The Impact of Covid-19 on Higher-Age Mortality

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Agenda

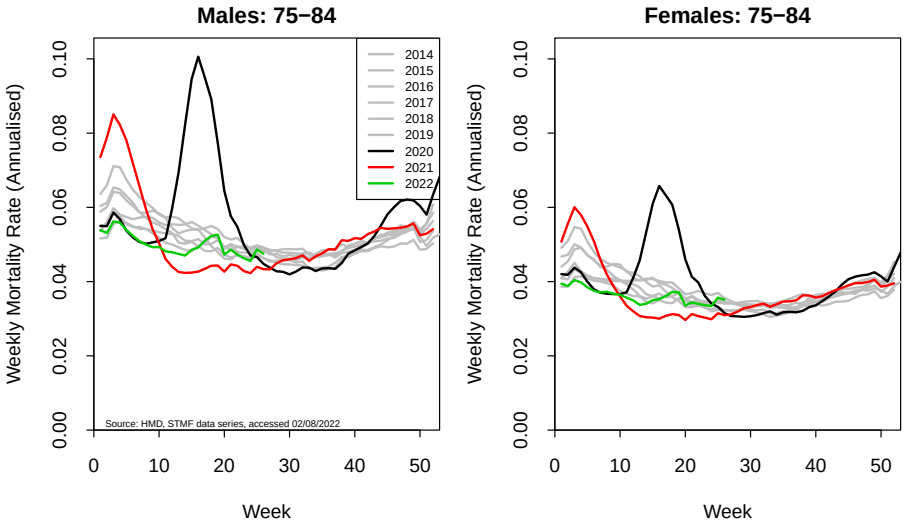
- Objectives
- The three phases of Covid-19:
  initial pandemic/pre-vaccination phase; vaccination phase; endemic phase
- The challenges of long-term forecasting
- Risk management perspective

Focus on English data, mostly from the Office for National Statistics (ONS)
But many conclusions will apply to other countries.

Objectives of Our Work

- What did the mixture of people dying from Covid-19 look like in the pre-vaccination phase?
  - 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?
- How has this changed during the course of the pandemic?
- What was the impact of vaccinations and new variants?
- Do we need to revise our catalogue of extreme mortality scenarios?
- What revisions are required to future mortality improvement assumptions?

2020-22 in Context: English Weekly Mortality Rates Since 2014

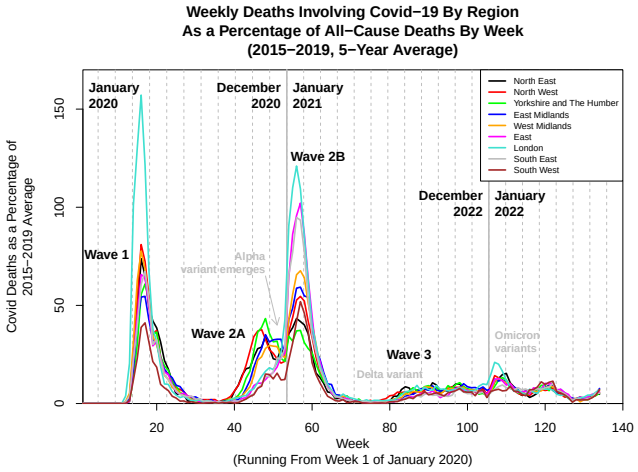


Variation By Region

North East
North West
Yorkshire & Humber
East Midlands
West Midlands
East of England
London
South East
South West

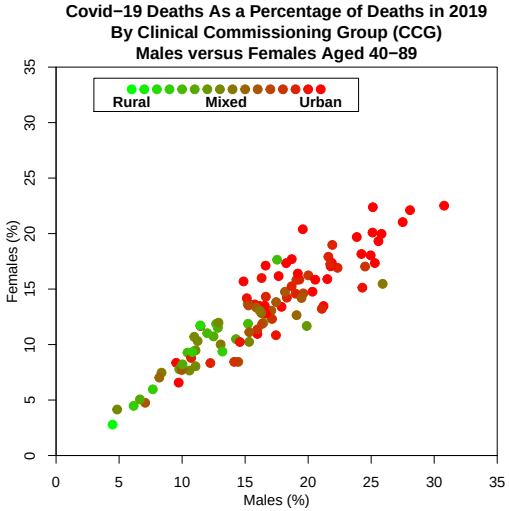
Not in dataset:
Scotland, Wales,
Northern Ireland

