Projections and management of the COVID-19 emergency in India

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Brief Communication

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Abstract

The unfolding COVID-19 emergency in India not only points to the explosive speed with which SARS-CoV-2 can spread in populations if unchecked, but also to the gross misreading of the status of the pandemic when decisions to reopen the economy were made in March this year. In this modelling analysis, we isolate the population and policy-related factors underlying the current viral resurgence, and project the growth and magnitude of the health impact and demand for hospital care that may arise if immediate measures to contain the pandemic are not implemented. We indicate that only by re-introducing some measure of social mitigation alongside a swift ramping up of vaccinations will the country be able to contain and ultimately end the pandemic safely. Our results together with the scale of the virus resurgence reported in India also highlight the need for national decision-making that is driven primarily by scientific analysis and data.

Main

The devastating second wave of COVID-19 unfolding currently in India demonstrates, on the one hand, the explosive power and speed with which disease outbreaks caused by extremely contagious respiratory infections can spread in populations and overwhelm national health systems if unchecked[1,2]. It also epitomizes the challenges to governmental decision making in response to a complex infectious disease that is marked by vast transmission uncertainties, poor surveillance, and asymmetry in the risks produced (eg. trade-offs between multidimensional impacts on health, economy and society at large) that make it difficult to formulate effective policies[3-5]. As has been pointed out, these difficulties are further exacerbated when political exigencies favor a particular reading of the “evidence” to support societal reopening decisions in the midst of an ongoing pandemic[2].

The COVID-19 emergency in India has also focused attention on the important need to continuously evaluate and forecast the likely future paths that can be taken by a pandemic in response to fast-changing transmission conditions. Two key pieces of information are paramount during a pandemic wave: what the likely impacts of the surge might be in terms of the development of the pandemic, healthcare demand, and fatalities over time, and how best to curb the ongoing transmission to reduce these health burdens rapidly[6,7]. These specifically include, on the one hand, data on how quickly the pandemic is growing, when it will peak, its overall magnitude and health impacts, and how long it may last, while results of intervention modelling analyses to inform policies are also required secondly to inform on how best to respond effectively to control catastrophic outcomes[6]. Epidemic models offer an important informational tool for making both these situational and pandemic response assessments, but in addition, they can also play an important role in improving the public’s and policy makers’ understanding of the factors involved in the changing risk status of a population, and how such changes in turn may drive future pandemic growth[5].

Here, our goal is threefold. First, to elucidate the size and likely future paths of the current viral resurgence in India; second, to facilitate insights into the underlying factors driving the current wave of cases; and third, to project and evaluate the measures required to achieve the control of the pandemic in the country. We extended our previous data-driven SEIR-based COVID-19 mathematical model to include the dynamics of imperfect vaccines and social mitigation measures in order to address these goals in this paper.

Figure 1a depicts the rate of vaccinations administered to date, model fits to vaccination data and predictions of the fractions of the population presently immune or susceptible, and the times at which herd immunity (at least 80% if immunity is assumed reasonably long-term[8,9]) can be expected to be accomplished with the prevailing vaccines in the country. These results indicate that, inclusive of naturally acquired and vaccine-induced immunity, only about 13% of Indian population may be currently immunized to the virus. While the slow roll out of vaccinations in the country is indubitably a key factor underpinning the low level of immunity acquired thus far by the population, it is important to note that this outcome is also the result of the strict lockdown that India imposed successfully to curb the first wave of the pandemic[10]. Thus, even though the country managed to reduce infection and spread drastically during that wave, this was achieved at the expense of a critically low rate of development of natural immunity that left a large fraction of the population susceptible and vulnerable to infection with the virus once the lockdown was eased from March this year[1,2] (Figure 1a).

