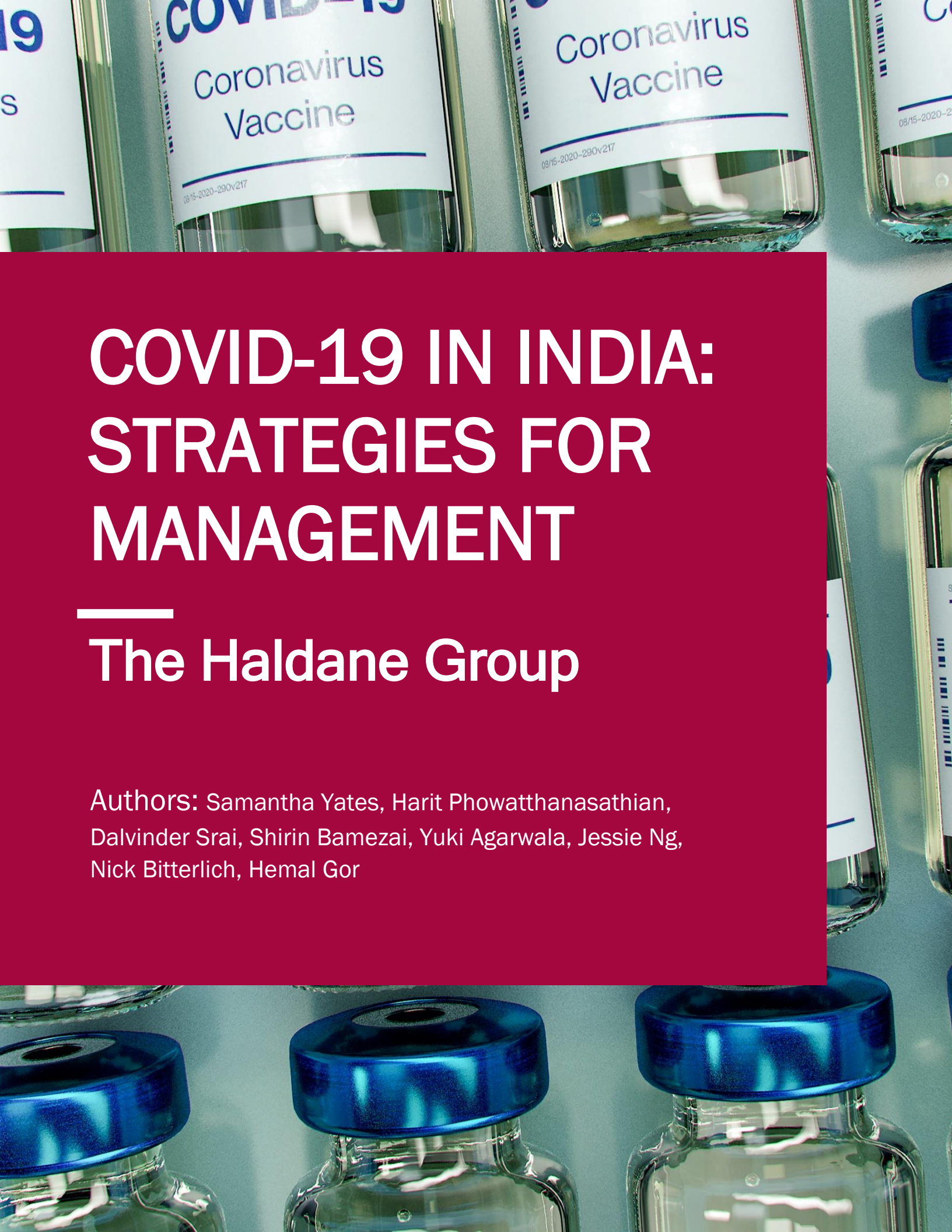

COVID-19 IN INDIA: STRATEGIES FOR MANAGEMENT

The Haldane Group

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Executive summary

This paper details four crucial areas of consideration for COVID-19 management in India, namely, vaccination strategies, resources and supply chain, public structures and social attitudes. The COVID-19 pandemic was a stress test for public policy worldwide – this has provided a rare opportunity for evaluation of government strategies. India, with its vast population and its infamous socio-economic disparities, provides an extreme example of the consequences of inadequate policy and non-resilient structures. In this paper, we isolate the key challenges India has faced across these areas and offer management routes for both national and international policymakers alike.

Below is a summary of recommendations for improved policies within the context of vaccinations, resources and supply chains, public structures and social attitudes.

