Measuring excess mortality across different nations: strengths and limitations

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Focus on:

The concept of ‘excess mortality’:

- observed deaths during catastrophic events, e.g. the COVID-19 pandemic, compared to the expected number of deaths at ‘normal’ times

based on different measures of excess mortality

Investigating patterns in excess mortality across different nations

- by age and gender
- from 2020 to the most recent calendar year

What we have done:

- Focusing on all-cause mortality in 16 countries to

  . . . avoid discrepancies due to the reporting of COVID-19 deaths

  . . . examine the direct and indirect impacts of the pandemic

- Short-Term Fluctuations (STMF) data series

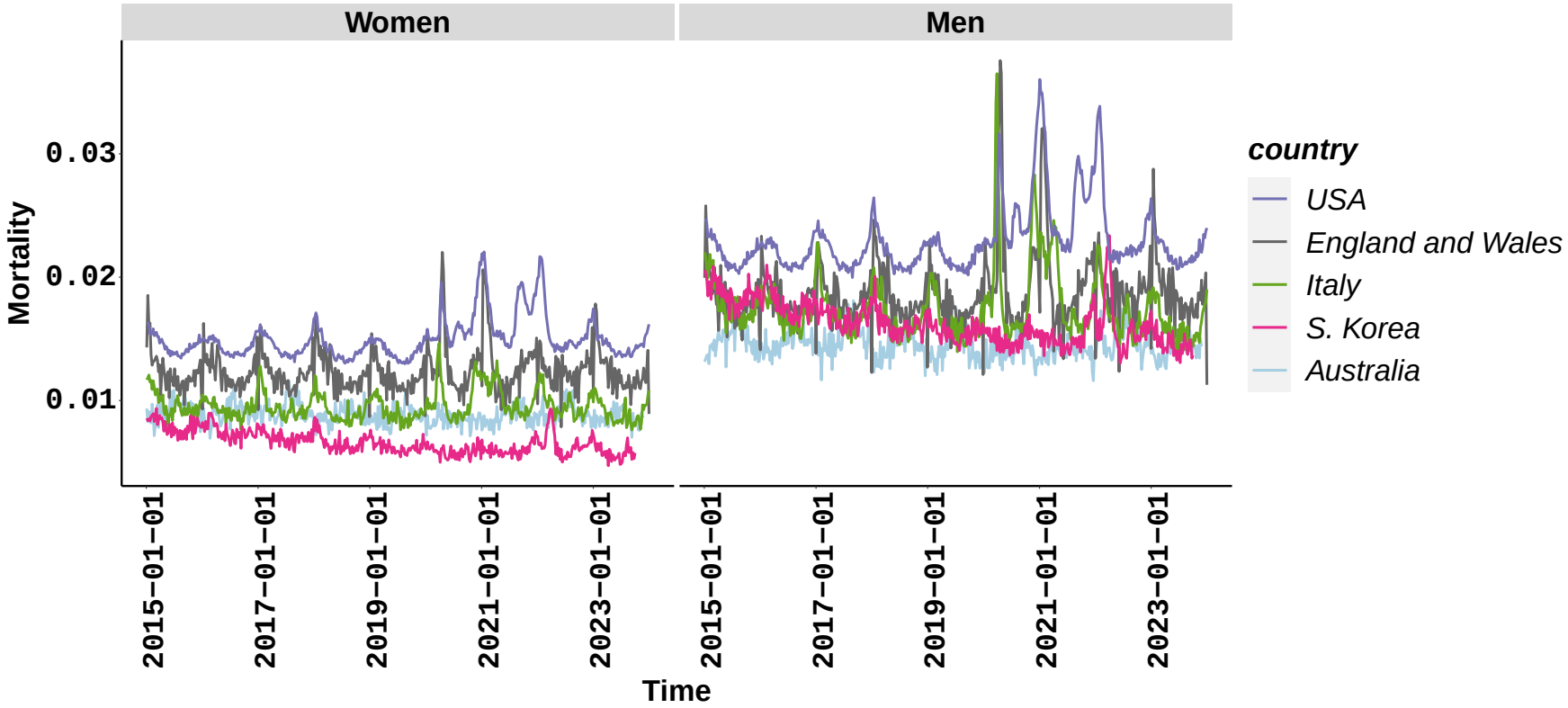
- Investigating excess mortality based on:
  - Proportional excess mortality (P-scores)
  - Relative age-standardised excess mortality (ASMR)
  - A methodological approach, i.e. a statistical model

STMF dataset

All-cause deaths data
STMF, Human Mortality Database (HMD)

- Age groups: 0–14, 15–64, 65–74, 75–84, 85+
- Gender
- Years: 2015–2023 (*weekly*)
- Country: Australia, Belgium, Canada, England and Wales, France, Germany, Hungary, Israel, Italy, Netherlands, Poland, South Korea, Spain, Sweden, Switzerland, and the USA

