Partial unlock model for COVID-19 or similar pandemic averts medical and economic disaster

Robert L. Shuler[1][2][*]

[1]ShulerResearch.org

[*]Corresponding author

E-mail: robert@shulerresearch.org (RS)

March 30, 2020

Abstract

2   Data as of March 29, 2020 show that the "flattening" strategy for COVID-19 in the U.S. is

3   working so well that a clean removal of social distancing (aka "unlock") at any time in 2020 will

4   produce a renewed catastrophe, overloading the healthcare system. Leaving the economy locked down

5   for a long time is its own catastrophe. An SIR-type model with clear parameters suitable for public

6   information, and both tracking and predictive capabilities which "learns" disease spread characteristics

7   rapidly as policy changes, suggests that a solution to the problem is a partial unlock. Case load can be

8   managed so as not to exceed critical resources such as ventilators, yet allow enough people to get sick

9   that herd immunity develops and a full unlock can be achieved in as little as five weeks from beginning

10   of implementation. The partial unlock could be for example 3 full working days per week. Given that

11   not all areas or individuals will respond, and travel and public gatherings are still unlikely, the partial

12   unlock might be 5 full working days per week. The model can be regionalized easily, and by

13   expediting the resolution of the pandemic in the U.S. medical equipment and volunteers, many of them

14   with already acquired immunity, can be made available to other countries.

Introduction

16   After failure to contain COVID-19 in China, the global response has largely been social isolation,

17   with effective cessation of global and local travel except by personal vehicle, and in some cities by bus

18   and subway with frequent sterilization protocols. The strategy is called "curve flattening" and is

19   intended to contain demand for special medical equipment, especially ventilators and related devices,

20   from exceeding supply, which would cause unnecessary deaths.

21   A vaccine reputed to be 18 months away, the remaining strategy is herd immunity. For COVID-

22   19 with an R0 (R-naught, number of people to whom each victim transmits the virus) of 1.4 to 3.28 [1],

23   and seemingly everyone susceptible with no natural immunity, up to 70% of the population must have

24   the disease for herd immunity to come into play. With half a million known and likely 2.5 million

25   unknown cases worldwide, a high spread rate, many very mild cases, and a contagious incubation

26   period, containment is no longer a viable option. The disease is substantially different than MERS or

27   SARS. Although, many in the public and some officials seem to be behaving as if containment were

28   viable.

29   In fighting a disease with public policy that relies on compliance, it is important to avoid the

30   following sort of dilemma. Suppose we posit two policy choices, lockdown and unlock. Suppose the

31   implementation of a policy has two parts: a planned scientific and administrative decision, and the

32   public compliance with that decision. Suppose either one of those parts amounts to "If the disease is

33   spreading and there is horror in the hospitals, lockdown, otherwise unlock." Then lockdown reduces

34   spread and produces a sense of relief, which results in unlock, which in turn restores the pandemic. A

35   Gödel undecidability ensues and the actual strategy flip flops ineffectively. In this paper we propose a

36   model which rapidly measures and uses public response to policy, rather than depending on how well a

37   particular policy is implemented or accepted, dodging the dilemma. This leaves individuals free to

38   self-isolate or risk working without overly compelling them. It leaves regional governments free to

39   modify the policy to fit their area, if for example the disease is spreading faster and threatening hospital

40   resources. To predict the effect of an "unlock" the model (or the person using it) can use a response

41   calibration from a previous time, or estimate a new one. For this paper, we use the initial spread rate to

42   model "unlock." This may be high, as people will likely not go back to mass gatherings and flying on

43   airplanes immediately, which simply means we model a worst case scenario which gives the model a

44   margin of safety.

45   A principle objective of this paper is to share results and strategy possibilities before the

46   conclusion of the COVID-19 outbreak. If studying frequently repeating phenomena, the scientific

47   approach is to present complete data. However, we are studying a rare (roughly once in 100 years)

48   phenomena, with the aim to intervene before it is concluded.

Approach

49

50   The goal of our approach then discards containment as an opportunity past (and perhaps not

51   realistic from early on), and a vaccine as a prospect too far in the future to avoid economic catastrophe.

52   Opinions differ as to the effect of severe and prolonged recession on mortality and health. For

53   example, there are fewer motorway deaths due to less driving [2]. On the other hand the 2008 financial

54   crisis resulted over the next few years at least 260,000 additional cancer deaths [3]. Economic losses

55   from pandemics, even without a long term global shutdown, have been estimated at the low end of but

56   within the range of impacts from climate change [4].