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



- Considerable variation between regions
- More variation around Europe
- 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 2.7× the South West
  (Urban areas 6× rural areas)

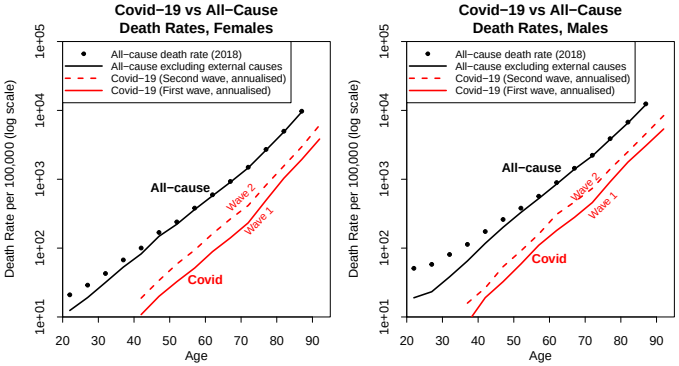
Covid Deaths in 2020 as a Percentage of All Deaths in 2019 By CCG



$D(\text{covid}, \text{CCG}, \text{sex}, 2020)/D(\text{all}, \text{CCG}, \text{sex}, 2019)$

- CCG: Clinical Commissioning Group
  = health administrative area
  average population $\sim 500,000$
- 106 CCGs across England
- Compare Covid-19 deaths in 2020 with deaths from all causes in 2019
- Covid-19 deaths: 5% to 30% of 2019 deaths
- Strong correlation between males and females
- Rural CCGs have much lower Covid death rates than urban

Covid-19 Death Rates, 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).

Spiegelhalter, D. (2020) What are the risks of COVID? And what is meant by 'the risks of COVID'? Blog 13/5/2020.

https://medium.com/wintoncentre/what-are-the-risks-of-covid-and-what-is-meant-by-the-risks-of-covid-c828695aea69

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 the *proportional to all-cause mortality* concept

We know that individuals aged x, have varying levels of 'frailty':

- Individual risk factors (e.g. smoking, poor diet, exercise, access to good-quality healthcare, ...)
  $\Rightarrow$ variation in individuals' states of health
- Prevalence of specific risk factors various by socio-economic group
- Data $\Rightarrow$ significant variation by sub-group (e.g. deprivation/wealth/affluence/education)

General observation about Covid-19: if infected

- Older people are more at risk
- People who have more co-morbidities *than the average for their age group* are more at risk
- *People who are more frail are more at risk from Covid*

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

Consequence: 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 $\Rightarrow$

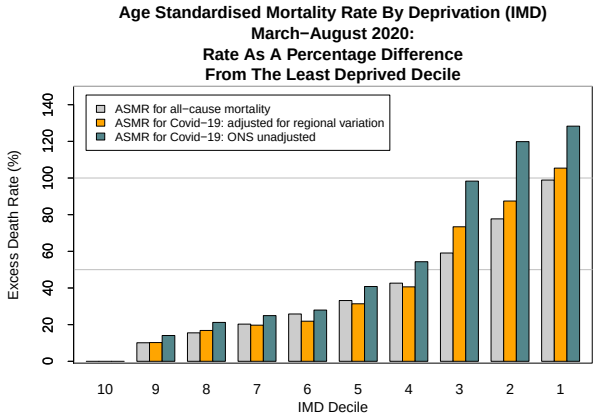
- About 6% of adults were infected
- Relatively little variation by age and sex
- Relatively little variation by deprivation (Index of Multiple Deprivation, IMD)
- Significant variation by region (e.g. London $>>$ South West)

