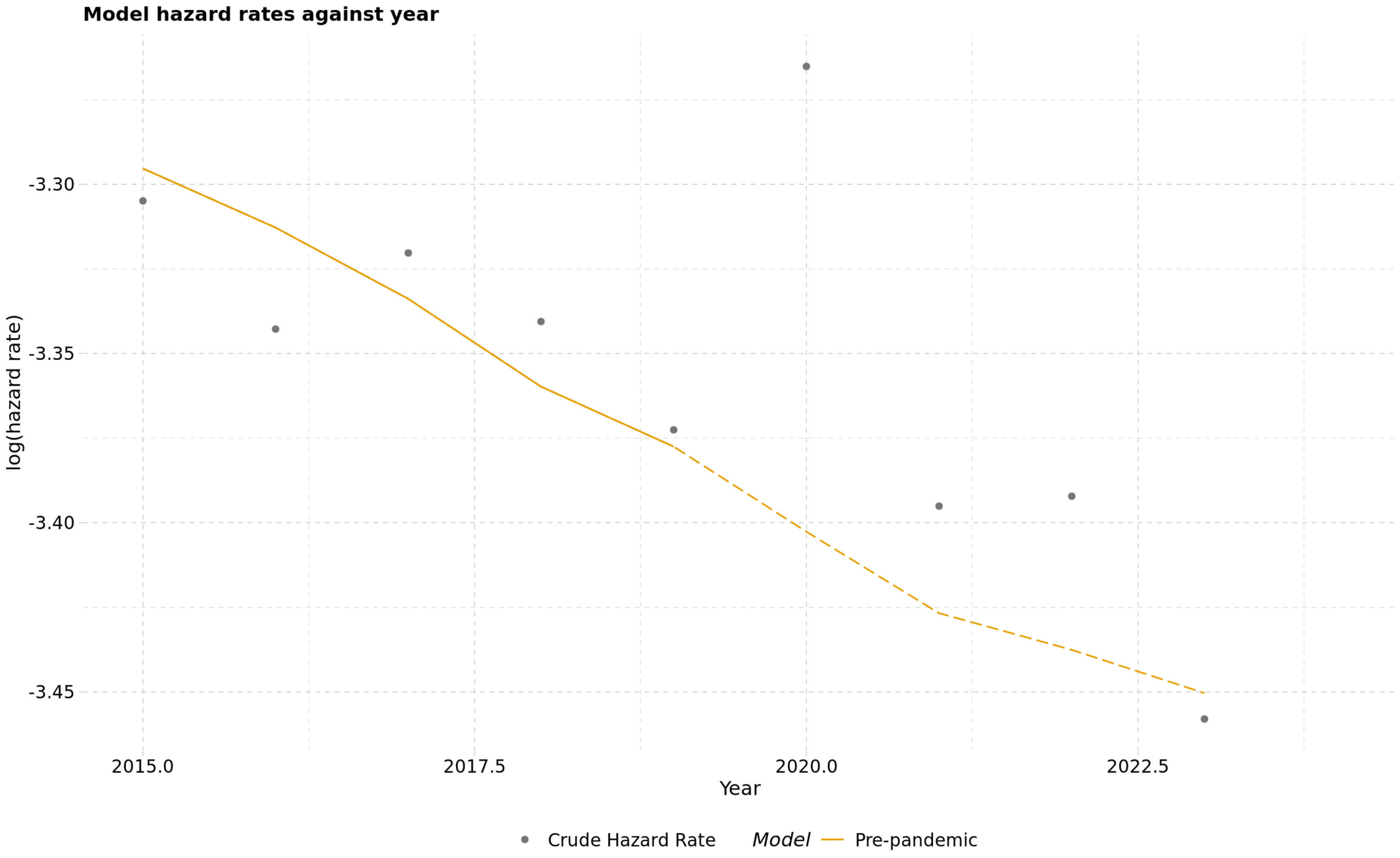
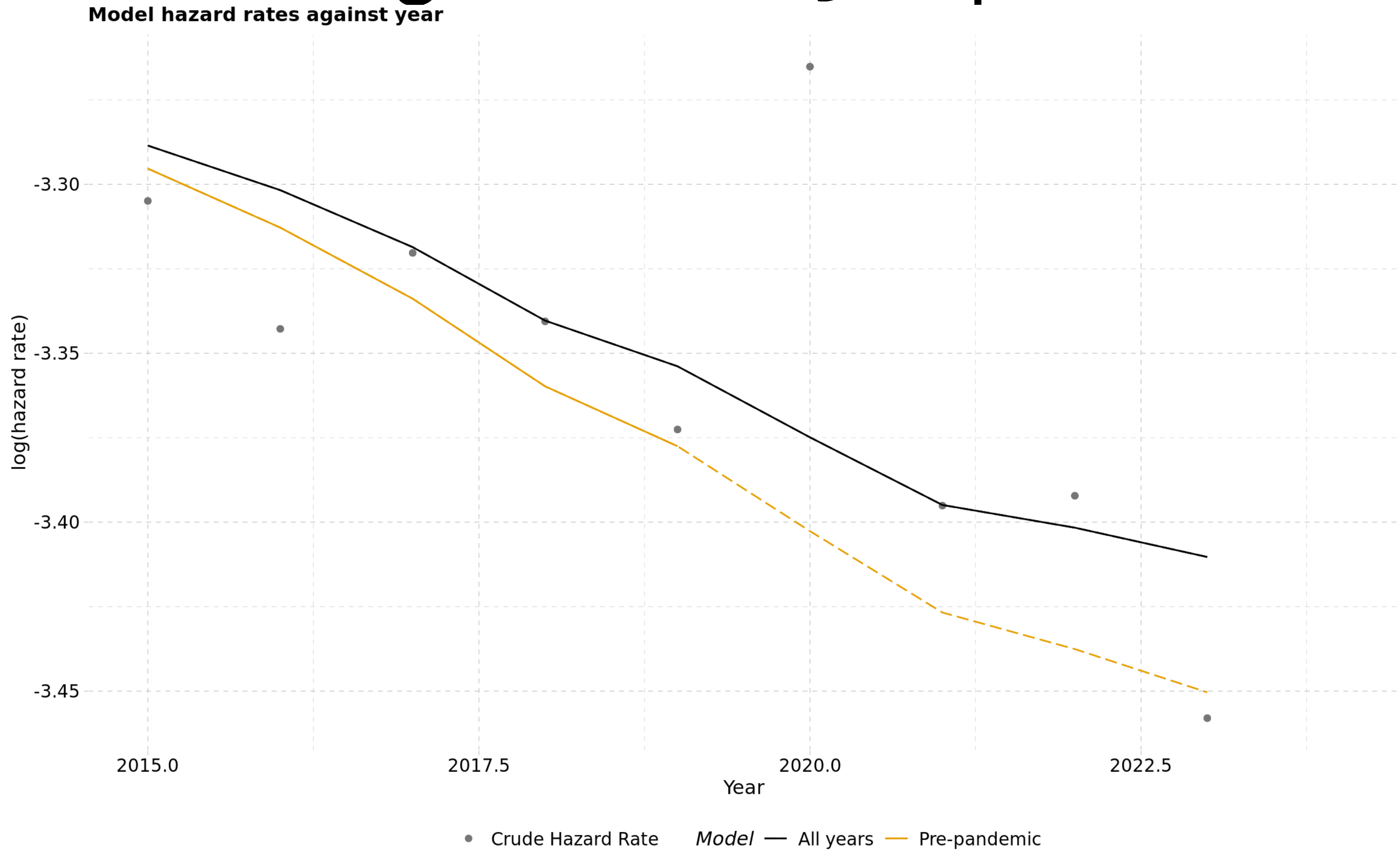