57   Therefore the goal we adopt is to use public policy supported by modeling to achieve herd

58   immunity as rapidly as possible, without overloading the healthcare system's critical resources (we use

59   ventilators as a general proxy for resources) and causing unnecessary deaths. Given our assumptions

60   about vaccines, containment and R0, 70% of the population will get sick anyway. Our approach of

61   voluntary compliance with unlocks allows individuals and regional governments to manage their health

62   and economic risks as they see fit. As the U.S. has ventilators per capita among the highest in the

63   world, and stands to suffer high economic damage, it is a logical place to attempt this strategy. If the

64   U.S. develops herd immunity, then it might choose to make some of its ventilators, and its production

65   capacity for more ventilators, available to other countries. At the current time the hoarding mentality

66   which arises from uncertainty is impairing the sharing of medical equipment and New York and Italy

67   plead for ventilators and masks, as other countries protest they need their own stockpiles. But China,

68   feeling it has the spread under control, is more forthcoming.

69   **Model parameters**

70   The purpose of this paper is more to illustrate an approach than to propose a specific model. We

71   suggest following Huppert and Katriel's guidance: "*To examine which of the predictions made by a*

72   *model are trustworthy, it is essential to examine the outcomes of different models. Thus, if a highly*

73   *simplified model makes a prediction, and if the same or a very similar prediction is made by a more*

74   *elaborate model that includes some mechanisms or details that the first model did not, then we gain*

75   *some confidence that the prediction is robust. An important benefit derived from mathematical*

76   *modelling activity is that it demands transparency and accuracy regarding our assumptions, thus*

77   *enabling us to test our understanding of the disease epidemiology by comparing model results and*

78   *observed patterns. Models can also assist in decision-making by making projections regarding*

79   *important issues such as intervention-induced changes in the spread of disease.*" [5]

80   To that end we select parameters according to the following criteria:

5

81

       1. Provide sufficient realism to assure relevance

       2. Keep the model simple

       3. Compatible with easily accessible public data for updating/tracking

       4. Err toward the worst case rather than optimism

We expect numerous models to come into play in an actual policy implementation, and regional authorities to do their own modeling. In addition, we want our model to be comprehensible by the public and to aid in the important goal of informing the public and enlisting their rational choices in implementing the strategy. To this end our first parameter reformulates the traditional R0 reproduction rate, which does not have a specific time base, as a time-based spreading rate "R." Data from the CDC https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html#investigation for number of cases for March 16-21 in the US (4226, 7038, 10442, 15219, 18747, 24583) represent a time period when local spread had begun to act exponentially. These data correspond to daily spread rates of (1.665, 1.48, 1.45, 1.23, 1.311). Previously a slow rate attributable to travel had been dominant. After March 21 the rate of spread decreases continuously, which we presume is due to increased government directed social distancing including widespread business closure, stay at home orders, and increased public compliance with these policies. For the model's initial value we adopted a daily spread rate of 1.414. The fraction of *new* cases is then R=0.414. This number is immediately replaced in the model by the next day's rate, and adjusted by the computed herd immunity factor when re-used following unlock. The unlock spread rate should be measured and adjusted, but there has yet been no unlock.

Our R can be compared with R0 by selecting a time window for transmission. Several possibilities exist, and since our R is empirically measured we are not too concerned with determining the exact relation. But for example, suppose there is a window of 4 days before a person discovers

104   they have the disease and self-isolates. At our presumed R (cases doubling every two days) there

105   would be 4 people with the disease at the end of this time, or 3 new cases. That corresponds to R0=3,

106   which is in line with the high end of estimates given above (3.28 maximum).

107   The number of ventilators in the U.S. including reserves, alternatives (anesthesia machines) and

108   older equipment is taken at 200,000 [6].

109   The ratio of total likely cases to known reported cases is taken at 6 (16.6% known) with alternative

110   scenarios checked at 5 (20% known). The lower numbers are more critical due to the way the model

111   calculates ventilator requirements. Published numbers are typically around 14% [7], so our assumption

112   has some margin of safety.

113   A precise number for how long a case of COVID-19 lasts is of course not obtainable due to the

114   wide variation. However this number is not critical for our model. They could last forever and the

115   herd immunity calculation would be unaffected since it includes both recovered and infected people.