Vaccination strategies:

- Provide security, health insurance, and transport for healthcare workers, alongside sufficient and effective protective equipment
- Ongoing and up-to-date training for ASHA workers
- Implementation of a comprehensive healthcare database to track the extent of the pandemic's spread, hotspots, and priority regions of vaccination
- Research into varied vaccine regimens including heterogeneous vaccination regimens to afford a more flexibility

Resources and Supply chain:

- Patent and technology-transfer buyouts for widespread vaccine manufacturing 'know-how' and capitalisation of latent vaccine capacity
- Deployment of data tools for holistic and improved resource allocation strategies
- Policies for greater government control in marshalling private sector resources
- Creation of surge capacity in the human supply chain to withstand high-demand situations

Public structures:

- Broadcast appropriate medical information via radio, the media source that most of the population has access to, for more efficient and complete communication
- Optimize hospital capacity levels via temporary and specialist hospitals
- Increase the usage of at-home monitoring devices and teleconsultation platforms to reduce the need for in-person consultations

Social attitudes:

- Governmental transparency and action to rectify damaged public approval by compensating disadvantaged communities
- Recruitment of influential figures to sway public opinion in favour of vaccination, despite previous government setbacks and failures that have soured public opinion

Introduction

Within each focus area of this report, we have isolated the principal drivers impacting the COVID-19 crisis in India. In detailing the core issues within each focus area, we hope to illustrate the need for responsive and robust structures to be adopted – both within India and internationally. Recommendations for developing such structures are given within the fields of vaccination, resources and supply chain, and public structures. However, we recognize that implementation strategies must be adapted and reactive to the social fabric of a nation – our section on social attitudes explores India's key governing challenges, setting out options for improved communication policies that generate greater compliance among the population.

Vaccination

India has had a successful history with vaccination programs, coordinating a multitude of government branches to eradicate smallpox and polio. Surveillance and containment efforts consequently have been set up to monitor for any potential recurrence of these deadly infections. However, the endeavor of a smallpox- and polio-free India was not without its obstacles. Regarding India's first vaccination effort, with smallpox, the 175 years it took to achieve full eradication was littered with logistical and economic issues ranging from differing vaccination standards and dealing with India's large population to a lack of health activist funding. India's Accredited Social Health Activists (ASHAs) have been a core aspect of the vaccination effort from the smallpox era until now – but remnants of these historical problems still linger. The relatively recent large vaccination effort for polio eradication was significantly more efficient with technological developments and support from the WHO. Administration protocol standards and production were still an issue that came with a sped-up manufacturing and distribution cycle. Now with the SARS-CoV-2 pandemic, India is facing similar problems to those faced in both the smallpox and polio era. As such, it would be constructive to assess potential solutions by reviewing previous vaccination effort experiences.

Alongside drawing from their abundant historical experience, India should also utilize their technological and research advancements from the past few decades. Being the largest vaccine provider in the world, India has the leading edge in vaccine resource management and distribution. Currently, India has developed 2 vaccines of their own, Covishield and Covaxin, whilst importing other vaccines from abroad. Despite India's vaccine track record, they are arguably one of the hardest hit countries during the current pandemic. The SARS-CoV-2 pandemic has been the breeding ground for misinformation and distrust between the government and the public, exacerbated by the widespread availability of false information. The distrustful atmosphere cultivated in some regions of India is not a new phenomenon, but one that needs to be swiftly corrected. Additionally, India has not fully utilized their technological capability in coordination with their healthcare system - leading to gaps in their patient information and hindering analysts from attaining the full depth of the pandemic damage. Further research is also required on the available vaccines and their scheduled regimens to not only evidence its efficacy, but to also provide a degree of transparency to the public.

Resources and Supply chain

Pandemic management benefits from adopting best-practice strategies for resource optimisation and allocation. India, much like other countries, has faced equipment and resource shortages that challenge health systems. However, unlike most countries, India possesses a powerful pharmaceutical manufacturing industry – which should be leveraged, particularly in the context of vaccines. Long-term control of SARS-CoV-2 will require vaccines that can combat the most prevalent viral variants. This will require rapid vaccine production

cycles for the coming years, and latent vaccine capacity in India can be harnessed to deliver this. The allocation of existing resources (such as personal protective equipment) should also receive greater attention. During healthcare emergencies, where supplies are limited, decisions on distribution strategies often only consider a fraction of the available situation data. There is good reason for this – emergencies require quick choices for impactful action – but advanced capabilities in predictive analytics and data handling should encourage change here. Advanced data tools can aid decision-making in time pressured situations - such as the need to establish which regions should be a priority in health resource distribution. The capability provided by data tools to quickly synthesise large amounts of information allows for better decision making at crucial turning points of the pandemic.

Key to any pandemic response is the concept of surge capacity, however, the Indian healthcare system is constrained by acute scarcity and resource inequality. These issues can be examined in two dimensions: the divide between the private and public healthcare systems, and the human supply chain. Although the private healthcare system holds a greater number of vital resources, from beds to ventilators, these remain mostly inaccessible in times of crisis. Market-based government policies, as well as the power of the federal and state-administrations to commandeer private hospitals, have proven insufficient in the effort to redistribute resources for an effective and equitable response to a public health crisis. Another fundamental obstacle in growing and maintaining surge capacity is the breakdown of the human supply chain in the healthcare sector, or rather the workforce issues that permeate every level of the public healthcare system. Healthcare personnel are the only line of defence against a pandemic, and thus a fundamental component of successful pandemic response strategies are the public policies surrounding them - from how best to repurpose specialised personnel to how health workers should be safeguarded. In the Indian context, this includes frontline workers operating outside of the infrastructure of a hospital or a clinic, especially in rural regions.