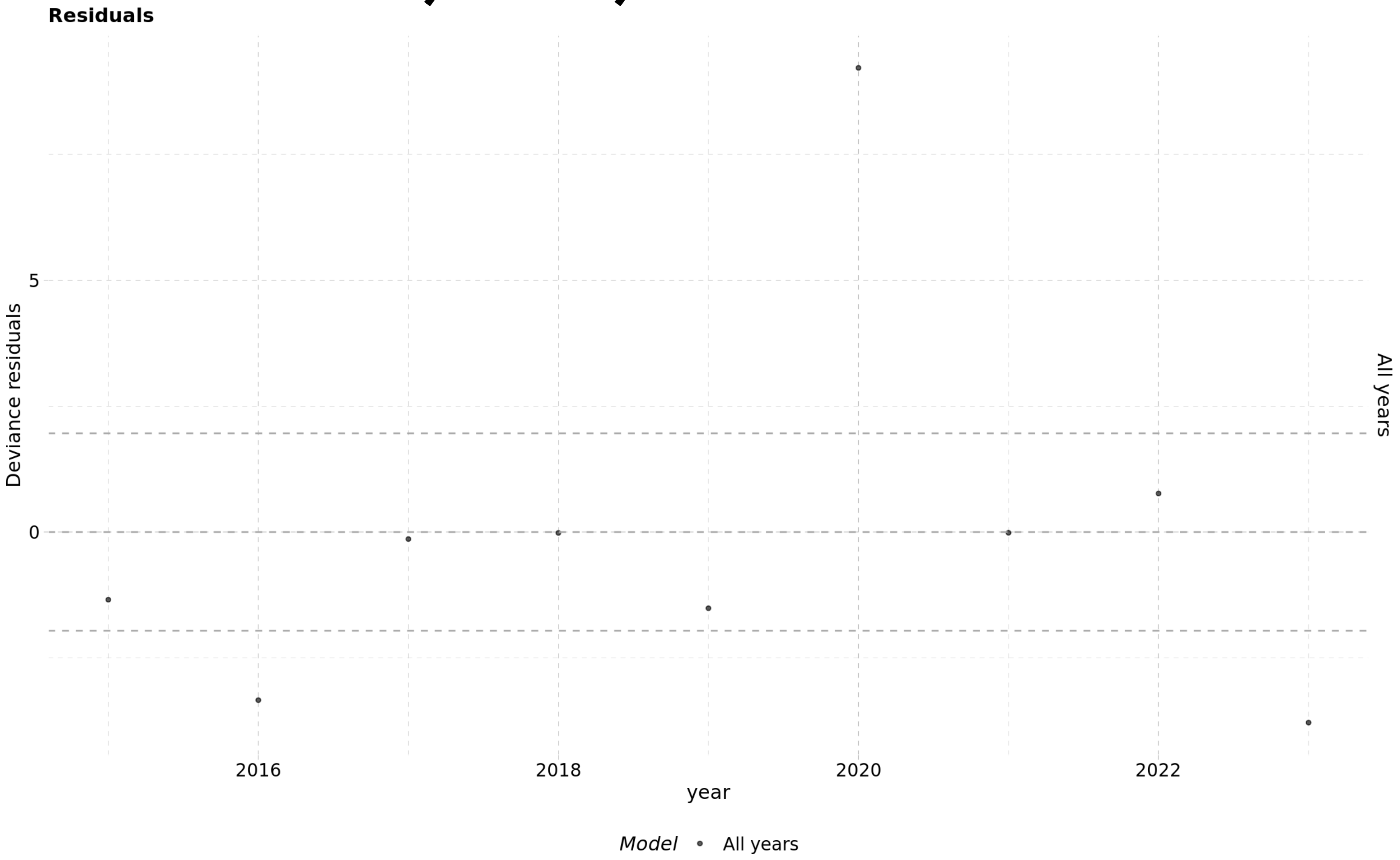
Pre-pandemic Trend