116   Somewhat more important is the length of time a ventilator is required, if one is required. The best

117   estimate we could obtain was "up to weeks" since this too is highly variable. We used 14 days for both

118   numbers.

119   The fraction of cases which require resources such as a ventilator is also important. We used 3.2%

120   of known cases, or about half of critical cases, taken from Meng, et. al. [8] Lower estimates exist.

121   This is an area in which additional data and input from more specialized simulations would be used

122   before public policy formulated.   Regionalization is also important as ventilators may not be

123   distributed where needed. Publication daily of model predictions, assuming they predict or exceed the

124   actual data coming in, we believe would increase confidence and promote redistribution of ventilators

125   according to need.

126   Social networks, location tracking and other massive data mining efforts recommended in

127   research of more persistent (non-pandemic) diseases [9] are specifically not part of our approach. They

128   take time, where we require rapid feedback. They invite abuse for other applications later. But most

129   important, social networks change as soon as a pandemic is announced, change again when

130   government policy is announced, and keep changing. An aggregated tracking and feedback method

131   will work better.

132   **Model dynamics**

133   We use a standard SIR modeling approach [10] but with the time based reproductive factor as

134   described above. The number of new cases is our R factor times the existing cases which are only 4

135   days old or less.

136   During "lockdown" the R factor is adjusted according to (a) the ratio of new cases from the

137   previous day, and (b) the increase in herd immunity factor over the previous day. Only when the

138   caseload is rapidly peaking will day to day changes in herd immunity factor be relevant. When an

139   "unlock" policy is established in the predictive model, the R factor is re-established at the initial value

140   reduced by the herd immunity factor. When actual unlock data is available, this will need further

141   adjustment which we do not specify at this time.

142   This simple model was implemented in a spreadsheet with some facilities for setting days to be

143   unlocked, or they can be set manually. The spreadsheet will be available as supplementary materials

8

144   and   in   the   http://medRxiv.org   preprint   repository,   and   is   currently   available   at

145   http://shulerresearch.org/covid19.htm . Each day actual data was used to replace predicted data based

146   on CDC data at the link specified above. This affects the model's integration base and the effective

147   reproduction rate R. The number of "new" cases, necessary for bookkeeping active and spreading

148   cases and ventilator utilization, is deduced from the day to day change is number of cases. Total cases,

149   used for the herd immunity calculation, is calculated by either 5 or 6 times the known cases as

150   described.

Results

152   The progress toward "curve flattening" is shown in Figure 1, with predicted plots based on actual

153   data from 3/21, 3/25 and 3/29. One can see that to say flattening was successful is putting it mildly.

154   Thus arises the dilemma: not enough people are getting sick to develop herd immunity.

155   In the 3/25 and 3/29 cases in Figure 1, herd immunity is incomplete. In the 3/21 case it appears

156   90% of the population is infected because of numerical overshoot during the rapid rise. One day

157   quantization may not be enough resolution, the rise is so rapid. The extent to which such an overshoot

158   might happen in reality (it might) is not of concern to us since this case will not be allowed. In the

159   following cases it will be apparent that where a slower rise is allowed due to partial lockdown, the total

160   cases peaks around 70% just where it should for R0=3.

161   Figure 2 shows two different dates for total unlock, beginning with the day after the current

162   extension of lockdown through April 30th. The second scenario begins 6 months later on November 1.

163   Though the peak is reduced somewhat, ventilator capacity is still wildly exceeded. More ventilators

9

164   may be produced by then, but 6 months have been wasted when people could have been building herd

165   immunity, and the economic loss, the permanent loss of houses and business from loan default, and

166   consequent loss of jobs, will be known is the worst "man-made" disaster of all time, since it was a

167   reactionary policy decision which we will show is easily prevented.

168   Figure 3 shows a three day a week partial unlock strategy beginning as soon as April 9th.

169   Actually it could begin April 2nd, but this paper is not likely to be in public view by then. Five weeks

170   later, total unlock is possible. Critical resource (ventilator) usage expands smoothly toward the 70-

171   80% range, then drops dramatically just at the time of full unlock. It is possible to unlock a week

172   earlier, but doing so causes a rise in critical cases which might undermine public confidence.