Mortality Rates

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

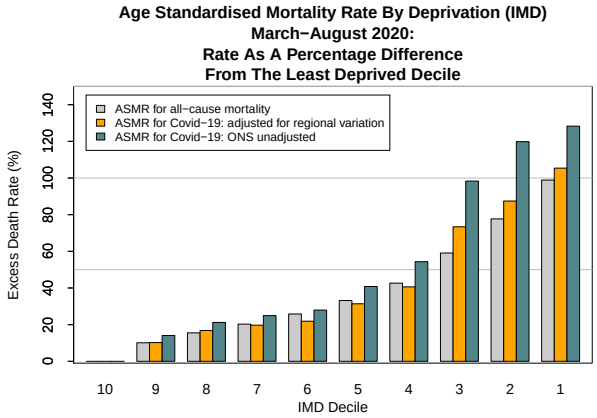
- Data: Age Standardised Mortality Rates (ASMR) by deprivation decile
- Data: Age Standardised Mortality Rates by region
- But: ASMR by deprivation decile is distorted by regional effects (e.g. London more deprived and higher infection rates)
- ASMR by region allows us to adjust the ASMR by deprivation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

ASMRs by deprivation: Wave 1, Adjusted for Regional Variation



- Grey bars: ASMRs for all-cause mortality relative to least-deprived Group 10
- Blue bars: Covid-19 ASMRs with no adjustment for regional variation
- **Orange bars: Covid-19 ASMRs with the effect of regional variation filtered out**

ASMRs by deprivation: Wave 1, Adjusted for Regional Variation



- Orange bars match, approximately, the grey bars
  $\Rightarrow$ 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**

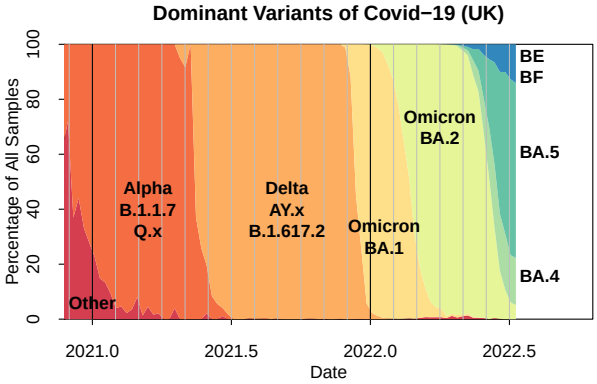
Vaccination Phase

- Weekly or monthly data allow us to dig deeper and gain further insights
- 2020 $\rightarrow$ 2021 $\rightarrow$ 2022:
  - Vaccinations commence: older or clinically vulnerable first; healthy and younger later
  - Infection rates begin to vary much more by age, region, socio-economic group
  - New variants
- Plots reveal some of the impacts of these changes

The impact of vaccination and new variants

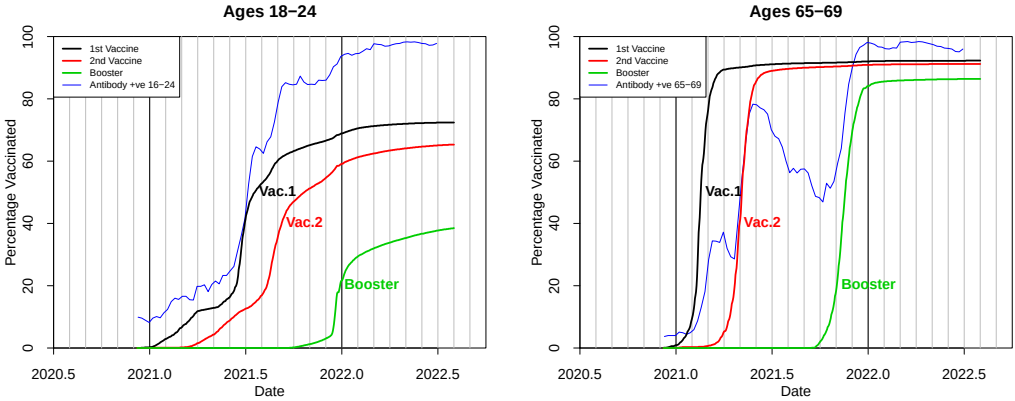
- Data for 2021: much more complex
- Vaccination: oldest ages in December 2020 $\rightarrow$ teenagers in October/November 2021
- New variants in the UK:
  - Alpha: December 2020
  - Delta: May/June 2021 (more infectious than Alpha)
  - Omicron BA.1: December 2021 (more infectious than Delta, less severe)
  - Omicron BA.2: February 2022 (more infectious than Omicron BA.1)
  - Omicron BA.4, BA.5: May 2022
- More variation in behaviour than in 2020
- What have been the impacts at different ages on:
  - Infection rates?
  - Hospital admissions?
  - Deaths?

