Assessment of Changes to Lock-Down and Other Controls

University of Warwick

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The Warwick approach uses a deterministic SEIR-style age-structured model, matched to the early UK age-distribution of cases and then fitted to the temporal dynamics across 11 regions. There are a variety of ways in which the early matching can occur, and our results average across this uncertainty. A full description of the model formulation is being drafted (draft available on request).[1]

CURRENT SITUATION ESTIMATES

As requested estimated infections (both symptomatic and asymptomatic), R_t and the halving times (with 95% Cis) – for all regions and nations. I'd treat the R_t estimates with some caution, as it's a composite estimate largely based on growth rates. These are all based on predictions for Monday 27th April.

Region	Estimated Infection	R_t	Halving Time, days (CI)
East of England	47531	0.833551	27.58 (13.28-45.23)
London	15109	0.703825	12.18 (8.81-14.21)
Midlands	36705	0.696775	13.49 (10.93-17.41)
North East and Yorkshire	23128	0.74413	18.37 (12.27-31.19)
North West	22405	0.690725	13.74 (9.69-17.56)
South East	39329	0.816881	22.70 (17.61-32.03)
South West	6539	0.807095	26.14 (17.31-53.76)
England	84439	0.713979	14.94 (11.90-20.66)
Wales	194	0.908575	45.72 (17.98-68.67)
Scotland	16652	0.85288	28.52 (19.70-37.5)
Northern Ireland	415	0.483516	12.09 (4.26-22.75)

SIMULATION METHODS

Given the number of different scenarios we considered, it was impractical to generate results across the entire posterior parameter distribution, instead we used the median values from 10 independent chains and averaged the findings. We performed three forms of assessment as detailed below, simulations were run until mid 2023.

Elderly Lockdown

The model was simulated until 7th May under current lock-down parameters, following which those below a given age (A) were able to resume normal life, whereas those over age A remained in lock-down. We assessed difference stringencies of lockdown for the elderly age-group (current, boosted

[1] Footnote added for release: Keeling, M. J., Hill, E., Gorsich, E., Penman, B., Guyver-Fletcher, G., Holmes, A., McKimm, H., Tamborrino, M, Dyson, L., and Tildesley, M. (2020). "Predictions of COVID-19 dynamics in the UK: short-term forecasting and analysis of potential exit strategies" *PLoS Comp. Biol.* **17**(1): e1008619. https://doi.org/10.1371/journal.pcbi.1008619

and extreme – representing increased isolation) and different durations of this second phase of lockdown (until 31st Dec 2020, until 7th May 2021 and until 31st Dec 2021).

Responsive to ICU occupancy

The model was simulated until 7th May under current lock-down parameters. Lock-down was then released for any of the 11 regions where the ICU occupancy was less than a given pro rata threshold (corresponding to 2000, 3000, 4000 and 5000 beds nationally); and re-instated if ICU occupancy exceeded this threshold. This provides a means of reactive control in each region. The delay between changes to the lock-down and changes in ICU occupancy ensures that we do not observe rapid policy switching.

Waning Compliance

As a more theoretical exercise, we consider gradual chances in the lockdown – generated in the model through smooth changes in compliance. These are more theoretical as they do not directly map onto distinct policy changes, but do indicate what might be achieved with a gradual relaxation of controls. The model where $R_t \sim 1$ by continual adjustments to the level of lock-down provides an optimal solution for what can be achieved through isolation.

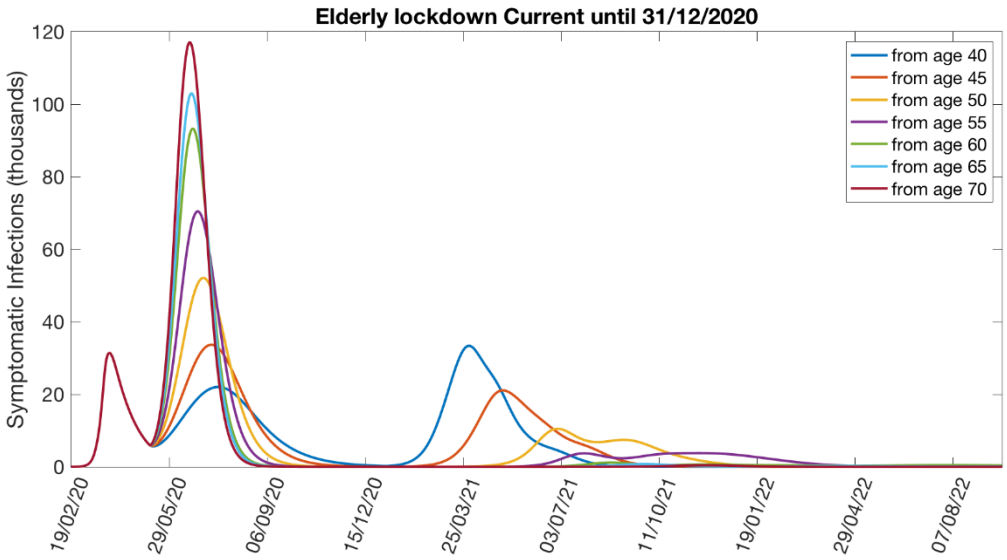
As an additional scenario, we consider maintaining $R_t \sim 1$ by gradually allowing more age-groups to be released from lock-down (youngest first).

RESULTS

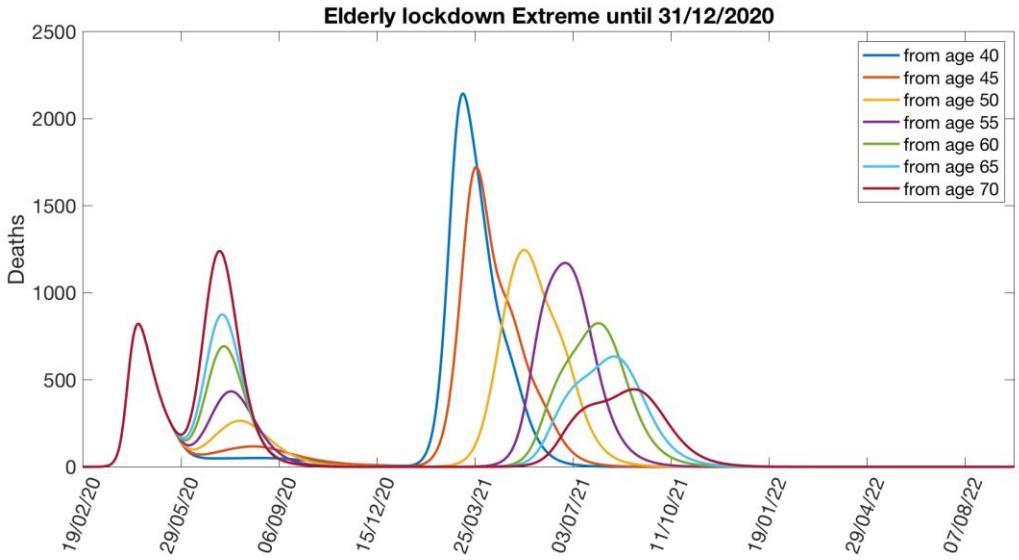
All graphs are given in the Appendix; but here we focus on the major findings.

Elderly Lockdown

Given the age profile of severe cases, a set of restrictions targeted at the elderly would seem the ideal. However, the immediate relaxing controls for the younger population inevitably leads to second waves of infection (whose size is governed by the age-groups that are restricted); while the later relaxation of all measures often gives a third wave (unless the second wave is huge).



