Original Article

Coronavirus disease 2019 in India: Post-lockdown scenarios and provisioning for health care

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ABSTRACT

Background: With the rise of Coronavirus disease 2019 (COVID-19) cases in India, lockdown was imposed from March 25, 2020. We studied post-lockdown scenarios and evaluated health-care constraints. Our aim was to identify the scenarios in which health-care availability would not be overwhelmed.

Methods: A modified compartmental SEIR stochastic model was used to calculate peak cases at various levels of effectiveness of prevention of transmission. Health-care constraints were evaluated using a Delphi study. We developed “q-metric” to evaluate the epidemic. Key constraints were matched against scenarios generated, and a monitoring mechanism was devised.

Results: Continuing lockdown (“q-metric” of >50) until mid-August was theoretically the most effective solution to end the epidemic. Lockdown might however be lifted earlier owing to various compulsions. The key constraints were identified as trained manpower and ventilators. It was estimated that shortfall of specialists to operate ventilators for COVID-19 intensive care units was approximately 40,000. This requires re-purposing of other specialists and short-term training to meet the surge. The shortage of ventilators is around 40,000–50,000. Procuring beyond those numbers would be infructuous owing to limits of training manpower. After lifting lockdown, the aim should be to contain the epidemic within the availability of key constraints. Our model suggests that this can be achieved by community containment and other non-pharmacological interventions at a “q-metric” of 19. An algorithm using “q-metric” was developed to monitor the epidemic.

Conclusion: Various post-lockdown scenarios were simulated. Trained manpower and ventilators were identified as key health-care constraints. Partial community containment measures will require to be continued after the current lockdown is lifted.

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Introduction

With the number of Coronavirus disease 19 (Covid-19) cases rising steadily in India, the central government announced a lockdown from March 25, 2020, until April 14, 2020, that was subsequently extended to May 3, 2020, and beyond.1 A stochastic mathematical model to study the impact of non-pharmaceutical interventions (NPIs) on the growth of the epidemic was published earlier.2 The study showed that the peak number of infectious cases decreased rapidly as a greater percentage of them were quarantined or isolated.3 Successful isolation of more than 40–50% of infectious cases was shown to be associated with reduction in the increase in the number of cases to numbers that could be managed within existing health-care resources.

Steady state of the epidemic shall eventually be reached when herd immunity is achieved either through natural transmission or development of an effective vaccine.3 Until then, it is imperative to protect those who are vulnerable, like the elderly or those with specific comorbidities.4 It is equally important to build capacity to handle the expected surge in cases. All NPIs, including lockdown, lower and delay the increase in the number of cases, making available precious time required for capacity building. Lockdown also comes with considerable economic, social, and cultural costs.5

There is a need to identify optimal strategies to be implemented after lifting of lockdown in India. Our study modeled various post-lockdown scenarios and evaluated key health-care constraints. Our aim was to identify the scenarios in which health-care availability would not be overwhelmed by the epidemic.

Material and methods

The impact of NPIs, including community containment, on growth of the pandemic in India and selected nations was mapped, to identify possible post-lockdown trajectories, using the data available in the public domain.6

The effect of increasing fraction of isolation/quarantine of infectious cases was studied using a stochastic mathematical model.3 A SEIR compartment model was modified to account for infectious cases that were isolated, preventing spread to the susceptible population (Table 1 and Suppl Table 1). The death rate was stratified across age with a calculated mean infection fatality rate of 0.498% (Suppl Table 2).7–9

The number of individuals quarantined (Q0) was assumed to be the sum of the number of patients under active treatment and/or quarantined/isolated. The initial number of infectious patients (I0) was estimated from Q0, assuming that Q0 is q% of total infectious cases (I0 + Q0) (Suppl Table 3). Initial numbers of cases quarantined, recovered, and dead were taken from data Ministry of Health & Family Welfare, Govt of India (MOHFW, GOI), on Apr 7, 2020.

