Covid-19:
Its Evolving Impact on Mortality

Andrew J.G. Cairns

Heriot-Watt University, Edinburgh

Joint work with David Blake, Amy Kessler and Marsha Kessler

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PFI

Agenda

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

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

Objectives for This Presentation

- How did Covid mortality and related statistics change during the pandemic as vaccines were rolled out and new variants emerged?
- What are the key issues for setting mortality improvement assumptions post pandemic?

Previous Work: the Proportionality Hypothesis

Covid mortality in the pre-vaccination phase depends on: age; socio-economic group; and other factors.

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

E.g. $i \Rightarrow$
region; urban/rural; neighbourhood deprivation; ethnic group etc.

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

Related concept:

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

Vaccination Phase

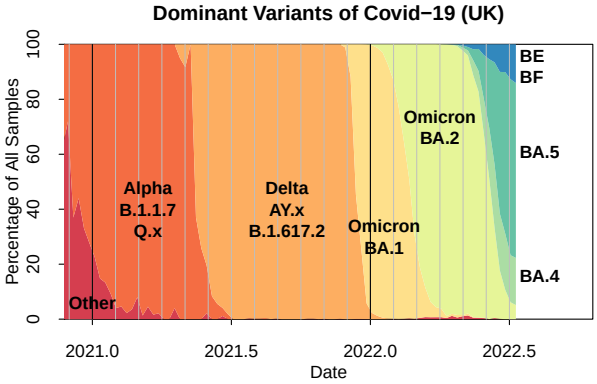
- Weekly data allow us to dig deeper and gain further insights

- 2020 $\rightarrow$ 2021 $\rightarrow$ 2022:
  1. Vaccinations commence: older or clinically vulnerable first; younger and healthy later
  2. Infection rates begin to vary much more by age, region, socio-economic group
  3. New variants: different levels of infectiousness, severity and lethality
- Plots reveal some of the impacts of these changes

What have been the impacts at different ages on:

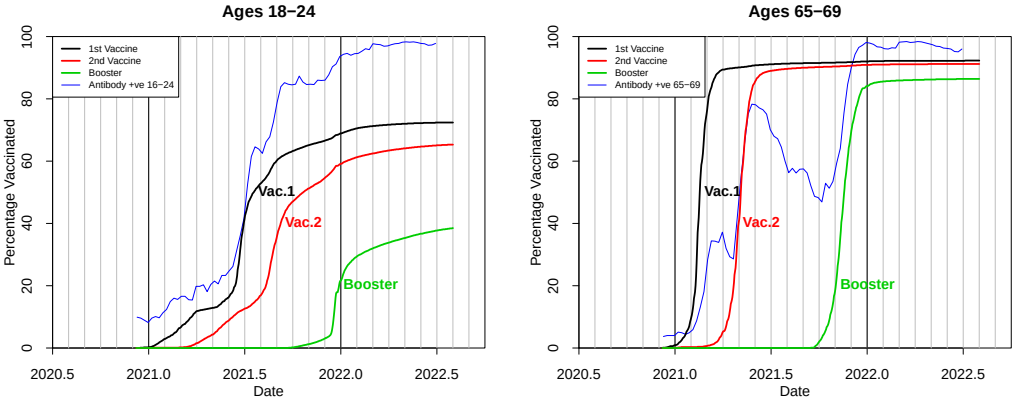
- Infection rates?
- Hospital admissions?
- Deaths?

Dominant variants



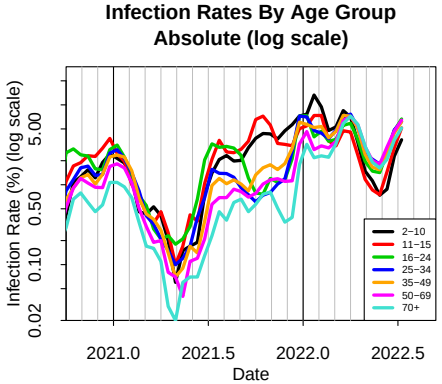
- Source: Office for National Statistics
- Each new variant takes over quite rapidly
- Each has a different level of infectiousness, severity and lethality

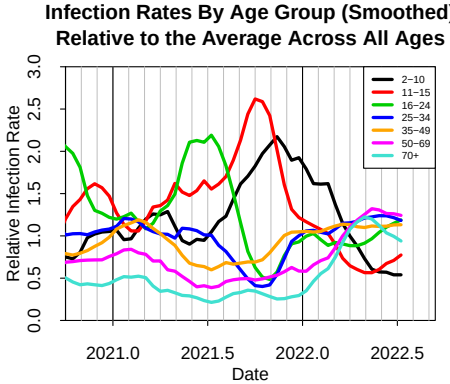
Vaccination and antibody status: Ages 18-24 and 65-69