If we strengthen the lockdown of the elderly (more comparable to the isolation recommended for those with severe comorbidities), then we can achieve both a reduced second wave of deaths and although at the cost of a larger third wave.

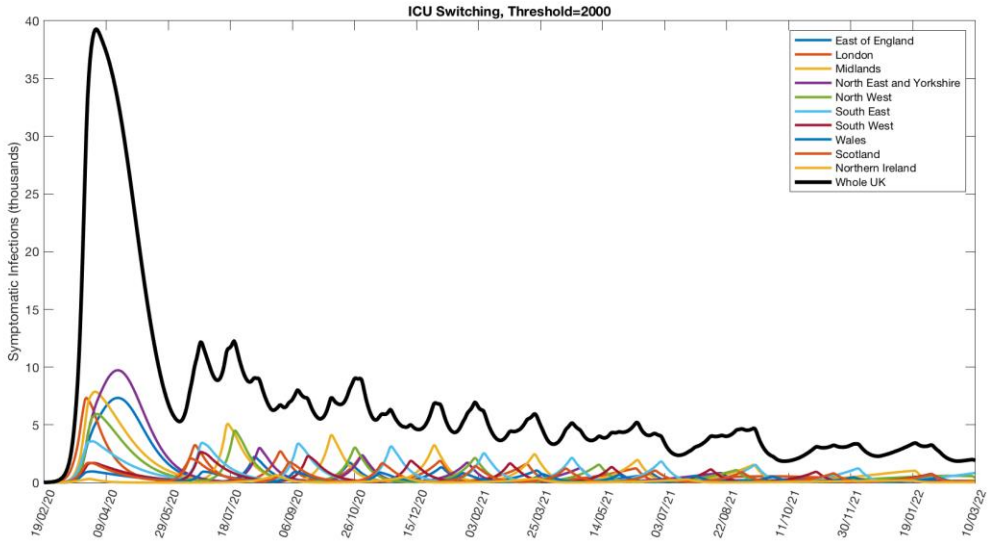


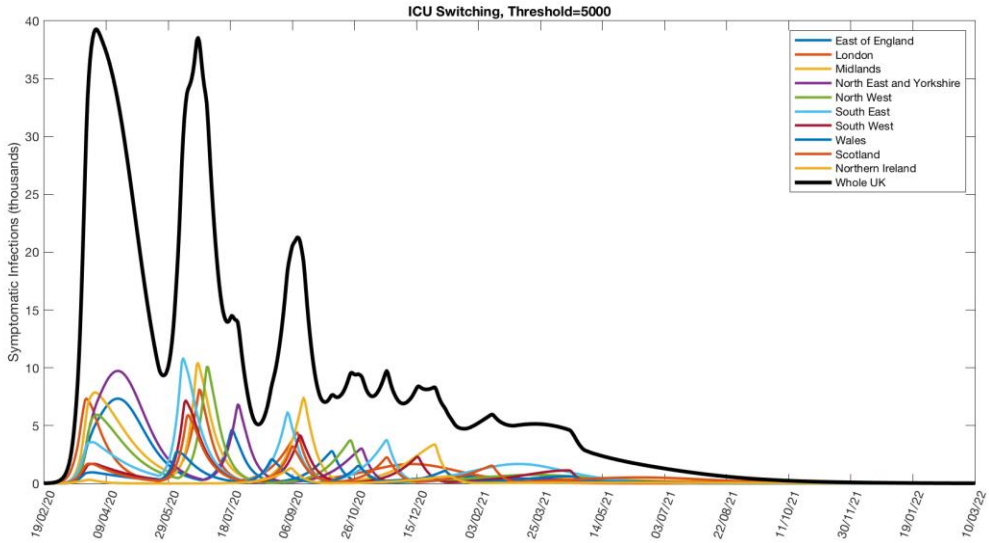
Changes to the duration of elderly lockdown simply shift the third peak to later.

Responsive to ICU occupancy

Switching the lock-down on and off regionally depending on ICU occupancy provides a means of the local NHS retaining capacity. When the threshold capacity is low (corresponding to 2000 ICU beds nationally) the outbreak is extremely protracted with substantial numbers of cases into 2022 and still isolated regions needing lock-down.

When the threshold is higher (5000 ICU beds) there are substantial synchronised waves of infection, but this would allow all controls to be lifted by April/May 2021.



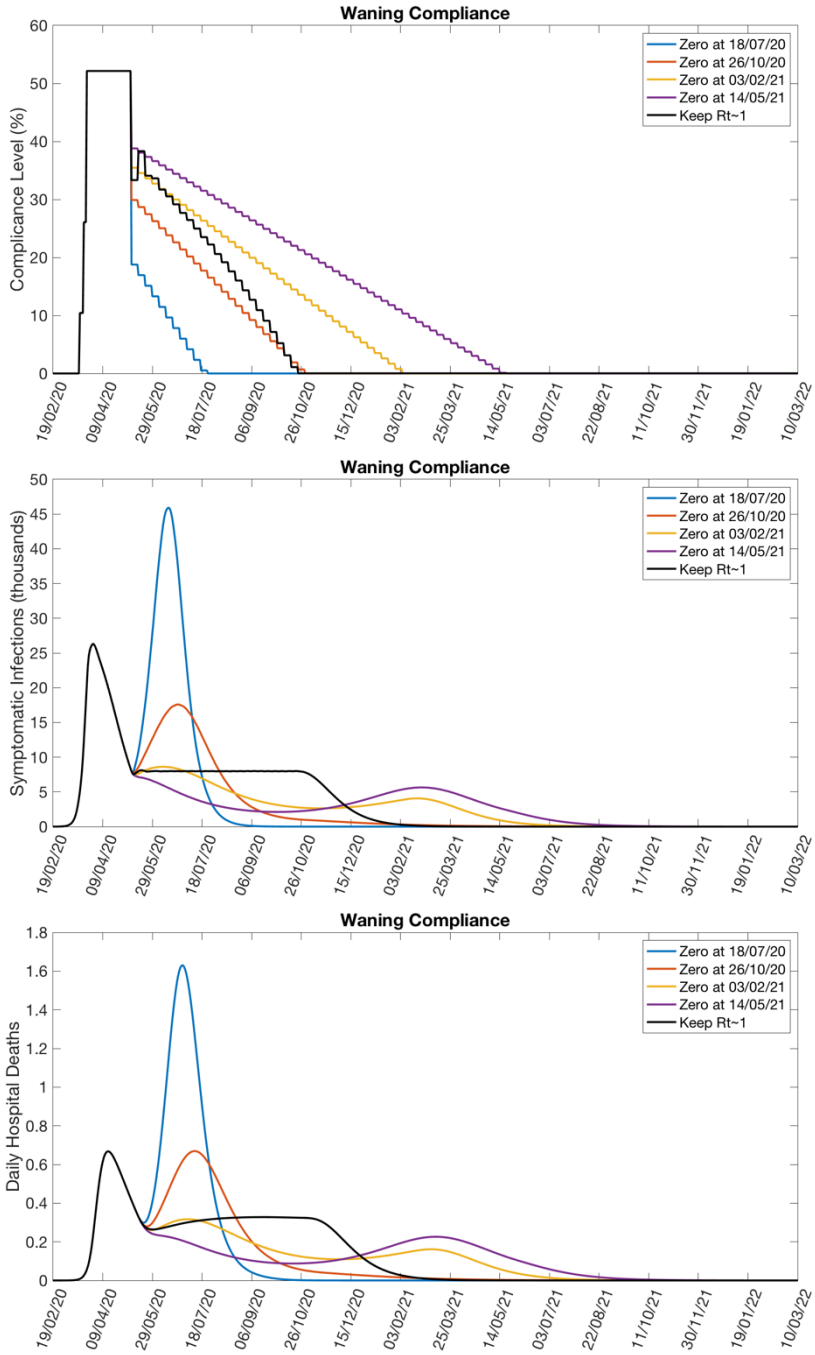


Other options could be considered, such as partial (rather than complete) lifting of lock-downs but this exacerbates the long tail of the epidemic.

