The Impact of Covid-19 on Higher Age Mortality

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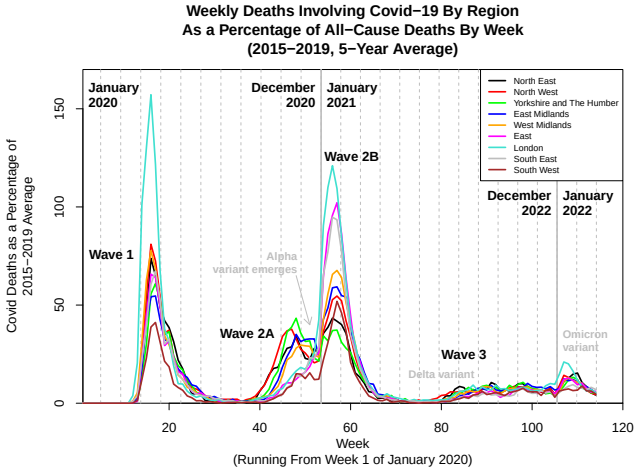
Agenda

- Objectives
- Demographics of the Covid-19 victims
  - What is the relationship between Covid mortality and all-cause mortality?
  - What do we know about infection rates?
  - What has the impact of vaccination and new variants been?
- Demographics of the surviving population
  - The Accelerated Deaths Model
  - Adjusted (Post-Pandemic) Life Expectancy

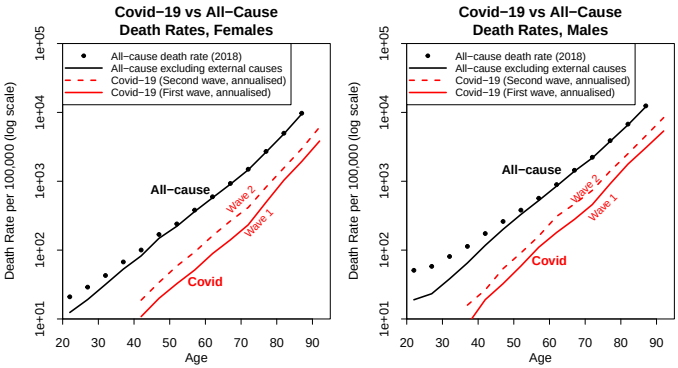
Focus on English data.
But many conclusions will apply to other countries.

Weekly Covid-19 Death Rates: 2020/21 by English Region



- Considerable variation between the 9 English regions
- Wave 1:
  - London leads, but similar timing
  - Very different magnitudes
- Wave 2:
  - Wave 2A more focused in the northern regions
  - Wave 2B stronger in the south
- London Covid death rates 170% higher than the South West
- Urban/rural variation is even wider

Covid-19 Death Rates By Age, Waves 1 and 2 (up to January 2021)



(Adapted from a David Spiegelhalter blog)

- Death rates are on a logarithmic scale
- All cause: with and without external causes
- Waves 1, 2 and 2018-all-cause are almost parallel!
- Waves 1 & 2: very similar age profile
- Conclusion: Covid death rates by age are approximately proportional to all-cause mortality (excluding external causes).

Provisional Takeaway: The Proportionality Hypothesis

The comparison with all-cause death rates suggests the following way to look at Covid-19 mortality for age x:

$$\text{Covid Mortality Rate}(x) = \text{all-cause mortality rate}(x) \times \text{infection rate}(x) \times \text{relative frailty}(x)$$

- "Relative Frailty" measures the probability of death from Covid-19 (if infected) *relative to* the annual probability of death from all causes.
- The graphic suggests that infection rate(x) $\times$ relative frailty(x) changes only slowly with age

Generalising this concept by group

Group i

$$\text{Covid Mortality Rate}(i,x) = \text{All-cause mortality rate}(i,x) \times \text{infection rate}(i,x) \times \text{relative frailty}(i,x)$$

where group i might be characterised by e.g.
region; urban/rural; neighbourhood deprivation; ethnic group; ...

Hypothesis: relative frailty(i,x) does not vary much by age or sub-group

i.e. differences in Covid-19 mortality between groups are largely due to differences in all-cause mortality and in infection rates

How to verify if this is true?