Dominant variants



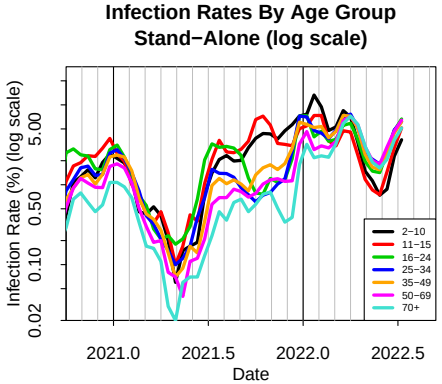
- Source: Office for National Statistics
- Each new variant takes over quite rapidly
- Each has a different level of infectiousness, severity and lethality

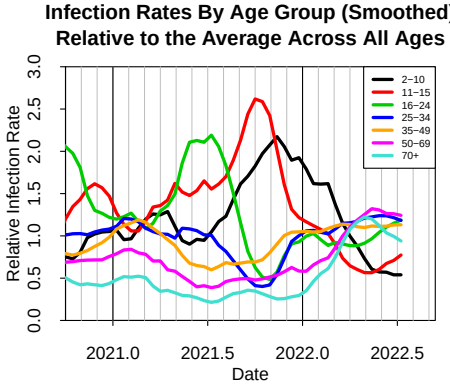
Vaccination and antibody status: Ages 18-24 and 65-69



- Older groups: higher vaccine uptake; antibody decline
- Younger groups: clinically vulnerable vaccinated early + main wave of vaccinations
- All groups: by March 2022, almost 100% either infected or vaccinated; timing $\Rightarrow$ difficult to separate Omicron infections from impact of booster
- Some variation in vaccine uptake by region and socio-economic/ethnic group

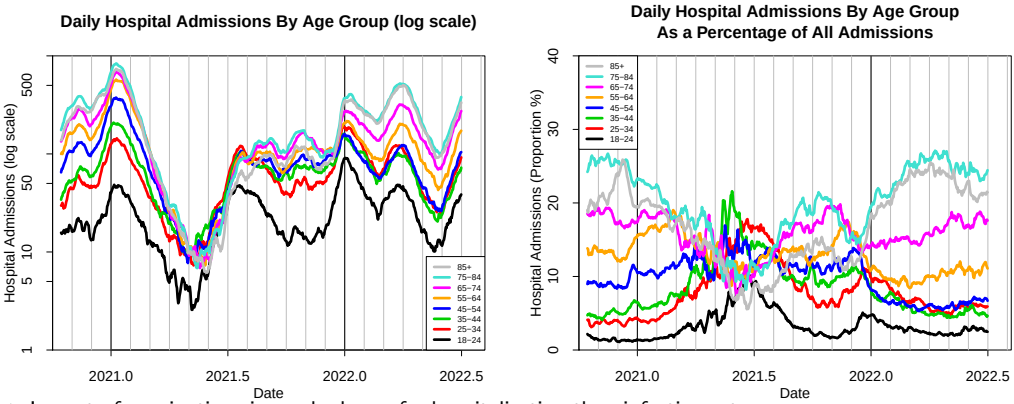
ONS: Infection rates (prevalence) by age group – stand-alone and relative