To measure the effectiveness of prevention of transmission, a “q-metric” was created. The q-metric represents the percentage of infectious individuals in the population who were successfully contained (not allowed to transmit the infection to others). This was generated across various proportions from 1% to 90%.

Various hypothetical post-lockdown scenarios were modeled for India. These ranged from total lifting of lockdown (permitting unrestricted mixing of the population) to extension of enforced lockdown (until current natural transmission subsides) and various possibilities in between.

Constraints were listed regarding delivery of effective health care for the COVID-19 epidemic in India, and their criticality was evaluated using Delphi method (Suppl Table 4). Criticality was assessed under the broad categories of infrastructure (creating intensive care units [ICUs], facilities for isolation of large numbers of cases), medical equipment (ventilators, other ICU equipment, personal protective equipment [PPE] for health-care providers, test kits), personnel requirements (upscaleing of ICU personnel, including training), and logistic processes (agility of response)10 (Table 2).

Capacity building constraints were matched against modeled scenarios. Feasible scenarios thus generated yielded planning inputs in terms of the likely number of cases, hospitalizations, and ICU admissions (Suppl Table 2).7–9 These scenarios were stochastically simulated to generate confidence intervals (Suppl Table 5). Monitoring mechanism to assess the effectiveness of prevention of transmission was evaluated using the “q-metric.” Death due to COVID-19 on a given day was taken as the input, which can be indirectly extrapolated to the number of active cases in the population around two weeks earlier (Suppl Table 6).7,11,12 An algorithm was developed to estimate trajectory using the death rate and progression of the epidemic. The total number of cases dead on a given day yielded the likely number of cases 14 days earlier.11 Using the doubling rate on that day, the likely number of cases on the initial day was now calculated. All mathematical models were developed using MATLAB/SIMULINK and SimVoi add-in for Microsoft Excel software.

Results and discussion

Plotting the growth of cases shows that NPIs used in the population, including lockdown, appear to have an effect in reducing the rate of growth (Fig. 1a and b). This is also further reflected in reduction of death rates (Fig. 1c and d).

Scenarios from other nations

Scenarios of different countries that had imposed some variation of community containment were compared (Suppl Fig 1). China was the only country that had imposed complete community containment in affected areas and removed restrictions later.13 On March 9, 2020, complete lockdown was imposed all over Italy, which was to be in place until April 13, and has then been extended up to May 3.14,15 Spain was placed in lockdown since March 14 for 4 weeks.16

Countries such as South Korea have followed a different path of early detection of infected patients through intensive contact tracing and testing. By successfully isolating people...
who have come in contact with cases, they have managed to keep their numbers low, without lockdown. The USA has adopted some NPIs such as social distancing. Although the USA has the highest number of COVID-19 cases, it has not yet proposed lockdown.

Post-lockdown scenarios

The post-lockdown scenario with minimally restricted mixing of the population using a “q-metric” of 1 yielded a curve with the epidemic peaking by the end of June 2020, with a total of 1086 million cases (Fig. 2). This scenario represents isolation of only those detected to be COVID-19 positive and hospitalized. At its peak, there would be 102 million active cases translating to peak critical care and ventilator requirements of approximately 800,000 ICU beds (Suppl Table 3). This represents a 20- to 25-fold increase over current availability.

It was shown that effective containment of >50% of infected cases was required to drastically reduce case numbers. We next modeled continuing stringent lockdown until the transmission to fresh cases had ceased and the number of new cases reached zero. This would be achieved by isolation of 50–90% of infectious persons, representing a “q-metric” of 50–90 (Fig 3).

This implies continued lockdown until mid-August when India would reach less than 100 active cases. This scenario, although mathematically elegant and possibly successful like in China, would come at significant economic and social costs, making it unfeasible. Permitting international travel during or after, might result in reseeding, as had happened in Heilongjiang province of China.

