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COVID-19 in India: Disease Burden, Managing the Second Wave and Innovations

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COVID-19 in India: Disease Burden, Managing the second wave and Innovations

ICT India Working Paper #54

Nirupam Bajpai and Manisha Wadhwa

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Center for Sustainable Development
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Executive Summary

The second wave of COVID-19 caused havoc across India. It was twice as severe as the first one. More than 400,000 COVID-19 cases per day were being reported. The worst affected states were Maharashtra, Kerala, Karnataka, Tamil Nadu, Delhi and Andhra Pradesh. The spike in cases was largely assumed to be the result of leniency in COVID-19 appropriate behaviour, such as people were not wearing masks, resumption of economic activity, gathering in large numbers e.g. in marriages, political meetings, rallies, IPL matches, religious gatherings like Kumbh Mela etc.

67 percent of India's population above the age of six years has been exposed to COVID-19 according to a national serological survey conducted by ICMR, the findings of which were revealed on July 20, 2021. The survey was conducted during June and July across 70 districts of 21 states. These are the very same districts where three earlier rounds of sero surveys were conducted during May-June 2020; August-September 2020 and December-January 2020/21.

On January 16th 2021, India launched the world's largest vaccination drive and as of July 15, more than 391,340,491 vaccine doses had been administered across the country. The vaccine has been administered in a phased manner with the initial focus being on priority groups like health workers, frontline workers like the police workforce, municipal workers, defence personnel etc., people above 60 years of age and those between 45-60 years with co-morbidities. From May 1, 2021, people between age group 18-45 were also eligible for vaccination. But, until a substantial proportion of the population is vaccinated, precautionary measures like wearing masks, sanitization, regular hand washing and physical distancing must remain the mainstay.

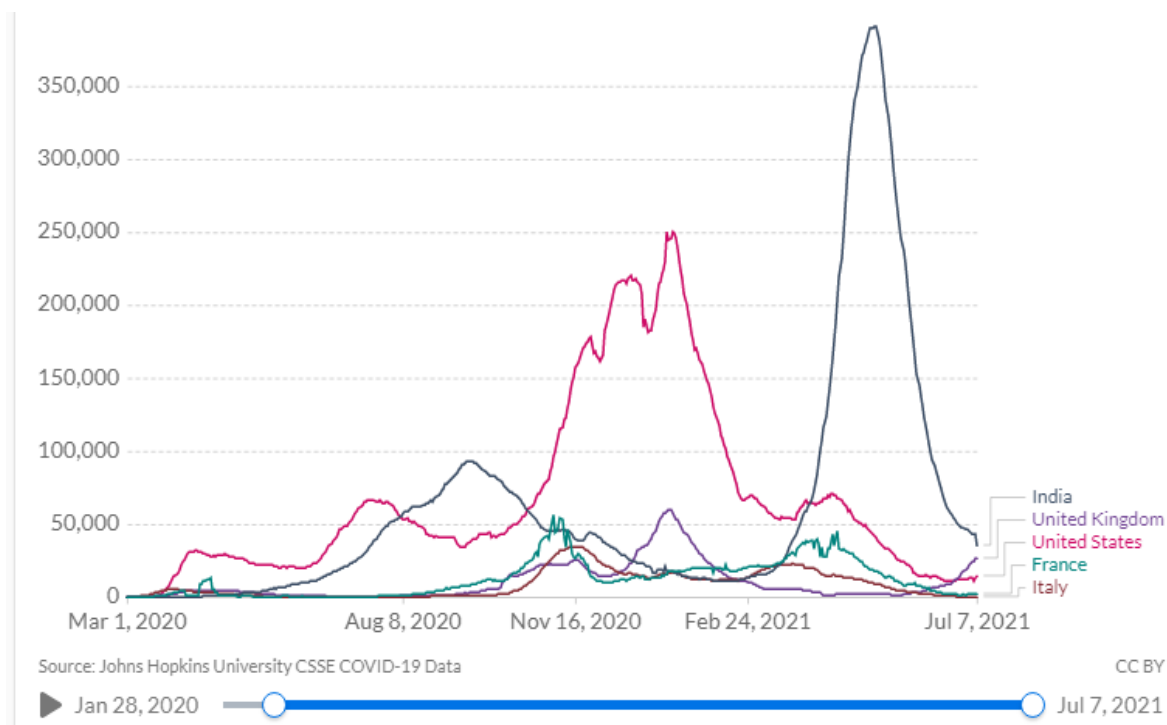
Inter-departmental coordination has been the cornerstone in dealing with COVID-19 situation in India. Various departments such as Health, Tourism, Defence, Information and Communication Technology (ICT), Finance etc. took various initiatives in collaboration with other departments to deal with the pandemic. Challenges posed by COVID-19 also sparked a wave of innovations across sectors in India. A host of new interventions were implemented by various departments, such as health, agriculture, education, police, railways etc.

This document is based on secondary data collected from government documents and websites, news reporting, media interviews, newspaper articles, various national and international journals and private websites. The present paper discusses current scenario of COVID-19 in India, COVID-19 vaccination drive, innovative approaches to address vaccine hesitancy in India, inter-departmental coordination and innovation across sectors in dealing with COVID-19 situation. We also put forward recommendations to deal with the surge in COVID-19 cases in future and to scale up innovations and undertake research studies to identify gaps and address challenges.

Introduction

The second wave of Covid-19 pandemic in India has been more devastating than the first (see Figure 1)(Our World in Data 2021). The daily cases during the second wave peaked on May 6, with more than 414,000 cases¹.

Figure 1: Daily New Confirmed COVID-19 Cases



Source: Our World in Data. 2021. "Daily New Confirmed COVID-19 Cases." 2021.

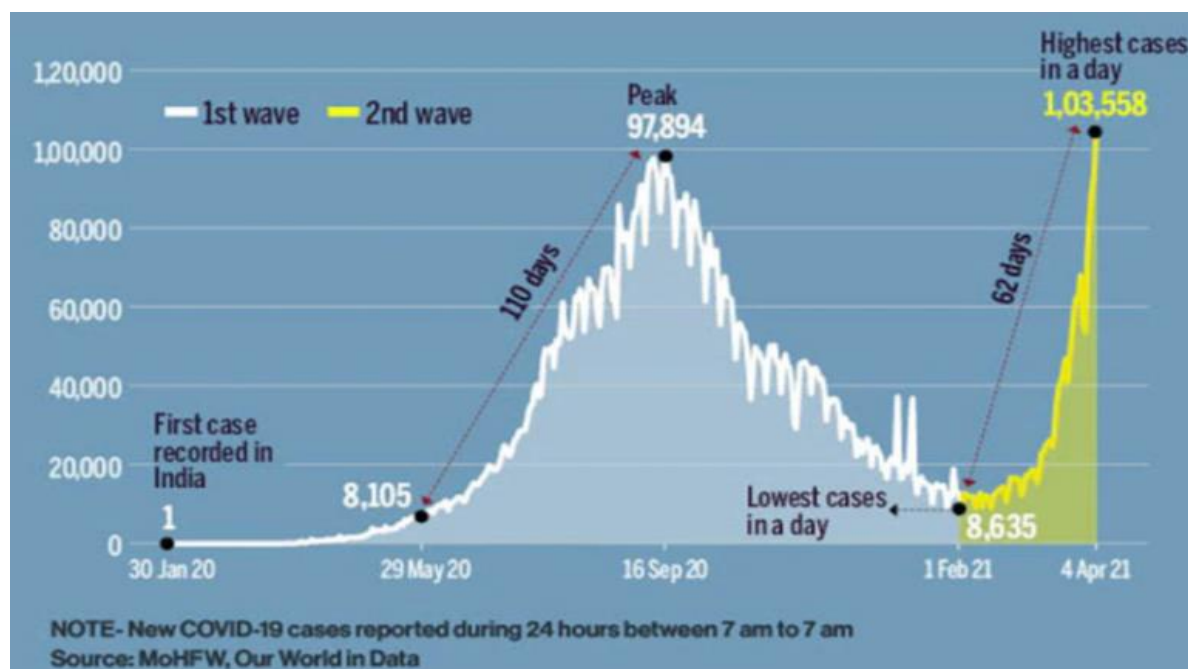
<https://ourworldindata.org/coronavirus/country/india?country=~IND>

With the beginning of the year 2021, new cases fell dramatically, however cases began to rise again from early March 2021. The second wave of COVID-19 has been twice as severe as the first one(Times of India 2021). During the first wave, it took 110 days for cases to rise from 8,105 in May 2020 to 97,894 in Sep 2020, while it took only 62 days for second wave to rise from 8,635 in Feb 2021 to 103,558 on April 5, 2021(see Figure 2)(Sharma and Kapoor 2021). However, unlike the first phase, the spread of cases was restricted only to selected states. More than 55% of total cases were reported from five states: Maharashtra, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh². COVID-19 related deaths also showed an increase by 51% since December 21-27)(Times of India 2021).

¹ <https://indianexpress.com/article/explained/india-covid-situation-coronavirus-deaths-how-far-is-peak-7328929/>

² https://cdn.who.int/media/docs/default-source/wrindia/situation-report/india-situation-report-63.pdf?sfvrsn=7d4fae4e_4

Figure 2: Second wave of COVID-19 is twice as severe as the first one



Source: Sharma, Manoj, and Mudit Kapoor. 2021. "From 8,000 to 1 Lakh in Just 62 Days; 2nd Covid-19 Wave Is More Infectious than 1st." 2021.

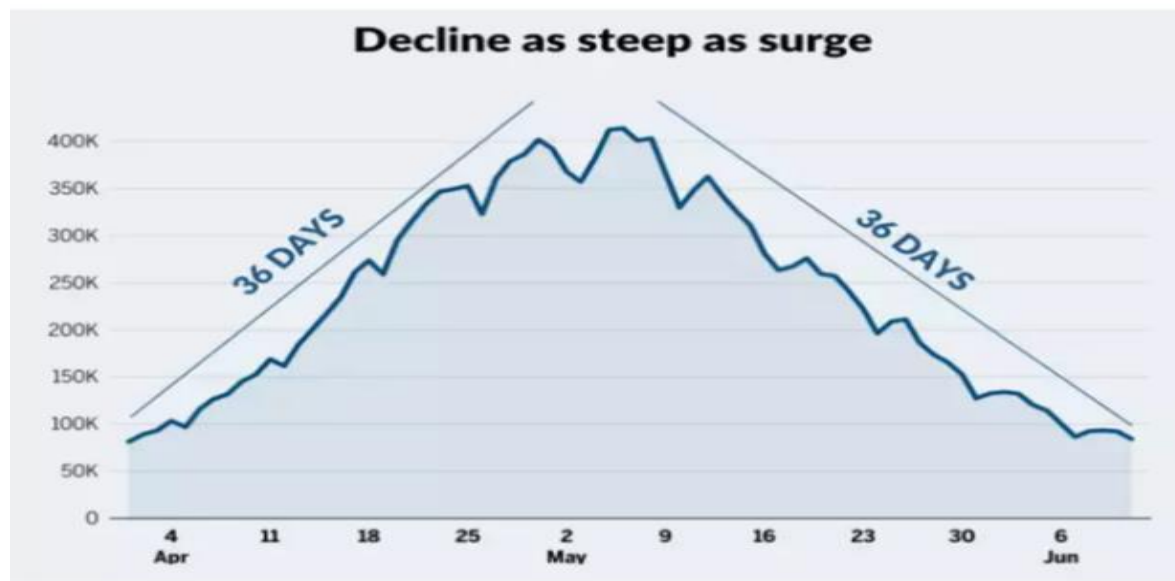
<https://www.businesstoday.in/coronavirus/from-8000-to-1-lakh-in-just-62-days-2nd-covid-19-wave-more-infectious-than-1s/story/435863.html>.

Many possible explanations emerged for the steep rise in cases during the second wave. Many thought that mutants of COVID-19 were responsible for this. The Indian SARS-CoV-2 Consortium on Genomics (INSACOG) conducted genome sequencing and analysis of 771 variants from 10,787 COVID-19 positive samples shared by various states/union territories (Ethiraj 2021). However, it was found that variants have not been detected in numbers sufficient to explain the rapid rise in cases. With the lowering of cases in early 2021, many people thought that herd immunity is already there and consequently at the individual level COVID-19 related precautions were not followed stringently. For instance, people were not wearing masks, gathering in large numbers for celebrations both in outdoor and indoor places etc. With the resumption of economic activity, a large number of people were brought together for a long period of time such as in work places like offices, factories, during transport in train, metro, buses etc. Because of block, local body and assembly level elections, a large number of political meetings and rallies were also organized. The IPL cricket matches and large religious gatherings during Kumbh Mela could also be a reason for the spike in cases. A lack of credible health information systems, particularly at smaller geographical levels in India, was also thought to be one of the reason for escaping the warning signals of the deadly second wave (Mehdi 2021).

Although the cases rose steeply during the second wave, but the decline was also as steep as the surge (see Figure 3). It took around 36 days to go from 80,000 COVID-19 cases on April 1 to

more than 414,000 cases on May 6 (the highest reported during the second wave)(Bhatnagar 2021). The decline in numbers thereafter has been just as quick and took almost the same time to fall back to similar numbers.