Our projections of the viral resurgence shown in figure 1b,c support the above conclusions. These indicate that the chief reason for the alarming current resurgence of the virus in the country is primarily a result of the recent loosening of social measures coupled with a low vaccination rate[1,2,11] among a still largely susceptible population. The projections further show that the resurgence could have peaked at 900,000 confirmed and 1.875 million total infectious new daily cases during the 3rd week of July 2021 if mitigation measures are not imposed immediately (Figure 1b,c). Indeed, the results show that only by the imposition of an immediate short duration lockdown in the most affected states will India be able to control the current wave. The insert in Figure 1b showing the good match between model predictions of declining cases against the latest confirmed new cases (since May 6th 2021) both supports the requirement of this action to slow down the pandemic resurgence and the decision made by the most affected Indian states to impose short lockdowns to contain the present wave. Note, however, that a third albeit smaller wave of the pandemic will likely occur during the fall once the short lockdowns are lifted if unaccompanied by an increase in the current vaccination rate. By contrast, ramping up the current vaccination rate will not only reduce the levels of such a resurgence, but could ultimately also allow the country to end the pandemic by the end of the year (Figure 1b,c).

The corresponding projections for daily hospitalizations, ICU beds, and deaths as a result of the second wave and attempts to curb its course using short-duration lockdowns (of different intensities) and rates of vaccinations are portrayed in Figures 2 and 3. The results in Figure 2 indicate that without an immediate intervention, daily hospitalizations and requirements for ICU

beds would increase exponentially to peaks that will occur towards the end of July 2021 at levels that would vastly surpass the current ICU bed availability (median peak daily need for 195,000 beds versus a capacity of just 95,000 beds country-wide[12]), while also consuming 31% of all available hospital beds in the country (peak requirement for 605,000 beds compared to total availability of 1.9 million beds (Figure 2)). Again, only immediate lockdowns would reduce this daily healthcare demands, with a moderately high lockdown strategy inclusive of vaccination ramp up possibly required to also facilitate the depression of ICU bed needs within the current ICU capacity (Figure 2b). While these forecasts allow an assessment of how the expected demand for heathcare needs relate to existing hospital capacities - which is useful for planning purposes - the results in Figure 3 provide, by contrast, estimations of the overall health impact that may result from the current viral resurgence in the country. These show that by December 22, up to a total of 16 million median new hospitalizations, 6.3 million median ICU cases, and approximately 2 million deaths may result from the current resurgent, if nothing is done immediately to curb viral transmission across the country. Introduction of short-term lockdowns will significantly reduce these staggering outcomes, with strong levels of lockdowns coupled with ramped up vaccinations able to reduce these burdens by 66% (hospitalizations), 63.5% (ICU cases), and 63% (deaths) respectively (magenta dot-dashed curves in each case).

These results, ultimately, point to both India's overconfidence in March 2021 based on confirmed reported cases during January/February of this year that the country had managed to control the pandemic[1,2], and its misreading of these data to mean that a high fraction of the Indian population had acquired immunity to the virus, possibly via cross-immunity gained through exposure to other infections[13]. Our present results show firstly the fallacy of relying on just - indutibly also underreported - confirmed case data to make this assessment given that we estimate the ratio of symptomatic (and presumably confirmed) to total infectious cases, including asymptomatic infections, to be 1: just over 2 (compare Figure 1b and 1c), meaning that a great deal of hidden infection was still ongoing in India when the national government deemed that the country was out of danger and began to open up the economy. Secondly, our modelling results give little credence to the notion that a population can develop high levels of SARS-CoV-2 - specific immunity following a stringent social lockdown, particularly like the one practiced in India to curb the first wave, and a slow vaccination rate as that which has been implemented in the country to date (Figure 1a). Finally, these results highlight that handling an highly contagious fast-spreading pandemic especially in dense populations by policy makers requires the enactment of effective surveillance measures, including apposite testing and data collection, greater understanding of the dynamics of pandemic spread, and careful analyses of

the data and intervention forecasts for enhancing pandemic situational awareness and preparatory outbreak planning[6,14]. While it is important for any country to weigh tradeoffs in protecting population health versus economy and social functions during a pandemic[15,16], our results show that such assessments must ultimately be made on the basis of robust scientific analysis and data. We indicate that the best way for India to contain and end the pandemic now is to re-introduce a measure of social mitigation, such as face mask wearing at the very least, whilst planning to swiftly ramp up vaccinations while the current vaccines are still effective against the variants of the virus circulating presently in that country.