All-cause mortality: women & men aged 65–74



- Usual seasonal patterns: winter v. summer deaths

  . . . with a reversed cycle in Australia v. other countries

  . . . mortality peaks during winter time

- Sharp increases in (especially winter) mortality from 2020

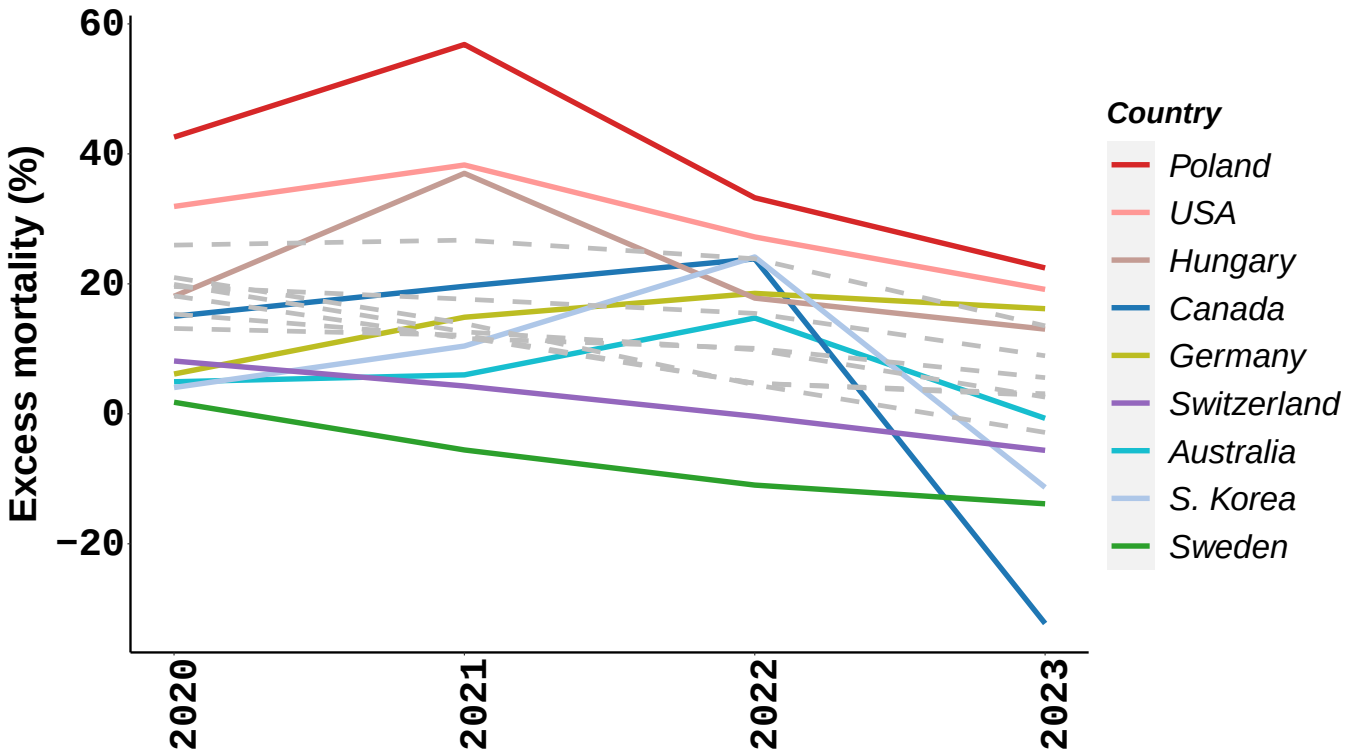
- Deaths in 2023 are complete, apart from Australia (until Week 47), Canada (Week 30), South Korea (Week 39)

Excess mortality: P-scores

$$P_{a,c,g,y} = \frac{D_{a,c,g,y} - \overline{D}_{a,c,g,\text{reference year}}}{\overline{D}_{a,c,g,\text{reference year}}}$$

- $P_{a,c,g,y}$: P-scores, excess deaths (%) at age-at-death a for gender g in country c at a given year y
- $D_{a,c,g,y}$: all-cause (observed) number of deaths
- $\overline{D}_{a,c,g,\text{reference year}}$: average number of deaths during the reference year(s), e.g. 2015–2019