Figure 3: Decline in COVID-19 cases during second wave as steep as surge



Source: Bhatnagar, Armaan. 2021. “In 5 Charts: How India’s Second Wave Is Declining as Quickly as It Peaked.” 2021. <https://timesofindia.indiatimes.com/india/in-5-charts-how-indias-second-wave-is-declining-as-quickly-as-it-peaked/articleshow/83462403.cms>

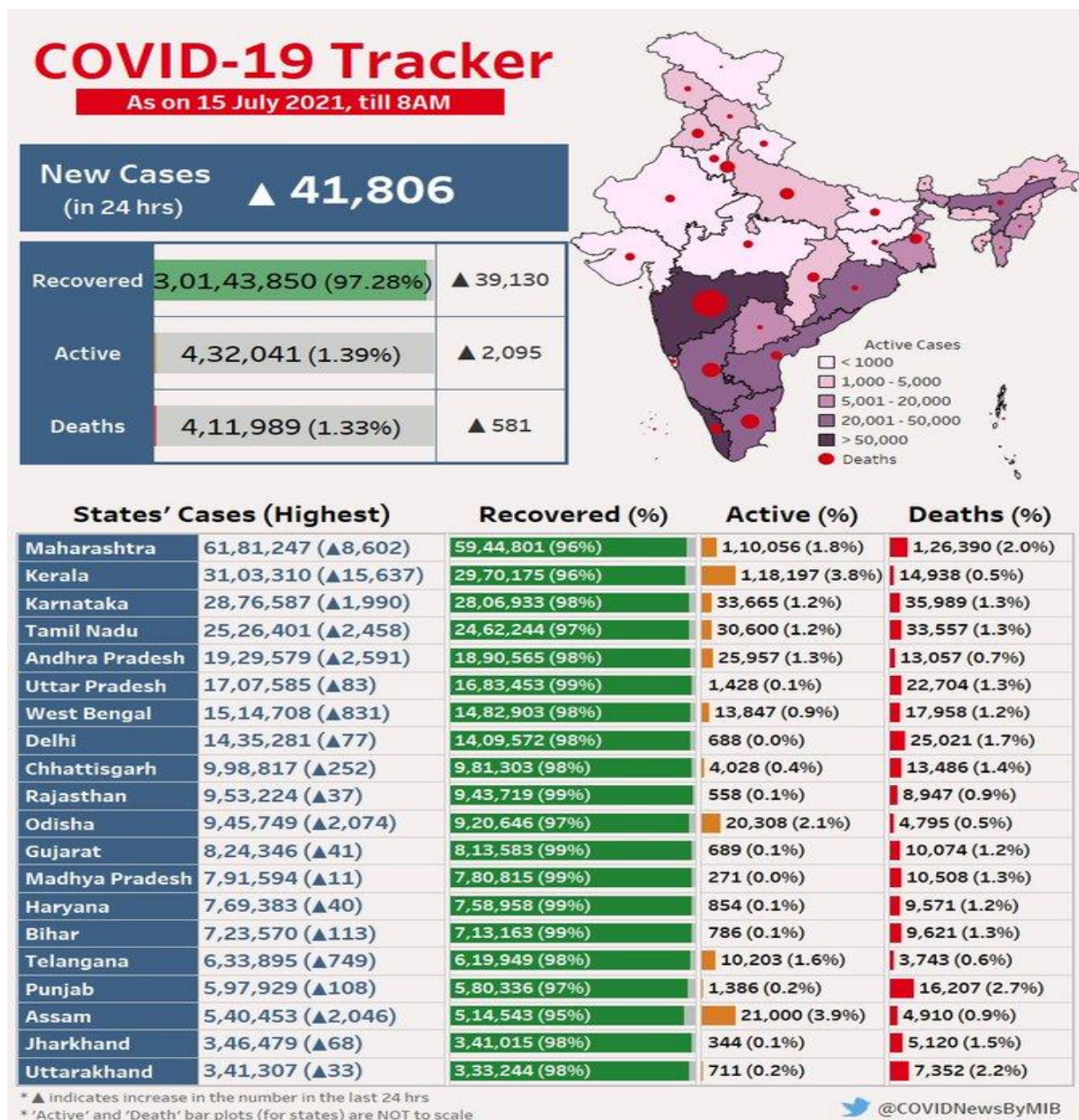
Both central and state governments took various measures to tackle second wave of COVID-19 in India. To deal with the shortage of oxygen cylinders, the central government provided an oxygen quota for all the states. Railways, airports and military were used for transporting liquid oxygen to states(Press Trust of India 2021). The bed capacity in COVID care centres and hospitals was also ramped up. More and more emphasis was laid on COVID appropriate behaviour such as wearing masks, maintaining physical distancing, regular hand washing and sanitization etc. Initially, many states implemented night curfews from 10 pm to 5/6 am to prevent unwanted movement of people, but later with the rise in cases lockdown was imposed in the worst affected states, apart from continued provision of essential services(Kapur 2021). Public gatherings in many states was limited to 20-50 people. The vaccination program was expanded to include all the adults above 18 years of age. RBI Governor announced various measures to deal with the financial crisis in the country(India Today 2021a).

The Delta variant of COVID-19 was responsible for the second wave across India, which was twice deadly as the first wave. Now, Delta plus strain which is a more lethal strain than Delta is assumed to drive a potential third wave in India. Delta plus has been found in samples from various states: Maharashtra, Kerala, Madhya Pradesh, Uttar Pradesh, Punjab, Gujarat, Andhra Pradesh, Odisha, Rajasthan, Jammu and Kashmir, Haryana and Karnataka(Biswas 2021;

Mehrotra 2021). Further, a new COVID-19 variant called ‘Lambda’ which is much more dangerous than the Delta strain has begun to appear in more than 30 countries(ANI 2021).

As on 15th July 2021,overall 30,987,880 COVID-19 cases have been reported in India, out of which 30,143,850 have recovered, 432,041 are active cases and 411,989 are deaths(see Figure 4) (Ministry of Health and Family Welfare, Government of India 2021).

Figure 4: COVID-19 cases in India



Source: Ministry of Health and Family Welfare, Government of India. 2021.

“CoronaVirusUpdates.” Twitter.

<https://twitter.com/COVIDNewsByMIB/status/1415537019095175168>

One of the rising concerns is the increasing test positivity rate in the districts of northeast. During the week of July 5- July 11, out of 58 districts which reported a test positivity rate of more than 10%, 37 were from the northeast region. Further, disproportionately lower share of RT-PCR test and more number of Rapid Antigen Tests (RAT) tends to result in high number of false positives (see Figure 5)(M Sheriff 2021).

Figure 5: Rising test positivity rate in the districts of northeast

RISING CONCERN

	Districts above 10% positivity	% RT PCR testing	First dose vaccine coverage*
Arunachal Pradesh	5	3%	61%
Assam	4	12%	29%
Manipur	8	19%	40%
Meghalaya	7	17%	34%
Mizoram	3	17%	74%
Nagaland	3	37%	30%
Sikkim	4	73%	95%
Tripura	3	28%	74%

** as a percentage of projected 18+ population*

Source: M Sheriff, Kaunain. 2021. "60% Districts with High Positivity in Northeast, PM to Meet CMs Today." 2021. <https://indianexpress.com/article/india/coronavirus-60-per-cent-dists-with-high-positivity-in-northeast-pm-to-meet-cms-today-7401626/>

Currently, the fall in cases after peak of the second deadly wave has slowed down. As per NITI Aayog member, Dr. VK Paul, this is a warning sign and next 3-4 months would be critical for India in the fight against COVID-19(NDTV 2021). As per one of the senior scientist at the Indian Council of Medical Research (ICMR), the third wave is likely to hit India by the end of August (Mordani 2021).

COVID-19 Vaccination Drive

On January 16th 2021, world's largest COVID-19 vaccination drive was launched in India(World Health Organization 2021a). Initially two vaccines: Oxford University-AstraZeneca's Covishield vaccine, manufactured by Serum Institute of India and Bharat Biotech's Covaxin were approved by the Drug Controller General of India (DCGI) for emergency use in India(Vinaykumar and Kapoor 2021). Across India 3,006 vaccination sites have been established. The National Expert Group on Vaccine Administration for COVID-19 (NEGVAC) is working on the management of

COVID-19 vaccine roll-out in India. COVID-19 vaccine has been rolled out in a phased manner. In phase-I, healthcare workers such as medical officers, nurse, ASHAs, ANMs, support staff etc. and frontline workers like police workforce, municipal workers, armed forces, home guard, disaster management workforce, civil defence personals, prison staff and revenue officials were included (PTI 2021). In phase-II, from March 1, people above 60 years and those between 45-60 years with co-morbidities were vaccinated (please see Annexure 1 for the list of comorbidities included under the programme). In phase-III, from April 1, all people between 45-60 years were included under the programme(India Today 2021b; PTI 2021).

On 8th April, a four-day Teeka Utsav (Vaccine Festival) was launched by the Prime Minister of India with the aim to increase the speed of the vaccination drive(Wikipedia 2021). On 12th April, the DCGI approved Russia's Sputnik V vaccine for emergency use in India. In Phase IV, from May 1, people in the age group 18-45years became eligible for vaccination. As possibility of a third wave is being predicted by the experts, the Government of India made a slight change in India's vaccination policy. It recommends more and more people to get vaccinated at least once (the first dose) which could possibly result in decline in the rate of severe cases and ultimately leading to lower number of deaths(Ghosh 2021). In this regard, on May 13, following the recommendation from the National Technical Advisory Group on Immunization (NTAGI), the gap between the two doses of Covishield vaccine has been extended from 4-8 weeks to 12-16 weeks. Further, some assert that increasing the gap improves the efficacy of vaccine as well, while some felt the decision came out to deal with the vaccine shortage in the country.

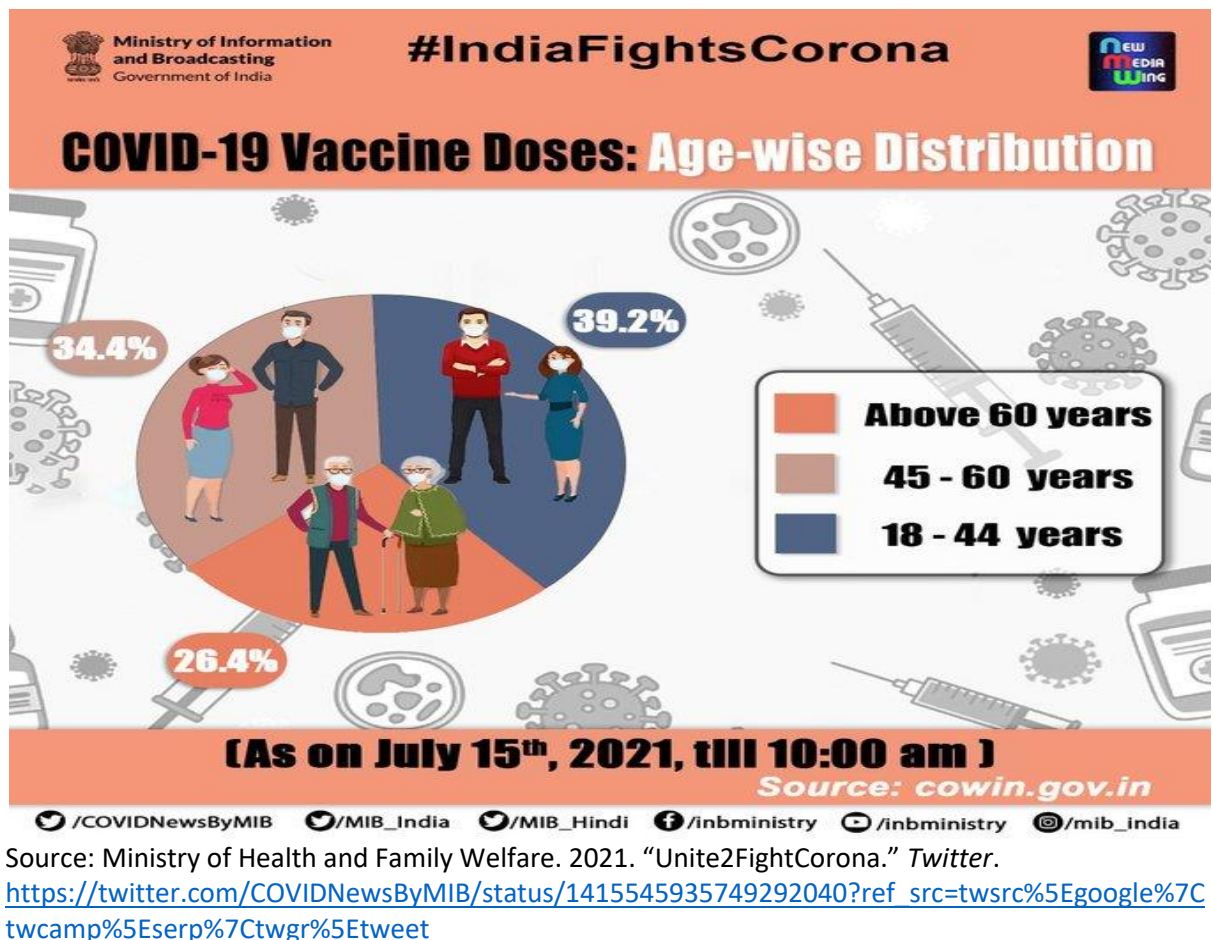
On 3rd June, the Ministry of Health and Family Welfare, Government of India has pre-ordered 300 million doses of 'Corbevax', a potential fourth vaccine undergoing phase 3 trials(Wikipedia 2021). As many states in India faced shortage of COVID-19 vaccine supplies, Prime Minister Narendra Modi launched centralized COVID-19 vaccination drive in the country from June 21, 2021. Under this initiative all vaccine doses will be procured by the central government (Meara 2021). On 29 June, the DCGI approved the Moderna vaccine for emergency use in India and soon the approval for Pfizer vaccine will also be granted.

As on July 15, 2021, more than 391,340,491 vaccine doses have been administered across the country (see Figure 6)(Ministry of Health and Family Welfare 2021).

Figure 6: COVID-19 vaccination status as on July 15, 2021

HCWs	1 st Dose	1,02,59,902
	2 nd Dose	74,67,814
FLWs	1 st Dose	1,77,49,670
	2 nd Dose	1,01,08,761
Age Group 18-44 years	1 st Dose	11,80,17,979
	2 nd Dose	42,03,947
Age Group 45-59 years	1 st Dose	9,60,12,486
	2 nd Dose	2,62,71,510
Over 60 years	1 st Dose	7,14,89,465
	2 nd Dose	2,97,58,957
Total		39,13,40,491

Source: Ministry of Health and Family Welfare. 2021. "Unite2FightCorona." *Twitter*.
<https://twitter.com/COVIDNewsByMIB/status/1415559894632075266>



Challenges related to COVID-19 vaccination Drive

Gaps in Digital Platform

The digital platform 'COVID-19 Vaccine Intelligence Network (Co-WIN)' has been launched by the Indian Government for the purpose of booking vaccination appointment, checking the vaccination status, downloading vaccination certificate and tracking the beneficiaries on a real-time basis. However, the system has its own share of problems. As soon as the Phase 2 vaccination campaign for the elderly was launched in the month of March, millions of users tried booking the vaccination slot via Co-WIN portal. As a result, the portal was overloaded, servers gone down and users found it difficult to book the slot(Pathak 2021). This problem was further exaggerated when phase 3 for those above 45 years with comorbidities and phase 4 for those above 18 years was launched. The ease of access and use of portal is more challenging in rural areas.

Shortage of Vaccine

Shortage of vaccines have been a major challenge in dealing with COVID-19 pandemic in India(Mehdi 2021). Many states in India such as West Bengal, Delhi, Gujarat, Jharkhand and Maharashtra are facing shortage of COVID-19 vaccines(Madur 2021). This has been witnessed soon after June 21 policy change (when the Central government resumed responsibility for vaccine procurement) which allows anyone to walk-in to the vaccination centre for getting the jab.