Infection rates

$$\text{Covid Mortality Rate}(i,x) = \text{All-cause mortality rate}(i,x) \times \text{infection rate}(i,x) \times \text{relative frailty}(i,x)$$

Infection rates: antibody prevalence data following the first wave $\Rightarrow$

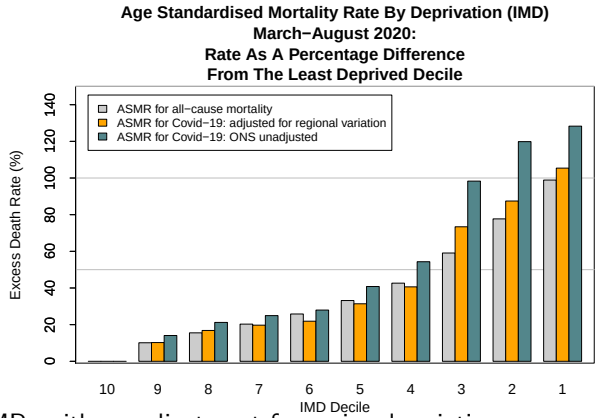
- About 6% of adults were infected
- Relatively little variation by age and sex
- Relatively little variation by deprivation (Index of Multiple Deprivation, IMD)
- Significant variation by region (e.g. London $>>$ South West)

Mortality Rates

$$\text{Covid Mortality Rate}(i,x) = \text{All-cause mortality rate}(i,x) \times \text{infection rate}(i,x) \times \text{relative frailty}(i,x)$$

- Data: Age Standardised Mortality Rates (ASMR) by deprivation decile (i)
- Data: Age Standardised Mortality Rates by region
- But: ASMR by deprivation decile is distorted by regional effects (e.g. London more deprived and higher infection rates)
- ASMR by region allows us to adjust the ASMR by deprivation decile

ASMRs by deprivation: Wave 1, Adjusted for Regional Variation

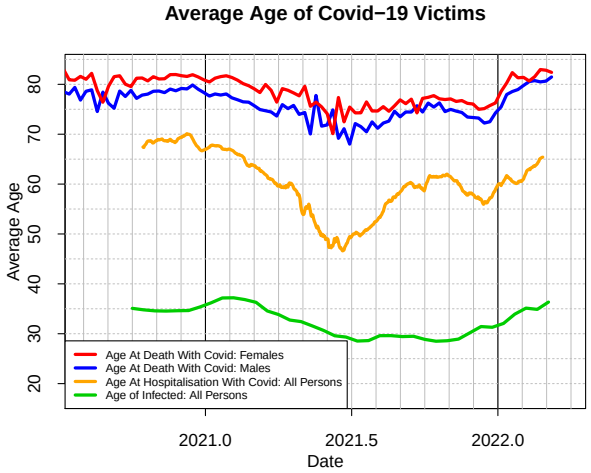


- Blue bars: ASMRs with no adjustment for regional variation
- **Orange bars: ASMRs with the effect of regional variation filtered out**
- Covid-19 ASMRs by decile are now approximately proportional to all-cause ASMRs
- Conclusion: Relative Frailty(i, x) varies very little across deprivation deciles $i = 1, ..., 10$

2021/22: The impact of vaccination and new variants

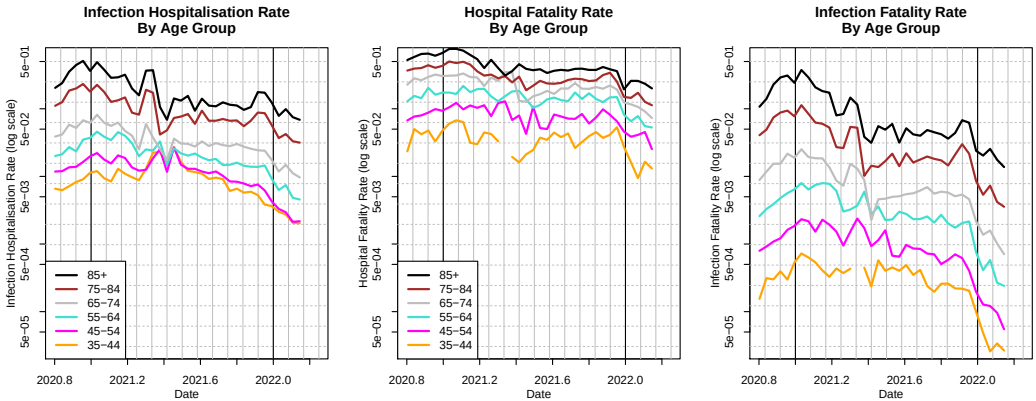
- Data for 2021: much more complex
- Vaccination: oldest ages in December 2020 $\rightarrow$ teenagers in October/November 2021
- New variants in the UK:
  - Alpha: December 2020
  - Delta: May/June 2021 (more infectious than Alpha)
  - Omicron BA.1: December 2021 (more infectious than Delta, less severe)
  - Omicron BA.2: February 2022 (more infectious than Omicron BA.1)
- What have been the impacts at different ages on:
  - Infection rates
  - Hospital admissions
  - Deaths