Waning Compliance

Results are shown in full for these scenarios, displaying Symptomatic Infections (a proxy for cases), Deaths and the assumed level of compliance (a proxy for reductions in lockdown severity.

This illustrates that if relaxation is too rapid (blue line) we can generate a large second wave which is likely worse than the first wave; but if relaxation is too slow (purple line) we have a protracted epidemic into 2021. Maintaining $R_t \sim 1$, generates sustained cases until late 2020 and reaches herd immunity by 2021.



Conclusions

The fundamental problem is that until we reach herd immunity (either by infection or vaccination) we will have an outbreak unless controls are in place. This applies equally to all social distancing measures or non-pharmaceutical interventions including mobile phone tracing and isolation.

Of the strategies investigated here, very few do not lead to a sizeable second or third wave. Only a carefully timed relaxation of controls and ICU switching with a low threshold prevent a second wave – but lead to protracted outbreaks, especially for ICU switching.

If the aim is to minimise lives lost to the outbreak (and only considering the direct deaths in hospital) then the 'best' options of those considered are:

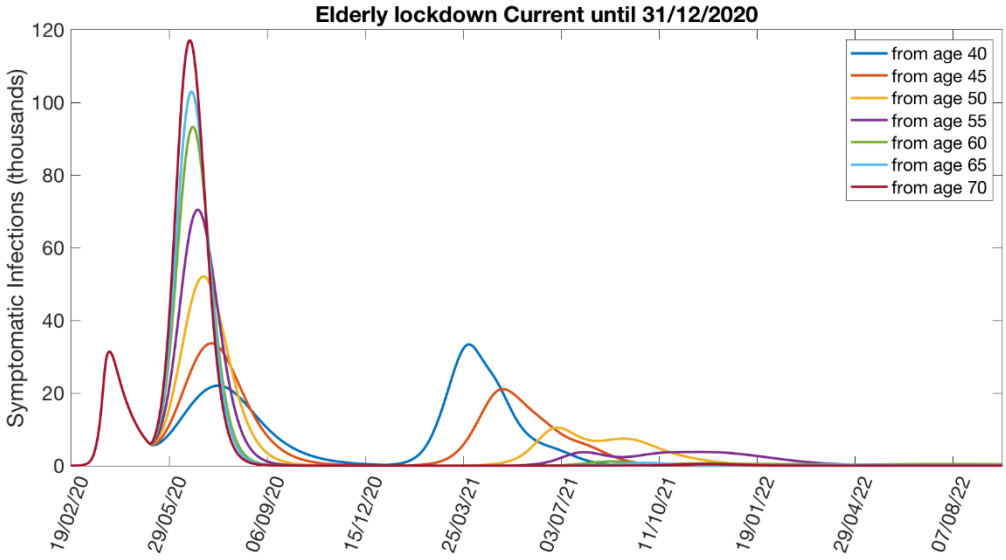
- Lockdown of age 60 and above until Dec 2021 (green line on associated graphs)– 109,000 deaths
- Switching, with an equivalent threshold to 2000 ICU beds across the UK – 144,000 deaths.
- Waning Compliance hitting zero by Feb 2021 (yellow line on associated graphs) – 116,000 deaths.
- An additional Waning Compliance method which seeks to keep R_t at around 1 by modifying the ages for which restrictions are relaxed leads to 117,000 deaths and releases most of the adult population by late 2020.

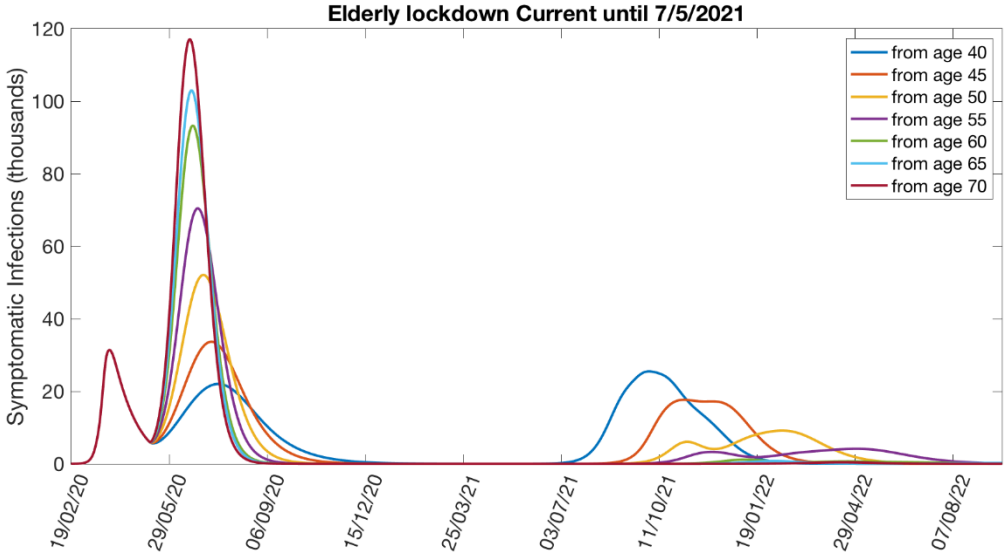
A reasonable assumption is that total deaths will be driven by the majority of cases that goes through the hospital system, but may be 30-50% higher.

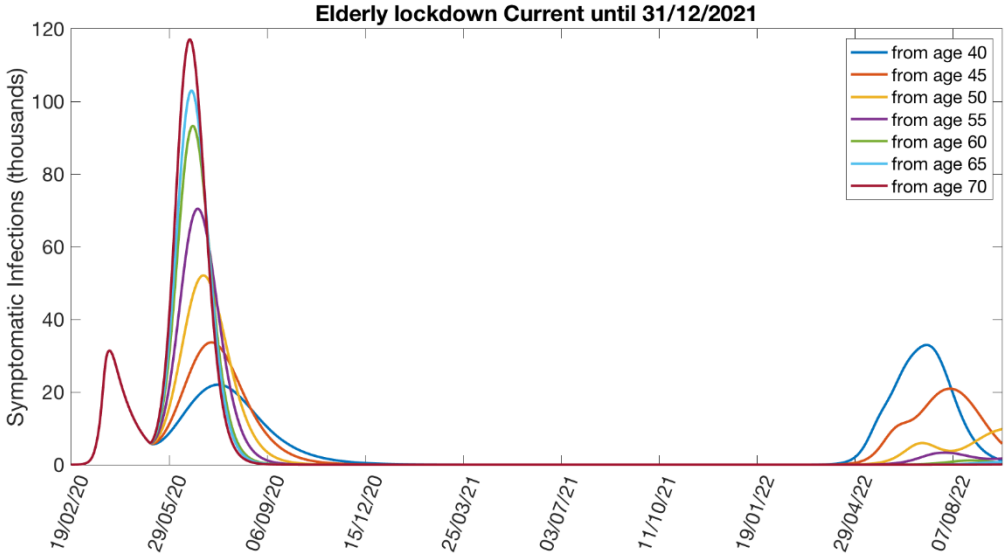
If we knew when a vaccine would be available, this would completely change the perspective on many of these calculations, as one option becomes containing the infection until mass immunisation is possible. In which case delaying strategies become preferred. For example, a scenario in which lock-down measures continued until mass vaccination was successful is predicted to lead to around 39,000 deaths.