Excess mortality: P-scores, 2015–2019, men aged 65–74

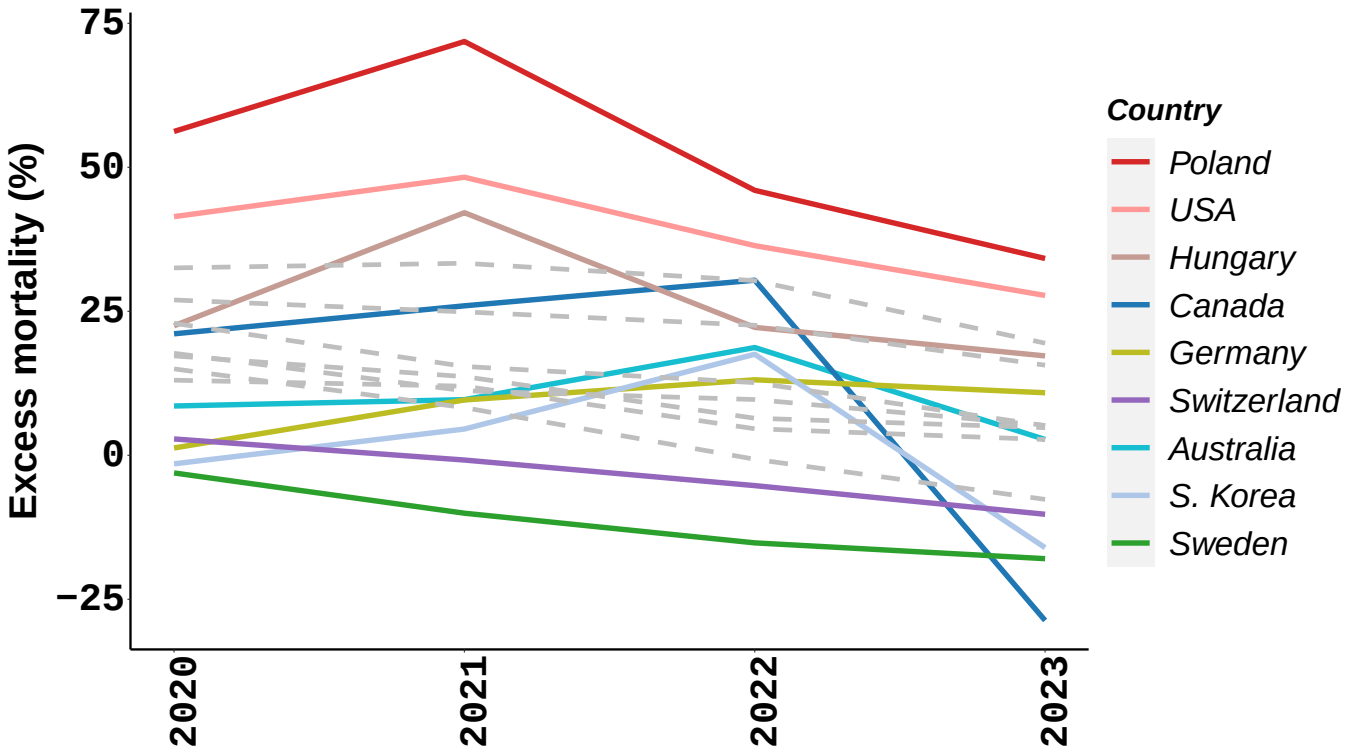


- The P-scores compared to the related average number of deaths bw 2015–2019
- Throughout 2020–2023

  . . . the USA and Poland are the most impacted

  . . . Sweden is the least impacted

Excess mortality: P-scores, 2019, men aged 65–74



- The P-scores compared to the related number of deaths in 2019
- Mostly comparable results across different reference years

  . . . bigger changes

  . . . similar trends

Excess mortality: relative ASMR

$$\text{rASMR}_{c,g,w,y} = \frac{\text{ASMR}_{c,g,w,y} - \overline{\text{ASMR}}_{c,g,w,\text{reference year}}}{\overline{\text{ASMR}}_{c,g,w,\text{reference year}}}$$

