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How to estimate the infection fatality rate of COVID-19 in Germany (and elsewhere)

COVID-19 mortality

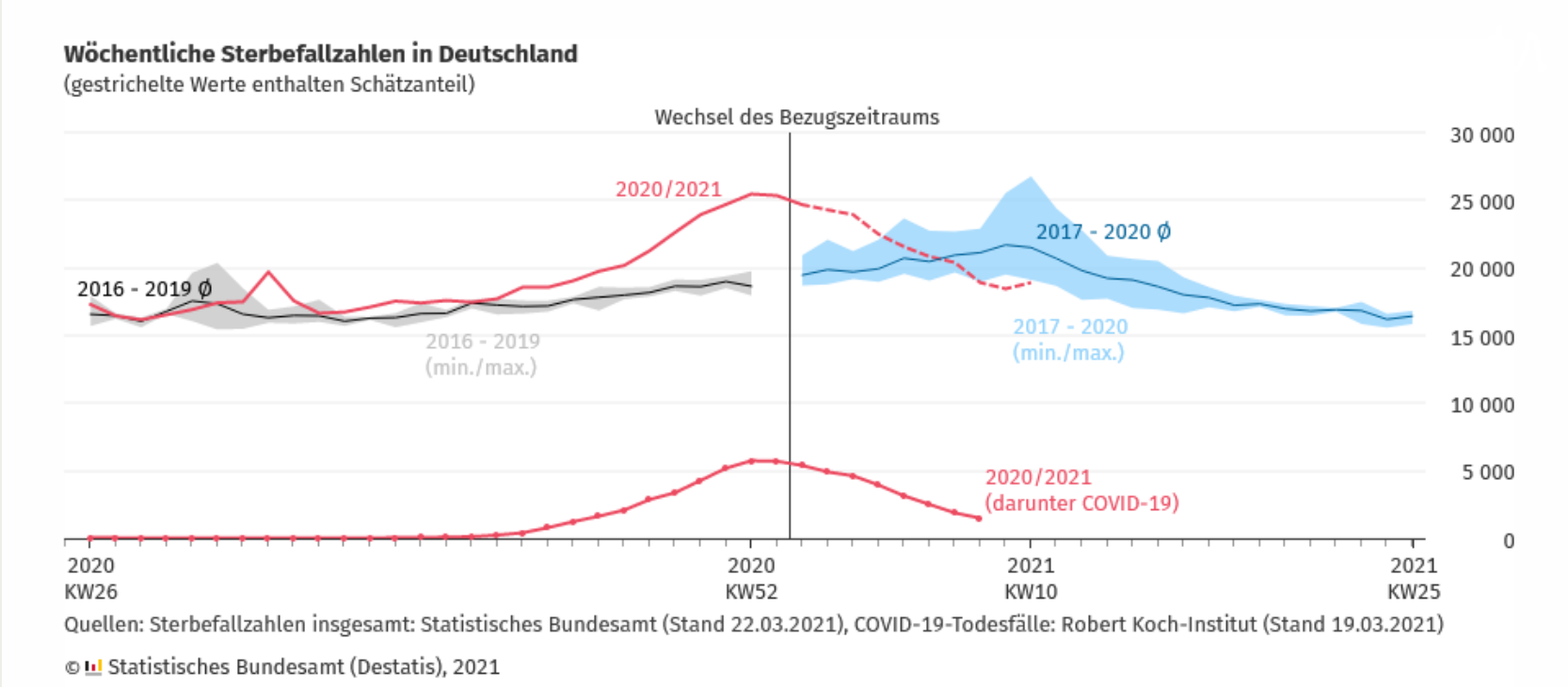
- How lethal is COVID-19?
- Major question since beginning of the pandemic
- Focus today on Germany, but generally applicable

How to measure COVID-19 mortality at the population level

Many ways to measure COVID-19 mortality, some key variants are:

- Absolute measures
  - Deaths associated with COVID-19 (e.g., death certificates)
  - Excess mortality
- Relative measures
  - Case fatality rate (CFR)
  - Infection fatality rate (IFR)

Deaths


Wöchentliche Sterbefallzahlen in Deutschland
(gestrichelte Werte enthalten Schätzanteil)
Wechsel des Bezugszeitraums
2020/2021
2016 - 2019 ∅
2016 - 2019
(min./max.)
2017 - 2020 ∅
2017 - 2020
(min./max.)
2020/2021
(darunter COVID-19)
30 000
25 000
20 000
15 000
10 000
5 000
0
2020
KW26
2020
KW52
2021
KW10
2021
KW25
Quellen: Sterbefallzahlen insgesamt: Statistisches Bundesamt (Stand 22.03.2021), COVID-19-Todesfälle: Robert Koch-Institut (Stand 19.03.2021)
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Case fatality rate

- CFR = Deaths associated with COVID-19 / COVID-19 positive cases
- Calculation is easy, data available
- Problem: Both numerator and denominator are not complete

Infection fatality rate

- IFR = All COVID-19 deaths / All COVID-19 cases
- Problem: Both numerator and denominator are usually not exactly known
- Solution: Take estimated IFR from somewhere else and account for age structure

Why adjust for age?

- Age is a major predictor of lethality of COVID-19 at the individual level
- The age structure of a population is a key predictor of country differences in mortality (Dowd et al., Dudel et al., Sudharsanan et al., . . .)