Average Age At Death With Covid and Average Age At Hospitalisation With Covid



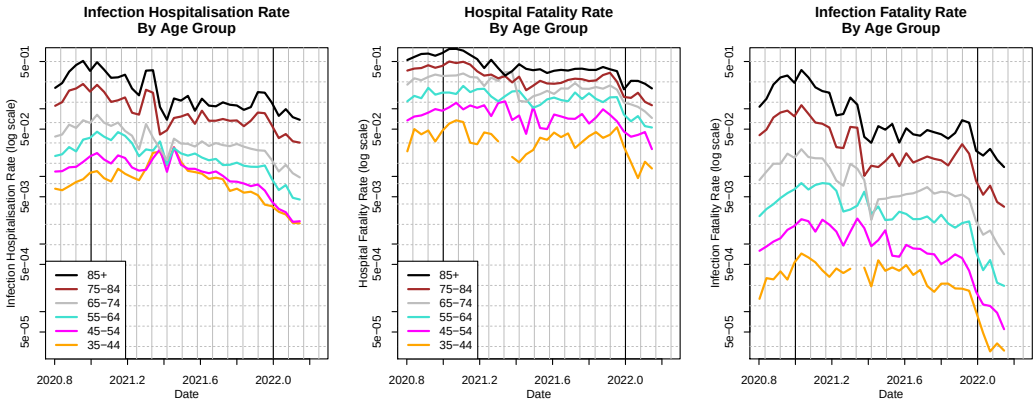
- Pre-covid seasonal variation: around 1 year higher in winter
- End 2020 to mid 2021:
  - Avg Age at Death drops by 7 to 9 years
  - Avg Age at Hospitalisation drops by 20 years
- Due to:
  - vaccination by age group
  - age-related behaviour

Estimated infection fatality rates and related quantities



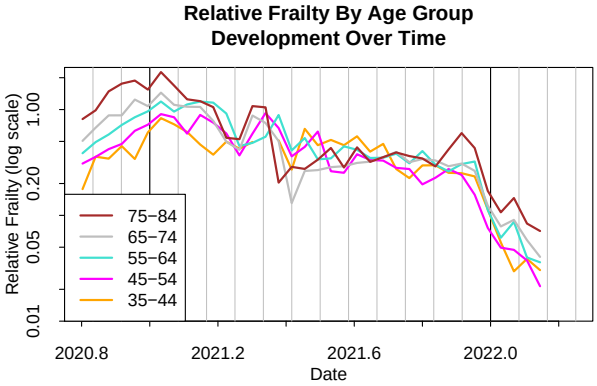
- Infection Hospitalisation Rate = Proportion of newly infected who are admitted to hospital
- Hospital Fatality Rate = Proportion of newly hospitalised who die from Covid
- Infection Fatality Rate = Proportion of newly infected who die from Covid

Estimated infection fatality rates and related quantities



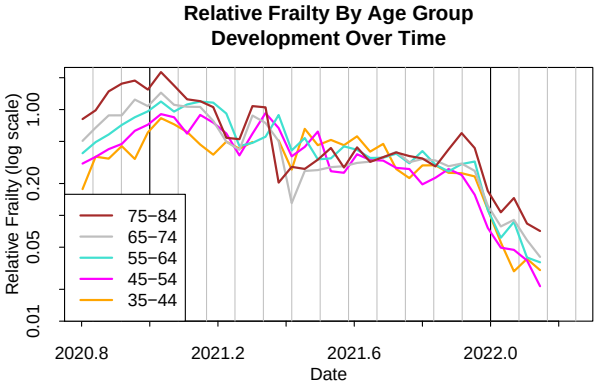
- Infection → Hospitalisation: strong benefit from vaccination
- Hospital → Dead: some vaccination effect, but weaker
- Infection Fatality Rate: declines sooner for the older groups due to vaccination
- Infection Fatality Rate: booster + Omicron ⇒ big decline