173

174
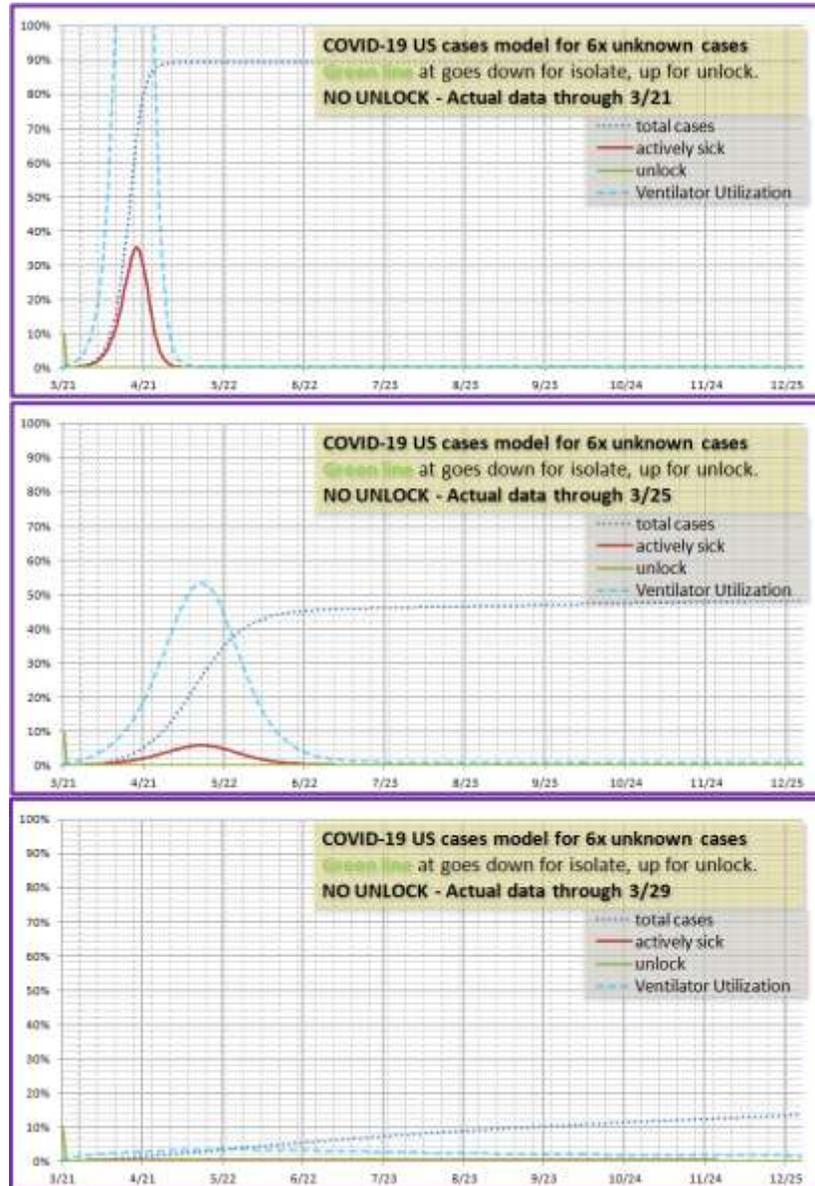
Figure 1. Progress toward "flattening" from 3/21 to 3/29.

176

177   Figure 4 shows a sensitivity analysis for the multiple of unknown to known cases of 5 instead of 6.

178   The situation is worse, but capacity is not exceeded. Most expert opinion is that the multiple will be

11

179   higher rather than lower, however additional studies involving testing random samples would clarify

180   this figure, which might vary by region.