Public structures

The governmental organisations involved in the control of the COVID-19 outbreak in India can be reviewed to determine which areas of pandemic management can be improved. Three key areas have been focused on here - "Education", where we have explored how public awareness can be enhanced, "Hospital numbers", where the lack of hospital capacity control has been assessed and lastly, "Transport accessibility", where we discuss how transport systems have been affected and how measures can be taken to minimize the effects of disrupted transportation infrastructure on healthcare. Research has shown that the public can be better and more widely educated on the disease itself and any advised precautions through broadcasting radio, rather than the internet. In addition, based on past success, collaboration with religious leaders could potentially be a strategy to educate the public. To reduce the impact of limited hospital resources and lack of transportation systems to these healthcare systems, the government can consider building temporary hospitals and implement teleconsultation platforms. These measures will be crucial for the government to improve education on COVID-19 among rural populations, and also make healthcare more available to the public, regardless of their living conditions or proximity to hospitals.

Social attitudes

The introduction of effective and safe vaccines is a central tool in controlling the COVID-19 pandemic. As of late June 2021, 23 vaccines have entered Stage 3 clinical trials, with another dozen vaccines having been approved. For example, the BNT162b vaccine from Pfizer-BioNTech, approved in approximately 90 countries, and the ChAdOx1 nCoV-19 vaccine from Oxford-AstraZeneca (approved in 115 countries) are spearheading this fight against the SARS-CoV-2. Despite the immense success in developing these vaccines within an unprecedented time frame, global vaccine distribution remains highly non-uniform, with only small proportions of vaccine stock directed towards lower or middle-income countries, including India. Despite an effective and equitable COVID-19 vaccine distribution being of utmost importance, ensuring the acceptance of the vaccine by the public may arguably be just as crucial. As is the case for any pandemic, trust in the available vaccines, as well as the governmental and healthcare institutions that administer them, are key to determining the success of the current COVID-19 vaccination campaign in India. This boils down to an ultimate determinant: social attitudes.

Vaccine hesitancy, as determined by social attitudes, remains a potential handicap to widespread community vaccine uptake and immunity. Extensive media coverage of adverse side reactions following receival COVID-19 vaccines may increase concerns about possible long-term health effects. The rapid influx of information about severe (but rare) cases of thrombosis following the AstraZeneca vaccine increased hesitancy levels worldwide. In India, conspiracy theories and rumours have been recognized as triggers for vaccine apprehension. In addition, misleading allegations that vaccines include infertility agents may cause people to refuse vaccinations. Such rumours frequently undermine health policies and actions by government and non-government officials, as well as international health organizations such as the World Health Organization, with detrimental effects. Whether a person believes the circulating misinformation or not is often dependent on the individual's level of health literacy and their risk perceptions. Constant exposure to social media and online anti-vaccine movements, on the other hand, may sway public opinion in favour of spreading vaccination disinformation and conspiracy theories. In addition, misinformation spread by figures of authority may further exacerbate this issue. Focusing on how the actions of the Indian government affected social opinion and attitudes during this pandemic is informative to social health policy initiatives. In this report, we propose interventions that challenge current practices and require immediate government attention to both mitigate the continuing crisis and prepare for future pandemic scenarios.

Vaccination

Vaccination in India: History and COVID-19

In 1802, India administered their first vaccination: a dose of the smallpox vaccine to a 3-year-old girl in Mumbai. India completely eradicated smallpox in 1977 and had since been declared polio-free in 2014, for which the first vaccination was administered in 1994. These are the only two human diseases to be completely eradicated through vaccination efforts in India (1).

As of May 2021, India has found itself entrenched in COVID-19 cases from its second wave, reaching peaks of 400,000 cases a day (2). Fortunately, India is home to Serum, the largest vaccine producer in the world, exporting to 170 counties and accounting for two thirds of vaccines delivered to children. Housing the production capability to output thousands of vaccines a minute, the question remains of why India is having a severe second wave (3). Currently, India has 2 available vaccines, Covishield and Covaxin, and are planning the production of a third, Sputnik (4). Furthermore, India is developing their own vaccines, which range in delivery method, production, and technology, and are in various stages of clinical trials, but not expected to be available any time soon (4).

Covishield is the more widely accepted vaccine of the two currently available, being the one directly adapted from the Oxford Astrazeneca vaccine. Emergency use authorization was granted at the start of January and as of the beginning of May, 130 million doses of Covishield have been administered, comprising 90% of the total vaccines given (5). Its counterpart, Covaxin, has had 13 million doses administered – a much lower figure, partly due to a lack of confidence in its development and clinical trial process (4). Covaxin was the first India-developed vaccine - however, a lack of transparency about its clinical trials and news of deaths that were attributed to some initial doses shattered the trust of the public. Sputnik is the latest of the vaccines to be available, with licensing recently completed and production ramping up. Doses of the Russian vaccine are expected to hit the population at the beginning of the third quarter, with expectations of 750 million doses being produced by 6 firms across India (4).