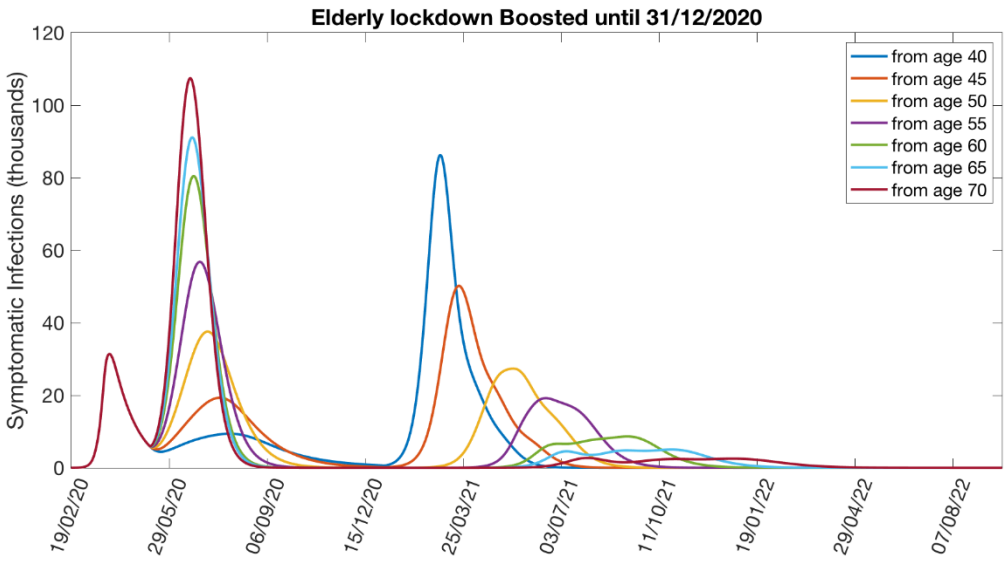
Finally, any of these scenarios could be coupled with an antigen test – allowing the increasing number of infected people to return to normal activities as the outbreak progresses.

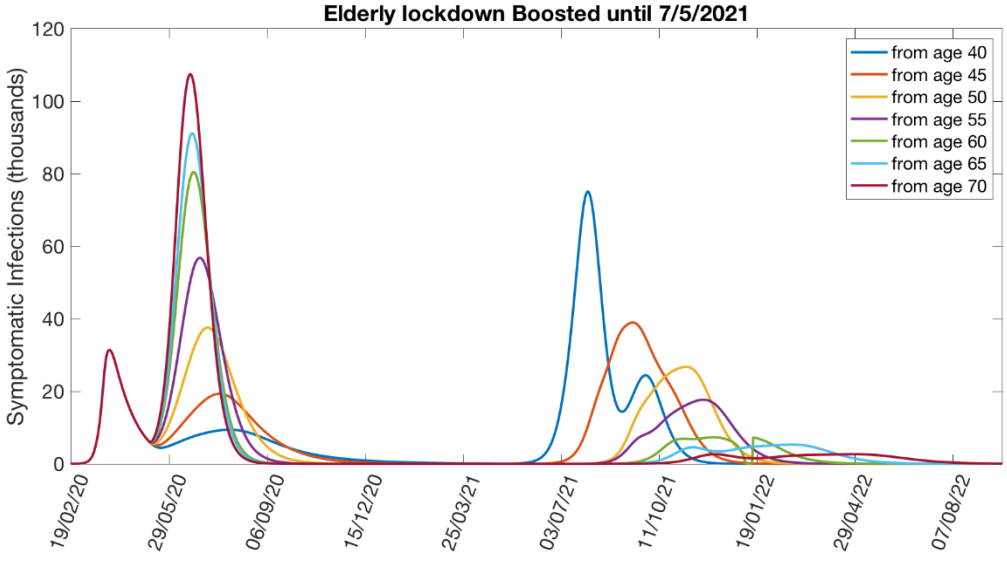
APPENDIX: Graphs for Age-dependent lockdown (Symptomatic Cases).








Elderly lockdown Boosted until 31/12/2020
Symptomatic Infections (thousands)
120
100
80
60
40
20
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22


Elderly lockdown Boosted until 7/5/2021
Symptomatic Infections (thousands)
120
100
80
60
40
20
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
06/09/20
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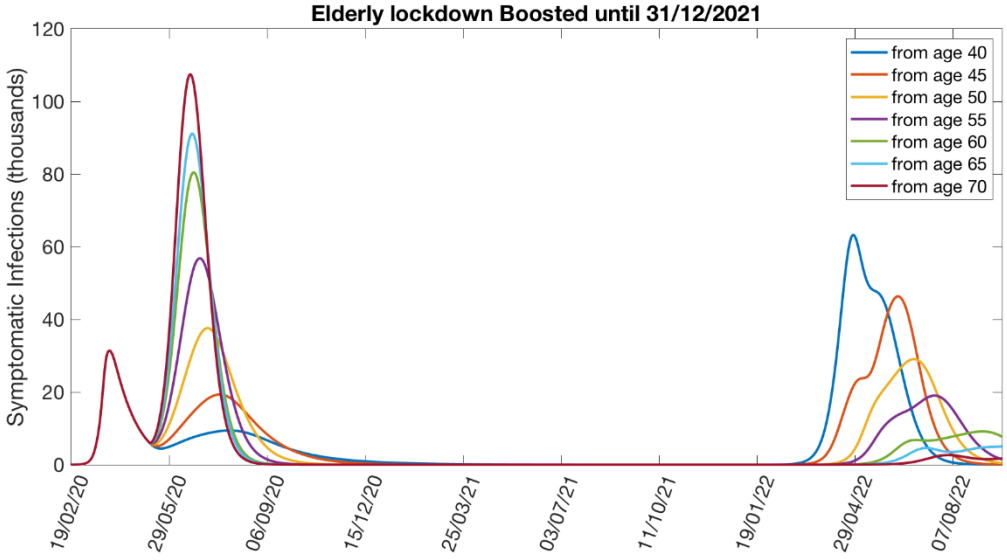
11/10/21
19/01/22
29/04/22
07/08/22