Figure legends

Figure 1: Model predictions of proportions of the Indian population vaccinated, susceptible, and immune plotted alongside reported vaccination data (A) and the corresponding long-term predictions of daily confirmed cases (B) and daily new total infectious cases (C). Results from five scenarios are shown: a) current estimates of social measures and the current vaccination rate (median along with 90% confidence levels – black curve), b) a 30-day 25% increase in social measures (red dotted curve), c) a 30-day 50% increase in social measures (red dot-dashed curve), d) a 30-day 25% increase in social measures, with a weekly 50% ramp in vaccination rate up to 3x the current rate (magenta dotted curve), and e) a 30-day 50% increase in social measures, with a weekly 50% ramp in vaccination rate up to 3x the current rate (magenta dot-dash curve). Median daily cases in India are forecasted to increase exponentially and peak in the 3rd week of July 2021 with 900,000 daily confirmed cases (B) and 1.875 million total infectious new daily cases (C) respectively, in the absence of any increase in social distancing measures or vaccination (black curve). The light red bands in B and C indicate the corresponding 90% confidence interval regions for the base scenario (a), and these show that peak confirmed cases as well as peak total infectious cases could be higher at >2 million and > 3.5 million, respectively.

Figure 2: Forecasts of daily hospitalizations (A) and ICU cases (B) over the course of the 2nd wave. Results are shown for the five scenarios as described in the legend to Figure 1. Peak daily hospitalizations is forecasted to occur on July 28th 2021, with nearly 600,000 hospitalizations in the absence of any increase in social distancing measures or vaccination (black curve). The corresponding peak daily ICU bed needs could reach nearly 195,000 beds at about the same time for this scenario, vastly exceeding the total capacity of 94,600 ICU beds in the country.

Figure 3: Model predictions of cumulative hospitalizations (A), cumulative ICU cases (B), and total deaths (C) to December 22 2021. Results are shown for each of the five scenarios described in the legend to Figure 1. In the absence of any increase in social distancing measures or vaccination (black curve), cumulative median hospitalizations could reach 16 million, while cumulative ICU cases could reach 6.3 million. The corresponding total deaths from the present resurgence of the virus could reach 2 million in the absence of any immediate mitigations. Cumulative hospitalizations, ICU cases and fatalities could be reduced to 5.4

million, 2.3 million, and 760,000 respectively, if strong social measures are taken, along with increased vaccination up to 3x the current rate.