- Older groups: higher vaccine uptake; antibody decline more rapid
- 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

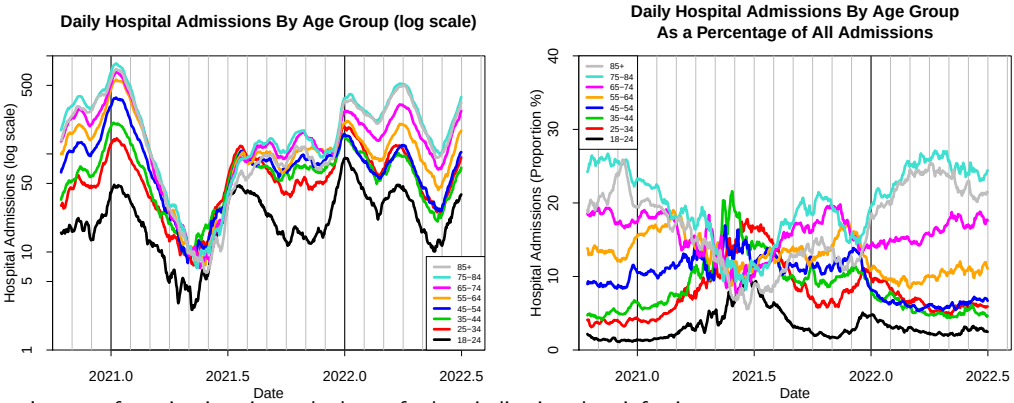
ONS: Infection rates (prevalence) by age group – absolute and relative





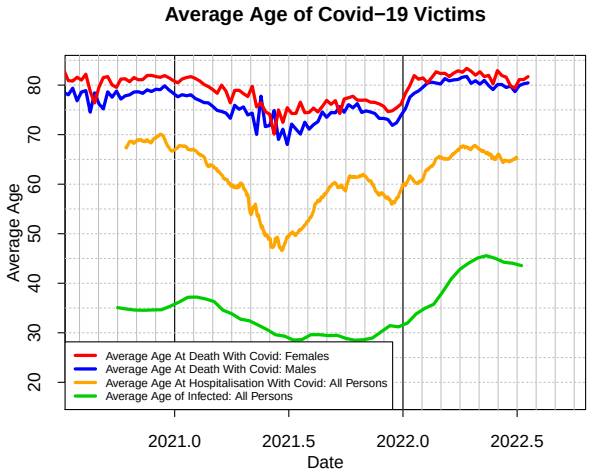
- **Left:** Different waves of infections in different groups: 16-24, 25-34 vs the rest
- **Right:** $IR(t, \text{age group})/\bar{IR}(t)$ (both with smoothing) $\Rightarrow$ remove effect of infection waves
- Highs and lows: different ages vaccinated at different times + different behaviour
- Ages 16-24 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



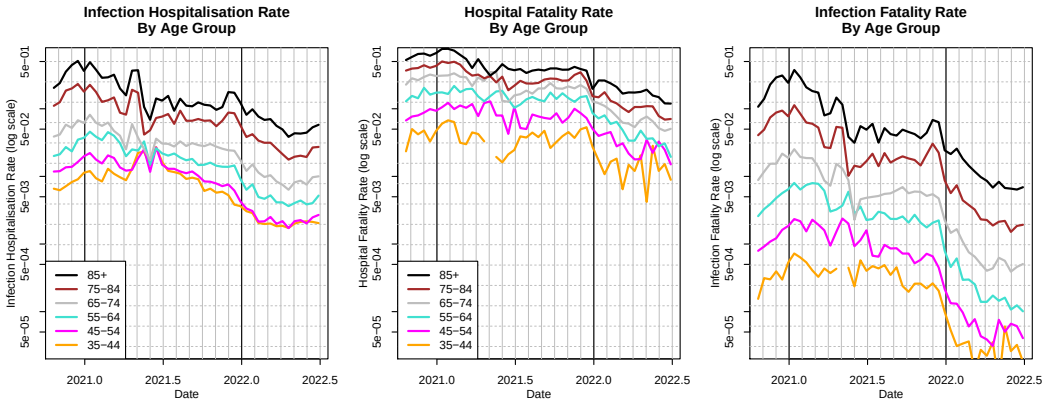
- Impact of vaccinations is much clearer for hospitalisation than infection rates
- Ages 75-84: early 2021 decline; later peak in 2021 (younger groups catch up + antibody decline); November 2021 booster
- Ages 25-34: mid-2021 peak prior to vaccinations
- March 2022: younger adults bunching up; greater booster take-up amongst 45-54 vs 25-34?