Elderly lockdown Boosted until 31/12/2021
Symptomatic Infections (thousands)
120
100
80
60
40
20
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
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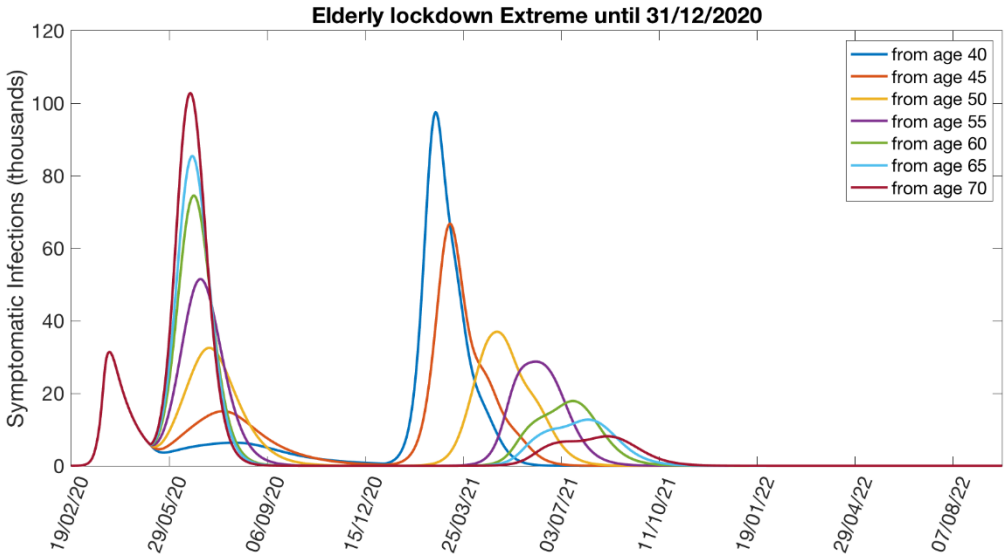
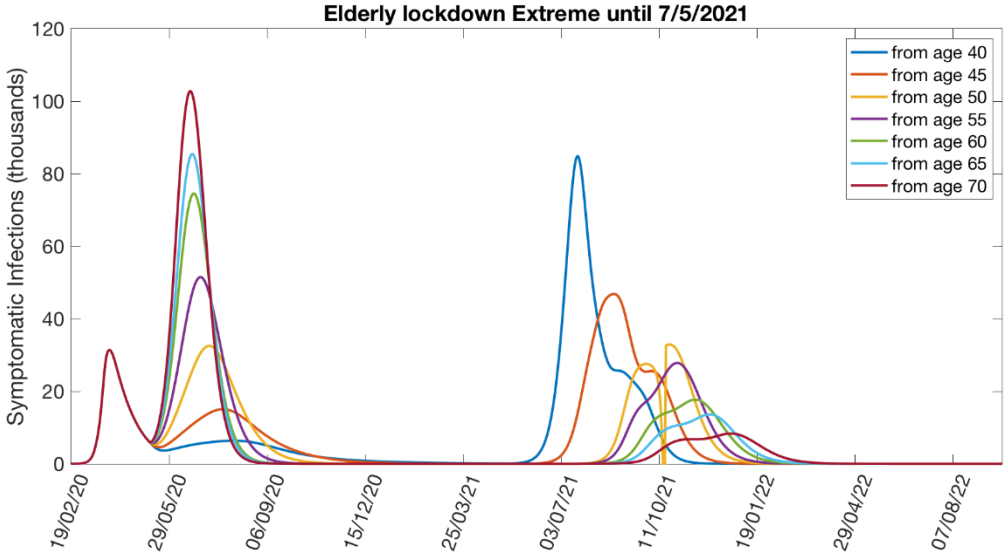
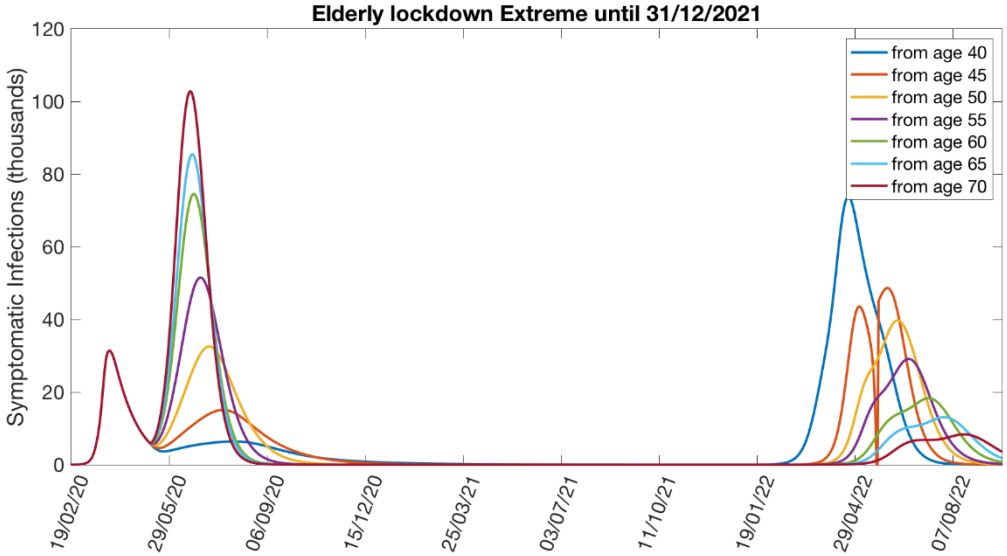
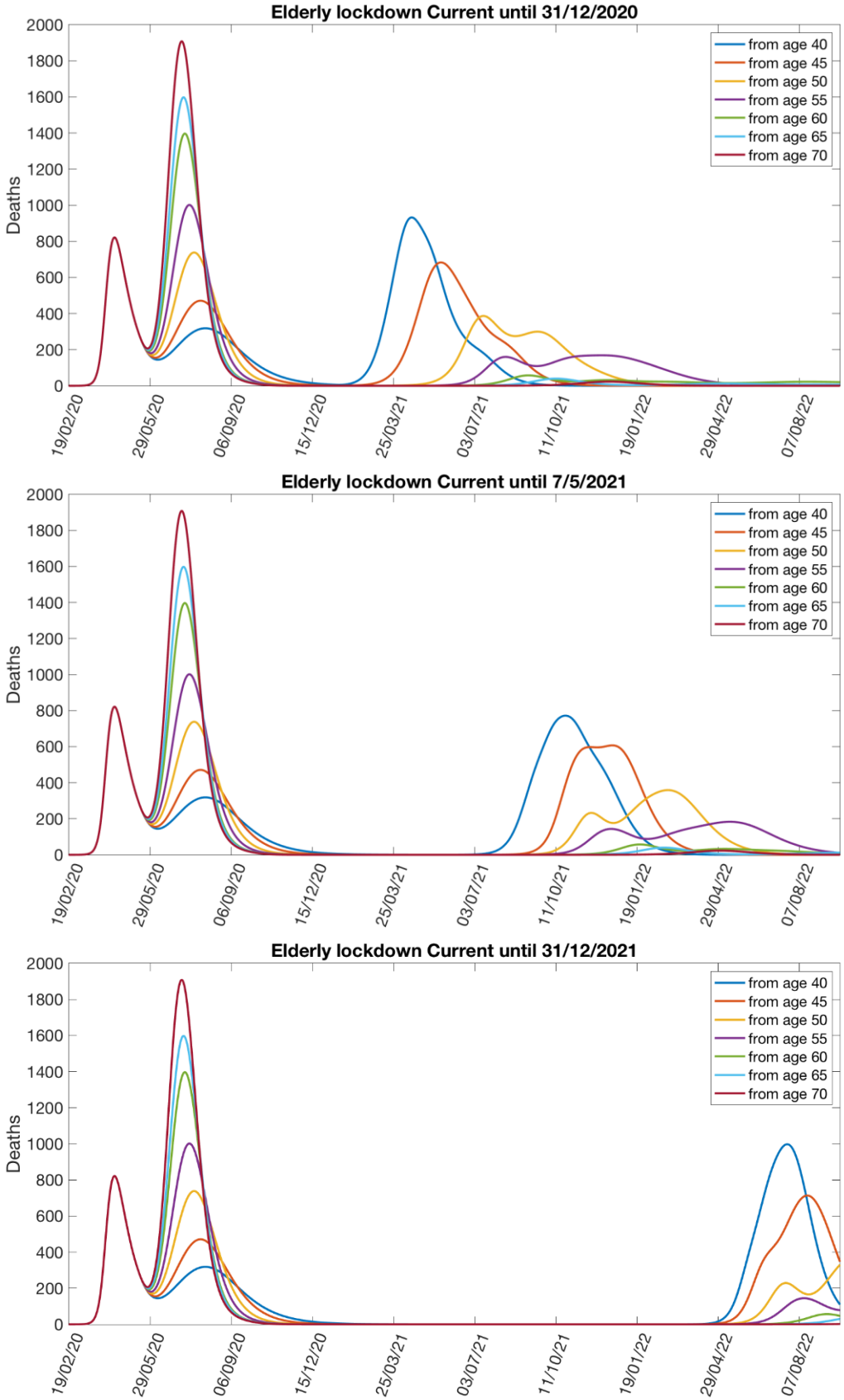
11/10/21
19/01/22
29/04/22
07/08/22