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Figure 1

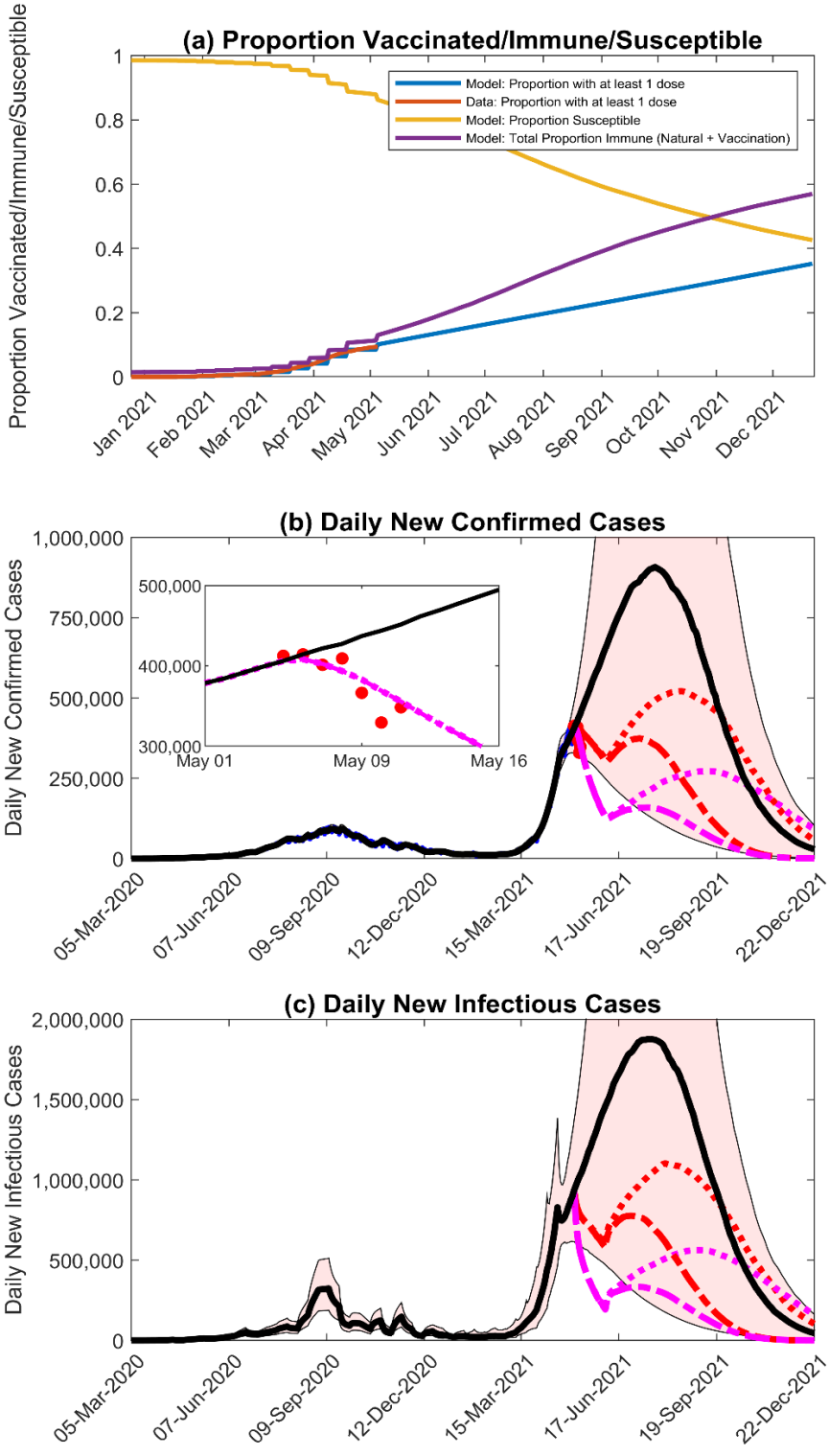

(a) Proportion Vaccinated/Immune/Susceptible
Proportion Vaccinated/Immune/Susceptible
Model: Proportion with at least 1 dose
Data: Proportion with at least 1 dose
Model: Proportion Susceptible
Model: Total Proportion Immune (Natural + Vaccination)
1
0.8
0.6
0.4
0.2
0
Jan 2021
Feb 2021
Mar 2021
Apr 2021
May 2021
Jun 2021
Jul 2021
Aug 2021
Sep 2021
Oct 2021
Nov 2021
Dec 2021
(b) Daily New Confirmed Cases
Daily New Confirmed Cases
1,000,000
750,000
500,000
250,000
0
500,000
400,000
300,000
May 01
May 09
May 16
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021
(c) Daily New Infectious Cases
Daily New Infectious Cases
2,000,000
1,500,000
1,000,000
500,000
0
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021