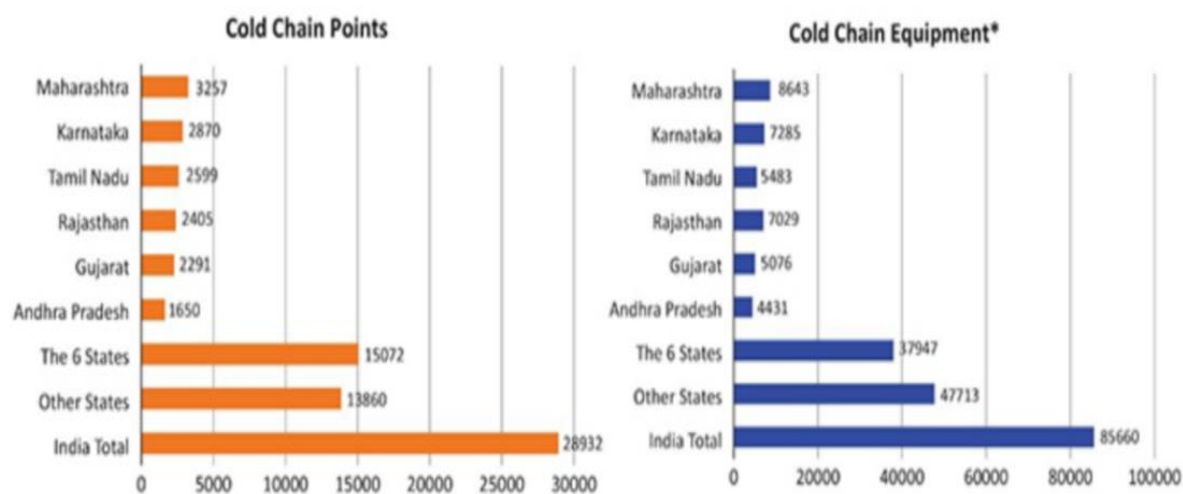
Vaccine Wastage

Wastage of vaccine as a result of improper cold-chain maintenance and poor vaccine administration practices such as not drawing stipulated number of doses from a vial is one of the issues leading to slow down of vaccination campaign(Pathak 2021). As on 25 May 2021, many states reported wastage of more than 30%, however, the national average remains at 6.5% (Pathak 2021).

Rural Challenge

The rural areas in India suffer from logistical constraints such as lack of infrastructure, poor supply chain and skilled manpower which is one of the major obstacle in the way of vaccination drive to succeed. The nationwide distribution of cold chain points is uneven. In March 2021, the IDFC Institute did a detailed analysis and found that six states in India with 34% of nation's population have 52% of the entire country's cold chain points (see Figure 7)(Pathak 2021).

Figure 7: Uneven distribution of Cold Chain Points



Source: IDFC (The Indian COVID-19 Alliance). *Cold Chain equipment includes walk-in coolers, freezers, and vaccine carriers.

Source: Pathak, Haryax. 2021. "India's COVID-19 Vaccination Campaign: A Marathon, Not a Sprint," 20. https://orfonline.org/wp-content/uploads/2021/06/ORF_SpecialReport_143_Vaccination-Marathon.pdf

Vaccine Hesitancy

Vaccine hesitancy especially among the rural masses is one the major obstacle in the way of India's vaccination drive. People are fearful of the vaccine adverse effects especially the post-vaccination clotting incidents.

Innovative approaches to address vaccine hesitancy

The government of Maharashtra and Goa have adopted creative routes to address challenges related to vaccine hesitancy among communities (World Health Organization 2021b; Ministry of Information & Broadcasting 2021). A unique outreach advocacy campaign was launched through the month of Feb to May 2021. Under this initiative, cultural troops were deployed at 11 400 strategic locations across 36 districts in Maharashtra and 2 in Goa to perform street plays in local languages to spread advocacy messages. This advocacy campaign was run by the Regional Outreach Bureau (Maharashtra and Goa Region) under Ministry of Information and Broadcasting, Government of India, in collaboration with Public Health Department of Government of Maharashtra, WHO Country Office for India, and UNICEF. Under the campaign, 88 empanelled performing troupes along with 16 vans- 15 in Maharashtra and 1 in Goa (equipped with LED panels and audio announcement systems) for disseminating COVID-19 related information in regional languages and local dialects were deployed. The campaign addressed concerns and infodemics that spread misinformation and fuel vaccine hesitancy. The campaign's script reiterated updated information about COVID-19, COVID-19 appropriate behaviours, and COVID19 vaccination.

Figure 8: Outreach Advocacy Campaign



Performers go "vocal for local" for to use local languages to promote safe behaviours and remove vaccine hesitancy in Thane, Maharashtra



WHO NPSP teams are providing support for capacity building of artistes performing street plays to address concerns and counter infodemics around vaccination in Thane

Source: World Health Organization. 2021b. "Maharashtra and Goa Use Popular Folk Performing Arts for COVID Vaccination Advocacy." 2021. <https://www.who.int/india/news/feature-stories/detail/maharashtra-and-go-a-use-popular-folk-performing-arts-for-covid-vaccination-advocacy>.

Inter-departmental Coordination

Inter-departmental coordination has been the cornerstone in dealing with COVID-19 situation in India. The early pandemic response required strong cross-departmental coordination between the state and central governments and within the State/Union Territory (UT). Various departments such as Health, Tourism, Defence, Information and Communication Technology (ICT), Finance, private sector etc. took various initiatives in collaboration with other departments to deal with the pandemic. Department of Tourism ensured screening protocols at the airports, imposed necessary restrictions and issued relevant advisories for the travellers. Department of Health issued timely and relevant health advisories for the public, conducted regular training of health workers, established COVID care centres and hospitals, made provision for online OPD, released containment plans, strengthened laboratory network etc. Department of Defence played a crucial role in bringing back Indian citizens struck in various parts of the world by launching Vande Bharat Mission and Samudra Setu Mission. Department of Information and Communication Technology (ICT) launched mobile applications for contact tracing COVID-19 cases and monitoring COVID-19 suspects, robots and remote monitoring systems for treatment of COVID-19 cases, drones for sanitization and monitoring movement of COVID-19 suspects etc. Department of Telecom adopted unique method of broadcasting COVID-19 awareness messages as a caller tune instead of regular ringtone for the purpose of mass awareness. Department of Finance initiatives such as monetary relief package under Pradhan Mantri Garib Kalyan Yojana and Uttar Pradesh Rojgar Abhiyaan has helped in dealing with the financial crisis due to COVID-19. City Governments (Municipal Corporation) collaborated with Fire Departments to sanitize city streets by using fire-tenders, water wash pumps, etc.

Some of the states such as Kerala and Rajasthan showcased an excellent example of inter-departmental coordination in defeating coronavirus. Kerala has been so successful in its effort to flatten the COVID-19 curve that many admirably called it 'Kerala Model' for dealing with COVID-19 situation. The government of Rajasthan launched 'Mission Lisa' - a coordinated effort to protect the lives of the most vulnerable groups (infants, pregnant women, elderly and those with chronic diseases) particularly in medically and socially high risk areas (Dalal 2020). Bhilwara (a district in Rajasthan) model also teaches the world how cross-department efforts such as door-door-door screening by health workers, strict vigilance by police, and regular sanitization by Municipal Corporation can help save countless lives. Many states established State Steering Committee, State Task Force, and District Task Force to ensure cross-departmental coordination to deal with the pandemic. Private firms such as Ola helped the government in managing the on-ground operations during COVID-19. "Ola CONNECTS" Platform was used for various purposes such as crowd control, geofencing app, tracking of goods and vehicles etc.

Challenges posed by COVID-19 sparked a wave of innovation across India. Entrepreneurs and innovators across sectors responded quickly to tackle the situation. A host of new interventions were implemented by various departments such as health, agriculture, education, police, railways etc. Some of these innovations are discussed below:

Health Initiatives

e-Sanjeevani OPD

Amidst COVID-19 lockdown in the country, the Ministry of Health and family welfare, Government of India launched a national teleconsultation service via portal '**E Sanjeevani OPD**' (Ministry of Health & Family Welfare, Government of India 2020). "The main objective of E sanjeevani OPD is to provide health advice to the individuals with the help of digitalisation who are finding it difficult to visit hospitals due to the pandemic of coronavirus" (Gul 2021). '**E Sanjeevani OPD**' is a doctor to patient telemedicine platform. It is deployed under Ayushman Bharat Scheme of Government of India and is the first of its kind online OPD service provided by national government to its citizens. This initiative has proven to be very useful amidst COVID-19 pandemic. '**E Sanjeevani OPD**' allow even people living in the remotest areas of the country to get their health related consultation. The 'E Sanjeevani OPD' platform provides the provision for online patient registration, token generation, queue management, audio-video consultation with a Doctor/Specialist, e-Prescription and SMS/Email notifications (Gul 2021).

Infectious disease diagnostic lab (I-lab)

On 18th June, 2020, the Minister for Science & Technology, Earth Sciences launched India's first Infectious disease diagnostic lab (I-lab) for Covid testing in rural, interior and inaccessible parts of the country (see figure 9) (Ministry of Science & Technology, Government of India 2020).

Figure 9: India's First Infectious disease diagnostic lab (I-Lab)



Source: Ministry of Science & Technology, Government of India. 2020. "Dr Harsh Vardhan Launches DBT – AMTZ Mobile Diagnostic Unit for Covid Testing- I-Lab [Press Release]." <https://pib.gov.in/PressReleasePage.aspx?PRID=1632393>.

Robots

State governments have launched robots to fight against COVID-19 situation. The Kerala Government has initiated the use of robots 'KARMI-Bot' and 'Nightingale-19' (Bhatia 2020; Zachariah 2020). These robots serve food and medicines to the COVID-19 patients, collect trash used by the patients, enable video call between patients and doctors or relatives and perform disinfection of the isolation ward. 'Milagrow iMap 9' a robot designed for floor disinfection purposes, is being pilot tested at All India Institute of Medical Sciences (AIIMS) in New

Delhi(Press Trust of India 2020d). Other states like Tamil Nadu and Jaipur have also explored the use of robots.

Drones

Garuda Aerospace, a Chennai based start-up, has developed an automated disinfecting Unmanned Aerial Vehicle (UAV) called “Corona-Killer 100” (a disinfectant spraying drone)³. Garuda Aerospace has deployed 300 “Corona-Killer 100” drones for disinfection purposes across 26 cities in India. Marut Dronetech partnered with states to explore the use of drones for various purposes such as monitoring social distancing, delivering medical supplies, and checking people’s temperature via thermal imaging(Khanna and Mayilvaganan 2020).

Remote monitoring systems

For monitoring COVID-19 Patients, states are exploring the use of remote monitoring systems. These include Indore 311 mobile app by state of Madhya Pradesh, Monal 2020 by the state of Uttarakhand, Milagrow Humanoid ELF in AIIMS, New Delhi, LiFi (Light Fidelity) technology in Ahmadabad(Press Trust of India 2020d; Vora 2020; Express News Service 2020). These remote monitoring systems enables remote monitoring of patient’s vital parameters like pulse rate, blood oxygen level, body temperature, respiration rate, heart rate etc.

AI-powered tools for screening

- An AI based voice tool has been developed and designed by a professor and her students in Mumbai(Press Trust of India 2020b). This tool is able to detect COVID-19 through voice-based diagnosis using a smartphone app.
- The Defence Institute of Advanced Technology (DIAT) in Pune, Maharashtra has also developed an AI based COVID-19 detection tool(Press Trust of India 2020e). The tool uses the chest x-rays of patients to identify COVID-19 infection. An IIT-Roorkee Professor has also developed similar software which can detect COVID-19 and measure its severity using X-ray scan of the suspected patient(Press Trust of India 2020c).
- The Government of Bihar in collaboration with Norway India Partnership Initiative (NIPI) approved development of an artificial intelligence (AI)-powered tool which will enable identification of COVID-19 through cough sound analysis(Kumar 2020).

Disinfectant Tunnel

On 1st April 2020, as a precautionary measure against COVID-19 , disinfectant tunnel was launched in Thennampalayam vegetable market in Tirupur district, Tamil Nadu(see Figure 10)(Akileish 2020). The disinfectant tunnel was the first of its kind in the state and across India. Similar tunnels were later established in various parts of the country.

³ Garuda Aerospace focuses on the design, build and customization of unmanned aerial vehicles (UAVs) or drones for various applications. <https://www.garudaerospace.com/about-us/>

Figure 10: Disinfection tunnel in Tirupur



Source: Akhilesh, R. 2020. "Tirupur Gets a Unique 'Disinfection Tunnel' to Fight against COVID-19." 2020. <https://www.thehindu.com/news/national/tamil-nadu/tiruppur-gets-a-unique-disinfection-tunnel-to-fight-against-covid-19/article31226348.ece>.

COVI-SAFE Transportation System

Doctors at Nagpur's Aureus Institute of Medical Sciences have designed a novel transportation system COVI-SAFE for COVID-19 patients (The Prodigal Techie 2020; Nagpur Today 2020). It is the first of its kind in India. The system includes a transparent rectangular box which is attached to a stretcher (see Figure 11). The box has an outlet for continuous oxygen supply and even allows patient to talk to those around him from the box.

Figure 11: COVI-SAFE Transportation System



Source: The Prodigal Techie. 2020. "COVI-SAFE Transportation System." 2020. <https://theprodigaltechie.com/covid-19/covi-safe/>.

Phone Booth Testing

To control the spread of corona virus, many states have adopted "Phone Booth" testing method(The Economic Times 2020). This technique of sample collection involves collection of samples from corona virus suspects inside a unit that looks like a public telephone booth. It is a small cubicle with one side made up of glass fitted with personal protective equipment like gloves from outside and the other three sides are made up of aluminium. The corona virus suspect stands (or sits) in front of the glass exterior and follows the instructions through a public address system for swab collection. This innovative sample collection method helps address the issues related to shortage of manpower and Protective Personal Equipment (PPE). It also helps in following the guidelines of social distancing. It is low cost and portable.

Figure 12: Phone Booth Testing Method



Source: The Economic Times. 2020. "The 'phone Booths' That Are Making Covid Tests in India Easier, Quicker and Safer." 2020.

<https://economictimes.indiatimes.com/industry/healthcare/biotech/healthcare/the-phone-booths-that-are-making-covid-tests-in-india-easier-quicker-and-safer/articleshow/75040280.cms?from=mdr>

IoT-Based BIN-19

Sree Chitra Tirumala Institute for Medical Sciences and Technology (SCTIMST), Trivandrum under Department of Science and Technology (DST), Government of India launched IoT based device called BIN-19(see Figure 13)(Ministry of Science and Technology, Government of India 2020a). It is used for collecting and disinfecting face masks. The IoT (Internet of Things) features of BIN-19 include Auto Sanitizer Dispenser (remotely alerts if it's empty), web Portal for Status Alerts, mobile Application to find/navigate Bin-19, alert for Power ON/OFF and Box open alert.