181   It appears that the unlock date need not be pinned down in advance. There will be a precipitous

182   drop in usage of critical resources, and unlock can then occur within a few days.
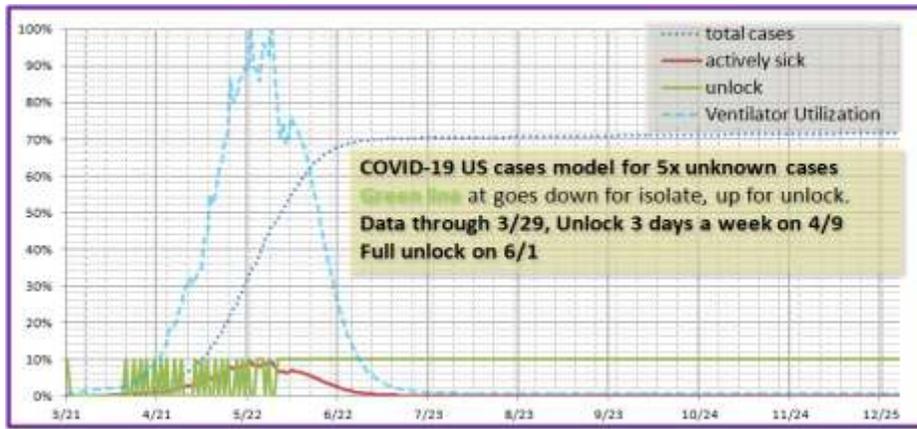
183
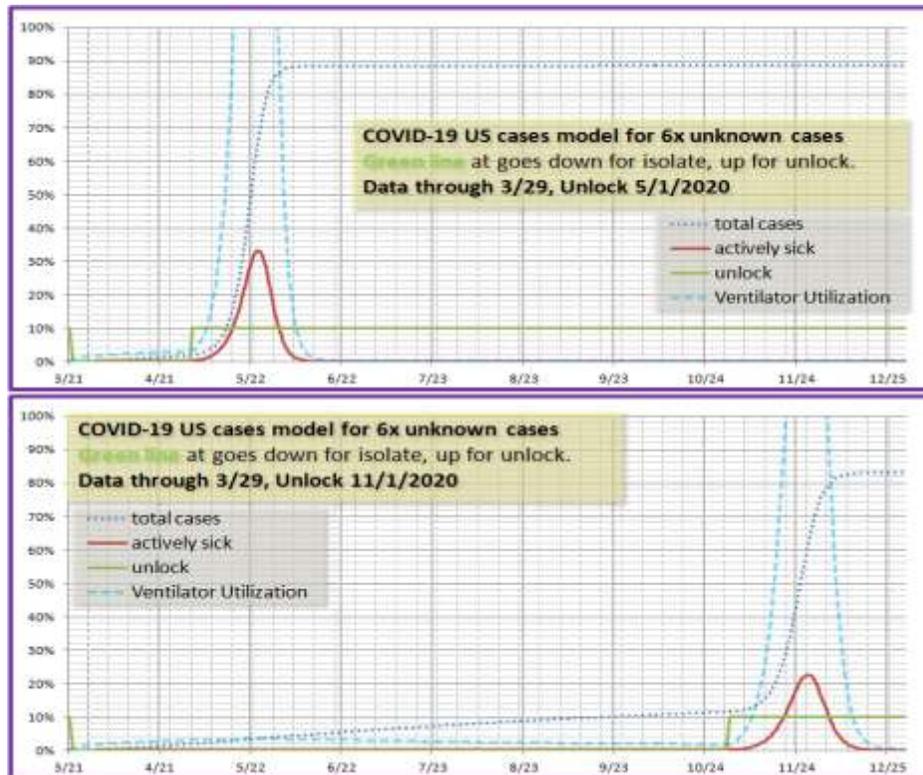
184   **Figure 2.** Alternatives for full unlock.

185
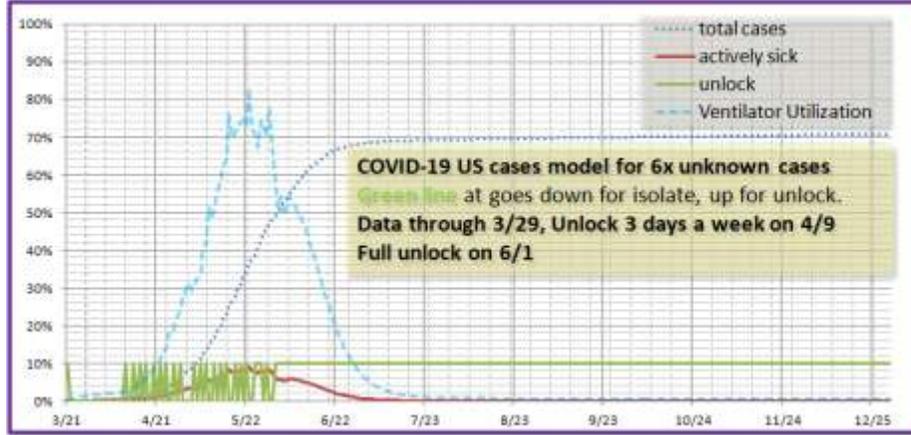
186

187
Figure 3. Three day a week unlock scenario.

188

189
Figure 4. Three day a week unlock scenario with 5x unknown to known cases.

190 # Conclusion

191   It appears that options are available that are not now openly under consideration that would lessen

192   economic impact of the CORVID-19 worldwide response by six to ten times, while operating within

193   existing critical medical resources and not causing unnecessary deaths.