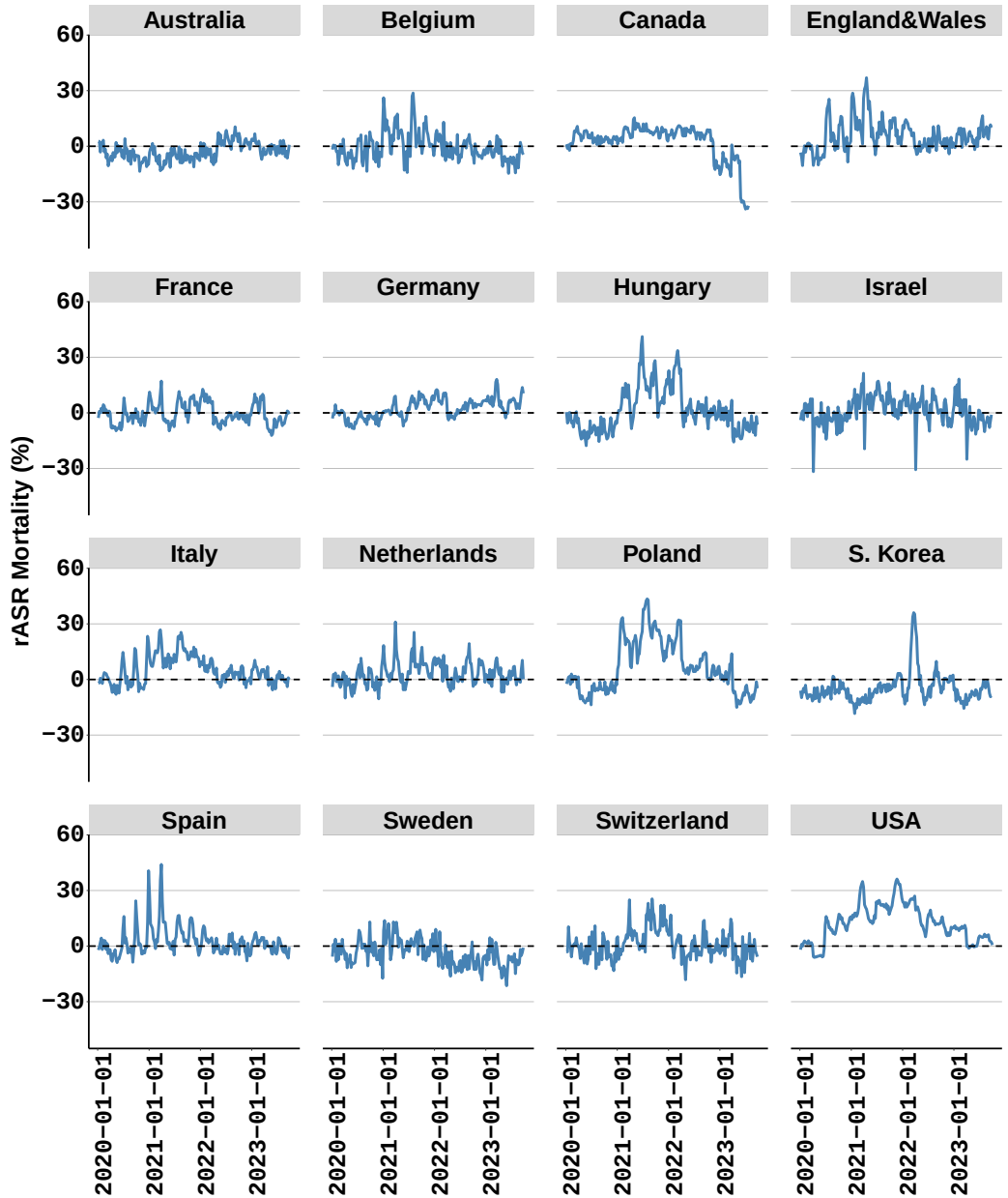
- $\text{rASMR}_{c,g,w,y}$: relative increase in ASMR for gender g in country c in week w of year y
- $\text{ASMR}_{c,g,w,y}$: age-standardised mortality rate

$$\text{ASMR}_{c,g,w,y} = \frac{\sum_a \theta_{a,c,g,w,y} E_a^{\text{std}}}{\sum_a E_a^{\text{std}}}$$

. . . E_a^{std} : standard population at age-at-death a
. . . $\theta_{a,c,g,w,y}$: mortality rates