Figure 13: IoT Based BIN-19



Source: Ministry of Science and Technology, Government of India. 2020. "Kerala Start-Ties up with SCTIMST to Launch IoT Based Used Mask Disposal Smart Bin & UV Light-Based Disinfection Device to Beat COVID 19." 2020. <https://dst.gov.in/kerala-start-ties-sctimst-launch-iot-based-used-mask-disposal-smart-bin-uv-light-based-disinfection>.

UV SPOT

Sree Chitra Tirumala Institute for Medical Sciences and Technology (SCTIMST), Trivandrum under Department of Science and Technology (DST), Government of India launched a UV light-based multipurpose disinfectant called UV SPOT (see Figure 14) (Ministry of Science and Technology, Government of India 2020a).

Figure 14: UV SPOT



Source: Ministry of Science and Technology, Government of India. 2020. “Kerala Start-Ties up with SCTIMST to Launch IoT Based Used Mask Disposal Smart Bin & UV Light-Based Disinfection Device to Beat COVID 19.” 2020. <https://dst.gov.in/kerala-start-ties-sctimst-launch-iot-based-used-mask-disposal-smart-bin-uv-light-based-disinfection>.

Foot-operated hand sanitation device

The National Innovation Foundation – India (NIF) under the Department of Science & Technology has launched foot-operated device for hand sanitization. Sanitizer, Soap and Water are stored in separate containers of the device and there is no hand-related contact between the user and the device (Ministry of Science and Technology, Government of India 2020b).

Figure 15: Foot-operated hand sanitation device



Implementation of Foot-operated device for Hand Sanitization and Washing at Warangal and Mahabubabad districts of Telangana

Source: Ministry of Science and Technology, Government of India. 2020b. “S&T Based Innovative Solutions by Common People Participating in NIFs Challenge COVID-19 Competition (C3) Ready to Make a Difference.” 2020. <https://dst.gov.in/st-based-innovative-solutions-common-people-participating-nifs-challenge-covid-19-competition-c3>.

Boat Clinics

In river Islands such as in the state of Assam where construction of structures for healthcare is almost impossible, boat clinics became the primary access to healthcare for islands especially during COVID-19 associated lockdown(Guha 2020). In addition to the provision of routine healthcare services such as immunization, pregnancy care, these clinics conducted door-to-door community surveillance for screening novel coronavirus.

Figure 16: Boat Clinic



Source: Guha, Nabarun. 2020. “Assam’s Boat Clinics Scan Remote Islands for COVID-19.” 2020. <https://india.mongabay.com/2020/05/assams-boat-clinics-scan-remote-islands-for-covid-19/>.

Bus Clinics

The Government of Maharashtra in coordination with Municipal Transport department utilized buses for providing vaccination and antenatal care during COVID-19 lockdown(World Health Organization 2020b).

Figure 17: Bus Clinic



Sources: World Health Organization. 2020. "WHO Supports the Government of Maharashtra's Initiatives to Maintain Routine Immunization during COVID-19." 2020.

<https://www.who.int/india/news/feature-stories/detail/who-supports-the-government-of-maharashtra-s-initiatives-to-maintain-routine-immunization-during-covid-19>.

Promoting use of Umbrellas for physical distancing

To ensure people live their lives safe during COVID-19, one of the innovative solutions came from a village in Kerala(World Health Organization 2020a). Umbrellas were distributed to its residents to promote physical distancing. Two persons holding open standard-size umbrellas (around 90 cm in diameter) will naturally be one metre apart and will thus ensure physical distancing.

Corona Shield

Droom, a start-up in India, has launched Corona Shield (anti-microbial surface protection) for vehicles. The start-up claims that Corona Shield is effective for four months against droplet-based viruses(Auto 2020).

Low Cost PPE Kits

A doctor of Indian Navy has developed low cost PPE kit, which is made up of specific fabric that makes it highly protective and breathable(Madaik 2020; PTI 2020). The kits have been tested by INMAS (Institute of Nuclear Medicine and Allied Sciences) and have received certification for

mass production. The designing and production of kits have been a collaborative effort by the team at the Innovation Cell, Institute of Naval Medicine, Mumbai and Naval Dockyard, Mumbai.

Figure 18: Low cost PPE Kits



Source: Madaik, Devyani. 2020. "Defence Ministry Patents Low-Cost PPE Developed By Indian Navy For Rapid Mass Production." 2020. <https://thelogicalindian.com/news/indian-navy-creates-low-cost-ppe-21121>

Innovative sprayer for sanitization

The National Innovation Foundation – India (NIF) under the Department of Science & Technology has launched innovative sprayer for sanitizing large areas such as compounds, roads, walls, societies etc. (Ministry of Science and Technology, Government of India 2020b). The machine can sanitize 30 feet horizontally and 15 feet vertically.

Figure 19: Innovative sprayer for sanitization



The Innovative sprayer for sanitization



The Sprayer is being deployed for sanitization on the streets of various locations in Maharashtra

Source: Ministry of Science and Technology, Government of India. 2020b. "S&T Based Innovative Solutions by Common People Participating in NIFs Challenge COVID-19 Competition (C3) Ready to Make a Difference." 2020. <https://dst.gov.in/st-based-innovative-solutions-common-people-participating-nifs-challenge-covid-19-competition-c3>.

Medicab

With the support from Indian Institute of Technology Madras, Modulus Housing, a start-up has developed a portable hospital unit called 'MediCab'(NDTV Education 2020; Deol 2020). This foldable unit could be installed anywhere by just four people in 2 hours time. It is basically a decentralized approach for detecting, screening, identifying, isolating and treating COVID-19 patients within the local communities. The unit consists of four zones- Doctor's room, a medical

ward, an isolation room, a twin-bed ICU (maintained at negative pressure)(see Figure20). It is spread over an area of 800 square feet and well-equipped with 15 beds. It is fire, water and termite-resistant. It is not only cost-effective in terms of transportation but also serve as an excellent option in times of healthcare infrastructure shortage. The units have been deployed in Wayanad district of Kerala.

Figure 20: Medicab



Source: Deol, Taran. 2020. "IIT Madras-Supported Startup Develops Portable Hospital Units to Aid Covid Fight." 2020. <https://theprint.in/india/iit-madras-supported-startup-develops-portable-hospital-units-to-aid-covid-fight/462226/>

Mobile Applications

The centre and state governments have launched various mobile applications for the purpose of mass awareness, providing information, contact tracing, monitoring suspects in quarantine etc. Table 1 enlists few of these mobile applications.

Table 1: Mobile applications launched by various state governments

National/State	Name of the mobile application	Purpose
National	Aarogya Setu	It is a contact tracing app available in 11 languages. It also provides COVID updates, a platform to register for COVID vaccination and information related to COVID vaccination. It has been developed by National Informatics Centre (NIC), Ministry of Electronics and Information Technology, Government of India.
Delhi	Delhi Corona	Provides real time information on the availability of beds and ventilators at both government and private hospitals, COVID-19 cases and number of tests conducted, government orders, containment zones, COVID-19 Health Services, and lockdown services like finding a hunger relief centre or a shelter or to apply for ration; a platform to donate to the Chief Minister/ Lt. Governor relief Fund

Punjab	COVA Punjab	Provides access to real time dashboard for COVID-19 statistics, helpline numbers, prevention measures, government advisories, travel instructions; a geofencing app; a platform for self-screening for COVID-19 and locates nearest COVID-19 hospital
Telangana	T-COVID'19	Provides live COVID-19 statistics, access to government and WHO advisories, details related to government approved labs and test centers, isolation wards in government and private hospitals and quarantine centers; self-assessment for COVID-19 ; a telemedicine platform
Kerala	Gok Direct Kerala	Generate awareness and disseminate credible information related to COVID-19
Goa	Test Yourself Goa	Assists in carrying out a self-assessment test for COVID-19
Karnataka	Test Yourself Karnataka	Assists in carrying out a self-assessment test for COVID-19
West Bengal	Sadhana	Trace COVID-19 suspects in rural and remote areas
Maharashtra	MahaKavach	Geofencing app: Helps track movement of COVID-19 suspect in quarantine
Tamil Nadu	Quarantine Monitor	Geofencing app: Helps track movement of COVID-19 suspect in quarantine
Karnataka	Corona Watch	Geofencing app: Helps track movement of COVID-19 suspect in quarantine
Himachal Pradesh	Corona Mukht Himachal	Geofencing app: Helps track movement of COVID-19 suspect in quarantine
Gujarat	SMC COVID-19 Tracker App	Geofencing app: Helps track movement of COVID-19 suspect in quarantine
Mizoram	mCOVID-19	Provides access to COVID-19 updates, government advisories, task force and volunteer registration, volunteer mPASS (pass to permit movement of goods, vehicles and people); a geofencing app

Source:(Mitter 2020; Anand 2020; ET Wing, Govt of Telangana 2020; Mizoram State e-Governance Society 2020; Press Trust of India 2020a; J. Nag 2020; ETGovernment 2020)

Agricultural Solutions

Various Innovative Agricultural interventions were implemented to deal with the COVID-19 crisis. Some of these are enlisted in Table 2(Indian Council of Agricultural Research, Division of Agricultural Extension 2020).

Table 2: Innovative Agricultural Interventions

<ul style="list-style-type: none"> • ICT tools such as Tele-training, tele-conferencing, zoom app, WhatsApp, audio visual aids, social media etc. were used extensively for training farmers on various farm related activities such as proper collection and storage of honey, use of machines like reaper and harvesters to undertake harvesting under shortage of labour etc. • KVK provided tractor operated spray pump to the farmers for sanitizing the rural areas.
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- Amidst COVID-19, the **Market on Wheel** came into existence with the detailed frame work provided by KVK scientists. Temporary licenses were given to the FPOs and farmers to sell their goods.
- With the provision of **low-cost equipment such as sewing machine and minimal training**, it was possible to provide an additional source of income to tribal women who lost job due to non-movement of labour because of COVID-19. This also ensured uninterrupted supply of masks during lockdown.
- **Special e-platforms** such as WhatsApp, Facebook groups and others were created to bring together the buyers and sellers of perishable agro-commodities and thus bridge the gap of demand and supply.
- **KVK Kalburagi Model**: KVK, Kalaburagi created WhatsApp groups of consumers containing 250 primary members. These primary members forwarded messages to average 5 other groups reaching around 5000 consumers in the city. WhatsApp group of producers was also formed from where the availability and quantity of products was regularly collected and based on this consumer were informed and indents were collected. This model helped in reducing consumers cost and doubling farmers income.
- **Green Basket Initiative**: KVK in East Midnapore collaborated with the Panskura vegetable producers' Company and Usha Agro, Panskura, to help farmers initiate home delivery of vegetables along with other articles of daily need to nearby areas.
- **Collective Marketing of Farm Produce with Online Platform**: A group of vegetable growers collectively harvested their crops, collected vegetables, graded, packaged and sent to the market. Vendors were contacted by the KVK via online portal of Dept. of Agriculture and Farmers Empowerment (<https://odihortmarketing.nic.in/>) for selling farm produce.
- **JFARM Services**: It is an initiative taken during COVID-19 lockdown by TAFE -Tractors and Farm Equipment Limited to provide free doorstep service of various farm implements to farmers.
- **Integrated Technology Enabled Agri Management System (i-TEAMS): Using ICT for empowering agriculture**: This is a govt. of Meghalaya initiative with a motto of "Connecting farmers to markets". It is a first of its kind project in the hilly terrain. It helps connect farmers to the Agri- Response Centre (ARC) via a toll-free number 1917 for agro-advisory services, market intelligence and transportation of agricultural produce via Agri-Response Vehicles (ARVs)(1917-iTEAMS Program Management Unit 2018).
- **Farm to Kitchen – An E-commerce Initiative**: "Farm to Kitchen" e-commerce initiative allows delivery of fresh fruits and vegetables from the farm directly to the doorstep of citizens. This service began on 11th April under the brand name 'Sarvadnya Foods' to Jalna city.
- **Door to Door Sale Model of vegetables**: Under this model, a team of 4-5 farmers from one village in Chatra District were selected for collecting and selling the produce via door to door visit. It was proposed that the group of selected farmers would purchase all the vegetables, sell them collectively and share the profit among all. The model proved to be a success.
- **Group Marketing Model of Self Help Groups**: During COVID-19, a women's self-help group "Maa Vaishnavi" in Jharsuguda, Odisha showed stewardship in vegetable marketing. The group members collected vegetables from the villages and sold it at a fix point in the village. This has set an example for other women groups in the district and across India.

- **Use of battery rickshaw** to sell fruits such as cucumber at consumer's doorstep
- **Establishment of low cost storage structure** from locally available material such as iron mesh to improve shelf life of onion, air hanging of stalked tomatoes on ceiling by tying with thread etc.

Source: Indian Council of Agricultural Research, Division of Agricultural Extension. 2020.

“Innovative Agri-Solutions during COVID-19.”

https://icar.org.in/sites/default/files/Innovative_Agri-Solutions_COVID-19-2020-1106.pdf

Educational Initiatives

Since the first lockdown in March 2020, education system responded to the situation with speed and innovation. Various inspiring initiatives were taken by the Education Department at National and states/UTs levels. Some of these initiatives are outlined in Table 3 (Department of School Education & Literacy, Ministry of Human Resource Development, and Government of India 2020).

Table 3: Educational Initiatives

National Level Initiatives

PM eVidya: This is a comprehensive initiative announced on May 17, 2020, which unifies all the efforts related to digital/online/on-air education to ensure equitable and multi-mode access to education.

DIKSHA: (Digital Infrastructure for Knowledge sharing) is the ‘one nation; one digital platform’ for school education in India. It was launched on September 5, 2017. During COVID-19 related disruption of schooling, DIKSHA made it possible for all states/UT's to ensure learning/ education at home via use of technology.

Swayam Prabha TV Channels: During Covid-19, MHRD devoted 32 DTH channels for telecasting high quality educational programmes. One DTH Channel was specifically operated in sign language for hearing impaired students.

Online MOOC courses: Around 92 online courses related to NIOS (grades 9 to 12 of open schooling) were made available via SWAYAM portal.

Radio broadcasting: Radio Stations were used to broadcast education content to children who do not have to internet (especially grades 1 to 5) in remote and rural areas.