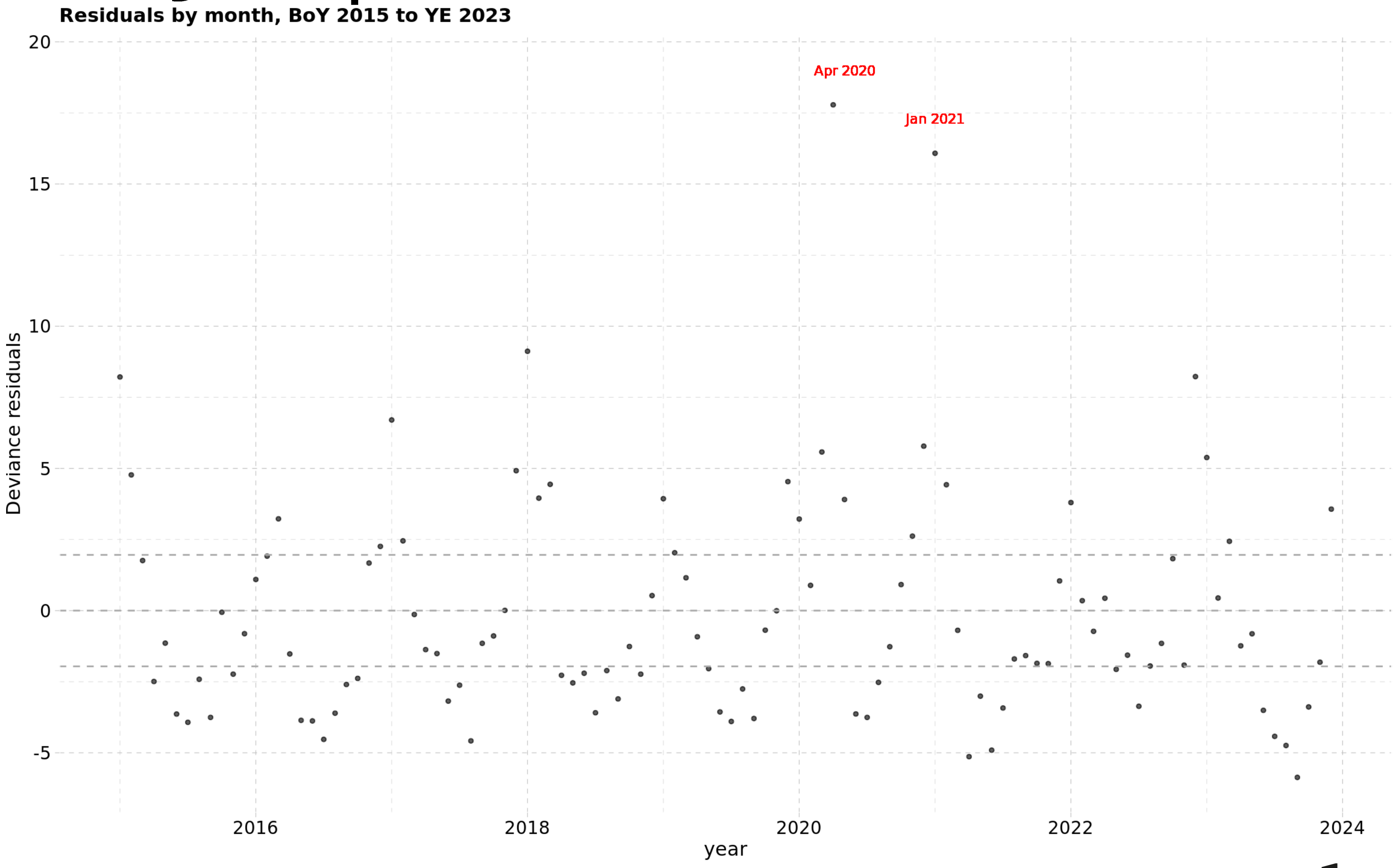
Trend including COVID-19 experience



Excess mortality only in 2020?