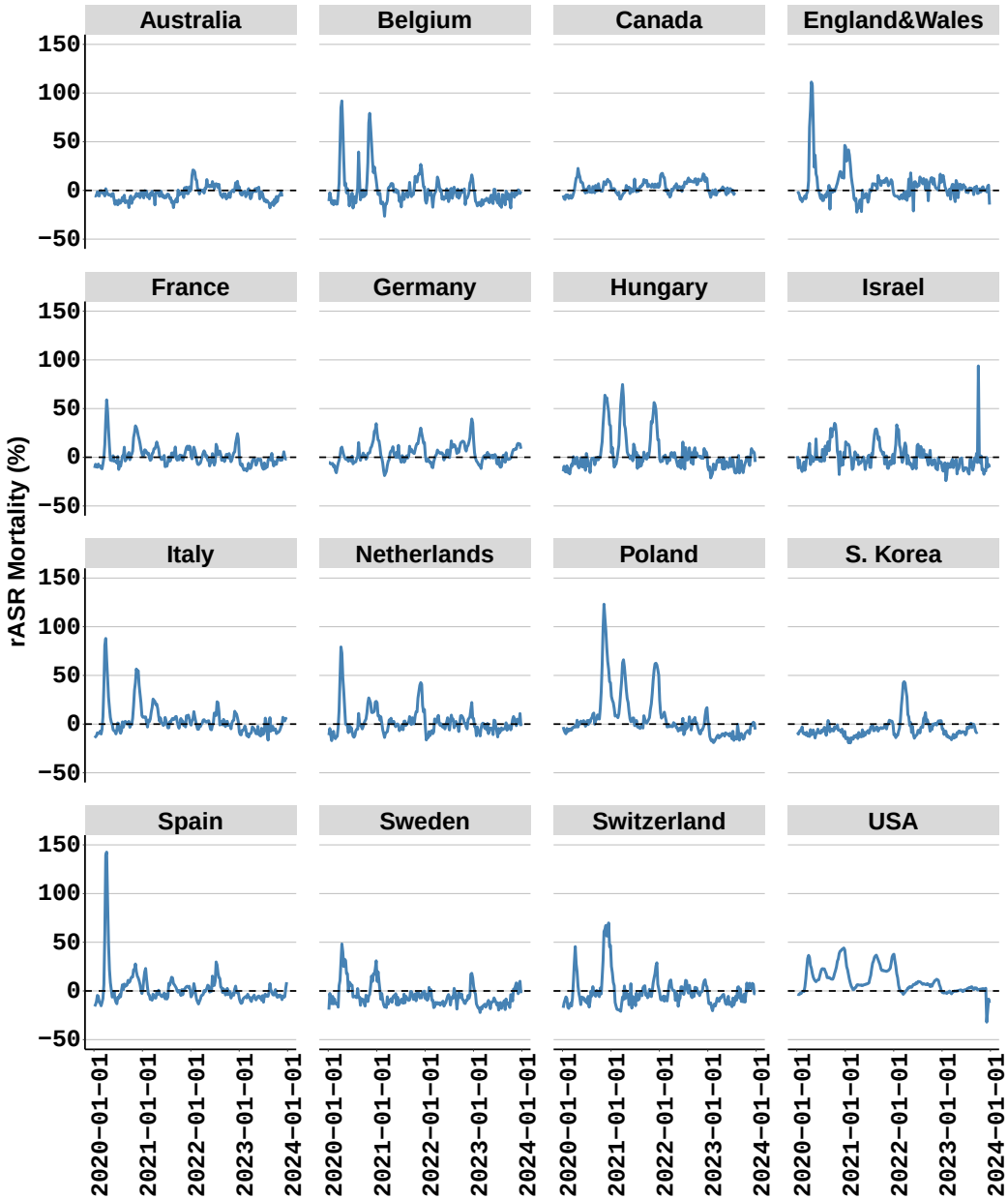
- $\overline{\text{ASMR}}_{c,g,w,\text{reference year}}$: average ASMR during the reference year(s), e.g. 2015–2019

Excess mortality: relative ASMR, men



- WHO Standard Population (2000–2025)
- Continuing high excess mortality in the USA
- A sharp peak in S. Korea in 2022
  - the Omicron variant?
  - age disparity?
- Negative excess trend in Canada since 2022
  - real or artefact?
- A shift in excess mortality in Australia since 2022
  - the Omicron variant?
  - re-opening of international borders?

Excess mortality: relative ASMR, men



- European Standard Population 2013

. . . notably older than the WHO standard

- The excess in the USA is relatively much lower, with potential mortality gain
- No negative excess trend in Canada
- How appropriate is the standard we refer to for international comparisons?

Excess mortality: a simple regression model

$$D_t^{\text{std}} = \alpha + \beta \times t + \epsilon_t$$

- D_t^{std} : age-, country- and gender-specific standardised all-cause deaths at time t