E-Content and Repository: Resources such as e-textbooks using e-Pathshala, National Repository of Open Educational Resources (NROER) etc. were made available amidst COVID-19.

Alternative Academic Calendar: A week-wise plan containing interesting activities related to topics in the syllabus were initiated for grades 1-12 by NCERT.

State/UTs Level Initiatives

Social Media based learning: Many states such as Assam, Andhra Pradesh, Bihar, Gujarat etc. have started YouTube channel, formed WhatsApp groups and conducted live training program on Facebook for students.

- **WhatsApp based initiatives** include Ghar Se Padhao WhatsApp Campaign by Haryana, Har Ghar Pathshala campaign by Himachal Pradesh, Digital Learning Enhancement Program (DigiLEP) by Madhya Pradesh, DIKSHA Abhyasmala campaign by Maharashtra, Odisha Shiksha Sanjog, Hawamahal- Joyful Saturday program by Rajasthan etc.
- **Facebook initiatives** include Three Facebook channels by Sikkim: Sikkim Chronicle, Summit Times and Sikkim Varta), TN Schools Facebook Workplace by Tamil Nadu etc.
- **You Tube Initiatives** include YouTube Rajiv Gandhi Career Portal by Rajasthan, TNSCERT YouTube channel by Tamil Nadu etc.

Mobile based initiatives: 'BiswaVidyaAssam' mobile App by Assam, 'Vidyavahini Bihar App' by Bihar, Sameeksha - Shiksha Saathi mobile App by Himachal Pradesh etc.

Bihar Easy School Tracking (BEST) – A Mobile Application for Real Time Monitoring of Schools

It allows real-time monitoring of schools, both elementary secondary schools, in the State of Bihar. It is first of its kind in the State of Bihar.

Top Parent App: It is free-of-cost and first-of-its-kind mobile app by the state of Madhya Pradesh. It empowers parents of children (3-8 years) with knowledge and strategies related to child development and thus help them engage with their children in a meaningful way.

E-Portals: Various states have launched E-Portals such as Jammu and Kashmir Knowledge Network (JKKN), E-Content Portal Manipal, E-Learning Portal Meghalaya, E-Learn Platform for Students by Tamil Nadu etc.

Radio School: Radio based initiatives include Biswa Vidya- Radio Learning Programme in Assam, Radio School in MP, Shikshavani – Education via Radio Rajasthan etc.

Programme on TV Channels: These include Vande Gujarat, KalviTholaikatchi (Television Channel for Students) by Tamil Nadu etc.

Samadhan AI-Based Educational Chatbot: This initiative by Jammu & Kashmir education department helps teachers and students get quick responses related to their educational queries. The chatbot is embedded as a link in JKKN platform.

Toll free Call centre to clear student's doubts: States such as Andhra Pradesh initiated a toll free call centre for students to clear their doubts on any subject/topic from an expert teacher.

MakkalaVani:

It is an innovative Edutainment Channel in YouTube by the department of Public Instructions, Karnataka. It telecasts daily Edutainment programs such as stories, crafts, riddles, plays, science experiments etc. The program was very successful and department plans to continue it in the future.

Project Phoenix: This initiative by Chandigarh Education Department is based on technology to assess the learning Outcomes. It helps in the identification of gaps and weak students who later receive remediation.

Pariksha Vani: The Education Department of Karnataka initiated this program for exam preparations. It was aired through Doordarshan “Chandana” channel in two languages: Kannada and English. The program was a success.

Source: Department of School Education & Literacy, Ministry of Human Resource Development, and Government of India. 2020. “India Report Digital Education: Remote Learning Initiatives Across India.”

https://www.education.gov.in/sites/upload_files/mhrd/files/India_Report_Digital_Education_0.pdf

Initiatives by Department of Police

Indian police officers acted as public health messengers and used innovative ideas such as unique themed helmets, special drives and messages to spread awareness about COVID-19 and ensured that people remain indoors during lockdown (see Figure 21)(Jacob 2020). The Kerala Police disseminated colourful videos with Malayalam music to spread awareness about social distancing and hand washing. Constables in the district of Gwalior have produced face masks from cloth to protect their colleagues working in the field. Police joined hands with municipal authorities and Department of Agriculture to create a makeshift kitchen to deliver food packets to the needy. Police officials either acted as the bridge between the kitchens run by the government or initiated a self-drive to feed the poor.

Figure 21: Innovative ideas by Indian Police to spread COVID-19 awareness





Source: Jacob, Urvi. 2020. "Indian Cops Get Creative with Their COVID-19 Messages." April 2020. <https://yourstory.com/weekender/indian-cops-creative-coronavirus-messages>

AYURAKSHA

On 30th April 2020, Delhi police in collaboration with All India Institute of Ayurveda (AIIA) under Ministry of AYUSH launched a programme called AYURAKSHA “*Corona Se Jung-Delhi Police Ke Sang*” for health promotion of frontline COVID-19 warriors like ‘Delhi Police Personnel’ (PIB Delhi 2020; News Services Division, All India Radio 2020). The programme aims to use Ayurveda immunity boosting measures to fight against corona. The recommended formulations include Ayurveda herbs that are time tested and scientifically proven such as Chyawanaprasha (Amla as main content), Anu Taila and SanshamaniVati (prepared from Guduchi). Over the period of two months nearly 80,000 AYURAKSHA kits were distributed to police personnel (10Pointer 2020). This joint venture is the biggest ever first of its kind and is a role model for others.

Initiatives by Indian Railways

In order to deal with the COVID-19 situation, some of the innovative strategies implemented by Indian Railways include:

- Train coaches were converted into isolation wards for COVID-19 patients (D. Nag 2020)
- The Rail Coach Factory (RCF), Kapurthala developed ventilator for use in the isolation or quarantine facilities of Indian Railways (D. Nag 2020)
- Mobile Doctor Booth called “CHARAK” was launched by the Coach Rehabilitation Workshop of the national transporter located in Bhopal (D. Nag 2020)
- Setting up of fumigation/disinfection tunnels at various locations such as at Jagadhri Workshop, Electric Loco Shed, Bhusawal (D. Nag 2020)

Figure 22: Innovations by Indian Railways



Source: Nag, Devanjana. 2020. “Indian Railways Goes Innovative in Fight against Coronavirus! Check out These Top 5 Unique Initiatives.” 2020.

<https://www.financialexpress.com/infrastructure/railways/indian-railways-goes-innovative-in-fight-against-coronavirus-check-out-these-top-5-unique-initiatives/1926455/>

Other innovations

Women Self-Help Groups

Women self-help groups have played a vital role in dealing with COVID-19. They have come forward to help in various activities such as running community kitchens, producing facemasks, raising awareness about COVID-19 and fighting misinformation, delivery of essential food supplies and providing financial and banking solutions to people in remote areas(The World Bank Group 2020).

Floating supermarket

In Alappuzha district of Kerala, the idea of floating supermarket brought ease to the residents amidst COVID-19 lockdown(Paul A. 2020). Floating store helped in bringing essentials like vegetables, fruits, spices, beverages etc. to the doorstep of the residents.

Figure 23: Floating Supermarket



Source: Paul A., Sam. 2020. "In Alappuzha, Floating Supermarket Brings Essentials to the Doorstep of Lockdown-Affected." 2020.

<https://www.thehindu.com/news/national/kerala/floating-supermarket-brings-essentials-to-the-doorstep-of-lockdown-affected/article31264618.ece>

Frugal Innovations in Kerala

Early in March 2020, the speed and severity of COVID-19 transmission prompted many frugal innovation responses⁴. The world known ‘Kerala model’ to deal with COVID-19 also used frugal innovations as one response to COVID-19. SoumodipSarkar in his paper “Breaking the chain: Governmental frugal innovation in Kerala to combat the COVID-19 pandemic” describes the types and nature of frugal innovations deployed by Kerala State Government (KSG)(Sarkar 2021) (see Figure 24). These are also discussed below:

1. Empowering

By adapting and contextualizing existing resources, KSG empowered citizens of the state via informing, educating, and communicating on resource management.

1.1 Informing

- **Break the Chain Campaign:** Under this campaign, KSG used slogan “SMS” (using soap or sanitizer, using masks, and maintaining social distance) to emphasize on the importance of hygiene. As a part of the campaign, prominent personalities and reputed cartoonists designed cartoons related to SMS on public walls. At the entry points of residence complexes, offices, on bus stops and other high contagion areas, ‘Break the Chain’ kiosks were installed.
- **Transmedia Storytelling:** KSG used multiple media platforms to create content that had potential to engage with citizens. A geo-tagged map was prepared and circulated using mainstream media to track the movement of COVID-19 cases. Media was also used to share experiences of people who lived in isolation, quarantine and recovered from COVID-19.
- **Social Media Platforms:** KSG used social media platforms like Facebook, twitter, TikTok and Instagram to promote COVID-19 appropriate behaviour among the public.

“The Kerala Police's Facebook follower count of over 1.4 million is one of the most followed police department pages across the world. Kerala police leveraged this follower base creatively. Measures such as policemen dancing and showing correct ways to wash hands, composing poems on social distancing in vernacular languages has been widely followed. The social media cell of Kerala police also produced a short clip promoting break-the-chain. They made use of VFX (visual effects) to portray containment by using sanitizers and protective gears, which were catchy, and aptly delivering the message”(Sarkar 2021).

1.2 Educating

- **GoK Direct Kerala:** This is a mobile application that acts as one stop source informing citizens of Kerala about COVID-19 situation: daily cases, sample tested, information for travellers, guidelines and quarantine protocol etc. The app is powered by Qkopy and is available in two languages: English and Malayalam.

⁴ Frugal innovations are generally understood to be low-cost and efficacious, new or adapted products (or services), mostly emerging from contexts of institutional voids and resource constraints, involving the creative use of existing resources.

<https://reader.elsevier.com/reader/sd/pii/S0740624X20303282?token=3327B4B62E651092D23CEC06F75DB907DAD76E9A8F3F21631B1C9CA210D88B0628313E3064C7D73613E781B201629B06&originRegion=eu-west-1&originCreation=20210415135331>

- **Search Engine:** A digital dashboard [Covid19kerala.info](https://covid19kerala.info), is a citizens' initiative and provides real time information about COVID-19.
- **Citizen Science:** *Corona safe network*, a dashboard of more than 20 web applications was developed by a team of software experts, data analysts, doctors, paramedics and KSG Officials.

1.3 Communicating on Resource Management

- **Corona Literacy Mission:** It aimed at spreading awareness on the way the corona virus spreads and related precautions to be taken.
- **Corona Care Centres:** These are temporary facilities created to enhance the existing healthcare infrastructures

2. Arming

Arming citizens focused on providing citizens appropriate protective tools to fight COVID-19. It involved three pathways: equipping, deploying and monitoring.

2.1 Equipping

- **Production of PEP:** On March 24th KSG issued directives to engage tailoring units of prisons in production of masks. The state also made early efforts to provide sanitizers to citizens at affordable price.
- **Breath of Hope:** It is an initiative under Kerala Start-up Mission (KSUM), a government-supported entrepreneurship development agency. This initiative involved interdisciplinary team of IT Professionals, biomedical engineers and doctors to develop innovative medical devices such as face shield and half-ventilator. The KSUM also used its Fablabs to facilitate the development of medical items such as masks and other respiratory items.

2.2 Deploying

- **Handwash:** Since alcohol based sanitizers are toxic and not safe for children, water-based sanitizer were launched by Aqoza technologies, a Chemtech company. With the support from KSG, the company was able to scale-up its production.
- **Robot-dispensing:** Robots were deployed for dispensing of sanitizers and masks. For instance, *Karmi-Bots* was deployed by Asimov Robotics. These robots stay connected through distributed sensor network and use Artificial Intelligence. A low-cost automated hand-sanitizer machine was also developed by a team of innovators.

2.3 Monitoring

- **Humble Shit:** Despite lockdown, lack of toilets forced people to step out of their home to use public toilets. *Humble Shit*, a Kerala-based start-up, developed a toilet monitoring system, to measure toilet cleanliness based on 24 different parameters. This initiative is facilitated by KSG.

3. Identifying

Identification involved two stages: Testing and Tracing.

3.1 Testing

- **Frugal Test Kit:** With the support from state's disaster management body, a frugal test kit 'Chitra N-Gene LAMP-N' was developed by Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST). The kit cuts testing costs by 80% and by reducing false negatives, it is 100% confirmatory. The tests do not require Bio Safety Level (BSL) 2 or 3 laboratories and can be carried out even in district hospitals.
- **Walk-in Sample Kiosks:** *Walk-in Sample Kiosks* or WISks, low-cost portable booths have a glass front with fixed extended gloves attached, through which a healthcare worker from inside the

cubicle collects sample from patient standing outside the cubicle. One of the major benefit of the WISks is that health workers are not required to wear PPE Kit(which is very expensive).

3.2 Tracing

- **Screening at Airport:** A stringent screening system was implemented at all four international airports in Kerala.
- **Check WhatsApp Information:** Contact tracing was done via WhatsApp information, mobile phone tower locations, Google maps timeline, CCTV footage etc.
- **News/Social Media monitoring:** Contact tracing was also done via social media and news platforms.
- **Spatio-temporal map:** A *Spatio-temporal map* (a geographical flow-chart) was published in the local media to serve as an alert for the local population.

4. Containing

Frugal Innovations were used in two containment strategies: Fencing and Isolation.

4.1 Fencing

- Cyberdome (Kerala police cyber cell) developed a geofencing surveillance platform.
- The Kerala Police deployed quadcopters — drones for monitoring movement in lockdown. Under the 'Project Eagle Eye', police invited private players to build a network of 350 drones to scan every corner of the state. The small drones fitted with flashing lights and sirens were also used for making announcements.
- Billion Lives, a Kochi-based start-up, with support from KSG established Interactive Voice Response (IVR) System to place automatic calls to those under quarantine and assess their medical parameters.
- An app meTrack was developed by Keralite entrepreneur based in Japan to monitor suspects under quarantine.

4.2 Isolating

- For purpose of quarantine, 27,000 institutions were identified where around one million people can stay.
- Tourist houseboats, Schools, Colleges were turned into isolation wards.

5. Supporting

Kerala's strategy to deal with the pandemic involved a set of supporting measures-food, medical and psychological.

5.1 Food

- Community kitchen initiative was launched in every gram panchayat.
- Community mutual aid networks were established.
- Kerala Police in collaboration with Invent Labs Innovations launched mobile app 'shopapp' to inform citizens about shops that were open in the neighbourhood to purchase essential supplies.