Estimated relatively frailty



- Relative Frailty (t, x) := Infection Fatality Rate (t, x) $\div$ All-Cause Death Rate $(2018, x)$
- All-cause Death Rate excludes external causes
- Steady decline as vaccines take effect and new variants replace older variants

Estimated relatively frailty: further remarks



- Pre-vaccination (end of 2020): relative frailty has some variation with age (increases by 3-4% per year of age)
- Vaccination causes the age gradient to disappear in mid 2021
- Age gradient re-emerges in 2022 after booster roll out to all age groups

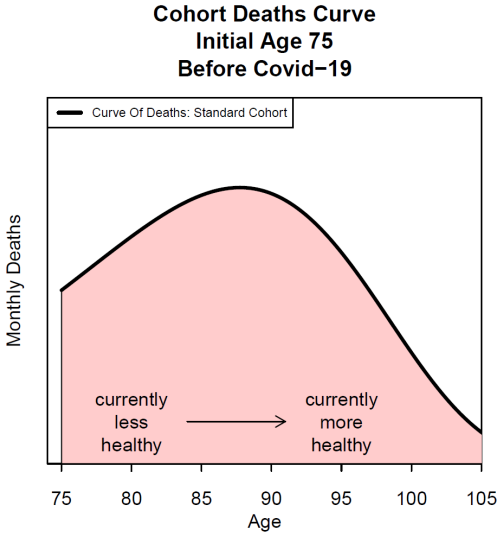
The Impact of Covid-19 on Future Mortality

Preceeding discussion:

People of the same age who are more "frail" are more likely to die if they become infected with Covid-19.

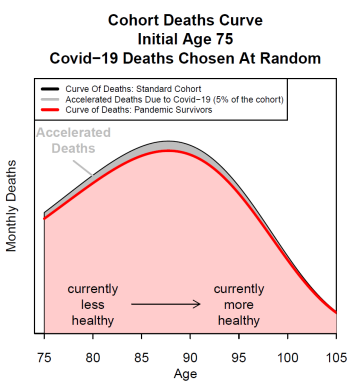
What is the impact on the surviving population?

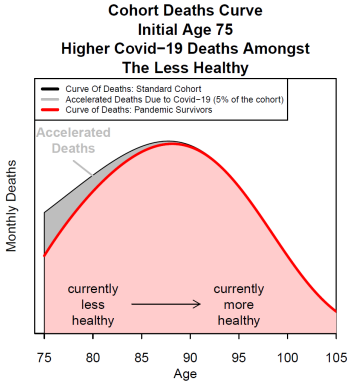
Pre-Covid: Cohort Curve of Deaths



- For a cohort currently aged 75: what will be the ages at death?
- Less healthy now $\Rightarrow$ more likely to die earlier

Impact of Covid-19 on the Curve of Deaths





- A (left): Covid victims randomly chosen from the cohort
- B (right): Covid deaths more prevalent amongst the less healthy

Scenario B is consistent with the empirical evidence that those with co-morbidities are more likely to die if they get infected

The Accelerated Deaths Model

Example: Consider a cohort currently aged x (e.g. 75)

- Initial cohort size: 100,000
- $d(t, x)$ = pre-Covid curve of deaths, $t = 0, 1, 2, \ldots$

- Out of the original $d(t, x)$ "scheduled" to die at t

  a proportion $\pi(t, x)$ die in the short term from Covid

The Accelerated Deaths Model (cont.)

- Simple starting point:

$$\pi(t,x) = \alpha(x)R(x)\exp[-t/\rho(x)]$$

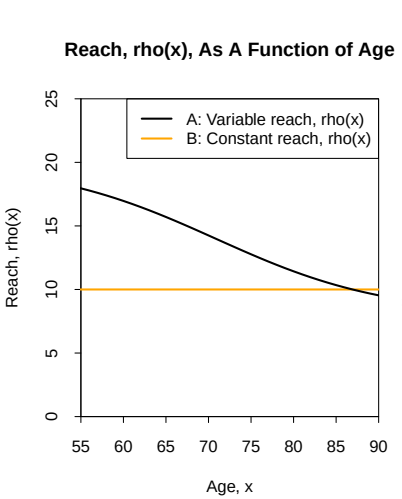
- $\alpha(x) =$ "amplitude" $\Rightarrow$
  this determines the proportion of the entire cohort who die from Covid
- $\rho(x) =$ "reach" $\Rightarrow$
  links to the years-of-life-lost (YLL) by those who die from Covid
- $R(x) =$ normalising const. depending on $\rho(x)$ and the shape of $d(t,x)$