$$D_t^{\text{std}} = \frac{D_t - \mu_{t(w)}}{\text{sd}_{t(w)}}$$

. . . t : time index corresponding to a specific week w of year y

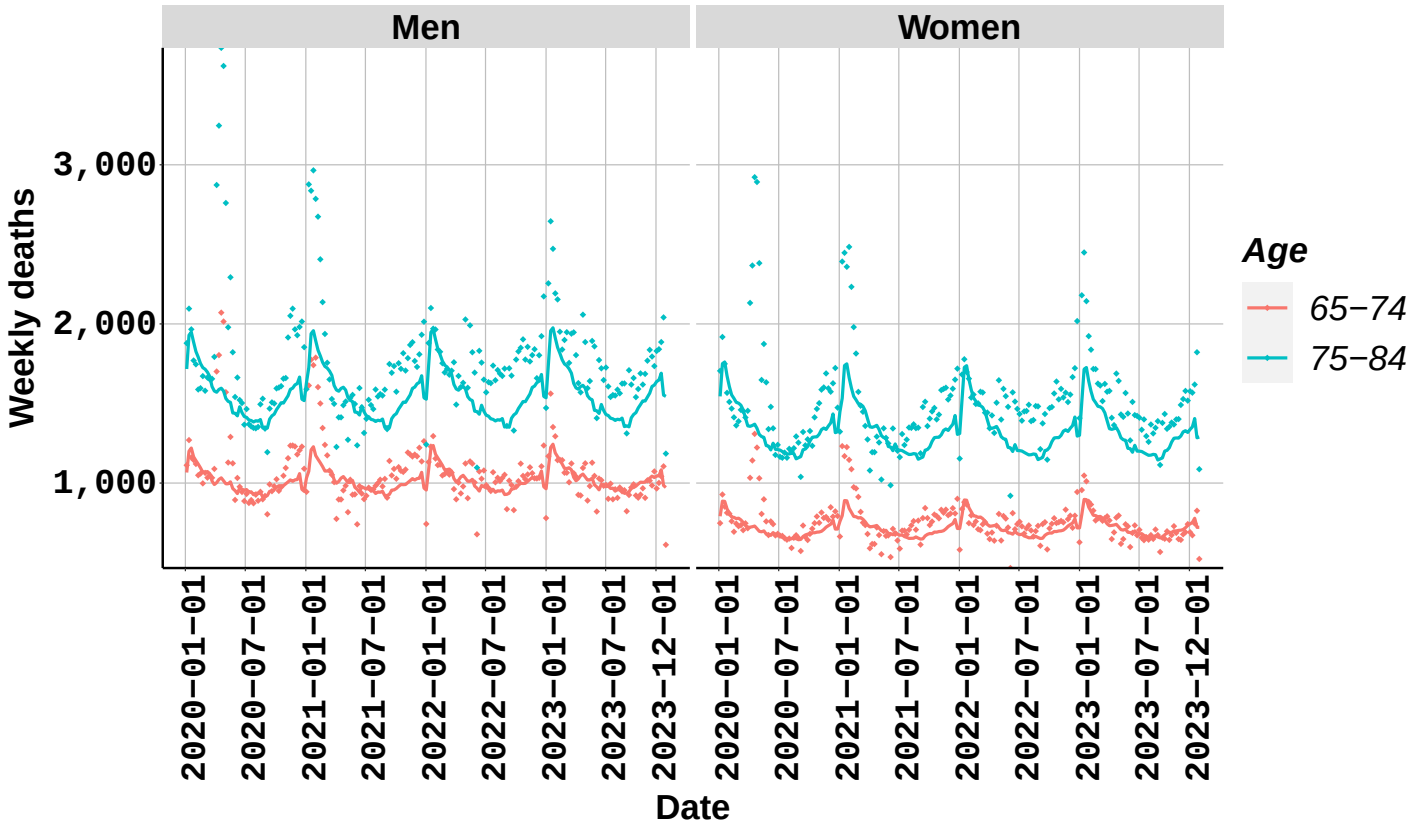
. . . $\mu_{t(w)}$: average death over the weeks $w-1$, w, and $w+1$ between 2015 and 2019

. . . $\text{sd}_{t(w)}$: standard deviation in deaths over the weeks $w-1$, w, and $w+1$ between 2015 and 2019

- α : coefficient of intercept
- β : coefficient of time trend
- ϵ_t : error term modelled through ARIMA(p, d, q)