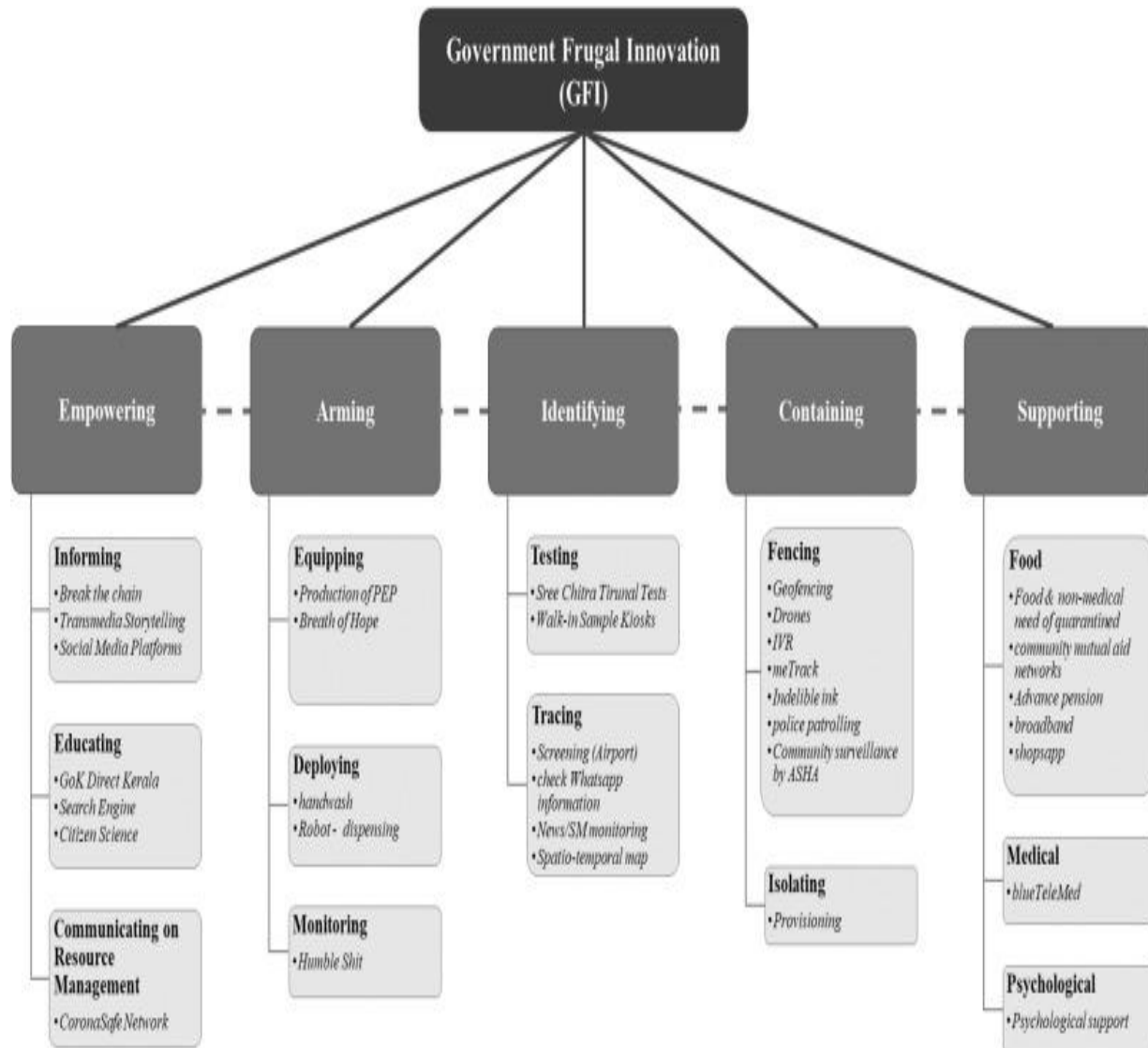
5.2 Medical

- The Kerala police in collaboration with the state chapter of Indian Medical Association (IMA) and a firm BlueEHR made doctors' consultations available online via blue Telemed, a telemedicine app.

5.3 Psychological

- Telephone counselling and support were provided by psychologists and psychiatric social workers to those in quarantine.

Figure 24: Government Frugal Innovation in Kerala



Source: Sarkar, Soumodip. 2021. "Breaking the Chain: Governmental Frugal Innovation in Kerala to Combat the COVID-19 Pandemic." *Government Information Quarterly*, 15.

<https://reader.elsevier.com/reader/sd/pii/S0740624X20303282?token=C06160030A9B46DC854556519A56592AFBB200EDCEE1B019ACDF506DA9F1606C9D19F3075106E54B1DB46B2F44769F9&originRegion=eu-west-1&originCreation=20210421125434>

Other Frugal Innovations

Antiviral Fabric

Fabiosys Innovations, a start-up, in collaboration with All India Institute of Medical Sciences has developed antiviral fabric (Indian Global Business Staff 2020). The fabric has been in use in various hospitals in Delhi in the form of uniforms, bed sheets and curtains. The fabric satisfies Indian standard of washing, is affordable and non-toxic.

AI-based Social Distancing Tracking Device

Students of IIT Kharagpur created an innovative AI-based low cost social distancing tracking device (India Today 2020) (Figure 25). The device can visually detect the gap between individuals and in case of violation of the social distancing norms it plays a proximity alert sound via audio output.

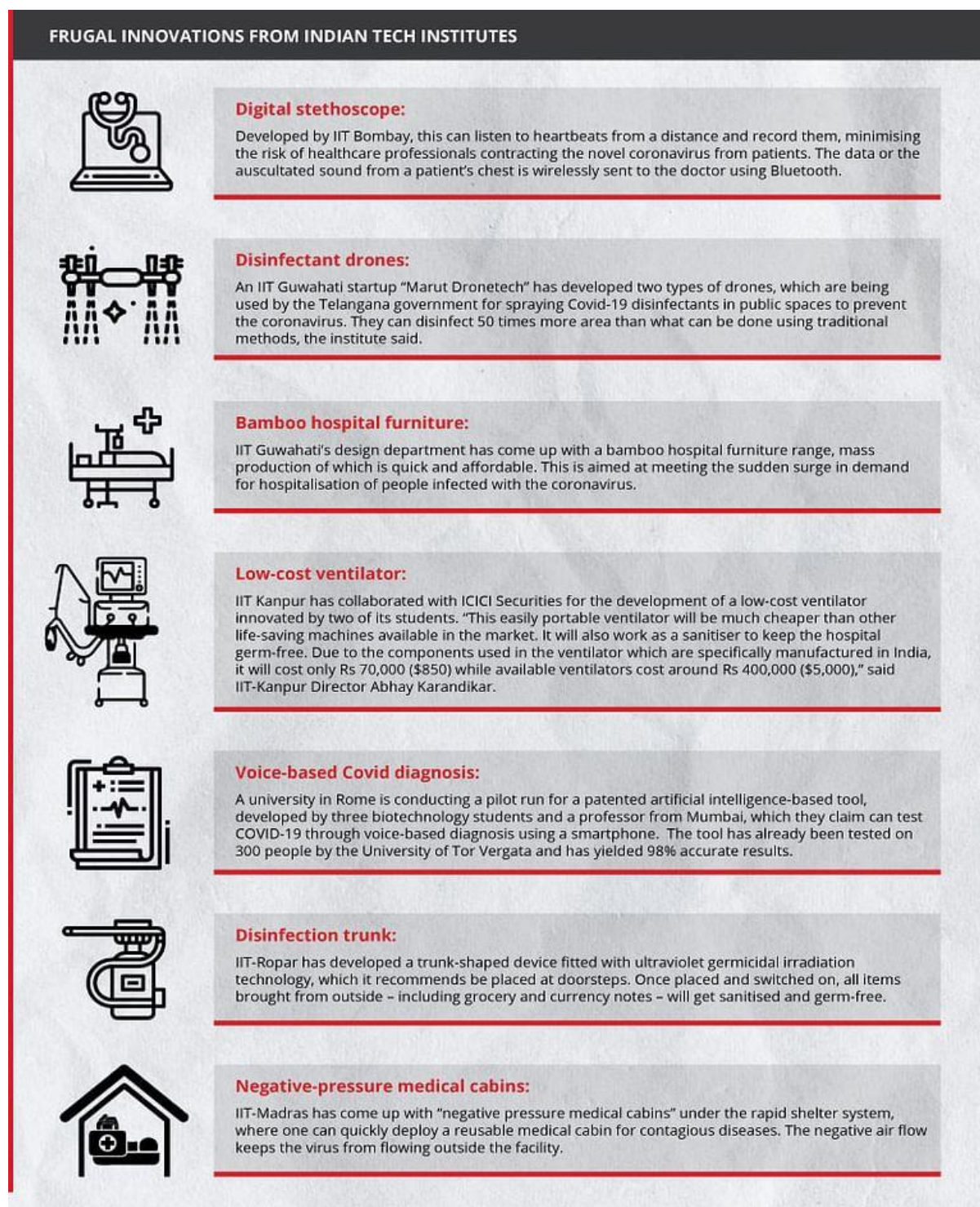
Figure 25: AI-based Social Distancing Tracking Device



Source: India Today. 2020. "IIT Kharagpur Students Create Innovative AI-Based Social Distancing Tracking Device." 2020. <https://www.indiatoday.in/education-today/news/story/iit-kharagpur-students-create-innovative-ai-based-social-distancing-tracking-device-1688573-2020-06-13>

Some of the other frugal innovations developed by Indian Tech Institutes are shown in Figure 26.

Figure 26: Frugal Innovation from Indian Tech Institutes



Source: Indian Global Business Staff. 2020. "Indian Innovation Leads the Fight against the Pandemic." 2020. <https://www.indiaglobalbusiness.com/analyses/snap-analysis/indian-innovation-leads-the-fight-against-the-pandemic>

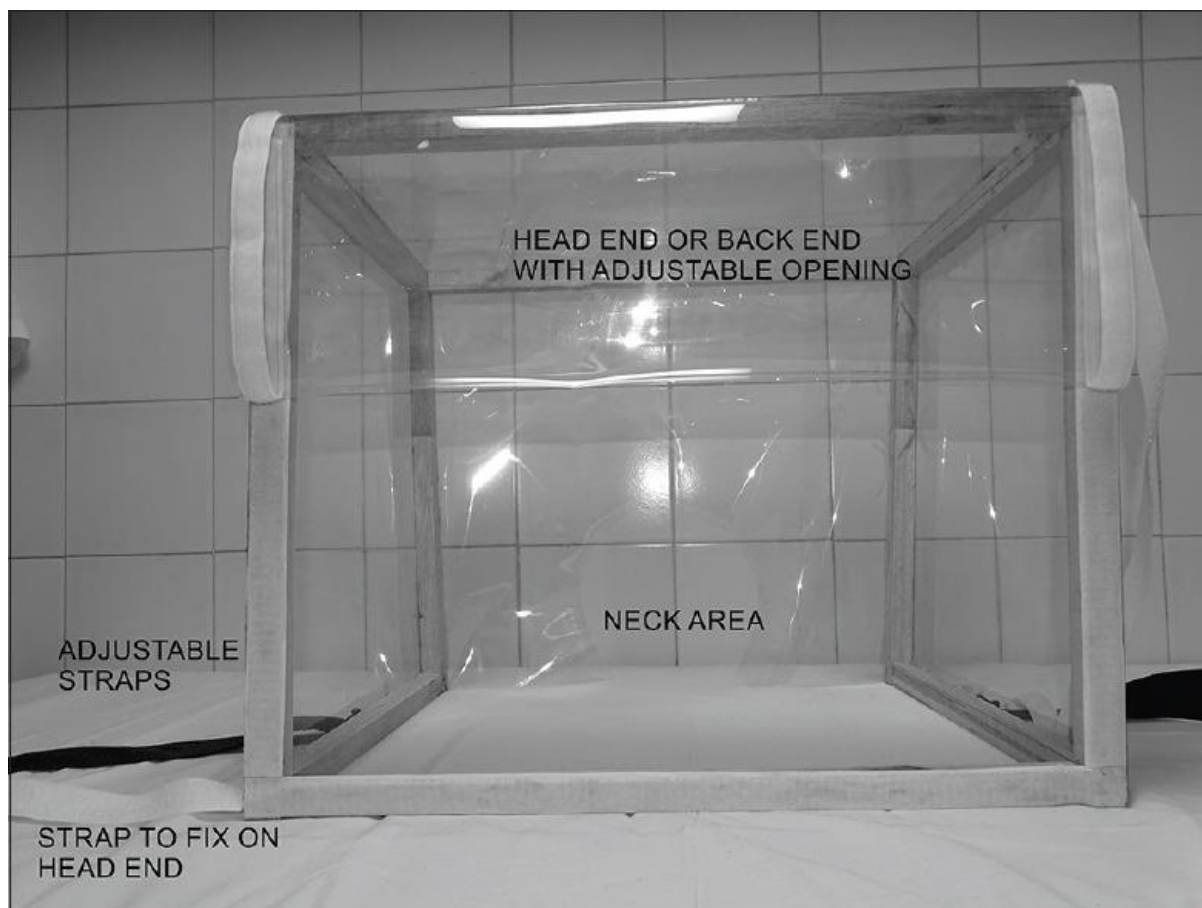
Rapid paper-strip test kit

In April 2020, the Council of Scientific and Industrial Research (CSIR) in collaboration with Industrial Research's Institute of Genomics and Integrative Biology (IGIB) have developed a low-cost paper strip test for COVID-19. The test was named after Bengal's most famous detective 'Feluda'. The specificity of the test is 100%.

Negative pressure aerosol containment box:

Gupta et al. proposes an aerosol containment box for use during intubation and extubation in COVID intensive care unit(Gupta et al. 2020) (See Figure 27). This low cost negative pressure containment box is low cost and can be made via readily available resources. The box can be reused every 6-8 hours after decontaminating with 1% hypochlorite.

Figure 27: Aerosol Containment Box



Source: Gupta, Vivek, Ashish Sahani, Bishav Mohan, and G.S Wander. 2020. "Negative Pressure Aerosol Containment Box: An Innovation to Reduce COVID-19 Infection Risk in Healthcare Workers." *J Anaesthesiol Clin Pharmacol* 36(Suppl 1): S144–S147 (August).

https://doi.org/10.4103/joacp.JOACP_217_20

Patient Coverall

Ayyan et al. describes a 'patient coverall' to cover the patient from head to toe to facilitate easy transfer of patient in between wards without the fear of transmitting aerosol and droplet

transmission (see Figure 28)(Ayyan et al. 2020). It is made up of PVC pipes over which plastic sheets were placed to cover the patient all around.