Multiple possibilities in between the two extreme scenarios described previously were modeled, reflecting intermediate levels of a “q-metric” of 10–40 (Suppl Fig 2 and Suppl Table 5). On the ground, these partial containment measures could be targeted at specified geographical areas or hot spots (e.g., a city or its part), specified at-risk populations (e.g., the elderly older than 65 years), or specified events (e.g., social, religious, sports-related, educational, entertainment-related, or political mass gatherings).

Community containment requires ongoing commitment from three groups. The health-care sector must continue to provide treatment to patients with COVID-19, along with aggressive contact tracing and isolation. The population must contribute by practicing health-affirming actions, such as wearing masks, handwashing, and personal hygiene, to reduce the risk of transmission to each other and especially to

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**Table 1 — Assumptions for the stochastic mathematical model.**

| Parameter | Value | Remarks |
|-----------|-------|---------|
| Incubation period (1/ε) | Mean = 5.1 days, shape = 0.1 | Gamma distributed |
| Infectious period (1/γ) | Mean = 7 days, shape = 0.1 | |
| Basic reproduction number (R₀) | Mean = 2.28, shape = 0.1 | |
| Mean death rate | 0.498% | |
| Period quarantined (qₜ) | 14 days | |
| No. of cases quarantined (Q₀) | 4312 | Data from the MOHFW website as on April 7, 2020 |
| No. of cases recovered (R₀) | 352 | |
| No. of deaths (D₀) | 124 | |
| Population of India (N)** | 1375.98 million | |
| Calculated growth rate¹ | 1.15 (rand triangular [1.11, 1.15, 1.19]) | Simulated on SimVoi software |
| Hospitalization rate | 3.22% (rand triangular [1.92, 3.22, 6.92]) | |
| ICU admission rate | 0.642% (rand triangular [0.382, 0.642, 1.31]) | |
| Death rate | 0.498% (rand triangular [0.21, 0.498, 0.77]) | |

ICU = intensive care unit.

** Ministry of health & Family Welfare (MOHFW); rand = random.
** Projected population of India on 20 Mar 2020 from https://www.worldometers.info/world-population/india-population/.
¹ Growth rate was calculated from data available on MOHFW website from 04 Mar-22 Mar 2020.

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**Table 2 — Key constraints (from the Delphi study in Supplementary Table 4).**

| ICU Eqpt | Ventilators
|---------|--------------------------------------------------|
| ICU infrastructure | Multiparameter monitors
| Reserves of ICU equipment (including ventilators) and PPE | PPE for all personnel (with a N95 mask and face shield)
| ICU planning unit | Disinfectant solutions (adequate amounts)
| ICU equipment (including ventilators) and PPE | Module of 10 beds in clusters
| Type of response | Central (5–7%)
| Personnel and training | State (15%)
| Procurement of drugs | Agile – hot spot focused

ICU = intensive care unit; PPE = personal protective equipment.
the high-risk groups.\textsuperscript{4,20–22} High-risk individuals such as the elderly and those with comorbid conditions have to take all precautionary measures to prevent contracting the infection\textsuperscript{4,20,21} (Suppl Table 7). Good governance is the third arm that ensures resolute implementation, together with adequate and agile supply chains. This enables the other two to be effective.

**Health-care requirements**

India has 30,000–50,000 ICU beds with ventilators, translating to 2.18–3.64 per 100,000 population (Suppl Fig 3).\textsuperscript{23} A large proportion of these beds are already occupied by patients with other ailments, which will continue to be so. Thus, capacity inevitably has to be expanded to meet the additional demands. Expansion with a modular plan of a 10-bedded ICU setup, in clusters, appears workable from a logistics and personnel point of view. This might require upscaling of existing ICUs and/or creating new COVID-19 ICUs. Designated COVID-19 hospitals will be required to manage moderately and severely symptomatic patients.

