The Impact of Covid-19 on Higher Age Mortality

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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?
- 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.

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

Covid Mortality Rate($i, x$) = All-cause mortality rate($i, x$) $\times$ infection rate($i, x$) $\times$ 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

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

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 $1.1 \times$; reference Least depr.)

- Ages 18-24 $1.4 \times$ (reference 35-44)
- London $2.4 \times$, (reference S.E. England)
- Ethnic: Black $2 \times$, Asian $1.4 \times$ (reference White)
- Patient-facing healthcare worker $2.1 \times$
- Client-facing care home worker $3.1 \times$
- Household size “7+” $1.6 \times$ (reference Size = 1)
ASMRs by deprivation decile (ONS Data)

- **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)

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

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

\[i = \text{deprivation decile}\]

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
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 ⇒ the accelerated deaths model.
The Accelerated Deaths Model (ADM)

- Accelerated death ⇒ 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
⇒ In actuarial terms, a selection effect, with lower mortality reverting to original cohort forecasts.

Warning: This is a much exaggerated scenario for illustration.
“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) → 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 ⇒ 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 disproportionately affected by Covid-19 relative to all-cause mortality.
- But certain sub-groups are much more likely to get infected.
  ⇒ we observe higher Covid-19 death rates.
Conclusions 2

- Data → 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.