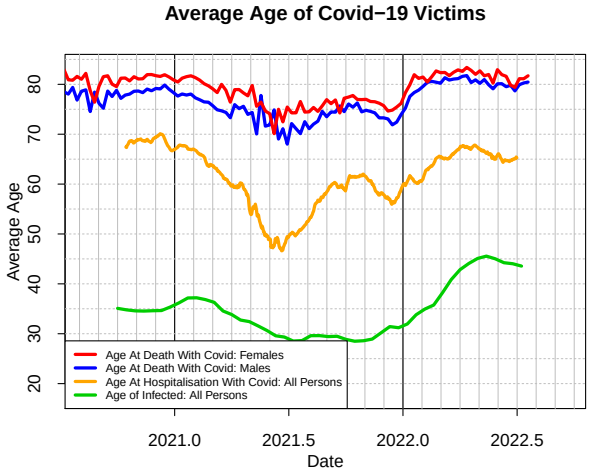
- **Left:** Different waves of infections in different groups: 16-24, 25-34 vs the rest
- **Right:** $IR(t, \text{age group})/\bar{IR}(t)$ (with smoothing) $\Rightarrow$ remove effect of infection waves
- Highs and lows: different ages vaccinated at different times + different behaviour
- Ages 16-24 peak: vaccinations 1, 2 in June-Sept 2021; older groups months earlier
- Ages 11-15: later start to vaccination + end of (2021) summer holidays $\Rightarrow$ later peak

Covid-related hospital admissions by age group



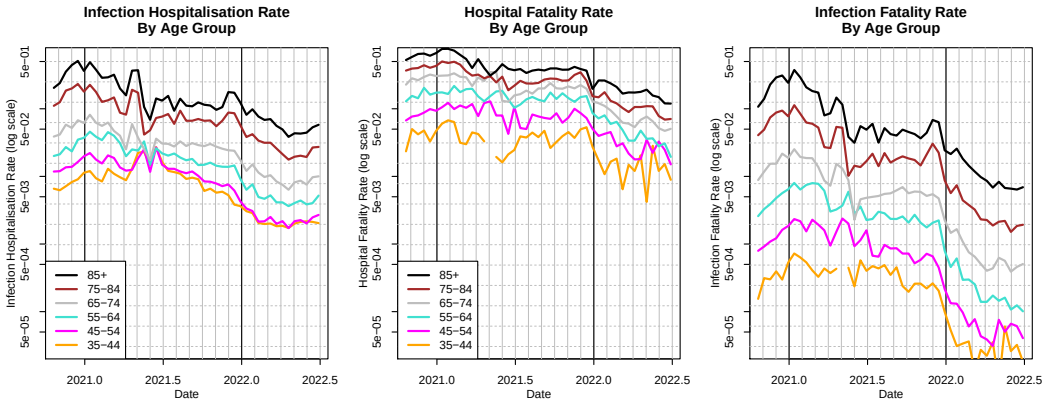
- Impact of vaccinations is much clearer for hospitalisation than infection rates
- Ages 75-84: early 2021 decline; later peak in 2021 (younger groups catch up + antibody decline); November 2021 booster
- Ages 25-34: mid-2021 peak prior to vaccinations
- March 2022: bunching up; ??? greater booster take-up amongst 45-64 versus 25-44

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



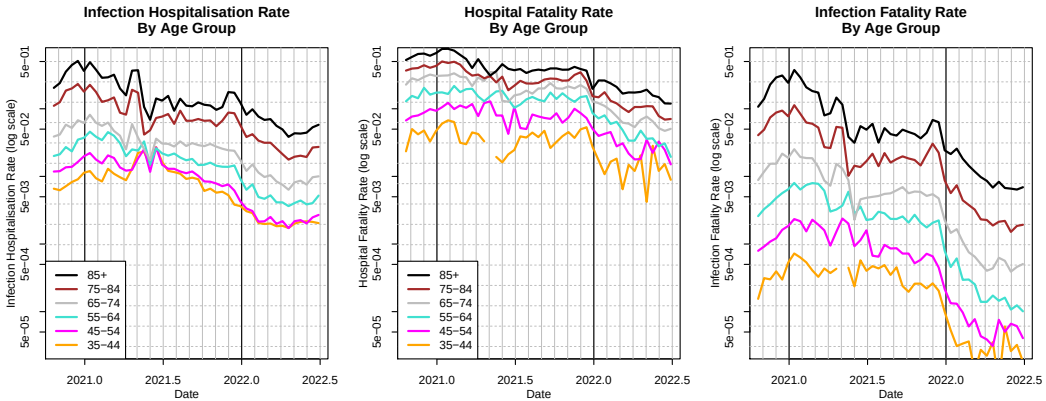
- Pre-covid seasonal variation: around 1 year higher in winter
- End 2020 to mid 2021:
  - Avg Age at Death drops by 7 to 9 years
  - Avg Age at Hospitalisation drops by 20 years
- Due to:
  - vaccination by age group
  - age-related behaviour