The asymptomatic or mildly symptomatic patients need isolation, which can be provided at separate COVID-19 care centers set up in public spaces (schools, other public buildings, stadiums, and so on). China had set up Fancang holding centers in stadiums where the nutritional, hygiene, and other needs of the positive cases were met, while they were medically monitored and evacuated to health-care facilities in case of worsening of symptoms.\textsuperscript{24} It is important to ensure that the asymptomatic or mildly symptomatic cases do not burden the already stretched health-care facilities.\textsuperscript{21}

Currently, ICU teams are usually led by intensivists, anesthesiologists, or physicians. It is roughly estimated that 60,000–80,000 such specialists (team leaders) exist in India who can operate complex ventilators effectively, which would be required for critical COVID-19 cases (Suppl table 8). Of these, maybe 25% can be spared for COVID-19 duties immediately without compromising the rest of health-care delivery. A 10-bedded COVID-19 ICU (with 5–7 ventilators) translates to 6000–8000 such modular units, each catering to approximately 2 lakh population. Each ICU will have to run 6-hourly shifts, each requiring a team leader, who will work 1 week every fortnight. This translates to 48,000–64,000 team leaders; of which, around 20,000 are already available. Expansion of manpower will require evolving a rapid training program conducted in functioning ICUs, in the duration before numbers rise exponentially.
Personal protective equipment is a protective gear designed for safety of health-care workers to minimize exposure to a biological agent (Suppl Table 9). PPE is required at multiple locations including screening clinics, sample collection areas, isolation wards, and ICUs. The estimated requirements of PPE are elaborated in Supplementary Table 9. As the epidemic spreads, the requirement for testing shall increase exponentially too, quickly overwhelming available capacity. There is not only a need to enhance the testing capacity but also a need to constantly evolve novel algorithms for diagnosis and incorporate cheaper and easier antibody testing.

Agility of organizational response is imperative. While catering for ventilators, it is expected that hot spots will appear at random locations. This has to be met with a reserve pool of personnel and equipment maintained centrally and at state levels, available for relocation at short notice.

Constraints to capacity building

Shortage of trained manpower to operate ventilators was identified as the key constraint. The maximum number of ventilators that can be operated will be limited by the availability of team leaders, i.e., specialists capable of operating ventilators comprising intensivists, anesthesiologists, and physicians. As the number of cases rise, more of these specialists can be pressed to duty, and the team can be augmented by pulmonologists, pediatricians, and so on in the expansion phase without significant additional training. In the surge phase, more numbers will be required. Therefore, short-course training of suitable personnel (physicians and other clinical specialties) needs to be planned and undertaken immediately to prepare for surge when it happens.

Shortage of ventilators was identified as the other key constraint. It was estimated that India can realistically upscale ventilator numbers by 2 times to 40,000 additional units. This would require an expanded production capacity of 5000 ventilators per month, together with a successful import of 10–12,000 ventilators. Thus, we can expect 80,000–85,000 total ventilators by October 2020; of which, not more than 40,000–50,000 can be dedicated for COVID-19 ICUs. This number might marginally increase if some of the low-cost innovations in ventilators are used for non-COVID-19 cases, permitting redistribution of existing ventilators. Of the 50,000 ventilators dedicated for COVID-19 cases, 5–10% should be held as reserve (between the center and states) for rapid deployment to hot spots as required.

The other important constraint was PPE. Although most of the PPE units can be sourced from manufacturers of hazmat (biological hazardous material) suits and other niche producers, the requirement for large numbers of N95 masks will have to be specifically addressed. In addition, the logistics of delivering complete sets, not component items, to hospitals needs to be ensured, to reduce procurement woes. It was estimated that 10,460 PPE units were required for 1000 diagnosed cases (Suppl Table 10). One simple innovation, the Korean sample collection kiosk, might reduce the requirement of PPE partially, and requires exploration. However, collection of samples using the kiosk may impact sensitivity owing to practical considerations and needs further study.

