The Impact of Covid-19 on Higher Age Mortality

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26 October 2020

Agenda

- Motivation and 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?
- Demographics of the surviving population (ADM's APPLE)
  - The Accelerated Deaths Model
  - Adjusted (Post-Pandemic) Life Expectancy
  - Secondary effects

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

News Headlines

BBC News website: (17/6/20)
Coronavirus: Death rates twice as high in deprived areas

BBC Today interview: President of the Acad. of Med. Sci. (12/10/20)
Covid-19 "exaggerates inequality whichever direction you turn"

NHS Confederation: (24/7/20)
ONS data lays bare ravages of COVID-19 on areas of high deprivation

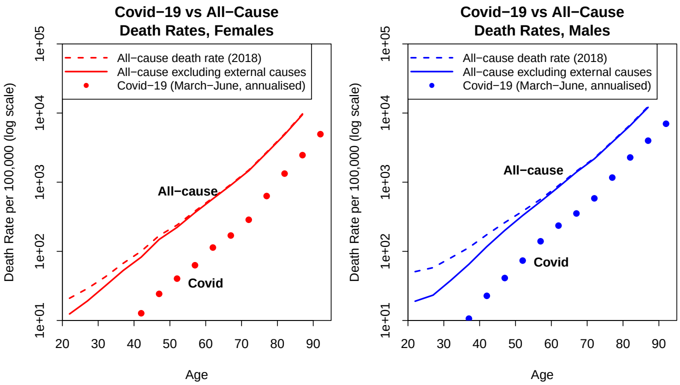
Health Europa: (18/6/20)
The disproportionate impact of COVID-19 on senior populations

Are these headlines distorting the real picture?

Objectives of Our Work

- What does the mixture of people dying from Covid-19 look like?
  - e.g. age profile, deprivation, region
- Is the level of Covid-19 mortality inequality different from the level of all-cause mortality inequality in 'normal' years?
- Are pandemic survivors more healthy than the pre-covid average?
  - Will they have higher life expectancies?
- What might the longer-term impacts be of the pandemic?

Covid-19 Death Rates, March-June 2020



- Adapted from a David Speigelhalter Blog (13 May)
- Death rates are on a logarithmic scale.
- The solid lines and the dots are almost parallel!
- Conclusion: Covid death rates by age are approximately proportional to all-cause mortality (excluding external causes).

Provisional Takeaway: the AIR Equation

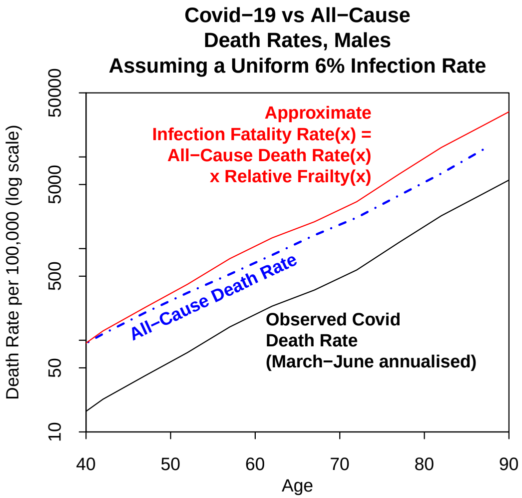
Spiegelhalter's graphic suggests the following way to look at Covid-19 mortality for age x:

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

- "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 $\text{infection rate}(x) \times \text{relative frailty}(x)$ does not depend much on age, but has some dependence on gender.

- $\text{All-cause mortality rate}(x) \times \text{relative frailty}(x)$
  $= \text{"Infection Fatality Rate"}(x)$ (IFR)

Approximate Infection Fatality Rates By Age (IFR)



- The shift (black to red) assumes a uniform 6% infection rate.
- Implication: the IFR is about $1\times$ to $2\times$ the annual all-cause death rate
- This is just the starting point for a more detailed analysis of infection rate and relative frailty separately.

Generalising this concept

Individuals aged x, have varying levels of ‘frailty’:

- Sub-group level (e.g. deprivation deciles)
- Individual risk factors
- Individual state of health

It is also widely believed that

- people dying from Covid-19 tend to have *underlying conditions* (co-morbidities)

More scientifically:

- Older people are more at risk (if infected)
- People who have more co-morbidities *than the average for their age group* are more at risk

Generalising this concept: the AIR equation 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.

- neighbourhood deprivation
- region; urban/rural etc.
- 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

Conjecture at the individual level

Original hypothesis:

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

Can this be extended down possibly down to the level of the individual?