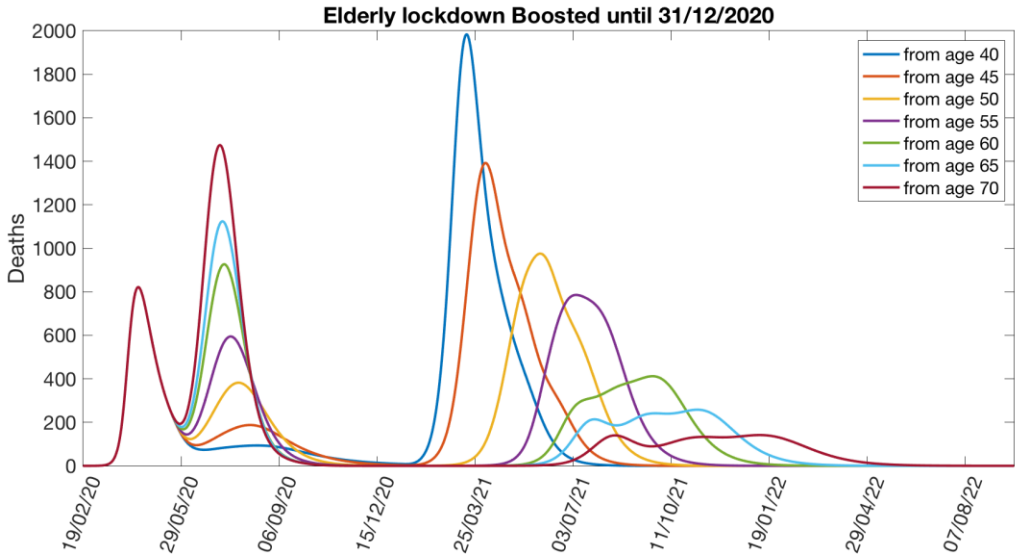

Elderly lockdown Extreme until 31/12/2020
Symptomatic Infections (thousands)
0
20
40
60
80
100
120
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70

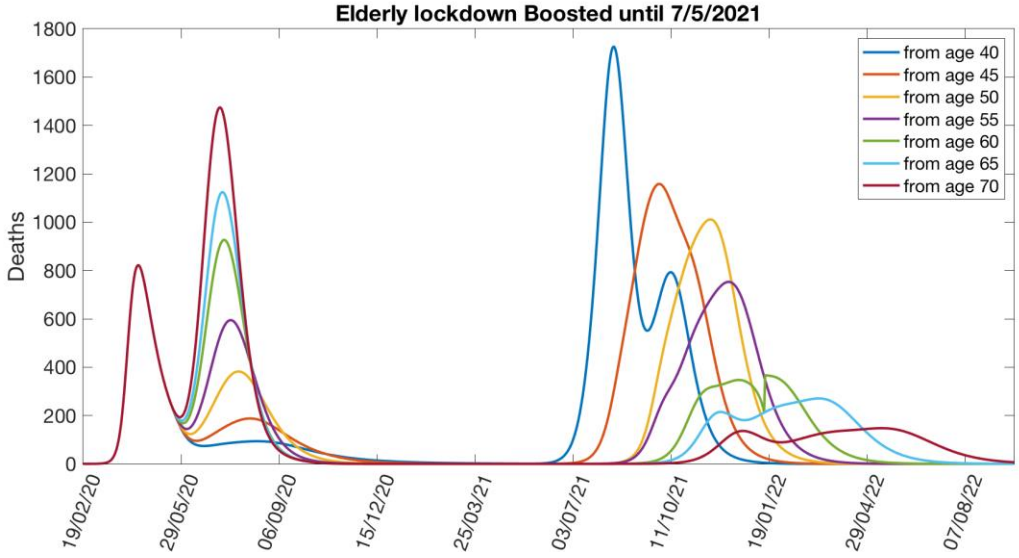

Elderly lockdown Extreme until 7/5/2021
Symptomatic Infections (thousands)
0
20
40
60
80
100
120
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70

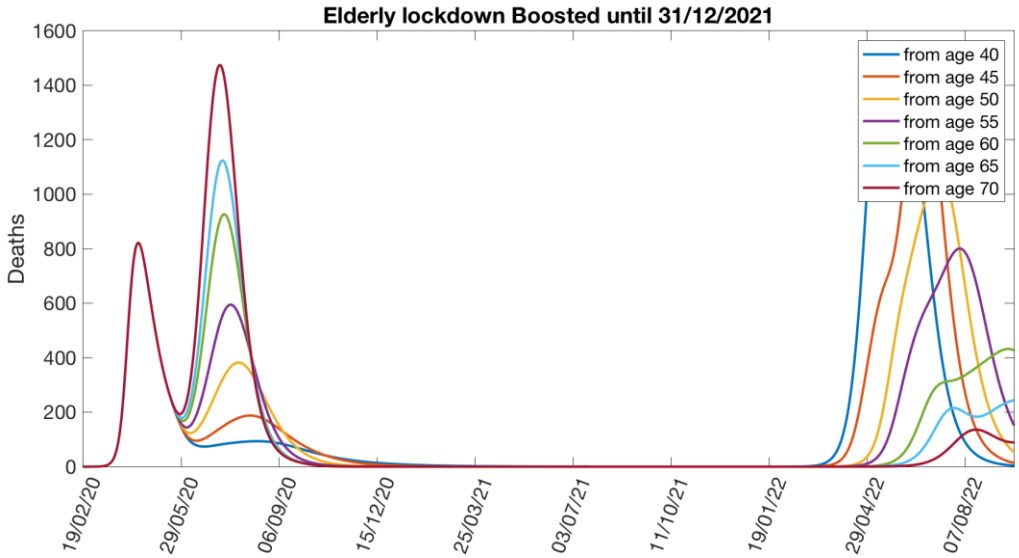

Elderly lockdown Extreme until 31/12/2021
Symptomatic Infections (thousands)
0
20
40
60
80
100
120
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70