Estimated infection fatality rates and related quantities



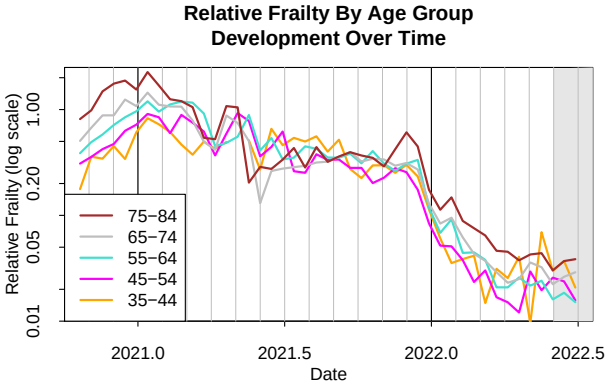
- Assumption: # new infections per day = infection prevalence÷10
- Infection Hospitalisation Rate = Proportion of newly infected who are admitted to hospital
- Hospital Fatality Rate = Proportion of newly hospitalised who die from Covid
- Infection Fatality Rate = Proportion of newly infected who die from Covid

Estimated infection fatality rates and related quantities



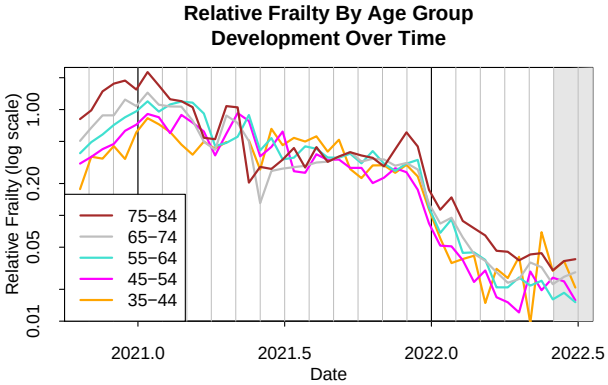
- Infection → Hospitalisation: strong benefit from vaccination
- Hospital → Dead: some vaccination effect, but weaker
- Infection Fatality Rate: declines sooner for the older groups due to vaccination
- Infection Fatality Rate: booster + Omicron ⇒ big decline

Estimated relatively frailty



- Covid mortality = all-cause mortality × infection rate × relative frailty
- Relative Frailty (t, x) := Infection Fatality Rate (t, x) ÷ 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

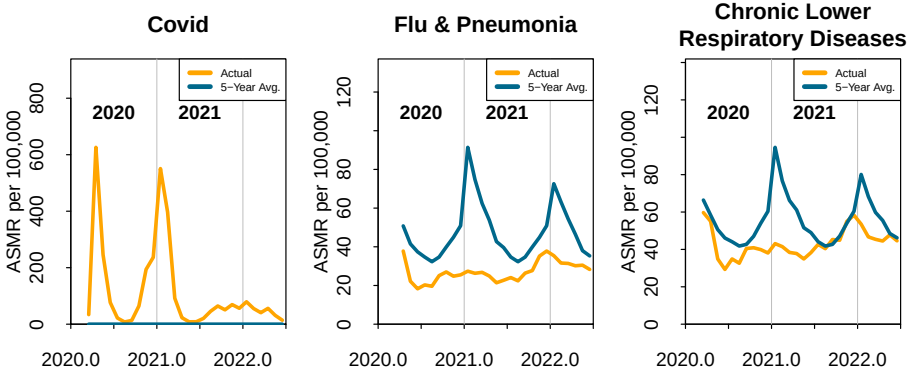


- Pre-vaccination (end of 2020): relative frailty has some variation with age (increases by 3-4% per year of age)
- Vaccination causes the age gradient to disappear in mid 2021
- Age gradient re-emerges in 2022 after booster roll out to all age groups