We might need to modify the core AIR equation

$$\begin{aligned} \text{Covid Mortality Rate}(i,x) &= \text{selected-cause mortality rate}(i,x) \\ &\times \text{infection rate}(i,x) \times \text{relative frailty}(i,x) \end{aligned}$$

selected-cause mortality rate(i,x) might reflect those co-morbidities believed to be linked to higher Covid-19 risk.

Infection Rates

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

Early evidence:

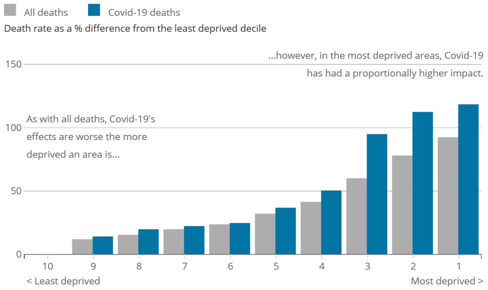
- Regional variation:
  death rates during the first wave $\Rightarrow$ e.g. London has experienced much higher infection rates
- Antigen testing (current infection rate)

Cumulative Infection Rates

Covid-19 Antibody testing

- Imperial College REACT study, August 2020
- Sample size c. 100,000
- England: 6.0% overall carrying antibodies
- Adjusted odds ratios:
  - Males, Females: similar infection rates
  - Deprivation quintiles: similar (Most deprived 1.1×; reference Least depr.)
  - Ages 18-24 1.4× (reference 35-44)
  - London 2.4×, (reference S.E. England)
  - Ethnic: Black 2×, Asian 1.4× (reference White)
  - Patient-facing healthcare worker 2.1×
  - Client-facing care home worker 3.1×
  - Household size "7+" 1.6× (reference Size = 1)

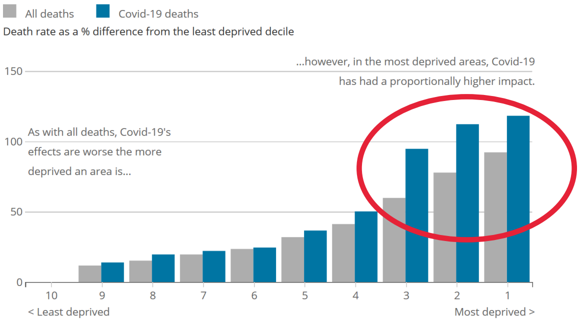
ASMRs by deprivation decile (ONS Data)



Source: Office for National Statistics – Deaths involving COVID-19

- ASMR = Age Standardised Mortality Rate
  - = weighted average of single age death rates
  - weights are based on a “standard” population
- Here we look at ASMRs by decile relative to decile 10
- Compare Covid-19 ASMRs (blue) against All-Cause ASMRs (grey)

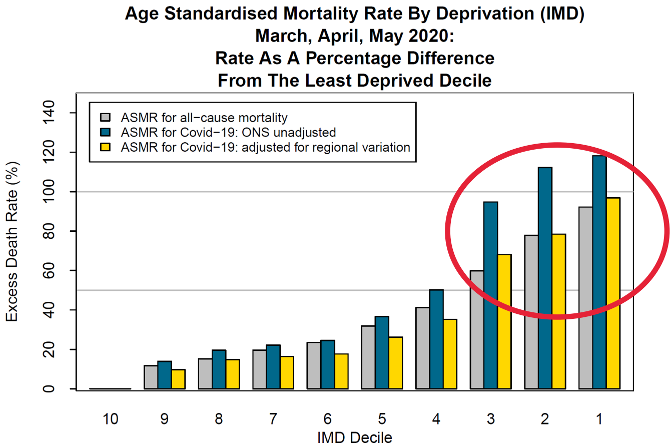
ASMRs by deprivation decile (ONS Data)



Source: Office for National Statistics – Deaths involving COVID-19

- Apparently deprived groups have been disproportionately affected
- But, e.g., London has had much higher infection rates
- And London has higher levels of deprivation
- So this might distort the comparison of ASMRs

ASMRs by deprivation: Adjusted for Regional Variation



- Gold bars: ASMRs with the effect of regional variation filtered out
- Covid-19 ASMRs by decile are now approximately proportional to all-cause ASMRs