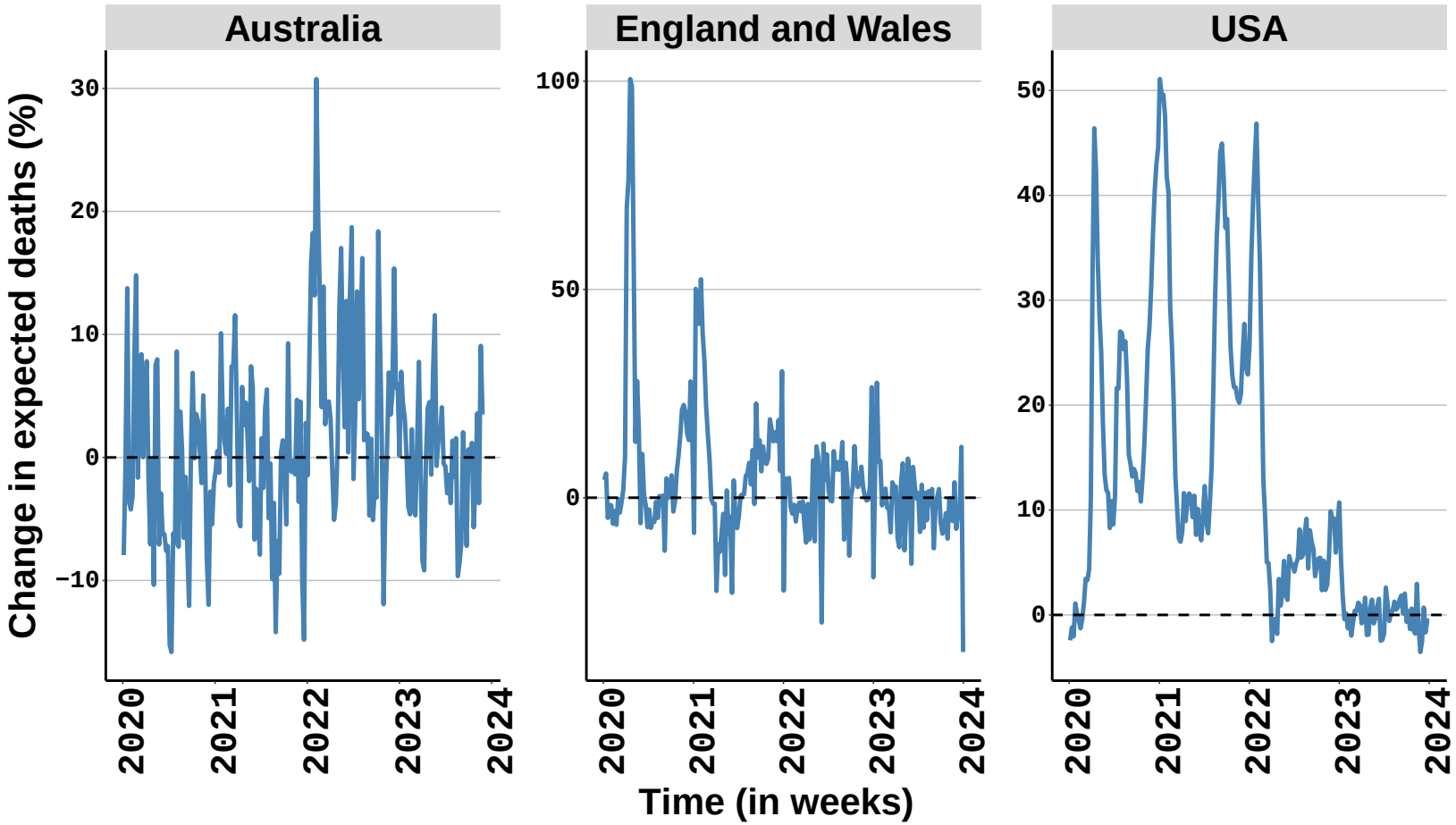
Excess mortality: a simple regression model

Observed **(dots)** and extrapolated **(solid lines)** deaths for men and women aged 65 to 84 in England and Wales



Excess deaths= Observed deaths -
Extrapolated deaths by using the data in 2015–2019

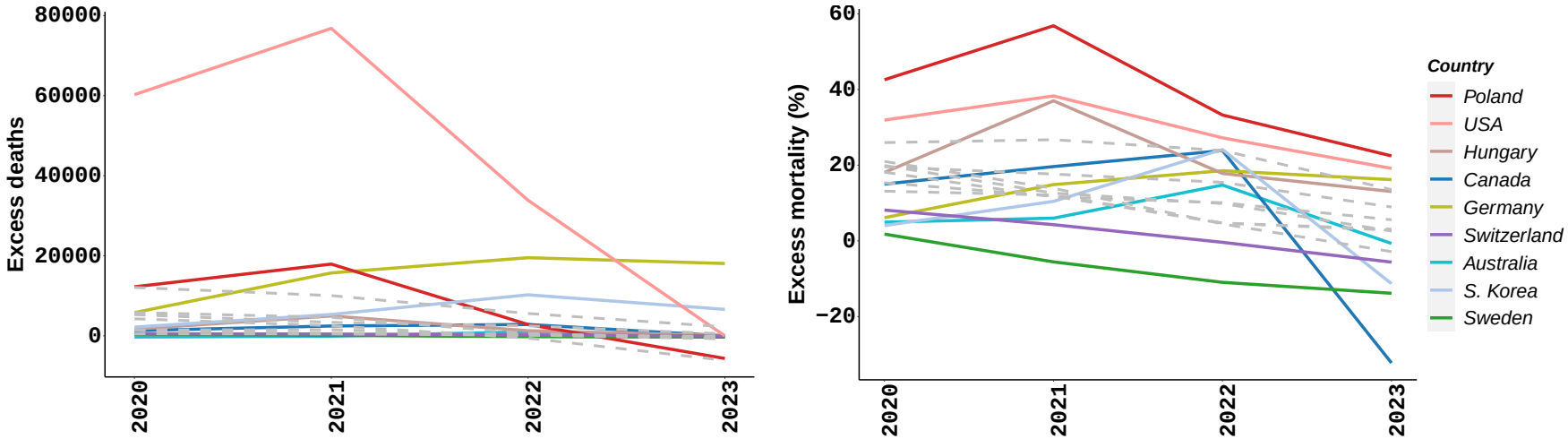
Excess mortality: regression model, % change, men aged 65–74



- Moving away from averages drawn from raw numbers
- Increasing coherence and better understanding
- Weekly changes in observed deaths compared to the expected deaths in the same weeks

. . . in selected countries

Excess mortality: regression model v. P-scores, men aged 65–74



Model (left) v. P-Scores, 2015–2019 (right)