COVID-19 requires a closer look



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Motivation

- Mortality experience during pandemic shows isolated spikes
- Only measurable against baseline with seasonal variation
- Additional excess mortality might be detected as trend change

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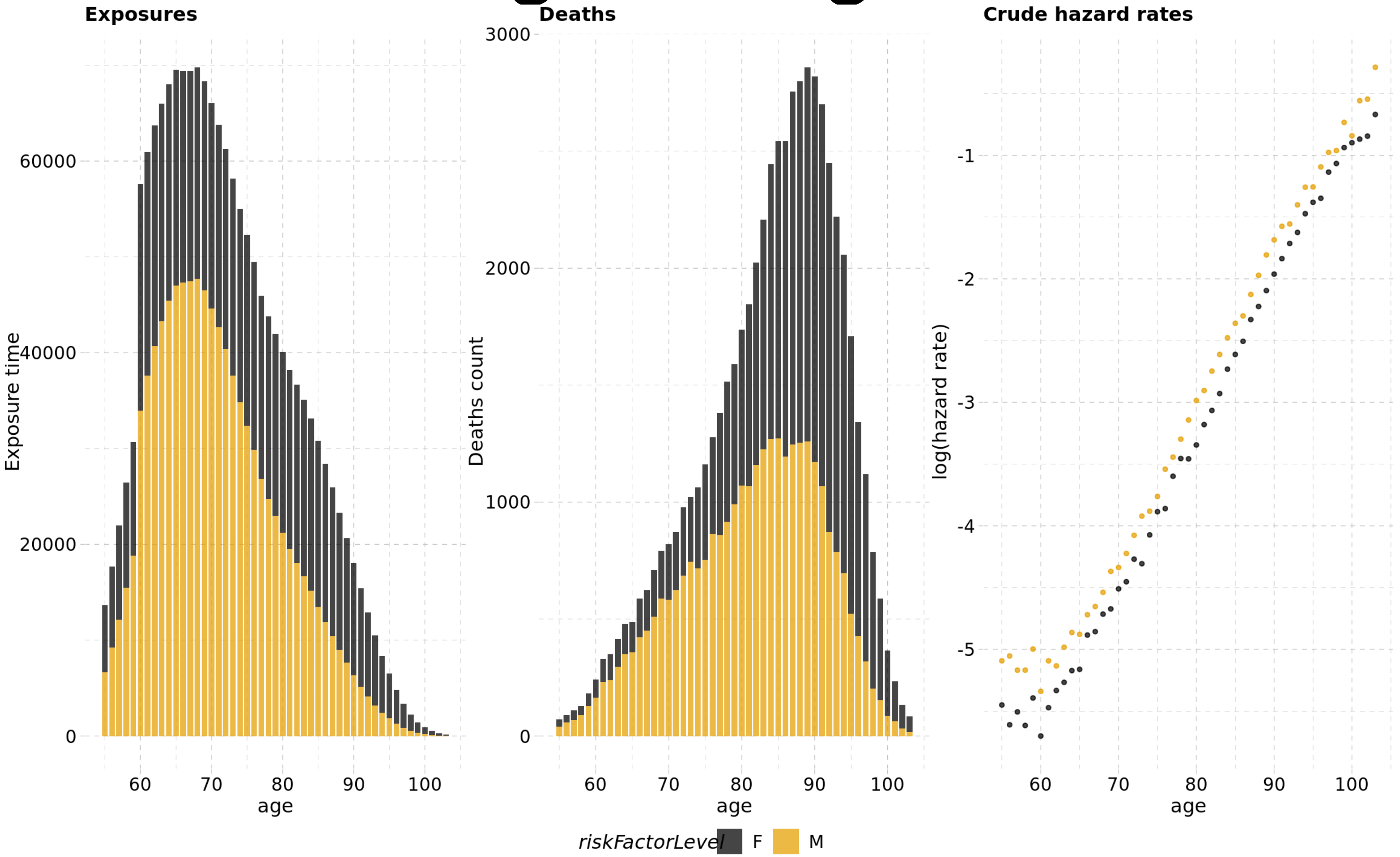
Individual-level data is king!