Vaccines are the best tried-and-tested solution in the event of a pandemic, making their production and administration the top priority for most countries. India, being the largest vaccine producer, were expected to be in a good position, despite seeing the number of vaccinations halt. March saw an average of 3.5 million daily doses of the vaccine, while a couple months later, at the beginning of May, reports showed 1.6 million daily doses were administered (5). Some current estimates expect India to only have vaccinated 300 million people in February of 2022 (5). A year after the second wave, only just over a fifth of the population will have been fully vaccinated, and at this rate, it will take India almost three and a half years to vaccinate their population up to herd immunity thresholds (5). To add to the complexity of the largest vaccination effort in human history, India is also responsible for producing vaccines for other countries, which is being slowed as India has prioritized vaccines to be used by their own frontline health workers, elderly, and at-risk patients.

Many have been dubious of India's potential for COVID-19 recovery due to their lack of transparency and data management. Reports, public forums, and social media threads have expressed that India's laxed patient record management during the stressful second wave led to inaccurate estimations of cases and deaths. The outraged public blames the repercussions of the second COVID-19 wave to the government's nonchalant initial response to the first surge in COVID-19 cases. Further, inconsistent reporting of case and death numbers detracts from India's perceived ability to identify hotspots, provinces in need of resources, and regions where vaccinations need to be prioritized.

Public unease and concerns about transparency from the government extends further than the COVID-19 pandemic. A collaborative initiative, involving the Indian government, its ministry of housing and urban affairs, along with foreign organizations, have invested in what is termed a "Smart City". The core aim is for large cities to become a hub of information that is transparent and easily accessible, allowing governing bodies and the public to analyse data, predict region-wide events - and in the case of the pandemic, help identify a plan of vaccination (6). In the specific case of the COVID-19 pandemic, a smart city would ideally coordinate between institutions and agencies, which involves sharing data between the public and the private healthcare sectors (6). A lack of patient in-and-out records, vaccine administration data, and other medically relevant information had inhibited the entire India healthcare system from effectively identifying locations of high risk, potential hotspots, and areas where vaccines need to be prioritized. A move towards a comprehensive overarching patient record system would directly benefit both the public and private sectors and allow for an analysis to indicate which hospital location requires the most support and resources (6). In addition to coordination, the healthcare system of a smart city would train and adequately staff a team dedicated to organizing, improving, and managing the patient record system (6). The time and monetary investment of this undertaking will be significant, but necessary in tackling future pandemics and or crises.

As of 5th July 2021, India has reported over 31 and a half million cases of COVID and over 400,000 deaths due to the virus. Given the broad spectrum of vaccinations available in India, and their prior success in eradicating smallpox and polio, many will wonder why India is struggling to administer COVID-19 vaccines and counter the pandemic. We will take a retrospective look at the strategies employed in the smallpox and polio vaccination schemes and reflect on what India could do next.

Case studies

Case Study 1: Smallpox

Smallpox is a highly infectious disease caused by the variola virus which can be split into two types, variola major and variola minor, the former being the life-threatening version. The earliest written descriptions of smallpox in India appeared in Sanskrit texts around the 7th century (7).

The World Health Organization (WHO) set out their plan to eradicate smallpox globally in 1958. Between 1962 and 1967, India embarked on their first mass vaccination campaign, the National Smallpox Eradication Programme (NSEP), but outbreaks were still being reported years later. This was possibly due to the difficulty of accessing rural populations, an issue which India is still facing in the COVID-19 pandemic. In 1969, the vaccination technique switched from the rotary lance to bifurcated needle, and more stable freeze-dried vaccines

were implemented in 1971, making vaccination simpler and increasing vaccine uptake. From mid-1973, intensive search and containment efforts, alongside mass vaccination, were underway in every village and each household was visited to detect and record any cases of smallpox. Even though the last case of smallpox reported in India was in 1975, the Government still continued surveillance of the disease (1).

Case Study 2: Polio

Poliomyelitis, more commonly known as polio, is an infection caused by the human poliovirus that can infect the central nervous system and cause muscle weakness and atrophy (8). In 1988, the World Health Assembly (WHA) resolved to eradicate polio worldwide by 2000. Following this announcement, India performed a state-wide vaccination campaign and carried out two National Immunisation Days (NIDs) in December 1995 and January 1996 in which a total of 87 million children up to the age of 3 years old were vaccinated against polio. Similarly, to the surveillance-containment method used in the eradication of smallpox, the National Polio Surveillance Project (NPSP) was set up in 1997 in collaboration with the WHO. As well as this highly organized approach to eradication, policies were passed by the Government of India in 2011 to extend the open vial policy for the oral polio vaccine (OPV) campaign in 2011 (1). This policy could have been a factor in the success of the polio vaccine campaign and could be extended and improved upon for application to the COVID-19 campaign.

Recommendations

Independent COVID-19 vaccination Taskforce:

The eradication of smallpox came 175 years after the first administration of the smallpox vaccine, and polio was eradicated 20 years after the first polio vaccine was administered in India. India could retrospectively look at the logistics and procedures of the “surveillance-containment” efforts used in 1973 to ensure all of India’s population, especially rural populations, are vaccinated. A taskforce could be set up to mimic the actions of 1973 - although, since then, India’s population has roughly doubled from 594.8 million to 1.366 billion, making this a much larger undertaking, with an estimated 305,000 personnel needed to successfully carry this out – over double the 133,000 personnel used in 1973 (9).