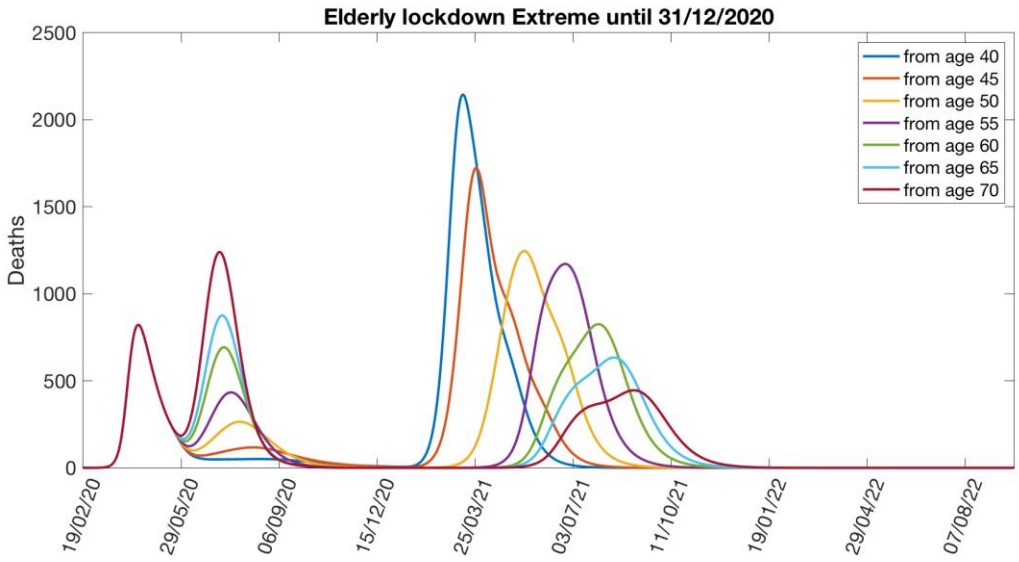
APPENDIX: Graphs for Age-dependent lockdown (Deaths).




Elderly lockdown Boosted until 31/12/2020
Deaths
2000
1800
1600
1400
1200
1000
800
600
400
200
0
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70


Elderly lockdown Boosted until 7/5/2021
Deaths
1800
1600
1400
1200
1000
800
600
400
200
0
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70


Elderly lockdown Boosted until 31/12/2021
Deaths
1600
1400
1200
1000
800
600
400
200
0
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70


Elderly lockdown Extreme until 31/12/2020
Deaths
2500
2000
1500
1000
500
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
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15/12/20
25/03/21
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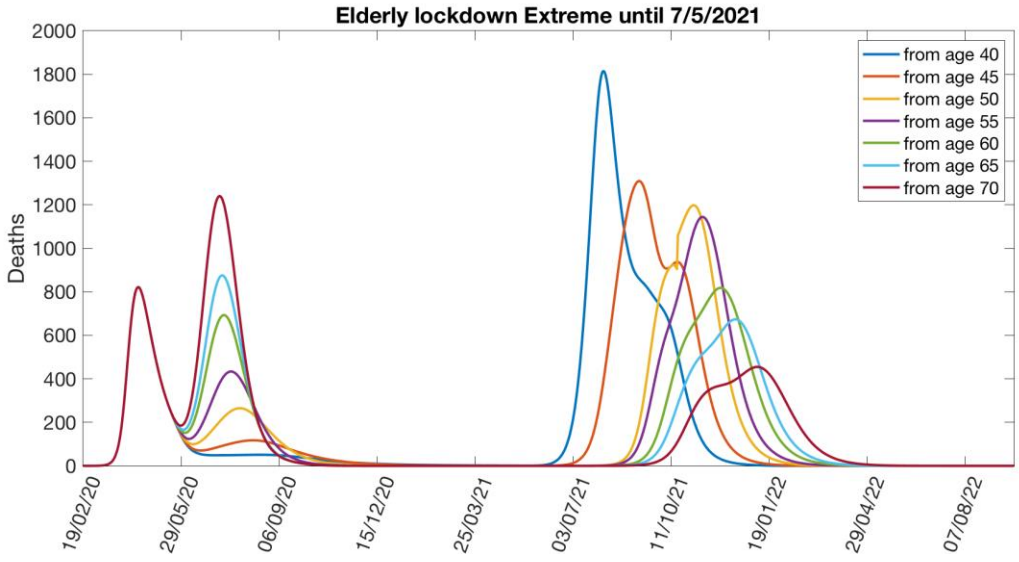
11/10/21
19/01/22
29/04/22
07/08/22