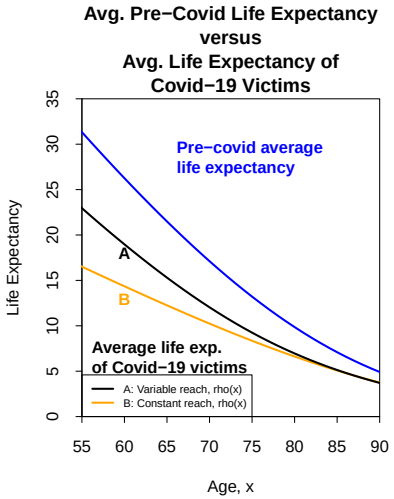
$$R(x) = d(0,x) \Big/ \int_0^\infty d(t,x)\exp[-t/\rho(x)]dt$$

- $R(x)$ definition $\Rightarrow$
  $\alpha(x) =$ infection rate $\times$ relative frailty

  covid mortality(x) = all cause mortality(x) $\times$ infection rate (x) $\times$ relative frailty(x)

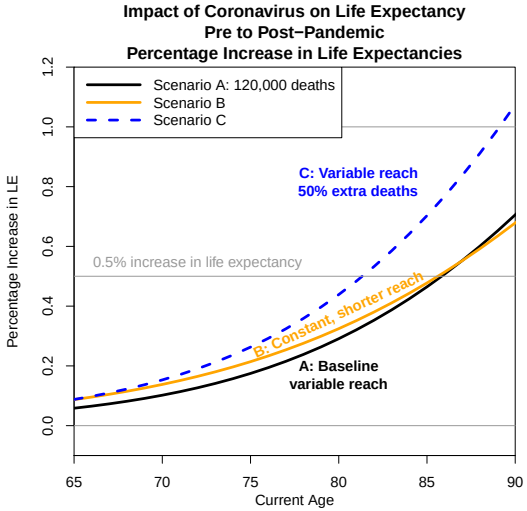
Calibrating the reach parameter, $\rho(x)$





- The shape of $\rho(x)$ depends on variability in underlying frailty
- Scenario A: (experimental) reach: ~ 18 (young) to ~ 10 (old)
- Scenario B: (extreme) reach $= 10$ constant
- B is simple but not very plausible

Adjusted (Post-Pandemic) Life Expectancy (APPLE)



- More realistic scenarios in terms of total Covid-19 deaths
- LE(pre-covid) $\rightarrow$ LE(survivors)
- What is the percentage increase?
- Scenarios:
  - A: 120,000 deaths + variable reach
  - B: 120,000 deaths + constant reach
  - C: 180,000 deaths + variable reach
- Age 65: APPLE of healthier survivors is less than 0.1% higher than pre-Covid cohort life expectancy
- Impact assumes no secondary effects e.g. no long-term impairments
  $\Rightarrow$ further data and modelling

What are the other secondary effects beyond this model?

- Non-Covid illnesses (e.g. late cancer diagnosis or delayed treatment)
- More extreme forms of "Long Covid"
  Covid survivors might have long-term health impairments
- Lasting impact of innovation during the pandemic
- Behavioural changes (positive and negative)
- Impact of increased long-term unemployment
- Economic impact on future health spending and research

Some secondary effects might be observable in 2020/21 cause of death data

- Higher cancer death rates in 2021, 2022, ...
- Potentially lower death rates in 2021 from e.g. respiratory diseases
  (due to accelerated death from Covid-19 in 2020)

Conclusions and Lessons Learned

1. Strong relationship between covid mortality(i, x) and all-cause mortality(i, x)
   - contrasts with Spanish Flu: younger affected much more; some prior immunity
   - Covid-19: novel $\Rightarrow$ no prior immunity
2. Significant variation by region and urban-rural $\Rightarrow$ much more than a normal year
3. In the absence of "secondary effects", the impact of the pandemic on the life expectancy of survivors is likely to be small
4. We will need time to understand the nature and magnitude of secondary effects

Thank you

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