Lifting the lockdown

How long to extend the lockdown then becomes a critical question. For the epidemic to die down, effective lockdown with a “q-metric” of 50 or more is required to be continued at least until mid-August as mentioned earlier.
In case that is not feasible and the lockdown is to be lifted before that, there is no option but to follow it up with partial community containment. To keep the number of patients with COVID-19 requiring utilization of these health-care resources to below the possibly expanded capacity, it would be imperative to keep the peak number of infectious cases below 6 million. At a “q-metric” of 19, the peak ventilator requirement of 44,575 (\(\pm 11,092\)) falls within the assumptions of expanded capacity (Suppl Fig 4, Table 3). This implies that if we manage to prevent 19% or more of infected cases from transmitting the disease, then India will stay within the projected health-care constraints (Fig 4).

**Monitoring**

There is a need to establish a monitoring system that should be able to track if the measures of containment fall below the expected trajectory of a q-metric of 19. Universal testing is impractical, given the size of our population. There is no ready surrogate measure available for the number of infectious cases in the population to track the effectiveness of containment measures. An objective measure available is the deaths due to COVID-19 on a given day, which can be indirectly extrapolated to the number of active cases in the population around two weeks earlier (Suppl Table 6). A simple monitoring system is devised. Using the actual number of deaths, the model estimated the total cases in the population. The ratio between the detected cases and predicted cases was plotted against containment bands to estimate the effectiveness of NPIs (Fig 5). This reveals the current q-metric achieved.

This would aid in decision-making about containment measures. It is envisaged that there would be areas of high concentration or high growth rates (local hot spots) that would continue to keep appearing across the country at various times. These hot spots may require a localized intensive response such as the Bhilwara model. Among Indian states, the state of Kerala has shown excellent containment. This has been

| q (%) | Total cases | Date of peak of the epidemic | Peak active cases | Peak ICU bed requirement | Total ICU admissions | Total deaths |
|-------|-------------|-----------------------------|-------------------|-------------------------|---------------------|-------------|
| q15   | 298,890,278 | Early October 2020          | 13,307,758 (12,820,516 e 13,795,000) | 103,615 (\(\pm 26,112\)) | 2,311,013 (\(\pm 572,023\)) | 1,456,590 (\(\pm 340,127\)) |
| q16   | 244,339,895 | Mid-October 2020            | 10,092,754 (8,779,939 e 11,405,569) | 77,524 (\(\pm 19,991\)) | 1,892,926 (\(\pm 471,907\)) | 1,218,610 (\(\pm 275,135\)) |
| q17   | 224,348,556 | Mid-October 2020            | 9,503,508 (8,235,402 e 10,771,615) | 73,459 (\(\pm 18,816\)) | 1,746,056 (\(\pm 425,400\)) | 1,108,476 (\(\pm 257,078\)) |
| q18   | 186,892,733 | Mid-October 2020            | 8,018,591 (6,798,213 e 9,238,969) | 62,424 (\(\pm 15,416\)) | 1,446,480 (\(\pm 360,207\)) | 928,644 (\(\pm 213,735\)) |
| q19   | 154,878,189 | Early November 2020         | 5,813,361 (4,914,345 e 6,712,376) | 44,575 (\(\pm 11,092\)) | 1,196,219 (\(\pm 305,333\)) | 769,682 (\(\pm 175,224\)) |
| q20   | 125,894,126 | Early November 2020         | 4,507,022 (4,242,217 e 4,771,827) | 35,299 (\(\pm 8,008\)) | 989,678 (\(\pm 244,642\)) | 617,032 (\(\pm 143,904\)) |

ICU = intensive care unit.
achieved by vigorous contact tracing, effective surveillance, efficient isolation/quarantine, and dedicating specialized COVID-19 care wards. However, replication of models might be difficult because of varying local conditions such as demographics, administrative capability and so on, and some models may be unscalable.

Limitations

This model has similar limitations as other predictive mathematical models. For ease of modeling, we have assumed homogenous distribution of the Indian population that does not capture variations in population density or the urban–rural variations. We have also assumed equal susceptibility to COVID-19, which does not cater for variation in mixing, with stratification for age, occupation, and travel. We have not modeled for pre-existing comorbidities, which alters outcomes. The estimated Infection Fatality Rate will undergo revision as more data becomes available.

