Age-based NPIs: simple model insight

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Summary:

- With such a high infectivity (doubling time of 2 days, R0 ~ 10), without any intervention, essentially all those who can get infected do get infected, but this strongly depends on modelling assumptions about the population immunity profile to Omicron, so we explore all-or-nothing VS leaky protection from vaccination.
- Immunity assumptions about protection from infection (no hospitalisation or severe disease in the model):
    - 0% for 0 or 1 doses
    - 30% for 2 doses
    - 70% for 3 doses (booster)
    - 28m boosters given (48% of all 12+, as of Dec 19), given to all 55+ and some of 0-54
- Two extreme scenarios for reduction in contacts are considered:
    - Only within the 55+ group, proxy for free mixing of them with family members
    - Both within the 55+ group and between 55+ and 0-54 (in both directions), proxy for taking extreme steps to reduce within-household transmission and family interaction.
- Key results:
    - Assuming all-or-nothing vaccine efficacy, about 1/3 of the population is assumed perfectly immune and all the rest gets infected; for leaky vaccine, everyone could potentially get infected, so baseline (i.e. no NPIs) final size is much larger.
    - Age-based NPIs have virtually no impact in the 0-54 group
    - Reduction only in contacts among the 55+ has no impact, unless accompanied by reductions in contacts between age groups
    - With 80% reduction in contacts both within 55+ and between 55+ and 0-54, about 1/2 of the cases in the 55+ could be averted if vaccine is all-or-nothing (but 2.5m would still get infected) and about 3/4 if vaccine is leaky (but this now means 4m, a larger absolute numbers). Absolute numbers are not expected to be precise, with all the caveats of this extremely simplistic model.
    - Intuitively, the wave is much larger in the 0-54 than in the 55+ due to a combination of higher protection in the 55+ and a lower contact rate (resulting in a slower, less peaky epidemic)

Further considerations:

- An age-based lockdown is potentially highly socially divisive, and possibly met with low adherence: those 55+ who are worried about themselves will likely reduce their contacts anyway, while the others might ignore recommendations.
- There is no evidence anything like this has been achieved in the past (e.g. care homes badly affected, cases in all ages, etc.): we now have better treatment, vaccines, etc. but also Omicron seems to be spreading even faster than wild-type.
- It is as yet unclear what the relative severity of a 55+ case (likely with booster) is, compared to a younger case, so the usefulness of limiting infections in the elderlies, though reasonable, is uncertain.
- Despite modelling these scenarios, we are personally doubtful such a policy alone would bring substantial benefits, as it relies heavily on individuals' choices on adherence (e.g. we believe 80% reduction in contacts is unrealistically high). Furthermore, a free-fall epidemic in the 0-54, less likely to have received their boosters, is likely to present significant hospital burden anyway (not quantified here).

Results:

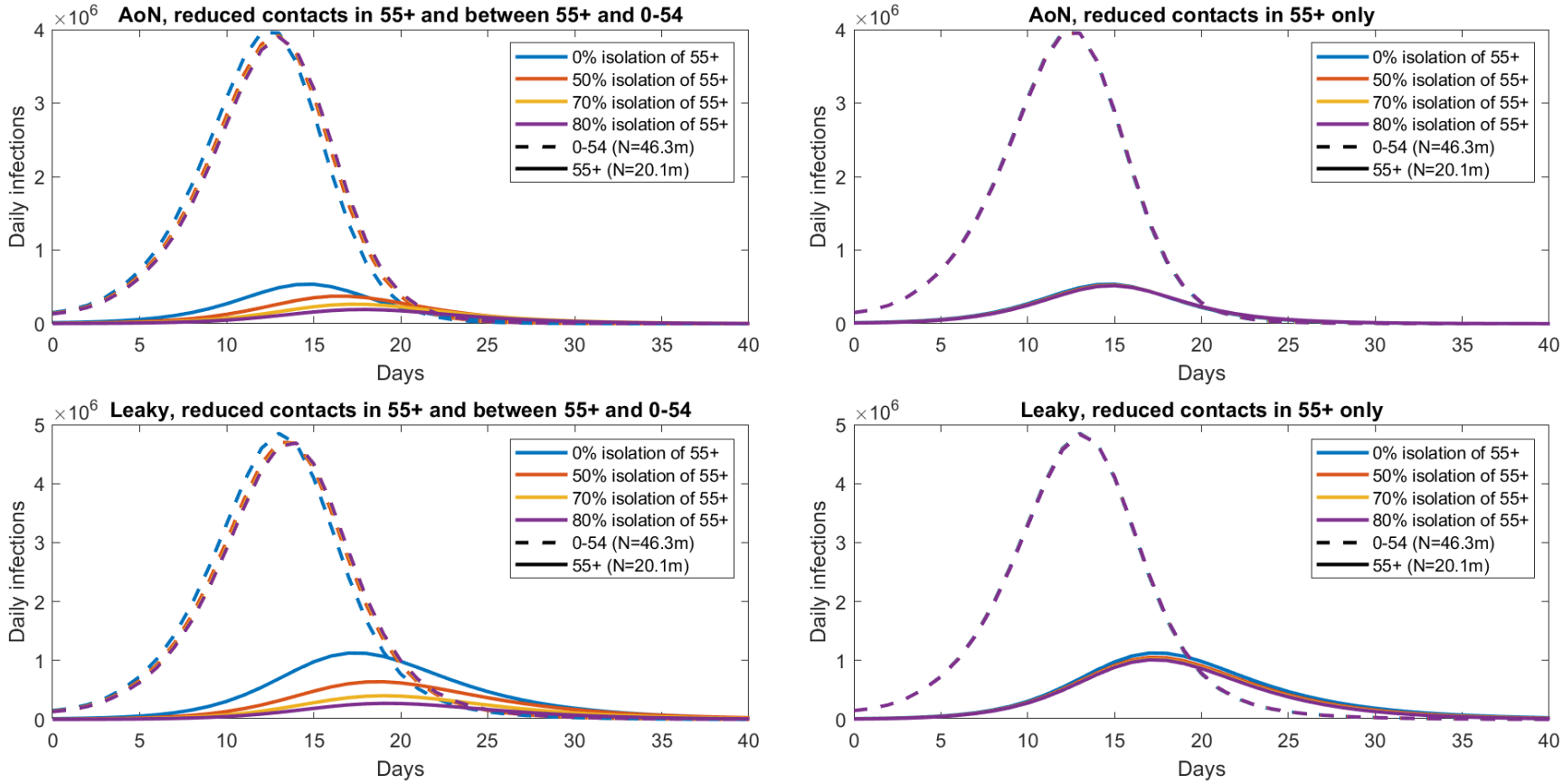

Figure 1: Epidemic dynamics in 0-54 (dashed) and 55+ (continuous lines) for 4 scenarios of reduction in contacts both within the 55+ and between 55+ and 0-54 (left), or among the 55+ only (right column), and assuming vaccine effectiveness in the population is all-or-nothing (top) or leaky (bottom row).