Elderly lockdown Extreme until 7/5/2021
Deaths
2000
1800
1600
1400
1200
1000
800
600
400
200
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
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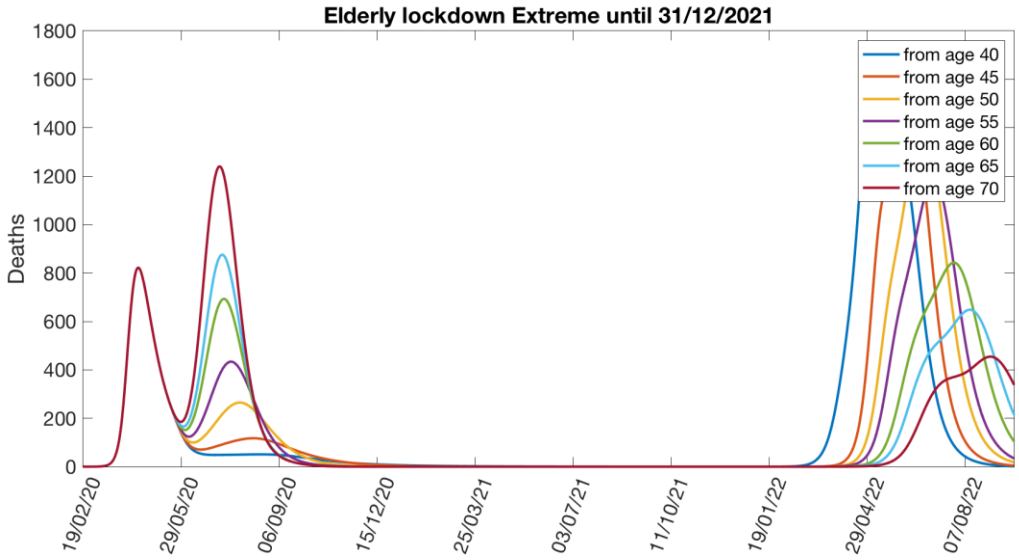
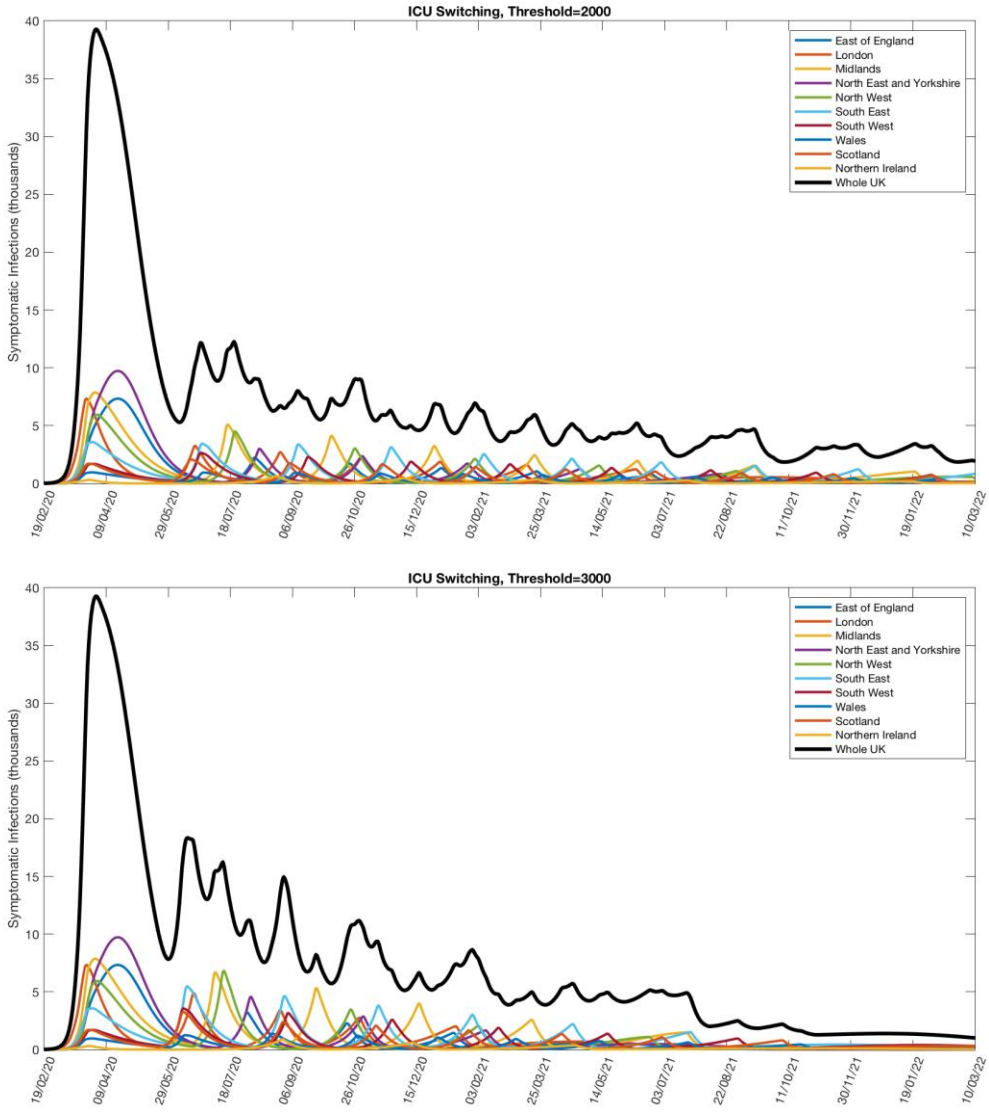
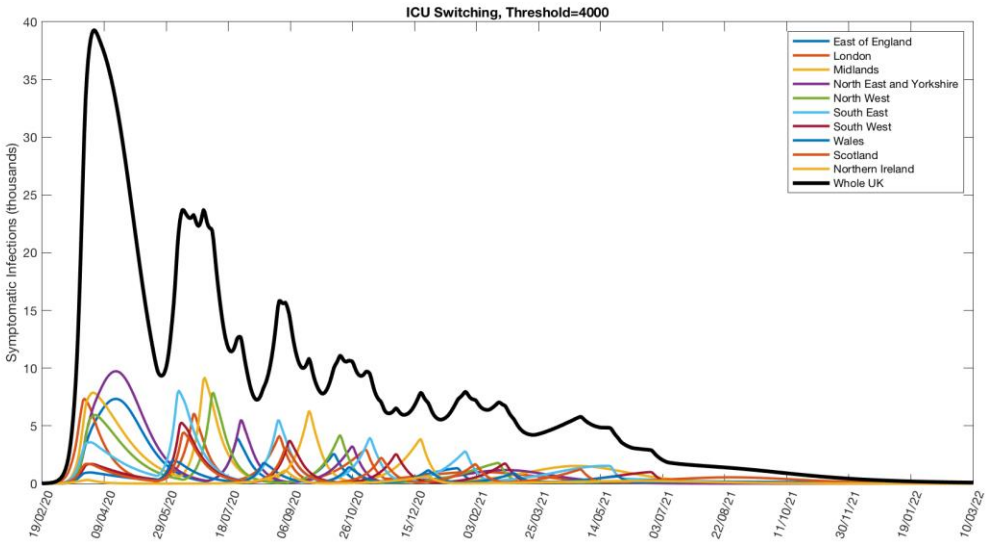
19/01/22
29/04/22
07/08/22


Elderly lockdown Extreme until 31/12/2021
Deaths
1800
1600
1400
1200
1000
800
600
400
200
0
from age 40
from age 45
from age 50
from age 55
from age 60
from age 65
from age 70
19/02/20
29/05/20
06/09/20
15/12/20
25/03/21
03/07/21
11/10/21
19/01/22
29/04/22
07/08/22

APPENDIX: Graphs for ICU-based Switching Strategies (Symptomatic Cases).




ICU Switching, Threshold=4000
Symptomatic Infections (thousands)
East of England
London
Midlands
North East and Yorkshire
North West
South East
South West
Wales
Scotland
Northern Ireland
Whole UK
0
5
10
15
20
25
30
35
40
19/02/20
09/04/20
29/05/20
18/07/20
06/09/20
26/10/20
15/12/20
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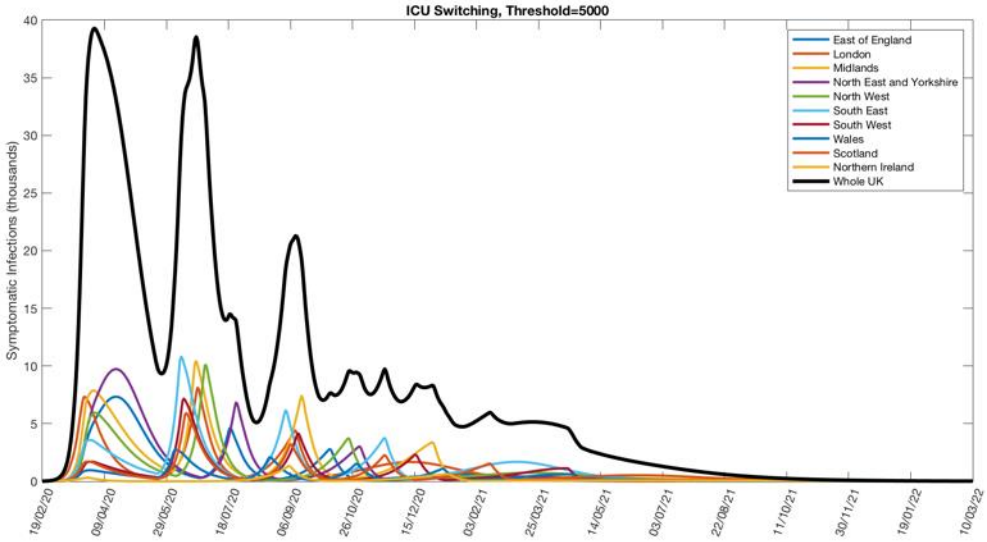
10/03/22


ICU Switching, Threshold=5000
Symptomatic Infections (thousands)
East of England
London
Midlands
North East and Yorkshire
North West
South East
South West
Wales
Scotland
Northern Ireland
Whole UK
0
5
10
15
20
25
30
35
40
19/02/20
09/04/20
29/05/20
18/07/20
06/09/20
26/10/20
15/12/20
03/02/21
25/03/21
14/05/21
03/07/21
22/08/21
11/10/21
30/11/21
19/01/22
10/03/22