India’s Accredited Social Health Activists (ASHAs) programme was set up in 2005 by the Government to improve rural access to healthcare, and currently has over 1 million registered members. Currently, India is using the ASHA workforce for pandemic-specific work (immunisation, recording cases and deaths, encouraging sanitisation) but also for public health work such as basic first aid, non-COVID-19 immunisations, Ante Natal Check-ups (ANCs), Post Natal Check-ups (PNCs), and general village sanitation (10). The current ASHA workforce is unable to handle both roles, leading to the workers being overworked, underpaid, and their lives being put at risk – one example is of Changodar, a village in Sanand which currently has only 6 ASHA workers to look after a population of 13,000 – that is roughly 1 ASHA worker for 2,166 people.

ASHA members’ pay and incentives are also dependent on the work completed by them; this is tracked by the ASHA-Soft portal, an online payment and performance monitoring system (10). However, many ASHA workers lose between 1000 to 1500 rupees per month due to lack of input into the software. This would be prevented by providing training in using the

software and how to properly record data – not only improving their pay but also the accuracy of COVID-19 data. To mimic the success of the surveillance-containment efforts of 1973, the Ministry of Health and Family Welfare would need to divide the ASHA programme into non-COVID and COVID-specific taskforces and train them accordingly to ensure there is sufficient staff in proportion to the population. Not only this, but the surveillance-containment efforts would have to be prolonged and maintained in the long-term to ensure the complete eradication or control of COVID-19.

Proposed training and provisions to be provided to the ASHA COVID-19 taskforce:

- Sufficient and effective protective equipment: gloves, hazmat suits or gowns, surgical face masks, respirator masks, and eye protection
- Protection against verbal and physical assault
- Access to transport to allow ease of movement between villages
- Health insurance or sick pay to ASHA members who contract COVID-19
- Training in inputting data into ASHA-Soft
- Ongoing training in the administration of different COVID-19 vaccines as they become available, i.e., using the relevant administration method (intramuscular, subcutaneous, or intradermal) (11).
- Training in the monitoring and management of common side effects of COVID-19 vaccination

Long-life and optimized vaccines:

The COVID-19 vaccines currently available to India have very short shelf lives once opened, with the maximum length being around 6 hours. This has led to a lot of open vaccines being discarded and wasted if all doses in the vial are not used. Research into multi-dose vials (MDVs) which have longer lifespans once opened would reduce this waste and improve the efficiency of both vaccine production and administration (12). Another vaccine design improvement is the switch to pre-filled syringes, which would allow for one syringe per dose, removing the issue of wastage (13). These would:

- Improve sterility
- Reduce time-of-contact between vaccinator and patient
- Reduce the skill and training required to administrate the vaccine – this would allow for more time in the training of ASHA in the correct use of the ASHA-Soft portal
- Reduce errors and contamination during syringe preparation
- Reduce material, time, and cost of glass vial production

Implementation of healthcare databases:

After the first COVID-19 wave subsided in India, around October 2020, many COVID-19 relief projects saw a slower progression in vaccination rates, vaccination imports, and compiling COVID-19 patient data. Specifically derived from the “Smart City” initiative from the Ministry of Urban Affairs, a comprehensive overarching database needs to be implemented, not only for tackling COVID-19 but potential future outbreaks (6). This database would be the reservoir of patient information for the majority of hospitals and would include patient medical data, area of hospitalizations, length of hospitalizations, vaccination status, and travelling history (6).

Many countries have shifted their focus to developing large databases for patient information, for instance, the United Kingdom, with their NHS patient data collection system being populated with hundreds of details from each patient (14). This information is constantly being

analysed and monitored to produce updated information for hotspot formations, vaccination rates by area, and is informing policies that need rapid implementation (14). India should follow suit and integrate their existing data storage platforms into one combined system capable of informing both the government and public of the current state India is in. This data would be available for public access and provide governing bodies and organizations with a starting point for analysis to inform public policies. Developing a system of this magnitude needs to be maintained by a professional team and requires constant monitoring of the changes in the pandemic situation.

When collecting large amounts of patient data, there needs to be a clear set of guidelines regarding transparency. Transparency, previously, has been an issue with regards to the development of the Covaxin vaccine. Patient information confidentiality, distribution of patient data, and database security guidelines need to be carefully and clearly communicated to the public to build a trustworthy rapport (6). A faulty move could, as seen before, develop a distrustful environment and vaccine hesitancy from the public, hindering COVID-19 relief efforts and become another hurdle for India.