- Bigger variability in the rankings, compared to the P-scores, with some comparable results

  . . . the USA is among the most impacted

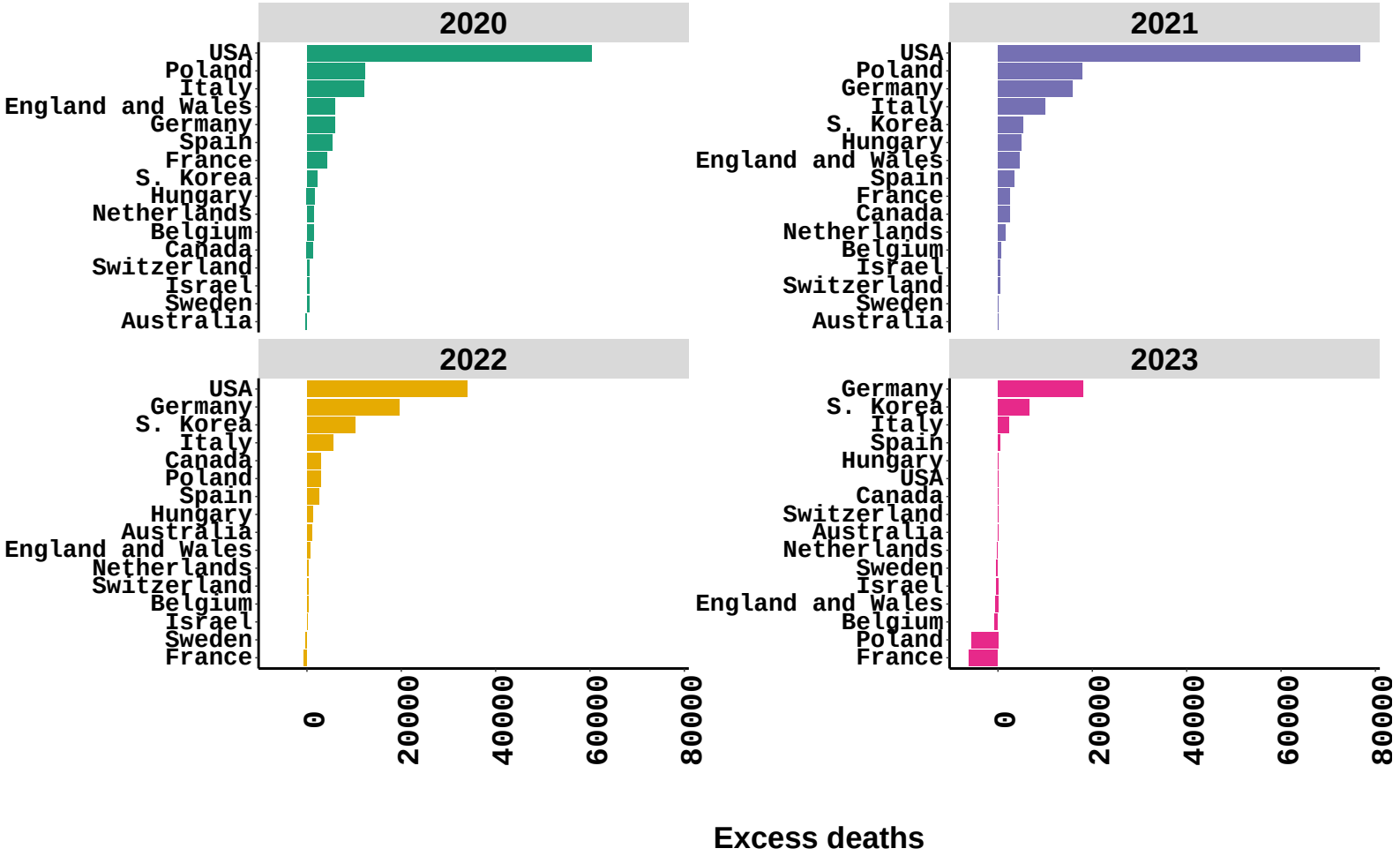
  . . . Sweden is among the least impacted

- Different trends over time

- Is the model too simple?

  . . . . . weekly v. annual?

Excess mortality: regression model, absolute change, men aged 65–74



- Excess deaths are in absolute terms
- Bigger variability among the countries least impacted by the pandemic compared to the P-scores

Summary

- Some consistent findings across different measures of excess mortality

  . . . e.g. among the most impacted countries at the earlier times of the pandemic

- Mostly comparable results by gender across different nations
- Over-generalisation should be avoided

  . . . e.g. for younger age groups and/or

  . . . in the most recent calendar years

- A more dynamic modelling structure

  . . . incorporating time series methodology to predict future deaths

  . . . separate models from the fitting period to the extrapolation period

- Measuring the impact of health measures introduced during COVID-19 on mortality?

Thank You!

Questions?

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