Observations

$$
\begin{aligned}
\text{Covid Mortality Rate}(i,x) &= \text{All-cause mortality rate}(i,x) \times \text{infection rate}(i,x) \\
&\times \text{relative frailty}(i,x) \\
i &= \text{deprivation decile}
\end{aligned}
$$

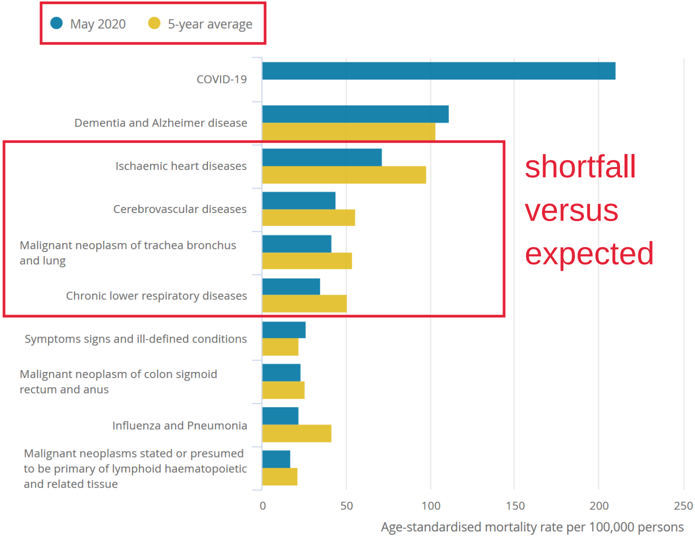
Summarising what we know:

- Imperial College antibody data $\Rightarrow$ different deprivation groups have similar infection rates
- ASMRs: Covid mortality by deprivation is approximately proportional to all-cause mortality by deprivation

What, therefore, do we infer?

- Relative frailty(i,x) is fairly constant across deprivation groups

Data For Other Causes of Death (May 2020)

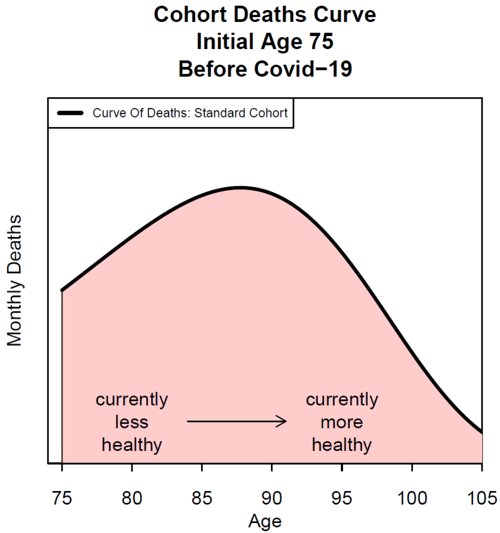


- *Some* people who would have died *soon*, might have died a bit earlier from Covid-19
- Many more Covid-19 deaths than the immediate "shortfall" in other causes
- This plus preceding discussion $\Rightarrow$ the accelerated deaths model

The Accelerated Deaths Model (ADM)

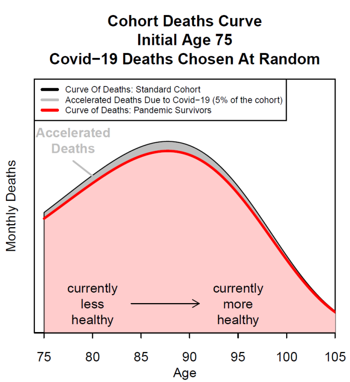
- Accelerated death $\Rightarrow$
  someone who would have died in the future from other causes
  dies earlier from Covid-19.
- For a given total number of deaths:
  we model the impact on *the surviving population*
- The model is not for predicting the size of the 2nd wave.

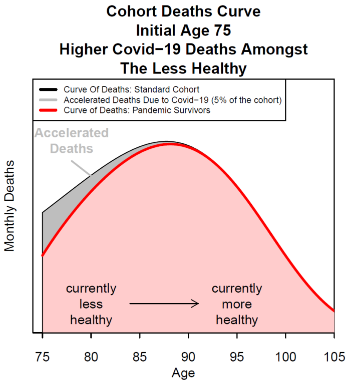
Pre-Covid: Cohort Curve of Deaths



- 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

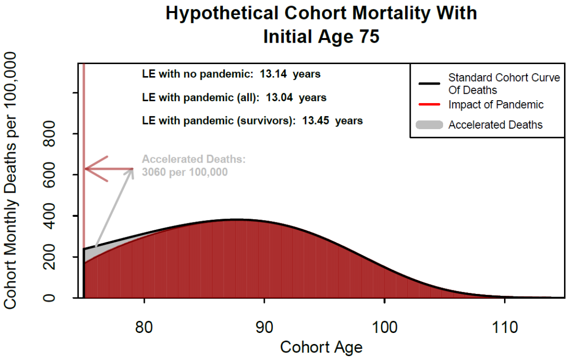




- A (left): Covid victims randomly chosen from the cohort
- B (right): Covid deaths more prevalent amongst the less healthy