Relative Frailty: Conclusions

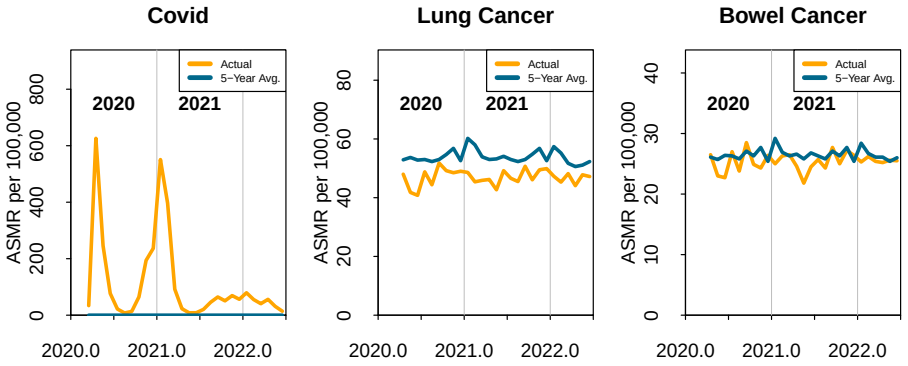
- ONS data + Epidemiological studies (e.g. Nyberg, Ferguson et al., Lancet, 2022)
- Relative frailty depends on
  - which vaccine
  - number of vaccines
  - timing of vaccines
  - variant
- So: it is complex!

Some secondary effects can already be observed in 2020-22 data



- Pneumonia deaths, e.g. August 2020: 60% of 5-year average
- Home working, hygiene etc. $\Rightarrow$ less exposure to pneumonia pathogens $\Rightarrow$ fewer deaths
- Health data $\Rightarrow$ *incidence* of many infectious diseases is well below normal
- Chronic lower respiratory diseases (mainly COPD): long-term disease but (???) less exposure to aggravating factors

But little impact on other major causes in 2020-22 data



- E.g. Bowel cancer deaths: unaffected by Covid pandemic
- Reflects the long-term nature of the illness
- Source: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/monthlymortalityanalysisenglandandwales/june2022

Rethinking future extreme scenarios

What has the Covid-19 pandemic revealed?

- Considerable variation by region/CCG (health region) and subgroups
- Some additional variation by age group
- Impact of Covid-19 on an insurer depends on regional and other characteristics of their portfolio

- So, *in a future extreme year*, the year-to-year correlation between regions and age groups might not be as high as in a "normal" year
- Losses in an extreme pandemic year will depend on how well diversified exposures are
  - Regional
  - Urban/rural
  - Socio-economic
  - Age groups

Rethinking future extreme scenarios (cont.)

Generating future scenarios:

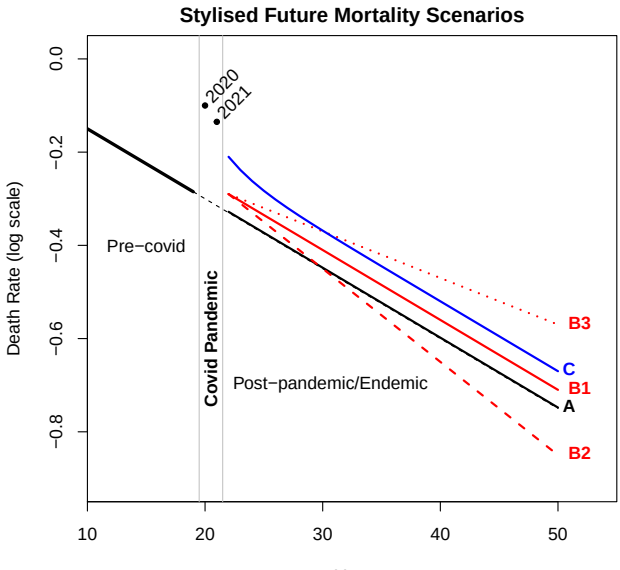
- Pandemic simulations need to allow for significant variation between
  - own life portfolio mix (diversification matters)
  - regions; urban/rural; socio-economic subgroups
  - age groups for viruses with prior exposure
  - age groups to allow for variation in social behaviour
- Less diversified life insurers will need to reserve for extremes (e.g. 99.5% level) at a higher level than well-diversified insurers

Mortality improvement assumptions

How will short, medium and long-term mortality assumptions change relative to where we were in 2019?