Heterologous vaccine regimen research:

Research on a heterologous vaccine regimen, where different vaccines could be combined to offer immunity, would be a step in the right direction. Research supporting the viability of mixing vaccines would afford a more flexible and potentially faster vaccination timeline for India. Studies on the efficacy of mixing multiple vaccines are limited, with studies in the United Kingdom starting to publish data on the mixing of Pfizer-BioNTech mRNA-vaccine (BNT162b2) and the AstraZeneca vector-vaccine (ChAdOx1 nCoV-19) (15). Initial results have shown promise by concluding that priming individuals with an AstraZeneca vector-vaccine followed with a boost of the Pfizer mRNA-vaccine provided a higher immunogenicity and increased components of the immune system in the majority of participants, compared to homologous vaccine regimens which delivered two doses of the same vaccine (15). Affirming results were quickly picked up by countries such as Germany who have begun to shift their vaccination policies to accommodate the new scientific data (16). More research is still required to further confirm these conclusions in larger cohorts and to consider the influence of age, gender, time between vaccinations, and other crucial factors. Due to the lack of current research on heterologous vaccination regimens, it would be beneficial for India to conduct their own research on the possibility of mixing available vaccines to better inform current policies.

Heterologous vaccine regimen studies, so far, have focused on vaccines available in their countries, specifically the mRNA-vaccine and vector-vaccine for the United Kingdom and European Union countries. India, however, has a different set of vaccines with differing production methods - Covishield, Covaxin, and Sputnik - therefore warranting a separate study into its immunogenicity and reactogenicity. Much of the limited, current research starts with preliminary retrospective research into any available data in the country regarding individuals who have taken different doses of the vaccine. This aspect of the research endeavor would benefit from an existing reservoir of information provided by healthcare system databases. Any potentially promising preliminary results would translate into further in-depth research with specified patient groups, controls, statistical analysis and further discussions. Results would provide a flexible and possibly faster vaccination timeline for India, which at this point has placed herd immunity thresholds at roughly 3 years away.

Resources and Supply chain

Resource optimization: Latent vaccine capacity

The likelihood of COVID-19 being eliminated globally is very low. New variants will continue to emerge, and effective control will rely largely on vaccine capacity. The G20 Rome declaration highlighted the importance of re-evaluating vaccine production strategies (17). Should new variants render the current vaccines for SARS-CoV-2 ineffective, new vaccines will be required. With a particularly widespread variant, this could mean a demand of 2.16 billion doses over just 5 months in India. This is a rate of approximately 400 million doses a month - which overshoots the current vaccine production capacity.

Vaccine supplies currently rely on the Covishield and Covaxin vaccines, produced by Serum Institute of India (SII) and Bharat Biotech respectively (18). Whilst other vaccines may be approved for use in the coming months, they cannot be relied upon to cover the vaccine demand. At the very least, the current challenges in vaccine scale-up will remain. Coupled with the risk of new vaccines being required for SARS-CoV-2 variants, the focus of pandemic mitigation should be on production capacities.

The bottlenecks that have emerged over the past year in COVID-19 vaccine production may offer important lessons here. However, some are difficult to address in the shorter term. For example, the US Defence Production Act (DPA) invoked by President Biden granted the US federal government authority over the exporting decisions of private firms (19). This extended to firms producing raw materials vital to vaccine production in India. Exemptions to this blockade were later made for some essential materials - but delays in the raw material supply chain still exist (19). However, these challenges are almost universally faced by all nations at times of global emergencies and offer little room for short-term resolutions.

Instead, production limitations can be addressed within national borders by optimizing capacity with existing resources. This is exemplified by the transfer of resources between Indian states on a needs basis, but a whole-system approach to resource optimization may prove more effective. Vaccine manufacturing companies need encouragement to maximize capacity through third-party contracts, voluntary licensing agreements and pooling of resources.

Resource allocation: Health informatics

Informatics provide novel opportunities for systems responses to pandemic control. Resource allocation requires access to ‘relevant’ data, and this determination of data relevance can benefit from systems thinking. Access to health resource data is currently achieved through many independent networks. This was designed to compartmentalize sectors of healthcare deliverables for ease of decision making. However, this disregards the inter-relationships between resources and may lead to co-operative solutions between different suppliers being overlooked.

Clinical, Public Health and Research sectors have access to large amounts of data - much of which is not utilized for effective resource allocation (20). Clinical settings have considerable informatics use for allocation of medical equipment (such as ventilators) to areas of greater need. There are similar networks (although of reduced connectedness) in research and public health settings. However, much of the information gathered in these independent networks is not communicated *outside* of the network (20).

Pandemic response requires quick reaction to new data. Current data security and sharing regulations create a bottleneck that is time costly and affects decision making. Some reasons for delay here include considerations for data privacy and data processing for minimal information (as per official guidelines). Whilst privacy of individual health data is still crucial to retain, the current legal requirements of data sharing in a health informatics setting are incompatible with effective resource allocation in emergency responses.

The allocation of resources based on health risks from COVID-19 (direct and indirect) must also be weighed with local population and infrastructure attributes. Different regions will have different thresholds beyond which their infrastructure becomes vulnerable. Whilst this can be managed subjectively by health officials, an objective tool that measures and quantifies the main factors affecting local vulnerability would be desirable.