Figure 28: Patient Coverall



Source: Ayyan, S.Manu, K.N.J Prakash Raju, Naman Jain, and M Vivekanandan. 2020. “Cost-Effective Innovative Personal Protective Equipment for the Management of COVID-19 Patients.” *J Glob Infect Dis* 12 (2): 113–14. https://doi.org/10.4103/jgid.jgid_93_20

M-19 Shields

Maker’s Asylum, a makerspace in Mumbai, founded the M-19 collective as a single, unified response to COVID-19 from maker initiatives across India(Corsini, Dammicco, and Moultrie 2021). Starting with just 10 employees, over 42 makerspaces joined the collective and in just 49 days they were able to provide 1 Million M-19 face shields to the front line workers (M as a tribute to the maker community and 19 for #COVID19).

Figure 29: Assembling M-19 face shields (left); Police wearing M-19 face shields (right)



Source: Corsini, Lucia, Valeria Dammicco, and James Moultrie. 2021. “Frugal Innovation in a Crisis: The Digital Fabrication Maker Response to COVID-19.” *R&D Management* 51 (2): 195–210. <https://doi.org/10.1111/radm.12446>

Recommendations

It is recommended that:

- In order to prevent third wave of COVID-19 infections in India, a coordinated national effort is needed.
- A strong and clear infection containment strategy is needed.
- Government should take necessary steps such as augmentation of healthcare infrastructure, capacity building of manpower, availability and supply of logistics, such as medical oxygen, ventilators etc. to prepare for any future spike in the cases.
- Deploy key celebrities from the film industry (not just in Hindi, but focusing more importantly on each state with their celebrities and in their language) and sports, such as cricketers to speak on national television about the importance of wearing masks when outside and more importantly on wearing it properly, including covering the nose. This messaging is critical.
- Until sizeable Indian population is vaccinated, perhaps a billion people, masks are our most protective non-pharmaceutical intervention (NPI).
- Just as the U.S. experience shows, infections are likely to spread across all the states in India too whether they are predominantly rural and/or in the hinterland. Right now is the time to plan and prepare to face the spread of infections in states that have not seen the spike in cases as yet.
- Use large stadiums to quickly set-up makeshift hospitals and urge the big corporates to help in this regard; they can use their CSR funds to do so.
- Mass gatherings need to be put a COMPLETE stop to.
- Government should step up the vaccination drive and adopt advanced procurement strategies.
- Districts with more than 75% of the cases should be prioritized for vaccination.
- Vaccine camps must be organized in high-risk areas.

- Efforts are needed to keep the vaccine wastage to a minimum.
- The unique outreach advocacy campaign using cultural troops to address vaccine hesitancy launched in the state of Maharashtra and Goa should be extended to other parts of India.
- It is recommended to build capacities, improve the health infrastructure including the cold chain component for the vaccination drive to be effective in rural areas.
- A study must be undertaken to explore early experiences of the 'e-Sanjeevani OPD' users (both healthcare providers and beneficiaries). This would be helpful in addressing the challenges faced by the users and making necessary improvements. This in-turn would be useful in making this intervention sustainable even during the post-COVID era.
- AYURAKSHA programme should be extended to include other frontline workers, such as municipal workers, armed forces, health workers, disaster management workforce, civil defence personals etc.
- Infectious disease diagnostic lab (I-lab) should be rolled out across India and it should be utilized for detection of other infectious diseases (apart from COVID) prevalent in the country.
- Remote monitoring systems which have been utilized during COVID should be explored for use for other health conditions. This would be helpful in reducing the burden of hospitalization in healthcare settings.
- Medicab-Portable hospital units could be deployed across India to deal with the sudden surge in COVID-19 cases. These units could also be helpful in dealing with any healthcare emergency in future. They can also be set up as micro-hospitals/clinics in rural India.
- Foot-operated hand sanitization device is a low cost device and can be deployed for use in all the public places across India.
- Disinfectant tunnels could be deployed at public places which are more crowded like market areas, airports, railway stations, metro stations, cinema halls etc.
- Training curriculum of police workforce should not only focus on hard skills but also emphasize on behavioural competencies and soft skills.
- Boat clinics, Bus clinics, Train clinics should be made available and accessible in more and more numbers for emergency/specialist/primary care in areas where construction of healthcare structure is not possible.
- The idea of floating supermarkets could be implemented in all the areas where boats are one of the major means of transport, even during post-covid era.
- Government should lay more emphasis on preventive measures such as wearing masks, sanitization, regular hand washing and physical distancing.
- Government should undertake regular review of COVID-19 vaccination drive.
- Surveillance activities to identify more lethal strains like lambda should be undertaken.
- Government should extend their support to women self-help groups for community related work.
- Efforts should be directed towards promoting e-initiatives which link farmers directly to the consumers such as Farm to Kitchen e-Commerce initiative.
- Integrated Technology Enabled Agri Management System (i-TEAMS) initiative in the state of Meghalaya should be extended to other parts of the country.

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- A study must be undertaken to explore experiences of 'DIKSHA' portal users. This would be helpful in addressing the challenges faced by the users and making necessary improvements.
- Student Toll free centres (as initiated by government of Andhra Pradesh) could be established in other states and union territories (UTs) to connect students to expert teachers for resolving queries related to a particular subject.
- States/UTs across India should launch applications like Madhya Pradesh "Top Parent App", to build parent skills as educators, especially in the times of COVID-19 when students are studying in online mode at home.
- Other states/UTs must learn from frugal innovations in Kerala and implement similar innovations, and
- Frugal Innovations like Aerosol Containment Box and Patient Coverall could be used on a wide scale in Covid care settings.

References

- 10Pointer. 2020. "Dhanwantari Rath to Bring Ayurveda at Doorsteps." August 2020. <https://www.10pointer.com/current-affairs/dhanwantari-rath-to-bring-ayurveda-at-doorsteps>
- 1917-iTEAMS Program Management Unit. 2018. "1917 INTEGRATED TECHNOLOGY ENABLED AGRI MANAGEMENT SYSTEM (ITEAMS) – Using ICT for Empowering Agriculture." 2018. <http://megagriculture.blogspot.com/2018/06/1917-integrated-technology-enabled-agri.html>
- Akileish, R. 2020. "Tiruppur Gets a Unique 'Disinfection Tunnel' to Fight against COVID-19." 2020. <https://www.thehindu.com/news/national/tamil-nadu/tiruppur-gets-a-unique-disinfection-tunnel-to-fight-against-covid-19/article31226348.ece>
- Anand, Jatin. 2020. "Kejriwal Launches 'Delhi Corona' App for Real-Time Information on Availability of Hospital Beds." Kejriwal Launches 'Delhi Corona' App for Real-Time Information on Availability of Hospital Beds. June 2020. <https://www.thehindu.com/news/cities/Delhi/kejriwal-launches-delhi-corona-app-for-real-time-information-on-availability-of-hospital-beds/article31729239.ece>
- ANI. 2021. "'Deadlier than Delta': Lambda Covid Variant Detected across 30 Countries." 2021. <https://www.livemint.com/science/health/deadlier-than-delta-lambda-covid-variant-detected-across-30-countries-11625615585768.html>
- Auto, YS. 2020. "This Startup Just Launched a Coronavirus Shield for Cars and Bikes." 2020. <https://yourstory.com/automotive/droom-launches-corona-shield-coronavirus>
- Ayyan, S.Manu, K.N.J Prakash Raju, Naman Jain, and M Vivekanandan. 2020. "Cost-Effective Innovative Personal Protective Equipment for the Management of COVID-19 Patients." *J Glob Infect Dis* 12 (2): 113–14. https://doi.org/10.4103/jgid.jgid_93_20
- Bhatia, Anuj. 2020. "From Kerala, a Robot to Take Care of Coronavirus Patients." From Kerala, a Robot to Take Care of Coronavirus Patients - The Indian Express. April 26, 2020. <https://indianexpress.com/article/technology/tech-news-technology/from-kerala-a-robot-to-take-care-of-coronavirus-patients-6329400/>
- Bhatnagar, Armaan. 2021. "In 5 Charts: How India's Second Wave Is Declining as Quickly as It Peaked." 2021. <https://timesofindia.indiatimes.com/india/in-5-charts-how-indias-second-wave-is-declining-as-quickly-as-it-peaked/articleshow/83462403.cms>
- Biswas, Soutik. 2021. "Delta plus India: Scientists Say Too Early to Tell Risk of Covid-19 Variant." 2021. <https://www.bbc.com/news/world-asia-india-57564560>
- Corsini, Lucia, Valeria Dammico, and James Moultrie. 2021. "Frugal Innovation in a Crisis: The Digital Fabrication Maker Response to COVID-19." *R&D Management* 51 (2): 195–210. <https://doi.org/10.1111/radm.12446>
- Dalal, Saachi. 2020. "Utilizing Digital Technology for Covid-19 Response and Ensuring Access to Essential Health Services in Rajasthan, India," 5. https://improvingphc.org/sites/default/files/Rajasthan_telehealth.pdf
- Deol, Taran. 2020. "IIT Madras-Supported Startup Develops Portable Hospital Units to Aid Covid Fight." 2020. <https://theprint.in/india/iit-madras-supported-startup-develops-portable-hospital-units-to-aid-covid-fight/462226/>

- Department of School Education & Literacy, Ministry of Human Resource Development, and Government of India. 2020. "India Report Digital Education: Remote Learning Initiatives Across India." https://www.education.gov.in/sites/upload_files/mhrd/files/India_Report_Digital_Education_0.pdf
- ET Wing, Govt of Telangana. 2020. "T COVID'19." April 2020. <https://play.google.com/store/apps/details?id=com.tsstate.citizen&hl=en>
- ETGovernment. 2020. "HP Govt Develops Mobile App to Monitor Quarantined People." Corona Mukt Himachal: HP Govt Develops Mobile App to Monitor Quarantined People. March 2020. <https://government.economictimes.indiatimes.com/news/digital-india/hp-govt-develops-mobile-app-to-monitor-quarantined-people/74907032>
- Ethiraj, Govindraj. 2021. "Interview: India Is Facing a Second Wave of Coronavirus Because It Let Its Guard down Too Soon." 2021. <https://scroll.in/article/990636/interview-india-is-facing-a-second-wave-of-coronavirus-because-it-let-its-guard-down-too-soon>
- Express News Service. 2020. "ECIL Develops Remote Monitoring System for Covid-19 Patients." ECIL Develops Remote Monitoring System for Covid-19 Patients. May 5, 2020. <https://indianexpress.com/article/cities/hyderabad/ecil-develops-remote-monitoring-system-for-covid-19-patients/>
- Ghosh, Soumya Kanti. 2021. "As Covid Cases Decline, What Should the Government's next Steps Be?" 2021. <https://indianexpress.com/article/opinion/columns/covid-cases-drop-vaccinating-children-msme-sector-crisis-health-infrastructure-7348542/>
- Guha, Nabarun. 2020. "Assam's Boat Clinics Scan Remote Islands for COVID-19." 2020. <https://india.mongabay.com/2020/05/assams-boat-clinics-scan-remote-islands-for-covid-19/>
- Gul, Afsha. 2021. "E Sanjeevani OPD: Patient Registration, Esanjeevaniopd.in Appointment." 2021. <https://pmmodiyojana.in/e-sanjeevani-opd/>
- Gupta, Vivek, Ashish Sahani, Bishav Mohan, and G.S Wander. 2020. "Negative Pressure Aerosol Containment Box: An Innovation to Reduce COVID-19 Infection Risk in Healthcare Workers." *J Anaesthesiol Clin Pharmacol* 36(Suppl 1): S144–S147 (August). https://doi.org/10.4103/joacp.JOACP_217_20
- India Today. 2020. "IIT Kharagpur Students Create Innovative AI-Based Social Distancing Tracking Device." 2020. <https://www.indiatoday.in/education-today/news/story/iit-kharagpur-students-create-innovative-ai-based-social-distancing-tracking-device-1688573-2020-06-13>
- . 2021a. "Covid-19: RBI Governor Announces Measures to Tackle 2nd Wave, Promises More Steps." <https://www.indiatoday.in/business/story/covid-19-rbi-governor-announces-measures-to-tackle-2nd-wave-promises-more-steps-1799007-2021-05-05>
- . 2021b. "Phase 3 Vaccination Starts Today to Cover All Aged 45+ as India's Covid Figures Soar Again | 10 Points." 2021. <https://www.indiatoday.in/coronavirus-outbreak/story/phase-3-covid19-vaccination-starts-today-india-coronavirus-case-situation-1785780-2021-04-01>
- Indian Council of Agricultural Research, Division of Agricultural Extension. 2020. "Innovative Agri-Solutions during COVID-19." https://icar.org.in/sites/default/files/Innovative_Agri-Solutions_COVID-19-2020-1106.pdf

- Indian Global Business Staff. 2020. "Indian Innovation Leads the Fight against the Pandemic." 2020. <https://www.indiaglobalbusiness.com/analyses/snap-analysis/indian-innovation-leads-the-fight-against-the-pandemic>
- Jacob, Urvi. 2020. "Indian Cops Get Creative with Their COVID-19 Messages." April 2020. <https://yourstory.com/weekender/indian-cops-creative-coronavirus-messages>
- Kapur, Yashoda. 2021. "What Is India Doing to Contain the Latest COVID Pandemic Wave?" 2021. <https://www.india-briefing.com/news/what-is-india-doing-to-contain-the-latest-covid-pandemic-wave-22139.html/>
- Khanna, Bharat, and Mayilvaganan. 2020. "Innovation in Times of COVID-19." 2020. https://timesofindia.indiatimes.com/articleshow/74942548.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst_prime
- Kumar, Ruchir. 2020. "Bihar Nod to NIPI to Develop AI-Powered Tool to Track Covid-19 Suspects." Bihar Nod to NIPI to Develop AI-Powered Tool to Track Covid-19 Suspects. April 2020. <https://www.hindustantimes.com/patna/bihar-nod-to-nipi-to-develop-ai-powered-tool-to-track-covid-19-suspects/story-YDXNp1x8jLpfOrKup4Uh6K.html>
- M Sheriff, Kaunain. 2021. "60% Districts with High Positivity in Northeast, PM to Meet CMs Today." 2021. <https://indianexpress.com/article/india/coronavirus-60-per-cent-dists-with-high-positivity-in-northeast-pm-to-meet-cms-today-7401626/>
- Madaik, Devyani. 2020. "Defence Ministry Patents Low-Cost PPE Developed By Indian Navy For Rapid Mass Production." 2020. <https://thelogicalindian.com/news/indian-navy-creates-low-cost-ppe-21121>
- Madur, G.S. 2021. "Covid: Several States Face Vaccine Shortage Following Centre Blitz." 2021. <https://www.telegraphindia.com/india/coronavirus-outbreak-several-states-face-vaccine-shortage-following-centre-blitz/cid/1820747>
- Meara, Killian. 2021. "Centralized COVID-19 Vaccine Drive Coming to India." 2021. <https://www.hcplive.com/view/covid-19-vaccine-drive-india>
- Mehdi, Ali. 2021. "Tackling COVID-19: Public Health and Socioeconomic Strategies." http://icrier.org/pdf/ICRIER-KAS_Covid-19_Policy_Brief_2.pdf
- Mehrotra, Isha. 2021. "Uttar Pradesh Reports First Two Cases of Delta Plus Variant, One Dies." 2021. <https://zeenews.india.com/india/uttar-pradesh-reports-first-two-cases-of-delta-plus-variant-one-dies-2374830.html>
- Ministry of Health & Family Welfare, Government of India. 2020. "Health Ministry's Telemedicine Service e Sanjeevani Completes 9 Lakh Consultations [Press Release]." <https://pib.gov.in/PressReleasePage.aspx?PRID=1677674>
- Ministry of Health and Family Welfare. 2021. "Unite2FightCorona." *Twitter*. <https://twitter.com/COVIDNewsByMIB/status/1415559894632075266>
- Ministry of Health and Family Welfare, Government of India. 2021. "CoronaVirusUpdates." *Twitter*. <https://twitter.com/COVIDNewsByMIB/status/1415537019095175168>
- Ministry of Information & Broadcasting. 2021. "Maharashtra and Goa Use Popular Performing Arts and Folk Media for COVID Vaccination Advocacy [Press Release]." <https://pib.gov.in/PressReleaselframePage.aspx?PRID=1707455>
- Ministry of Science & Technology, Government of India. 2020. "Dr Harsh Vardhan Launches DBT – AMTZ Mobile Diagnostic Unit for Covid Testing- I-Lab [Press Release]." <https://pib.gov.in/PressReleasePage.aspx?PRID=1632393>