- Covid becomes **endemic** with significant levels of direct mortality (level)
- Significant mortality from long covid (pandemic and endemic) (curvature, level)
- Two to three years of business-as-usual medical innovation lost (level)
- Change to the long-term mortality improvement rate (slope)
- Higher deaths in the short/medium term due to late diagnosis of e.g. cancers (curvature)
- Economic impact of the pandemic in the short/medium term (curvature, level)

Mortality improvement assumptions (cont.)



- **A:** benchmark 2019 projection
- **B1:** change in level
- **B2, B3:** change in level and slope
- **C:** change in level and curvature

Mortality improvement assumptions: further detail

- Endemic covid
  - e.g. England, late spring early summer $\Rightarrow\sim$ 5% of all-cause mortality (Covid mentioned on the death certificate – *with Covid*)
  - What proportion are *due to Covid*?
  - Might stabilise at a lower level
  - Depends on: improving treatments; new variants; new vaccines; previous infections; behavioural changes or reversion

Mortality improvement assumptions: further detail (cont.)

- Long covid
  - Definitions of long covid vary
    e.g. persistent cough for 12 weeks vs serious long-term impairment
  - Those *hospitalised* by Covid-19 might have higher mortality
  - Could be modelled as a *random* addition to individual mortality
  - Dependent on vaccination status (so dependent on age and socio-economic status)
  - Need good quality individual data + data from different sources

Mortality improvement assumptions: further detail (cont.)

- Delays to other medical advances
  - E.g. attention of pharmaceutical companies diverted towards Covid
  - But, by how much, if at all?

Mortality improvement assumptions: further detail (cont.)

- Long-term mortality improvement rate is adjusted (after factoring in the short-term change in level/parallel shift)
  - Faster improvements than previously assumed:
    e.g. new technology developed during the pandemic accelerates the pace of medical advances
    e.g. greater investment in pharmaceutical and medical research
  - No change:
    e.g. research gets back to business as usual
  - Slower improvements than previously assumed:
    e.g. less investment than before
    e.g. crystallises pre-pandemic slowdown
    e.g. revised estimates of future novel pandemics→endemics

    (Note: +5% per endemic, once every 50 years ⇒ 0.1% reduction in improvement rate)

Mortality improvement assumptions: further detail (cont.)

- Other causes of death: higher death rates in the short/medium term
  - Due to late diagnosis of potentially fatal diseases such as cancer
  - Due to delayed treatment of existing diseases
  - Short to medium-term while we deal with a backlog
  - Longer-term level shift if we never manage to deal fully with the backlog
- Other causes of death: lower or higher death rates in the short/medium term related to:
  - Psychological disorders
  - Other consequences of behavioural change during the pandemic
    - social distancing & better hygiene $\rightarrow$ lower pneumonia rates
    - heavy drinking
    - smoking habits
    - exercise $\leftrightarrow$ home working

Mortality improvement assumptions: further detail (cont.)

- Economic impact
  - e.g. long-term unemployment leads to higher mortality
  - e.g. economic downturn leads to reduced investment in research and medical staffing levels

Conclusions

1. Proportionality Hypothesis: Strong relationship between covid mortality(i, x) and all-cause mortality(i, x)
2. But this relationship is dependant on other factors as well
3. Significant variation by region and urban-rural $\Rightarrow$ much more than a normal year
4. Significant variation by age as the pandemic progressed
5. We will need time to understand the nature and magnitude of secondary effects
6. We need time to investigate: have the fundamentals underpinning long term improvements changed?

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