Resource allocation: Private and public resources

A major requirement for coping with pandemics is a public healthcare system with an appropriate surge capacity, defined as “the availability, in particular locations, of excess or redundant capacity that can quickly be brought online”. This is necessary to adequately address situations where there is a sudden increase in demands for healthcare, which can be only suitably provided in the context of hospital care (21). The Indian public healthcare system is chronically overloaded, facing severe shortages in facilities, equipment and specialized staff even outside of public health emergencies. Thus recent trends in public policy have been to manage a surge of patients by “purchasing” additional capacity in the private health sector via government-funded insurance programmes or other forms of contracting. Such policy has been employed especially for meeting true secondary and tertiary care needs, an example is the Prime Minister’s Jan Arogya Yojana (PM-JAY) a government-funded health insurance programme for those living under the poverty line and in the unorganized sector (21). However in the face of the COVID-19 pandemic, arrangements of this kind failed to bridge the gap in the public healthcare system. A reimbursement package for COVID-19 was added to the PM-JAY, but few private hospitals have claimed reimbursement for the same (22). Rather, several private hospitals proceeded with closures to safeguard themselves (23), and those that remained open to provide services did so at exorbitant costs to patients (24). Efforts to bring private hospitals under public authority were soon abandoned due to a lack of required political will and administrative capacity. Similarly, policies ensuring some private hospitals reserved beds for COVID-19 patients with a cap to rates charged could not be enforced effectively (21).

The pandemic has proven that the respond to a public health emergency is almost thoroughly dependent on the public healthcare system. In India, this is currently designed on the principle of satisfying the minimum capacity required with the acknowledgment that the majority seeking healthcare must access it through the private sector. In preparation for future public health emergencies, a network of public hospitals with a planned excess of beds, equipment diagnostics, ambulance services and staff must be designed.

Human Supply Chain

In the face of a pandemic, different frameworks can be adopted to analyse the resilience of health systems, a common factor across most, including the WHO Health Systems Framework, is the core dimension of workforce issues (21). The COVID-19 pandemic exposed the severe shortage of health care providers across India. Both public and private

hospitals have reported shortages in healthcare providers, in urban settings as well as more dire rural contexts (25). The acute issue of a scarcity in human resources was exacerbated by the pandemic, a key factor limiting effective response strategies, however it was not caused by it. Particularly in the public health sector, policies enabling the contractualization of staff with a poor salary structure has resulted in poor retention of healthcare workers (26).

The public healthcare system in India suffers from chronic shortfalls in staff, this is felt significantly outside of large metropolis. Healthcare in rural areas is structured in a three-tier system consisting of Sub-centres, Primary Healthcare Centres (PHC), and Community Health Centres (CHC). At each level there is currently a shortfall in health facilities: 18% at the Sub-Centre, 22% at the PHC level and 30% at the CHC level, according to data published in March 2018 (25). Although the number of facilities is increasing, the workforce availability is not adequate, it falls severely short of the recommended levels suggested by the WHO. There is a shortage of specialists at the CHC level (81.9%), including surgeons (84.6%), physicians (85.7%), pediatricians (82.6%) and gynecologists plus obstetricians (74.7%) (25). Thus, at the frontline of the pandemic response in these areas, have been Accredited Social Health Activists (ASHAs), a one million-strong force of female healthcare workers who serve as a connection between an overloaded public health system and smaller, low-income, rural communities. In many localities, ASHAs have been the only health providers available to address the spread of COVID-19, taking responsibility for testing, quarantining individuals, educating the community on prevention methods and ways to access care, as well as leading the vaccination campaign. A survey by Oxfam India, found that only 75% of ASHA workers were given masks and only 62% were provided with gloves. Sickness and in some cases loss of life due to COVID amongst healthcare workers, has been found to leave major gaps in effective response in rural areas (27).

To meet the current and future health care emergencies, it must be a priority to fill vacant posts in public health facilities, with an added focus on developing surge capacity. This is fundamental given that COVID-19 has demonstrated the crucial role of the public sector in addressing health care emergencies where the private sector is not willing to invest.

Recommendations

Patent buyouts and technology transfer buyouts for manufacturing ‘know-how’

Scaling vaccine manufacture is challenged by stringent intellectual property (IP) laws. At times of global emergencies, some suggest that IP protection should be suspended - an approach initially backed by the White House earlier in the pandemic (28). However, these measures may cause the breakdown of the incentive-based processes of pharmaceutical R&D and more importantly, may not be the best solution to freeing global manufacturing power.

Instead, a solution that allows pharmaceutical manufacturing companies to focus on existing, approved vaccines whilst maintaining production incentives should be sought. Consideration for profit incentives is key, as whilst government efforts funded scientific research into the vaccines, there was also significant impact driven by profit-minded individuals (29). The development of the COVID-19 vaccines cost billions of dollars and this investment was made on the basis that there would be profitable results. Removing all IP regulations may solve the current issue but will also create problems for future healthcare and pharmaceutical innovations. The current incentive-driven structure of pharmaceutical R&D created vaccines

for a novel virus in just a few short months - demonstrating the value of this structure and why it must be maintained (30).