Using mortality experience data from multiple U.K. pension schemes

Data summary

Risk Group	Lives	Exposure	Deaths
All	255,000	1,700,000	58,000
Female Pensioners	70,000	450,000	14,000
Male Pensioners	140,000	970,000	26,500
Female Dependants	40,000	250,000	15,000
Male Dependants	5,000	30,000	2,500
Normal retiral	244,000	1,610,000	54,000
Ill-Health retiral	11,000	90,000	4,000

Experience data against age



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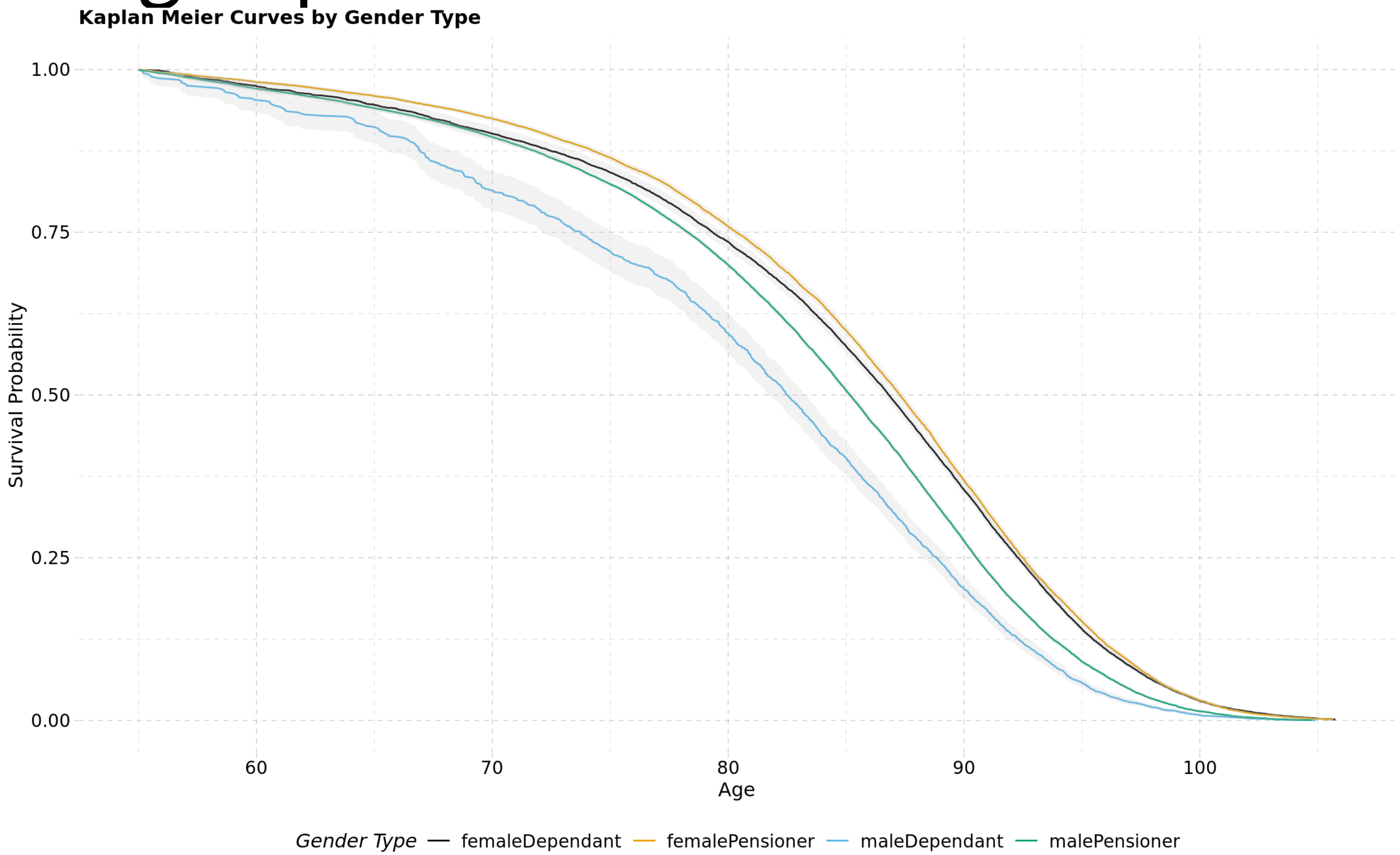
Checking expected relative risk