Figure 2

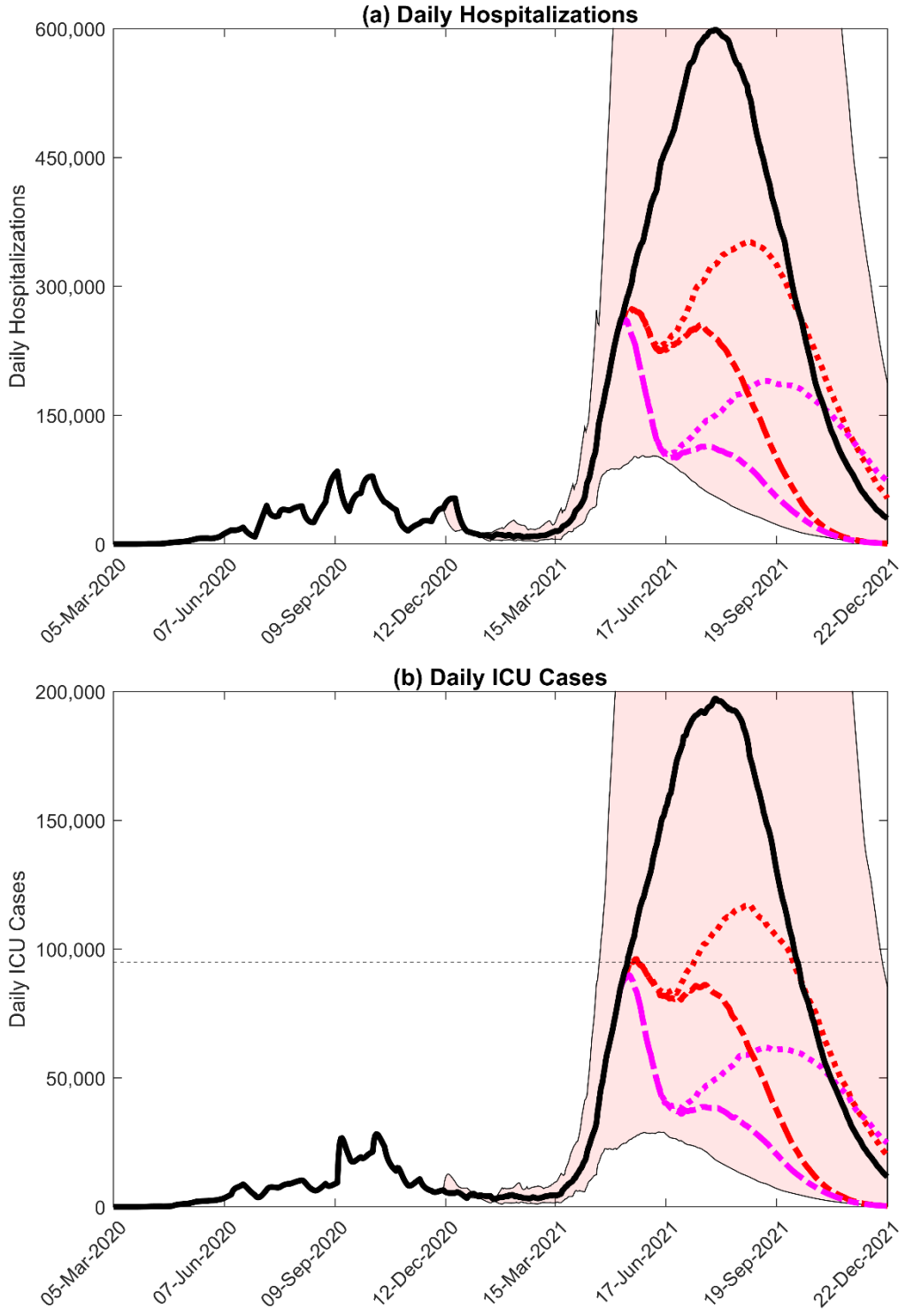
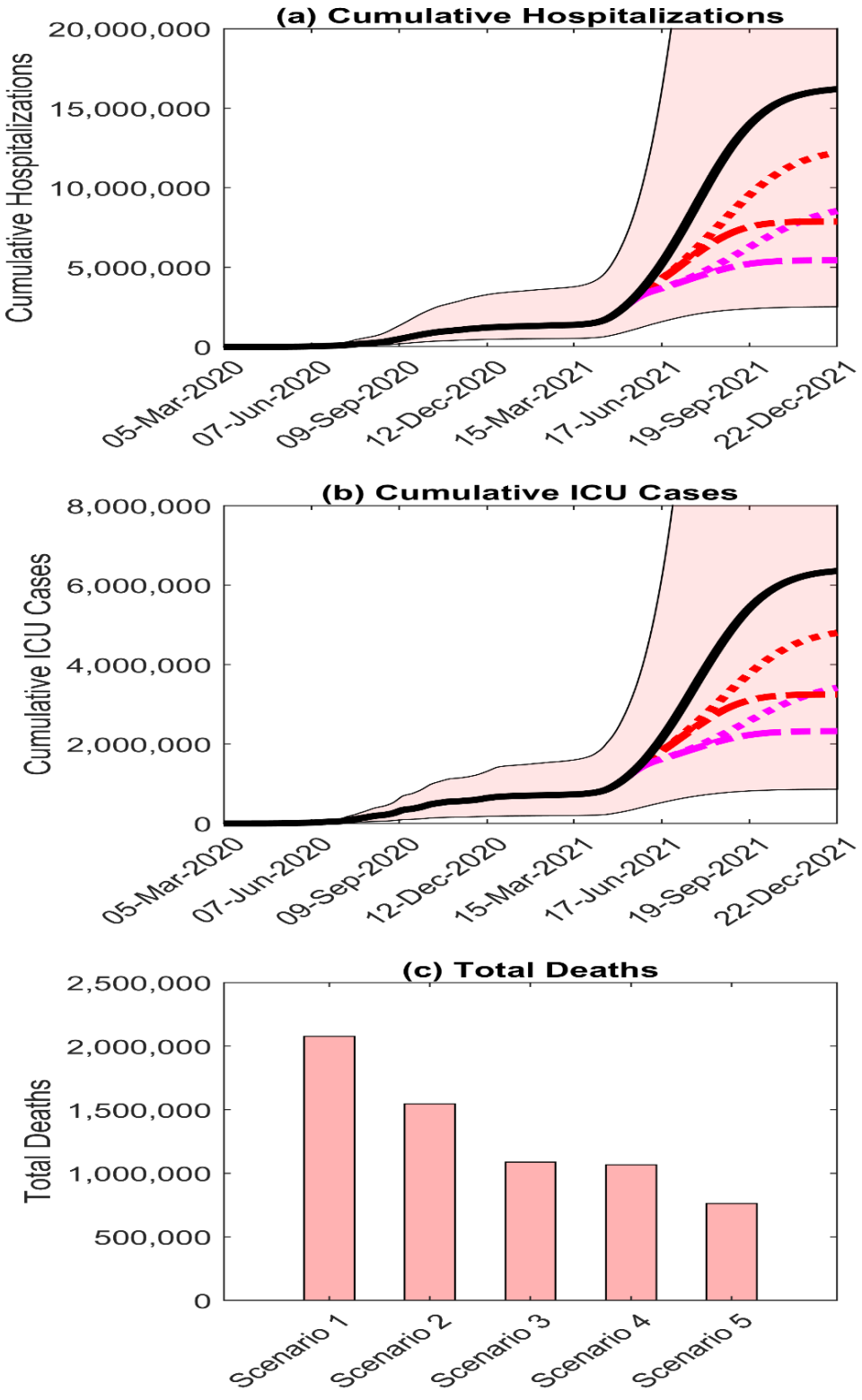

(a) Daily Hospitalizations
Daily Hospitalizations
600,000
450,000
300,000
150,000
0
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021
(b) Daily ICU Cases
Daily ICU Cases
200,000
150,000
100,000
50,000
0
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021

Figure 3


(a) Cumulative Hospitalizations
Cumulative Hospitalizations
20,000,000
15,000,000
10,000,000
5,000,000
0
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021
(b) Cumulative ICU Cases
Cumulative ICU Cases
8,000,000
6,000,000
4,000,000
2,000,000
0
05-Mar-2020
07-Jun-2020
09-Sep-2020
12-Dec-2020
15-Mar-2021
17-Jun-2021
19-Sep-2021
22-Dec-2021
(c) Total Deaths
Total Deaths
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

Supplementary Files

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