Approach

$$\text{IFR} = \frac{\sum_x N_x P_x I_x}{\sum_x N_x P_x} = \frac{\text{All COVID-19 deaths}}{\text{All COVID-19 cases}}$$

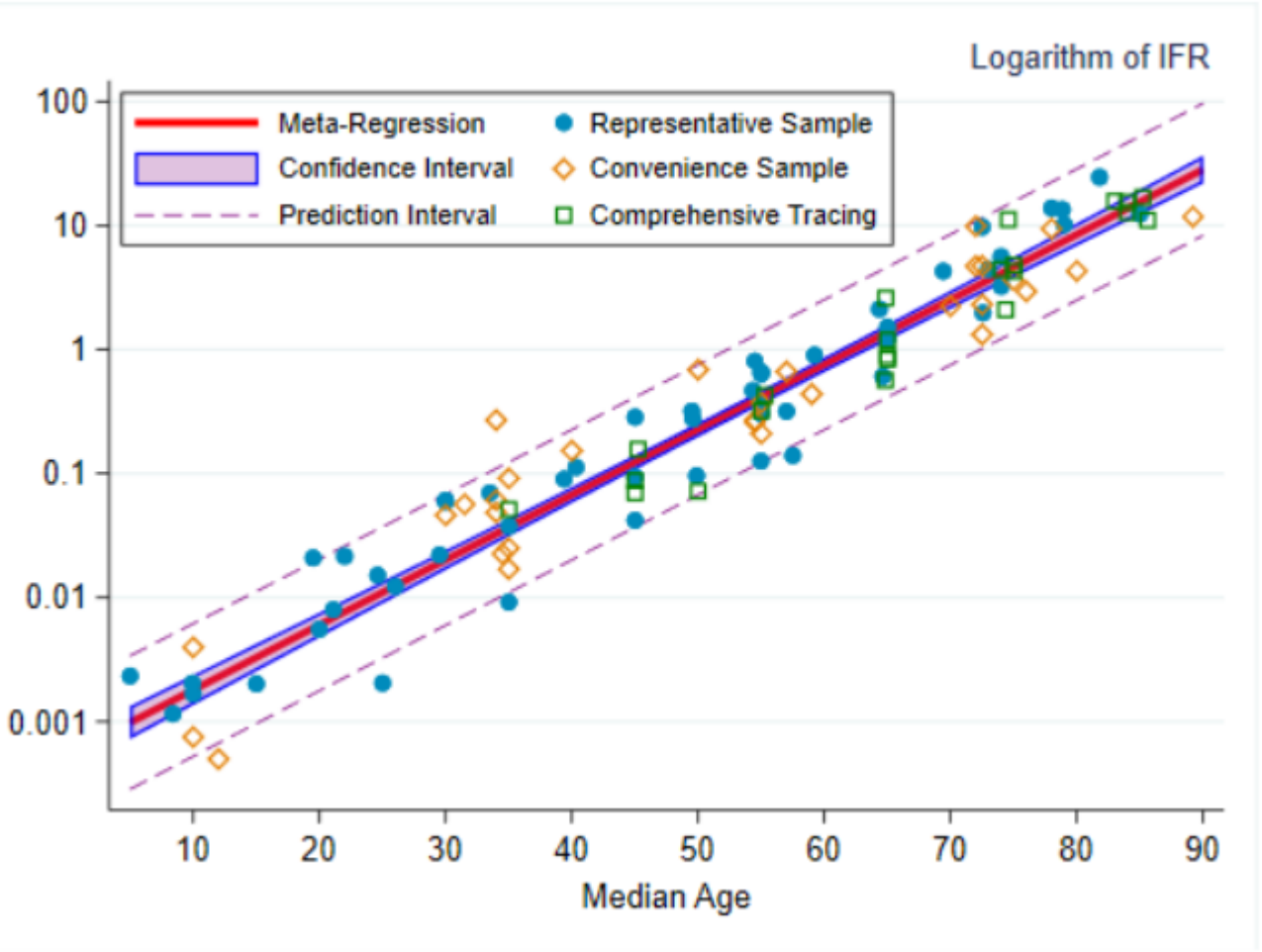
- N_x: Population in age x
- P_x: Proportion of individuals aged x who get COVID-19
- I_x: Infection fatality rate for age x

Age-specific IFR estimates l_x

- Several papers provide estimates of age-specific IFRs (e.g., Verity et al., Salje, et al.)
- Levin et al. combine these

Results of Levin et al. (1)

Figure 3: The log-linear relationship between IFR and age



Results of Levin et al. (2)

$$\log I_x = -7.53 + 0.119x$$

Proportion of COVID-19 cases, P_x

Also provided by Levin et al.

Scenario	Infection Rate by Age (*percent*)			
	All	**0-49**	**50-64**	**65+**
Scenario #1: *current pattern of age-specific prevalence*	20	23	16	14
Scenario #2: *uniform prevalence*	20	20	20	20
Scenario #3: *protection of vulnerable age groups*	20	26	10	6

Population in age x, N_x

Can be taken from many sources; e.g., Human Mortality Database

Summary

$$\mathrm{IFR} = \frac{\sum_x N_x P_x I_x}{\sum_x N_x P_x}$$

- N_x: From Human Mortality Database
- P_x: Levin et al.
- I_x: Levin et al.