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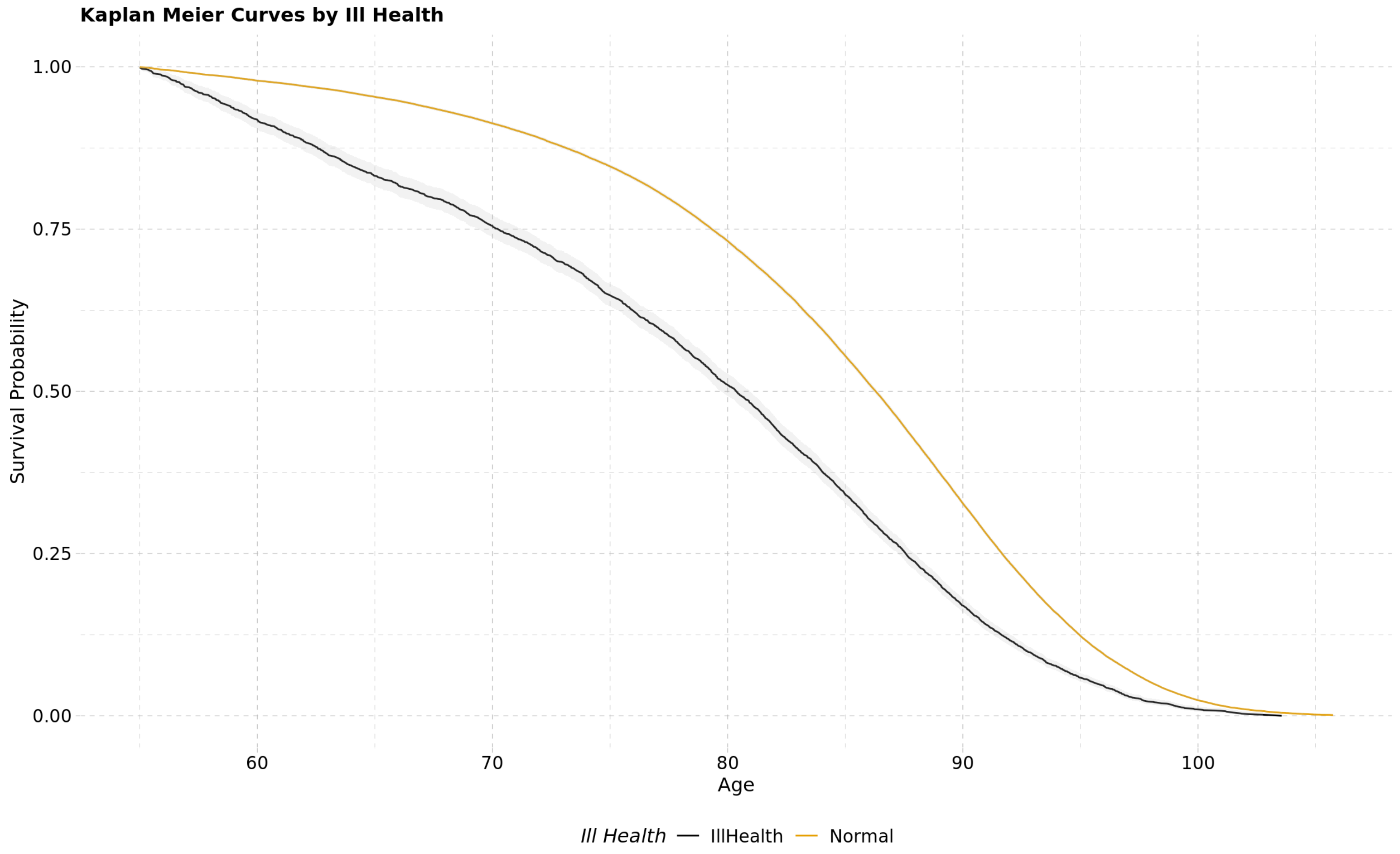
Normal vs. ill-health retirals



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Model Specification

Hermite-spline Hazard Rate Model with Periodic Overlay and Spikes

Hermite-splines for modelling mortality

$$\log(\mu_{x,y}) = \alpha\, h_{00}(t) + \omega\, h_{01}(t) + m_0\, h_{10}(t) + \eta\, h_q(t) + \delta\, y$$

$$t = (x - x_0)/(x_1 - x_0)$$

$$h_{00}(t) = (1 + 2t)(1 - t)^2$$

$$h_{01}(t) = t^2(3 - 2t)$$

$$h_{10}(t) = t(1 - t)^2$$

$$h_q(t) = 16t^2(1 - t)^2$$

The coefficients each have an intuitive meaning:

α – describes the log mortality at beginning of age range x_0

ω – describes the log mortality at the end of the age range x_1

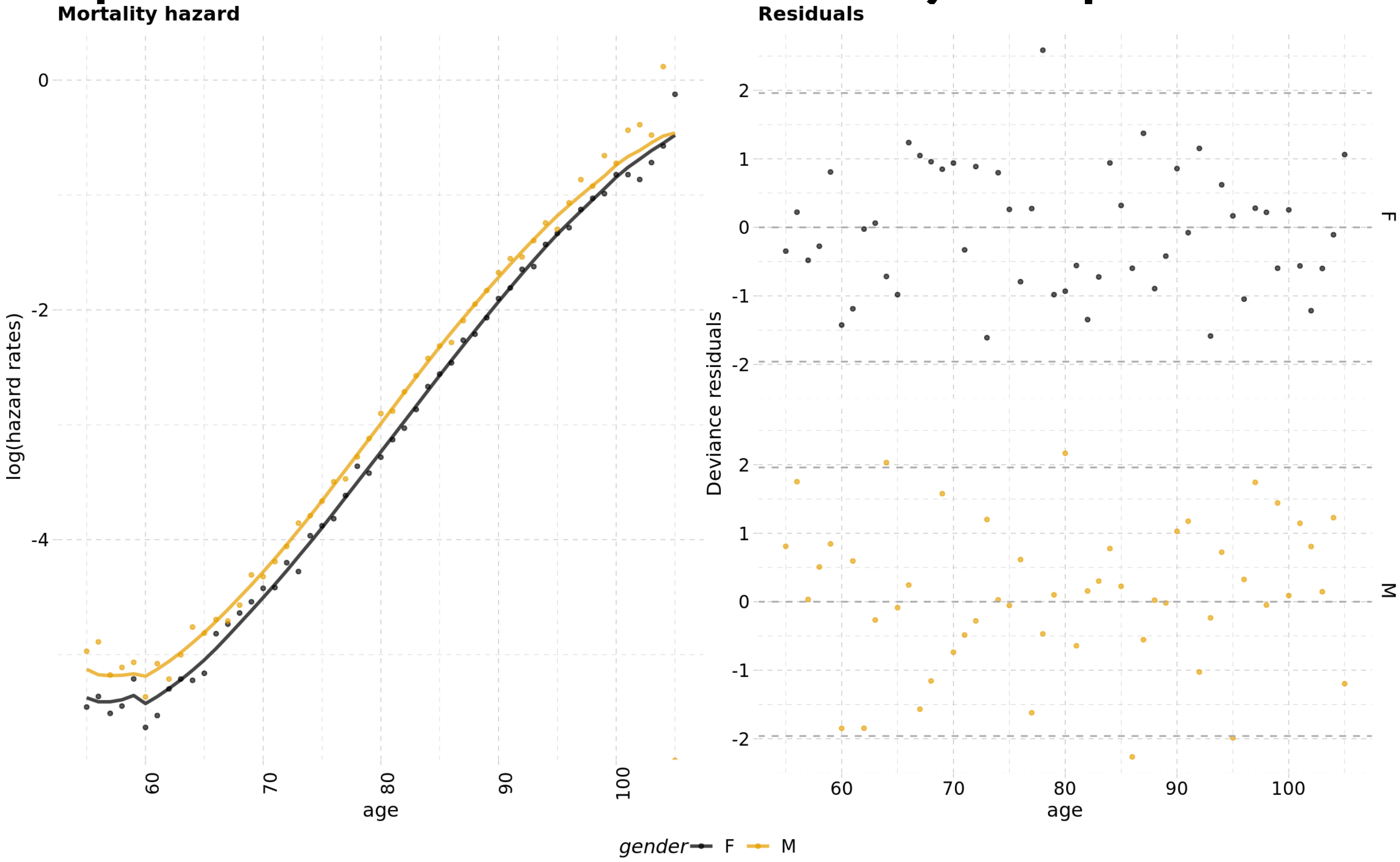
m_0 – describes the slope at the beginning of the age range x_0

η – influences the log mortality in the middle of the age range

δ – describes an age-independent trend by calendar time y

See Richards (2019) and Ramonat (2024)

Age-dependence of mortality captured



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Adding seasonal variation

$$\log(\mu^*_{x,y}) = \log(\mu_{x,y}) + e^{\zeta} s(2\pi(y-\tau))$$

$$s(t) = \begin{cases} \psi \neq 0: & 2\left[\dfrac{e^{\frac{\psi}{2}(1+\cos t)} - 1}{e^{\psi} - 1}\right] - 1 \\ \psi = 0: & \cos t \end{cases}$$

Coefficients

τ – Point after 1st January corresponding to the peak

ζ – Amplitude of the average-to-peak seasonal variation

ψ – Shape of seasonal pattern within year

See Richards et al. (2020)

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Adding mortality spikes

$$\log(\mu^{\dagger}_{x,y}) = \log(\mu^{*}_{x,y}) + \sum_i \begin{cases} s_i^p \frac{1}{2}\left(1 + \cos\left(2\pi \frac{y - s_i^c}{2\, e^{s_i^w}}\right)\right) & : where\ s_i^c - e^{s_i^w} < y < s_i^c + e^{s_i^w} \\ 0 & : otherwise \end{cases}$$