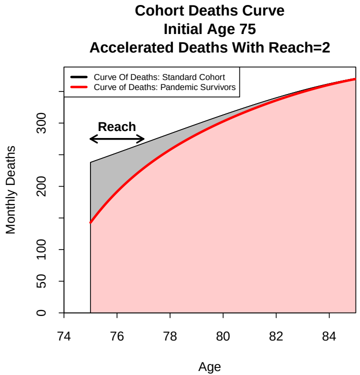
Scenario B is consistent with the empirical evidence that those with co-morbidities are more likely to die if they get infected

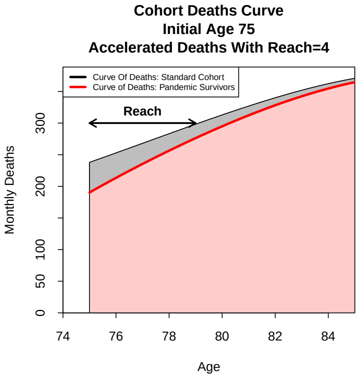
Are the survivors much healthier on average?



- The red region is the revised curve of deaths for survivors
  $\Rightarrow$ In actuarial terms, a *selection effect*, with lower mortality reverting to original cohort forecasts.
- Warning: This is a much exaggerated scenario for illustration.

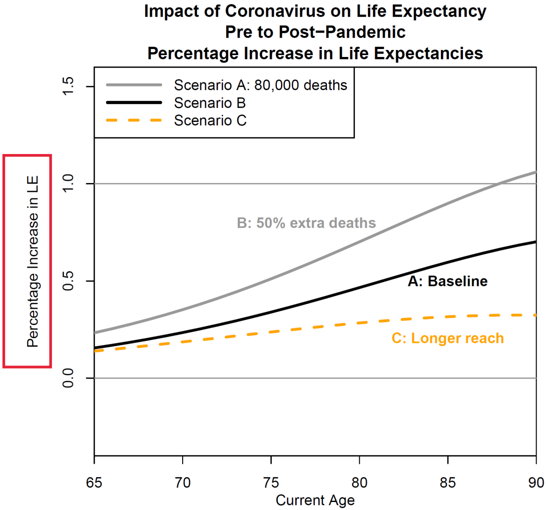
Model Features: Amplitude and Reach





- "Amplitude" affects the proportion out of the cohort who die
- "Reach" is related to the expected *years of life lost* per person who dies early from Covid-19
- "Reach" and the shape of the grey region also relates to the variation in frailty within an age group

Adjusted (Post-Pandemic) Life Expectancy



- More realistic scenarios in terms of total Covid-19 deaths
- LE(pre-covid) $\rightarrow$ LE(survivors)
- What is the percentage Increase?
- Scenarios:
  - A: 80,000 deaths + medium reach
  - B: 120,000 deaths + medium reach
  - C: 80,000 deaths + long reach
- Age 65: APPLE of healthier survivors is 0.2% 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 effects beyond this model?

- Non-Covid illnesses (e.g. late cancer diagnosis or delayed treatment)
- 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 2021 cause of death data

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

Conclusions 1

- Data are consistent with observations that people with co-morbidities are more likely to die if they get infected with Covid-19
- There is a strong relationship between Covid-19 death rates and all-cause mortality
  - by age
  - by deprivation
  - potentially other groups
- If infected, key sub-groups are not disproportiately affected by Covid-19 *relative to all-cause mortality*.
- But certain sub-groups are much more likely to get infected.
  $\Rightarrow$ we observe higher Covid-19 death rates

Conclusions 2

- Data $\rightarrow$ the accelerated deaths model.
  - Pandemic survivors will be healthier, on average, than the pre-pandemic population.
  - BUT, ... with the current scale of deaths and in the absence of secondary effects:
  - the impact on the collective life-expectancy of survivors will be small.
- Secondary effects could have a significant additional impact on life expectancies
  - but it will take some years to assess these impacts.