Derived Statistics: Average Age at Death, Hospitalisation & Infection



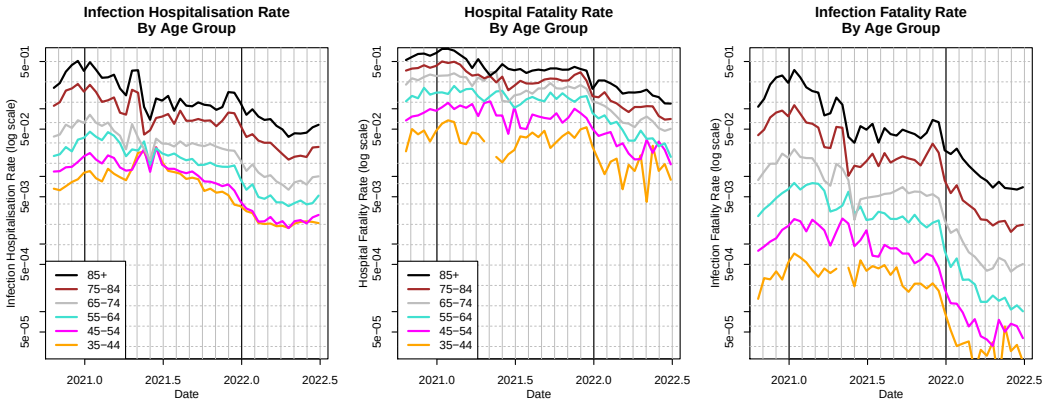
- Pre-covid seasonal variation in all-cause mortality:
  around 1 year higher in winter
- Here: Covid-19 victims only
- End 2020 to mid 2021:
  - Avg Age at Death drops by 7 to 9 years
  - Avg Age at Hospitalisation drops by 20 years
- Due to:
  - vaccination by age group
  - age-related behaviour

Estimated infection fatality rates and related quantities



- Assumption: people are infectious (test positive) for 10 days (some variant dependence)
- 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



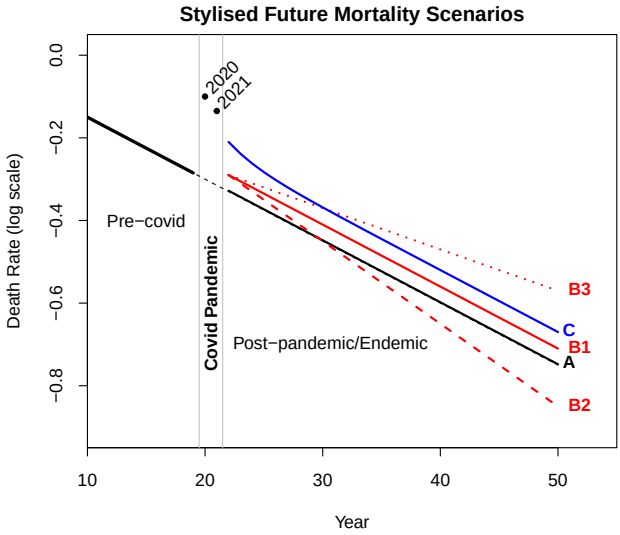
- Infection → Hospitalisation: strong benefit from vaccination (e.g. early 2021)
- Hospital → Dead: some vaccination effect, but weaker
- Infection Fatality Rate: declines sooner for the older groups due to vaccination
- Infection Fatality Rate: booster + Omicron ⇒ big decline

Mortality Improvement Assumptions

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

- 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: stylised scenarios



- **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
  - Endemic $\Rightarrow$ long term, low level of deaths from Covid-19
  - 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
  - Excess mortality risk might be dependent on
    - Hospitalised with Covid-19 or not
    - Vaccination status
  - Need good quality individual data + data from different sources
  - Cause of death data might help reveal more than all-cause data

Mortality improvement assumptions: further detail (cont.)

- Delays to non-Covid 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: impact
  - Due to late diagnosis of potentially fatal diseases such as cancer
  - Due to delayed treatment of existing diseases
- Other causes of death: impact of
  - 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 still holds as the pandemic has progressed but it is complex: *relative frailty* depends on several factors including vaccination status and variant
2. Significant variation by age as the pandemic progressed
3. We will need time to understand the nature and magnitude of secondary effects
4. We need time to investigate: have the fundamentals underpinning long term improvements changed?

E: A.J.G.Cairns@hw.ac.uk
W: www.macs.hw.ac.uk/∼andrewc

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