- Ministry of Science and Technology, Government of India. 2020a. "Kerala Start-Ties up with SCTIMST to Launch IoT Based Used Mask Disposal Smart Bin & UV Light-Based Disinfection Device to Beat COVID 19." 2020. <https://dst.gov.in/kerala-start-ties-sctimst-launch-iot-based-used-mask-disposal-smart-bin-uv-light-based-disinfection>
- . 2020b. "S&T Based Innovative Solutions by Common People Participating in NIFs Challenge COVID-19 Competition (C3) Ready to Make a Difference." 2020. <https://dst.gov.in/st-based-innovative-solutions-common-people-participating-nifs-challenge-covid-19-competition-c3>
- Mitter, Sohini. 2020. "Coronavirus: 7 Contact Tracing and Patient Monitoring Apps Being Used by India." Coronavirus: 7 Contact Tracing and Patient Monitoring Apps Being Used by India. April 2020. <https://yourstory.com/2020/04/coronavirus-contact-tracing-patient-monitoring-apps-india>
- Mizoram State e-Governance Society. 2020. "MCOVID-19." 2020. <https://mccovid19.mizoram.gov.in/>
- Mordani, Sneha. 2021. "Third Covid-19 Wave Likely in August, India to See 1 Lakh Cases Daily: Top ICMR Scientist." 2021. <https://www.indiatoday.in/coronavirus-outbreak/story/third-covid-19-wave-likely-in-august-india-to-see-1-lakh-cases-daily-top-icmr-scientist-1829134-2021-07-16>
- Nag, Devanjana. 2020. "Indian Railways Goes Innovative in Fight against Coronavirus! Check out These Top 5 Unique Initiatives." 2020. <https://www.financialexpress.com/infrastructure/railways/indian-railways-goes-innovative-in-fight-against-coronavirus-check-out-these-top-5-unique-initiatives/1926455/>
- Nag, Jayatri. 2020. "West Bengal Government Launches App to Track COVID-19." West Bengal Government Launches App to Track COVID-19. April 2020. <https://mumbaimirror.indiatimes.com/coronavirus/news/west-bengal-government-launches-app-to-track-covid-19/articleshow/75069663.cms>
- Nagpur Today. 2020. "COVI-SAFE: Nagpur's Aureus Hospital Make Transport System for Covid-19 Patients." 2020. <https://www.nagpurtoday.in/covi-safe-nagpurs-aureus-hospital-makes-first-make-in-india-transport-system-for-covid-19-affected-patients/04022102>
- NDTV. 2021. "Warning Signal, Next 100-125 Days Critical": NITI Aayog On Covid." 2021. <https://www.ndtv.com/india-news/warning-signal-next-100-125-critical-says-niti-aayog-dr-vk-paul-on-covid-19-2488324>
- NDTV Education. 2020. "IIT Madras Incubated Startup Develops Portable Covid-19 Hospital Unit 'MediCAB.'" 2020. <https://www.ndtv.com/education/iit-madras-incubated-startup-develops-portable-covid-19-hospital-unit-mediacab>
- News Services Division, All India Radio. 2020. "Delhi Police Commissioner Launches Initiative Ayuraksha- 'Corona Se Jung - Delhi Police Ke Sang.'" April 2020. <http://www.newsonair.com/News?title=Delhi-police-Commissioner-launches-initiative-Ayuraksha--%E2%80%98Corona-se-jung---Delhi-Police-ke-sang%E2%80%99&id=387198>
- Our World in Data. 2021. "Daily New Confirmed COVID-19 Cases." 2021. <https://ourworldindata.org/coronavirus/country/india>

- Pathak, Haryax. 2021. "India's COVID-19 Vaccination Campaign: A Marathon, Not a Sprint," 20. https://orfonline.org/wp-content/uploads/2021/06/ORF_SpecialReport_143_Vaccination-Marathon.pdf
- Paul A., Sam. 2020. "In Alappuzha, Floating Supermarket Brings Essentials to the Doorstep of Lockdown-Affected." 2020. <https://www.thehindu.com/news/national/kerala/floating-supermarket-brings-essentials-to-the-doorstep-of-lockdown-affected/article31264618.ece>
- PIB Delhi. 2020. "AYURAKSHA-Corona Se Jung- Delhi Police Ke Sang Launched by All India Institute of Ayurveda [Press Release]." <https://pib.gov.in/PressReleasePage.aspx?PRID=1619678>
- Press Trust of India. 2020a. "COVID-19: Guj Govt Launches App to Track Home-Quarantined Persons." COVID-19: Gujarat Launches App to Track Home-Quarantined Persons. March 2020. <https://www.thequint.com/news/india/coronavirus-gujarat-government-launches-mobile-app-to-track-home-quarantined-as-covid-suspects>
- . 2020b. "AI-Enabled Voice Tool Designed By Mumbai Professor To Detect COVID-19 Being Tested." Coronavirus: Artificial Intelligence Enabled Voice Tool. April 2020. <https://www.ndtv.com/india-news/coronavirus-artificial-intelligence-enabled-voice-tool-designed-by-mumbai-professor-to-detect-covid-2212853>
- . 2020c. "IIT Professor Develops Software to Detect COVID-19 within 5 Seconds Using X-Ray Scan." IIT Professor Develops Software to Detect COVID-19 within 5 Seconds Using X-Ray Scan. April 2020. <https://economictimes.indiatimes.com/news/science/iit-professor-develops-software-to-detect-covid-19-within-5-seconds-using-x-ray-scan/articleshow/75344027.cms?from=mdr>
- . 2020d. "AIIMS Deploying Milagrow Robots at Covid-19 Ward to Contain Spread of Disease." AIIMS Deploying Milagrow Robots at Covid-19 Ward to Contain Spread of Disease. April 22, 2020. https://economictimes.indiatimes.com/magazines/panache/aiims-deploying-milagrow-robots-at-covid-19-ward-to-contain-spread-of-disease/articleshow/75286073.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
- . 2020e. "Pune Institute Develops AI for Detection of COVID-19." Pune Institute Develops AI for Detection of COVID-19 - Fullstory. June 21, 2020. http://www.ptinews.com/news/11528013_Pune-institute-develops-AI-for-detection-of-COVID-19.html
- . 2021. "India Managed Covid Second Wave 'Very Well': Niti Member Saraswat." 2021. https://www.business-standard.com/article/current-affairs/india-managed-covid-second-wave-very-well-niti-member-saraswat-121060400710_1.html
- PTI. 2020. "Defence Ministry Patents Low Cost PPE Developed by Navy in Move toward Mass Production." 2020. <https://theprint.in/india/defence-ministry-patents-low-cost-ppe-developed-by-navy-in-move-toward-mass-production/421812/>
- . 2021. "Vaccine for All above Age of 45 Years from April 1: Govt." 2021. <https://health.economictimes.indiatimes.com/news/policy/vaccine-for-all-above-age-of-45-years-from-april-1-govt/81650212>

- Sarkar, Soumodip. 2021. "Breaking the Chain: Governmental Frugal Innovation in Kerala to Combat the COVID-19 Pandemic." *Government Information Quarterly*, 15.
<https://reader.elsevier.com/reader/sd/pii/S0740624X20303282?token=C06160030A9B46DC854556519A56592AFBB200EDCEE1B019ACDF506DA9F1606C9D19F3075106E54B1DB46B2F44769F9&originRegion=eu-west-1&originCreation=20210421125434>
- Sharma, Manoj, and Mudit Kapoor. 2021. "From 8,000 to 1 Lakh in Just 62 Days; 2nd Covid-19 Wave Is More Infectious than 1st." 2021.
<https://www.businesstoday.in/coronavirus/from-8000-to-1-lakh-in-just-62-days-2nd-covid-19-wave-more-infectious-than-1s/story/435863.html>
- The Economic Times. 2020. "The 'phone Booths' That Are Making Covid Tests in India Easier, Quicker and Safer." 2020.
<https://economictimes.indiatimes.com/industry/healthcare/biotech/healthcare/the-phone-booths-that-are-making-covid-tests-in-india-easier-quicker-and-safer/articleshow/75040280.cms?from=mdr>
- The Prodigal Techie. 2020. "COVI-SAFE Transportation System." 2020.
<https://theprodigaltechie.com/covid-19/covi-safe/>
- The World Bank Group. 2020. "In India, Women's Self-Help Groups Combat the COVID-19 (Coronavirus) Pandemic." April 2020.
<https://www.worldbank.org/en/news/feature/2020/04/11/women-self-help-groups-combat-covid19-coronavirus-pandemic-india>
- Times of India. 2021. "Explained in 10 Charts: How India's Second Covid Wave Is More Severe, Different than First." 2021. <https://timesofindia.indiatimes.com/india/indias-second-covid-wave-is-more-severe-and-likely-to-worsen/articleshow/81744654.cms>
- Vinaykumar, Rai, and Mudit Kapoor. 2021. "COVID-19 Vaccination: At Current Rate, India Will Take 10.8 Years to Vaccinate 70% Population." 2021.
<https://www.businesstoday.in/coronavirus/covid-19-vaccination-current-rate-india-take-12-years-vaccinate-70pc-population/story/433737.html>
- Vora, Rutam. 2020. "LiFi Technology to Monitor Covid-19 Patients." LiFi Technology to Monitor Covid-19 Patients - The Hindu. April 8, 2020.
<https://www.thehindubusinessline.com/news/science/lifi-technology-to-monitor-covid-19-patients/article31287574.ece#>
- Wikipedia. 2021. "COVID-19 Vaccination in India." 2021. https://en.wikipedia.org/wiki/COVID-19_vaccination_in_India
- World Health Organization. 2020a. "5 Innovative Ideas for People to Live Their Lives While Staying Safe from COVID-19." 2020. <https://www.who.int/westernpacific/news/feature-stories/detail/5-innovative-ideas-for-people-to-live-their-lives-while-staying-safe-from-covid-19>
- . 2020b. "WHO Supports the Government of Maharashtra's Initiatives to Maintain Routine Immunization during COVID-19." 2020.
<https://www.who.int/india/news/feature-stories/detail/who-supports-the-government-of-maharashtra-s-initiatives-to-maintain-routine-immunization-during-covid-19>
- . 2021a. "India Rolls out the World's Largest COVID-19 Vaccination Drive." 2021.
<https://www.who.int/india/news/feature-stories/detail/india-rolls-out-the-world-s-largest-covid-19-vaccination-drive>

- . 2021b. “Maharashtra and Goa Use Popular Folk Performing Arts for COVID Vaccination Advocacy.” 2021. <https://www.who.int/india/news/feature-stories/detail/maharashtra-and-go-a-use-popular-folk-performing-arts-for-covid-vaccination-advocacy>
- Zachariah, Serene Sarah. 2020. “Kerala’s ‘Nightingale-19’ Robot Serves Meals, Helps Doctors Treat COVID-19 Patients.” Kerala’s ‘Nightingale-19’ Robot Serves Meals, Helps Doctors Treat COVID-19 Patients. April 2020. <https://www.thebetterindia.com/224546/covid-19-kerala-robot-nightingale-19-innovation-protect-health-workers-india-ser106/>

Annexures

Annexure 1: List of Comorbidities included under the vaccination programme

List of Comorbidities

- Heart Failure with hospital admission in past one year
- Post Cardiac Transplant/Left Ventricular Assist Device (LVAD)
- Significant Left ventricular systolic dysfunction (LVEF <40%)
- Moderate or Severe Valvular Heart Disease
- Congenital heart disease with severe PAH or Idiopathic PAH
- Coronary Artery Disease with past CABG/PTCA/MI AND Hypertension/ Diabetes on treatment
- Angina AND Hypertension/ Diabetes on treatment
- CT/MRI documented stroke AND Hypertension/ Diabetes on treatment
- Pulmonary artery hypertension AND Hypertension/ Diabetes on treatment
- Diabetes (> 10 years OR with complications) AND Hypertension on treatment
- Kidney/ Liver/ Haematopoietic stem cell transplant: Recipient/On wait-list
- End Stage Kidney Disease on Haemodialysis/ CAPD
- Current prolonged use of oral corticosteroids/ immunosuppressant medications
- Decompensated cirrhosis
- Severe respiratory disease with hospitalizations in last two years/FEV1 <50%
- Lymphoma/ Leukaemia/ Myeloma
- Diagnosis of any solid cancer on or after 1 July 2020 OR currently on any cancer therapy
- Sickle Cell Disease/ Bone marrow failure/ Aplastic Anaemia/ Thalassemia Major
- Primary Immunodeficiency Diseases/ HIV infection
- Persons with disabilities due to Intellectual disabilities/ Muscular Dystrophy/ Acid attack with involvement of respiratory system/ Persons with disabilities having high support needs/ Multiple disabilities including deaf-blindness