13

194   The public desperately wants more concrete data and projections, projections which can be seen

195   to be valid as the data comes in. Current models involve obscure parameters that make investigators

196   hesitant to share them.   The use of a time base reproductive factor would likely be more

197   comprehensible and easier for the public to verify for themselves.

198   It is likely the response to a "partial unlock" would be underwhelming. Many businesses would

199   be hesitant to reopen. However, within a few days this effect will be apparent in the case data, and the

200   unlock schedule can be adjusted higher or lower. Using days of the week is a customary and usual way

201   of managing work schedules that is easily understood.

202   The public will realize, and it must be made clear, that partial unlock is not a declaration of

203   safety from CORVID-19. It is a declaration of reasonable assurance of adequate medical capacity. We

204   recommend a flexible policy allowing those at risk or those simply afraid to continue to isolate, and

205   those who wish or need to work to accept the risk. The end result is a great reduction of the isolation

206   time required for those who choose to continue to isolate.

207   The final and perhaps most important benefit of this methodology and strategy is the rapid

208   availability of excess medical resources from the U.S. (once unlock is achieved, in about 5 weeks from

209   start) to assist the rest of the world which is not so fortunate in number of ventilators or comparable

210   devices. Further, healthcare workers who have acquired immunity may well want to volunteer to help

211   in other countries. Let's do this.

Acknowledgements

References

[1] Liu, Y., Gayle, A.A., Wilder-Smith, A., Rocklöv, J. (2020). The reproductive number of COVID-19 is higher compared to SARS coronavirus. *Journal of Travel Medicine*, **27**, 2, March, taaa021, https://doi.org/10.1093/jtm/taaa021.

[2] He, M.M. (2016). Driving through the great recession: why does motor vehicle fatality decrease when the economy slows down? *Soc. Sci. Med.,* **155**, 1-11, April, https://doi.org/10.1016/j.socscimed.2016.02.016

[3] Maruthappu, M., Watkins, J., Noor, A.M., Williams, C., Ali, R., Sullivan, R., et. al. (2016). Economic downturns, universal health coverage, and cancer mortality in high-income and middle-income countries, 1990–2010: a longitudinal analysis, *The Lancet*, **388**, 10045, 684-695, August, https://doi.org/10.1016/S0140-6736(16)00577-8

[4] Fan, V.Y., Jamison, D.T., Summers, L.H. (2018). Pandemic risk: how large are the expected losses? *Policy & Practice, Bulletin of the World Health Organization*, **96**, 129-134, December, http://dx.doi.org/10.2471/BLT.17.199588

15

231 [5] Huppert, A. and Katriel, G. (2013). Mathematical modeling and prediction in infectious disease

232   epidemiology, *Clin. Microbiol. Infect.*, **19**, 999-1005, June, https://doi.org/10.1111/1469-

233   0691.12308

234 [6] Halpern, N.A. and Tan, K.S., (2020). U.S. ICU Resource Availability for COVID-19, *Soc. Of Crit.*

235   *Care Med., SCCM Ventilator Taskforce*, ver. 2, March 25,

236   https://www.sccm.org/getattachment/Blog/March-2020/United-States-Resource-Availability-for-

237   COVID-19/United-States-Resource-Availability-for-COVID-19.pdf?lang=en-US

238 [7] Li, R., Pei, S., Chen, B., Song, Y., Zhang, T., Yang, W. and Shaman, J. (2020). Substantial

239   undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV2),

240   *Science*, eabb3221, March, https://doi.org/10.1126/science.abb3221

241 [8] Meng, L., Qiu, H., Wan, L., Ai, Y., Xue, Z., et. al. (2020). Intubation and Ventilation amid the

242   COVID-19 Outbreak: Wuhan's Experience, *Anesthesiology*, special section on COVID-19, no

243   pagination specified, March, https://doi.org/10.1097/ALN.0000000000003296

244 [9] Marathe, M. and Ramakrishnan, N. (2013). Recent Advances in Computational Epidemiology,

245   *IEEE Intell. Syst.*, **28**, 4, 96-101, July-August, https://dx.doi.org/10.1109%2FMIS.2013.114

246 [10] Marathe, M., Vullikanti, A.K.S. (2013). Computational epidemiology, *Communications of the*
247   *ACM*, **56**, 7, 88-96, July, http://doi.acm.org/10.1145/2483852.2483871