For Delphi technique, only a small number of doctors were included. The modeling was not conducted for economic, social, and cultural costs. The present model is based on early data available on public platforms until April 7, 2020. Future models may include more data, leading to better predictions.

Conclusion

Our model revealed that “q-metric” appeared to be a promising way to evaluate the spread and to monitor the epidemic. Mathematically, continuing lockdown, reflected in a ‘q-metric’ of 50 or more until mid-August is the most effective solution for the epidemic to die down. As that might not be feasible owing to economic and social compulsions, the lockdown is likely to be lifted earlier. As such, the model indicates achievement of a q-metric of 10 during lockdown. The key constraints were identified as trained personnel to lead ICUs and ventilator requirement. Our health-care resources can at best be expanded to cater for the peak of the epidemic reflected at a “q-metric” of 19.

To achieve this, the health-care sector is required to continue aggressive contact tracing, expanded testing, and isolation of cases. The population would have to settle down to a collective “new normal” of physical distancing, universal handwashing, wearing masks, protection of at-risk individuals, and reduction of mass gatherings. Efficient governance would enable health-care and population measures to be effective.

Disclosure of competing interest

The authors have none to declare.

Acknowledgments

The authors would like to thank the following people: Shankar Narayan, Commanding Officer, INHS Kalyani, Visakhapatnam; R. Setlur, Professor and HOD, Department of Anesthesia, Armed Forces Medical College, Pune, and N. Jahan, Associate Professor, Department of Anesthesia, Armed Forces Medical College, Pune.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mjafi.2020.06.004.

REFERENCES

1. India Lockdown news. India to be under complete lockdown for 21 days starting midnight: Narendra Modi. Available at: https://economictimes.indiatimes.com/news/politics-and-
nation/india-will-be-under-complete-lockdown-starting-midnight-narendra-modi/articleshow/74796908.cms?from=mdr. Accessed April 6, 2020.

2. Chatterjee K, Chatterjee K, Kumar A, Shankar S. Healthcare impact of COVID-19 epidemic in India: a stochastic mathematical model. Med J Armed Forces India. 2020;76:147–155. https://doi.org/10.1016/j.mjafi.2020.03.022.

3. Fine P, Eames K, Heymann DL. “Herd immunity”: a rough guide. Clin Infect Dis. 2011;52:911–916. https://doi.org/10.1093/cid/cir007.

4. CDC. Coronavirus disease 2019 (COVID-19). Centers for disease control and prevention. Available at: www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/people-at-higher-risk.html. Accessed April 8, 2020.

5. Karron J. A simple decision analysis of a mandatory lockdown response to the COVID-19 pandemic. Appl Health Econ Health Pol. 2020. https://doi.org/10.1007/s40258-020-00581-w.

6. Homepage. European centre for disease prevention and control. Available at: https://www.ecdc.europa.eu/en. Accessed April 10, 2020.

7. Verity R, Okell LC, Dorogati I, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. Lancet Infect Dis. 2020. https://doi.org/10.1016/S1473-3099(20)30245-7.

8. Population Pyramids of the World from 1950 to 2100. PopulationPyramid.Net. Available at: https://www.populationpyramid.net/india/2019. Accessed May 6, 2020.

9. Ferguson NM, Laydon D, Nedjati-Gilani G, et al. Impact of Non-pharmaceutical Interventions (NPIs) to Reduce COVID-19 Mortality and Healthcare Demand. Imperial College COVID-19 Response Team; 2020.

10. Janati A, Hasanpoor E, Hajebrakhimi S, Sadeghi-Bazargani H, Khezri A. An evidence-based framework for evidence-based management in healthcare organizations: a Delphi study. Ethiop J Health Sci. 2018;28:305–314. https://doi.org/10.4314/ ejhs.v28i3.8.