Coefficients

s_i^p – Amplitude of the i[th] spike

s_i^c – Centre of the i[th] spike

s_i^w – Half-width of the i[th] spike

Results

Isolating two COVID-19 peaks in 2020 and 2021

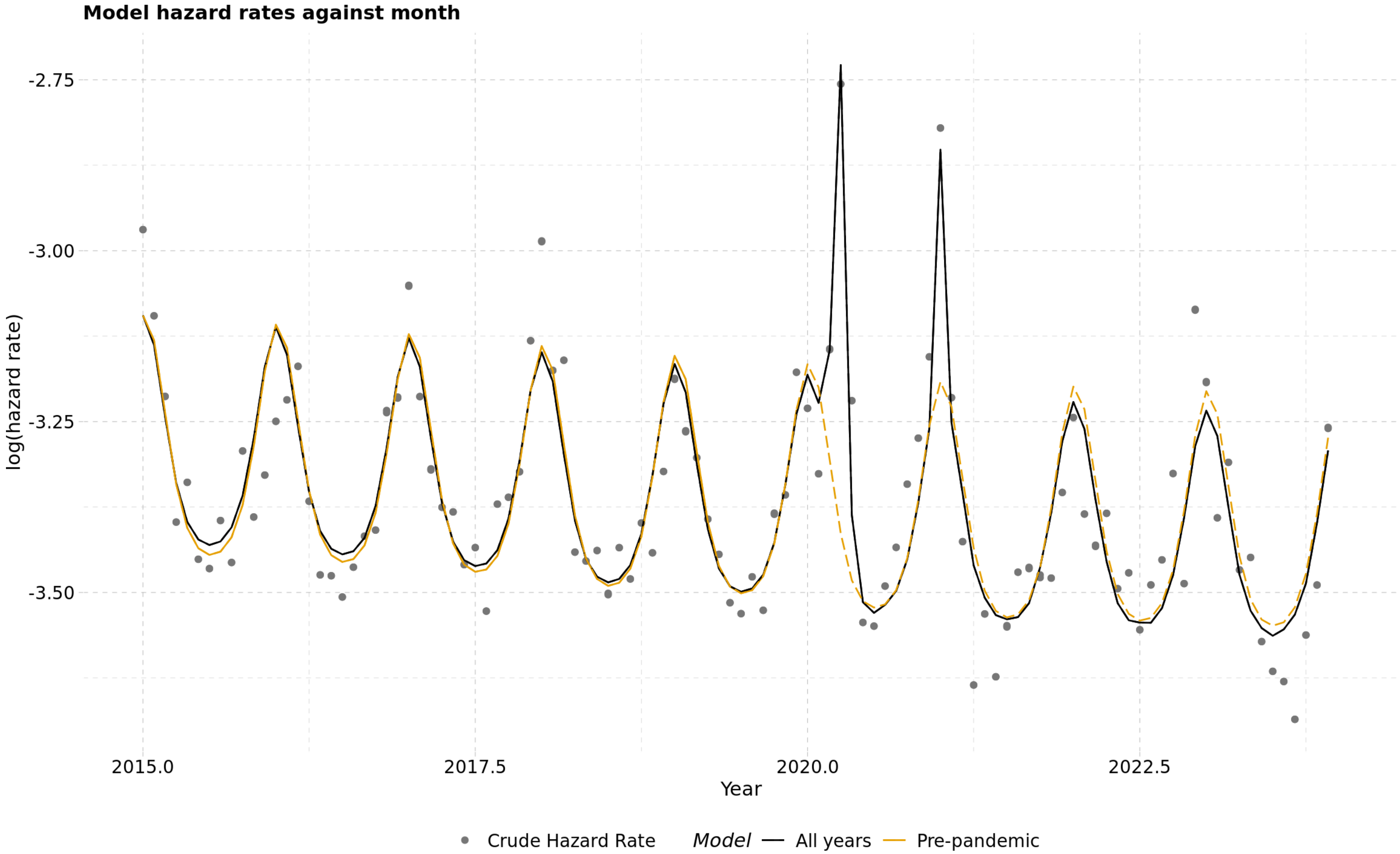
Spikes and Trends

Excess Mortality during Pandemic

Spike	Centre	Peak	Width
1	2020-04-14	0.806 ± 0.038	36.1 ± 1.6 days
2	2021-01-15	0.544 ± 0.050	19.8 ± 1.8 days

Mortality Trend Comparison

Model	Naïve Trend	Seasonal with Spikes
2015 – 2019	-0.0281 ± 0.0038	-0.0217 ± 0.0039
2015 – 2023	-0.0240 ± 0.0016	-0.0249 ± 0.0016


Model hazard rates against month
-2.75
-3.00
-3.25
-3.50
log(hazard rate)
2015.0
2017.5
2020.0
2022.5
Year
Crude Hazard Rate
Model
All years
Pre-pandemic

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Discussion

Summary

- Measuring mortality trend requires seasonal mortality variation
- Pandemic mortality modelling requires intra-year shape
- Combining both allows residual trend to be captured.
- How many spikes to model?

Ongoing Research

1. Does spike amplitude change by socio-economic group?
   - Pension amount band
   - Lifestyle groups based on postcode
2. Investigate trend change
3. Comparison to population
4. Implement time series for Hermite coefficients

References

- Ramonat, S. J. (**2024**). Extending the Hermite-spline basis for mortality modelling. Working Paper.
- Richards, S. J. (**2019**). A Hermite-spline model of post-retirement mortality. Scandinavian Actuarial Journal, 2020(2), 110–127. https://doi.org/10.1080/03461238.2019.1642239
- Richards, S. J., Ramonat, S. J., Vesper, G. T., & Kleinow, T. (**2020**). Modelling seasonal mortality with individual data. Scandinavian Actuarial Journal, 2020(10), 864–878. https://doi.org/10.1080/03461238.2020.1777194
- Richards, S.J. (**2022**) 'Allowing for shocks in portfolio mortality models', British Actuarial Journal, 27, p. e1. doi:10.1017/S1357321721000180.
- Zhou, R. and Li, J.S.-H. (**2022**) 'A multi-parameter-level model for simulating future mortality scenarios with COVID-alike effects', Annals of Actuarial Science, 16(3), pp. 453–477. doi:10.1017/S1748499522000033.

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See you later!

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Canadian Mortality Improvements

Results finally published

- Work completed April 2021 to December 2022
  - Publication of research report 11 April 2024: https://www.cia-ica.ca/publications/224043e/
  - Plus podcast, article and presentation at CIA conference in June 2024

- Ongoing discussion within CIA
  - Recommendations for pension actuaries and life actuaries
  - Implications of COVID-19
  - Waiting for new CPM tables to be completed