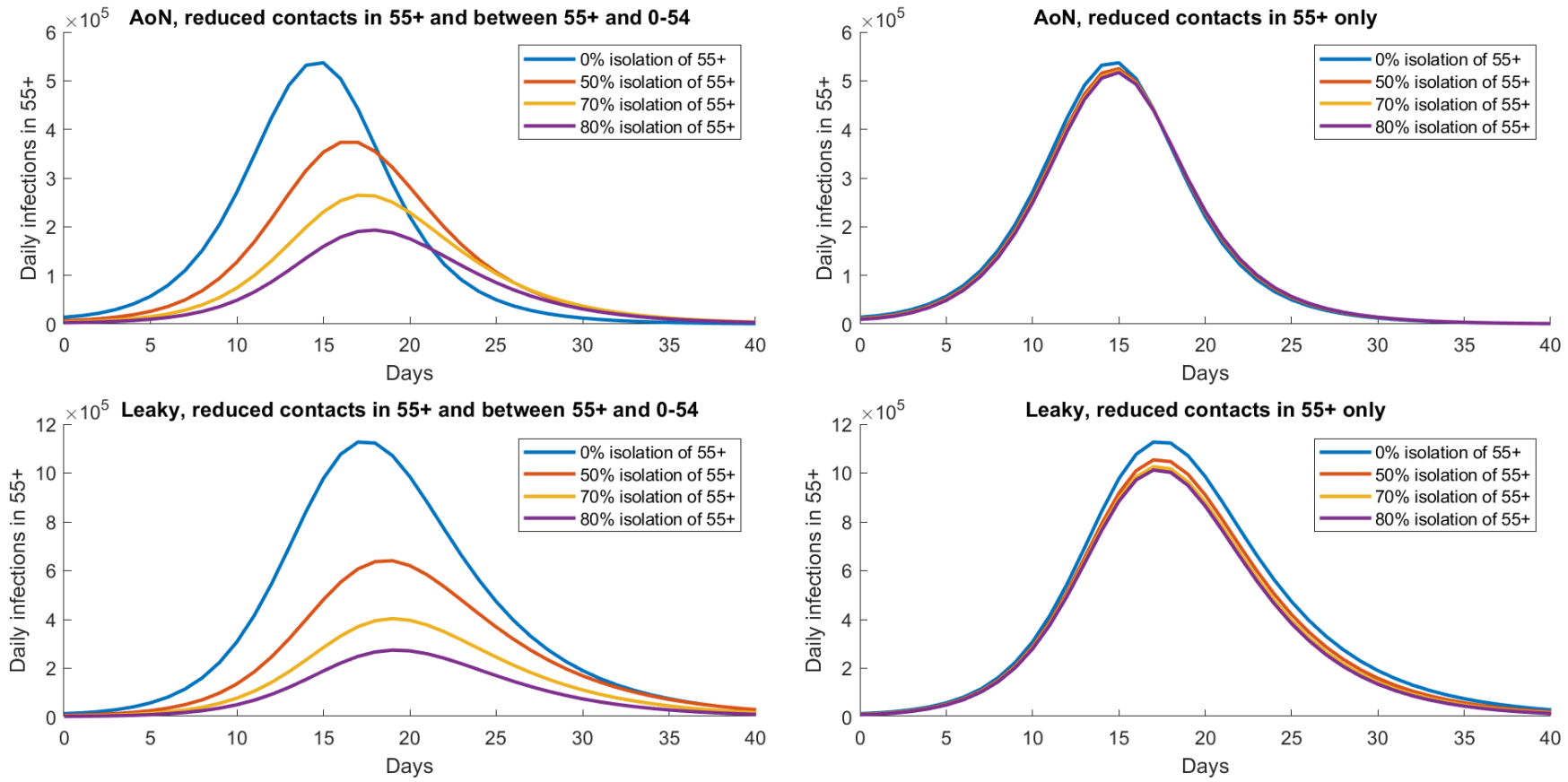

Figure 2: Zoom on the epidemics in the 55+ only from Figure 1. Note: absolute numbers are to be taken with caution, as they rely on assumptions on contact patterns and precise values of doubling times, which are uncertain.