11. Russell TW, Hellewell J, Jarvis CI, et al. Estimating the infection and case fatality ratio for coronavirus disease (COVID-19) using age-adjusted data from the outbreak on the Diamond Princess cruise ship, February 2020. Euro Surveill. 2020:25. https://doi.org/10.2807/1560-7917.ES.2020.25.12.2000256.

12. Coronavirus(Covid-19) updates worldwide & India with state wise status. COVID-19. Available at: https://covidindia.org/. Accessed May 6, 2020.

13. Lai H, Khosrawipour V, Kochba P, et al. The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. J Trav Med. 2020. https://doi.org/10.1093/jtm/taaa037.

14. Faterlini M. Lockdown in Italy: personal stories of doing science during the COVID-19 quarantine. Nature. 2020. https://doi.org/10.1038/d41586-020-01001-8.

15. Available at: www.governo.it. Accessed April 13, 2020. www.Governo.It. http://www.governo.it/it.

16. La Moncloa. Government to Ask Lower House to Extend State of Emergency to 25 April [President/News]; 04/04/2020. Available at: https://www.lamoncloa.gob.es/lang/en/presidente/news/Paginas/2020/20200404/emergency-extend.aspx. Accessed April 8, 2020.

17. disease 19(COVID-19) M of H and W Coronavirus. Coronavirus disease 19(COVID-19). Coronavirus disease 19(COVID-19). Available at: http://ncov.mohw.go.kr/en/. Accessed April 8, 2020.

18. Countries are imposing coronavirus lockdowns. China’s example highlights the costs - CNN. Available at: https://edition.cnn.com/2020/03/16/asia/coronavirus-xi-wuhan-anger-intl-hnk/index.html. Accessed April 10, 2020.

19. China faces fresh virus threat from its border with Russia - bloomberg. Available at: https://www.bloomberg.com/news/articles/2020-04-07/china-faces-fresh-virus-threat-from-its-border-with-russia. Accessed April 10, 2020.

20. Q&A on coronaviruses (COVID-19). Available at: https://www.who.int/news-room/q-a-detail/q-a-coronaviruses. Accessed April 11, 2020.

21. MoHFW. Home. Available at: https://www.mohfw.gov.in/. Accessed April 1, 2020.

22. Coronavirus and COVID-19: who is at higher risk?. Available at: https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/coronavirus-and-covid19-who-is-at-higher-risk. Accessed April 11, 2020.

23. Jayaram R, Ramakrishnan N. Cost of intensive care in India. Indian J Crit Care Med. 2008;12:55–61. https://doi.org/10.4103/0972-5229.42558.

24. Chen S, Zhang Z, Yang J, et al. Fangcang shelter hospitals: a novel concept for responding to public health emergencies. Lancet. 2020. https://doi.org/10.1016/S0140-6736(20)30744-3.

25. GuidelinesonrationaluseofPersonalProtectiveEquipment.pdf. Accessed May 6, 2020. https://www.mohfw.gov.in/.

26. COVID-19 | Indian Council of Medical Research]. Government of India; 2020. Available at: https://icmr.nic.in/node/39071. Accessed April 10, 2020.

27. Kerala Sets up South Korean-style COVID-19 Testing Kiosks. The News Minute; 2020; Available at: https://www.thenewsminute.com/article/kerala-sets-south-korean-style-covid-19-testing-kiosks-first-india-121973. Accessed April 10, 2020.

28. Bhilwara Model: How This Rajasthan District Brought Covid-19 under Control. Business Standard News; 2020; Available at: https://www.business-standard.com/article/current-affairs/bhilwara-model-how-this-rajasthan-district-brought-covid-19-under-control-120041000286_1.html. Accessed April 10, 2020.

29. A ‘Kerala Model’ Worthy of Emulation. Deccan Herald; 2020. Available at: https://www.deccanherald.com/opinion/first-edit/a-kerala-model-worthy-of-emulation-823916.html. Accessed April 13, 2020.