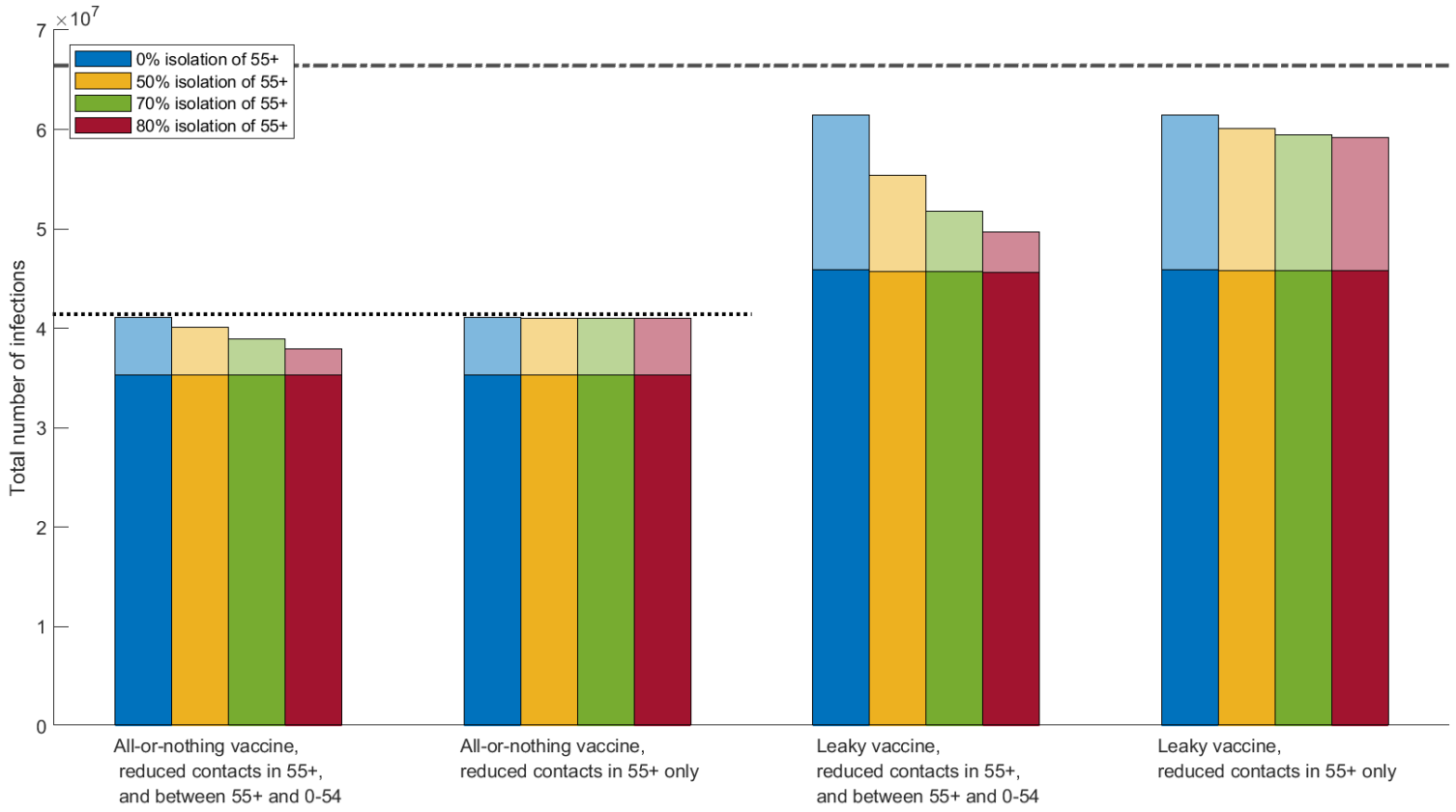

Figure 3: Final epidemic size 0-54 (bottom, full coloured part of each bar) and 55+ (whiter top of each bar) for 4 scenarios of reduction in contacts (colours) both within the 55+ and between 55+ and 0-54 (first and third group from the left), or among the 55+ only (second and fourth), and assuming vaccine effectiveness in the population is all-or-nothing (first two groups on the left) or leaky (last two groups on the right). Dash-dotted line gives total UK population, while dotted line given total susceptible population assuming all-or-nothing vaccine (left two groups only).

Methods:

- This is a simple model with 2 age groups and a 2x2 POLYMOD matrix of contacts, with a probability of transmission across a contact that is roughly calibrated to give a doubling time of 2 days.
- When vaccine is assumed to be leaky, the model is expanded to a 4x4 matrix where groups 1-3 are the 0-54 with <2, 2 and 3 doses, and group 4 gives the 55+ (all assumed boostered).
- Initial conditions are roughly calibrated so that they correspond to total cases as of 19 Dec 2021, but this has only limited impact on the dynamics and no impact on the final size bar plot.
- R0 is just "very high", as we don't really know what its real value might be. However, we have given the model an SEEILR structure with average sojourn times of 1.5 days in each latent classe E1 and E2, and in I (infectious pre-symptomatic), and a late infectious stage L of 3.5 days on average. This given an incubation period of around 4.5 days, and an overall infectious period of around 5 days. It might not be perfect, but anything simpler would have distorted excessively the relationship between the growth rate and R0 (e.g. in a simple SIR model, the epidemic would be much faster for the same R0, compared to here).
- With the parameters chosen for the figures, in the all-or-nothing case R0 = 9.3, and the doubling times are 2 days in 0-54 and 2.1 days in the 55+.
- Sensitivity analysis: an R0 = 6 corresponds, in this model, to a doubling time of 2.6 days in the 0-54 and 3 days in the 55+. Results are qualitatively similar, but peak incidence in 0-54 is 3m cases rather than 4m (AoN) and 3m rather than 5m (leaky).
- The generation time is assumed unchanged compared to Delta.