Focusing on delivering incentives for vaccine development can allow for increased production from both companies that are currently manufacturing vaccines and those that are not (29). Sanofi and GlaxoSmithKline are both pursuing vaccine trials of their own - these will likely not offer better protection than the existing vaccines but remain a focus due to the desirability of proprietary IP (31). So, even in companies that are leading the vaccine manufacturing effort, there is a lack of resource optimization. This is because the incentives of pharmaceutical companies are not aligned with social values - but the removal of IP laws will not be a long-term solution. Instead, companies need to be convinced to abandon alternative trials and scale production of existing vaccines.

This can be achieved with COVID-19 vaccine patent buyouts. This maintains the incentives for pharmaceutical innovation whilst providing companies with existing capabilities the knowledge to produce effective vaccines for pandemic control. This would involve the government paying the IP-holding company the sum of the current value of any expected future revenue generated from the patent. In fact, Moderna had pledged that they would require no buyouts - that IP regulations would not be enforced (32). Coupled with the freely available spike protein sequence for SARS-CoV-2, some might have expected Moderna vaccine 'dupes' to flood through - but this was not the case.

Even if IP rights are forsaken, blockades to quickly duplicating an existing vaccine exist. These blockades are mainly within manufacturing 'know-how'. Moderna did not share any details about the design and production specifics of their vaccine - and this is one of the most time-consuming aspects to developing a vaccine production pipeline. Without shared manufacturing knowledge (so-called 'soft IP'), other companies cannot make optimal use of existing vaccines (33). The 'soft IP' of a vaccine or pharmaceutical drug is not a new concept - a licensing deal allows the communication of technical production knowledge (33). So, to effectively scale vaccine manufacturing and make use of latent capacity, a simple patent buyout will not be enough. A broader, farther reaching 'technology buyout' will be needed that includes manufacturing know-how from existing vaccine producers.

This 'technology buyout' could be incentivized with a lump sum payment alongside a per-dose payment. This would help to ensure that the practical know-how is transferred between companies - and prioritized by the existing producer. The price of this 'technology buyout' is estimated to be in the region of $10-25 billion dollars per firm with a suggested per dose payment of approximately $1 (34). If this program was deployed globally to vaccinate an extra 4 billion people, this would incur a cost of roughly $36-56 billion dollars.

Whilst this 'technology buyout' could be deployed within individual nations, a global initiative may be beneficial considering the risk of new variants developing. These variants could once again plunge foreign nations into lockdowns and economic hardship, so a global initiative with a shared financial burden may be more cost-effective in the long term.

Data tools to optimize resource allocation

System topologies need to be controlled and optimized through well connected digital infrastructure. This will prevent a 'shock cascade', where failures have a knock-on effect on connected systems and lead to a general network breakdown (35). Tools designed to

facilitate decision making can prevent this system breakdown, particularly in health emergencies. Whilst many consider data analysis tools to be limited in their accuracy (as a result of incorrect or incomplete assumptions), many have been proven to deliver stronger recommendations in crisis situations.

One example of such a tool is a vulnerability index, which can allow for management and prioritization of regional issues. A vulnerability index has been developed for the COVID-19 epidemic in India which uses socioeconomic, demographic, housing and hygiene, epidemiological, and health system considerations (36). Interestingly, the states with an observed higher vulnerability index (Bihar, Telangana, Jharkhand, Uttar Pradesh, Maharashtra, West Bengal, Odisha, Gujarat, Madhya Pradesh) had a greater risk of COVID-19 infection (36). Whilst this was not the intention of the tool, this highlights the potential impact of focused resource prioritization - with resource allocation tools having potential to predict states where infection rates are likely to increase.

Non-standardized reporting of COVID-19 data (such as hospital numbers/capacity, health supply chain logistics data and demographic outcomes) has been a bottleneck in the handling of this pandemic (37). Structures that may otherwise work well (or well enough to not be a pressing issue) in normal situations may not be able to perform under the demands of a pandemic (or other health emergency) scenario. Therefore, the determination of vulnerability thresholds must be both tailored towards the COVID-19 pandemic and deployed widely.

Policy for marshalling private sector resources

Fundamentally, existing government strategies to liaise with the private healthcare system have proven to not be sufficient when responding to a crisis. Even though the private healthcare system has higher number of beds and ventilators, it is estimated to have handled less than 10% of total Covid-19 cases (23). As some private hospitals started to provide for Covid-19 care, they did so without using insurance cover and thus charging at exorbitant rates increasing healthcare inequality (21). In light of the clarity brought by the Covid-19 pandemic and the failure of market-based reforms employed over the last decade, it is clear that the role of the government cannot be limited to setting prices, regulating markets or contracting services. The main policy the government should invest in is the expansion of the public healthcare system, intervening in the organization and financing of health services as public goods.

Soon, in efforts to acquire surge capacity in lieu of universal healthcare, a central command with the power of marshalling private resources is required (38). While such a body would be part of the government, it could include expertise from the private sector, ensuring that decisions are made taking every factor and perspective into consideration. Policies would not be limited to market-based interventions but would be proactive in the organization of service delivery to ensure effective and equitable redistribution of resources. The body could be formed at a state level, if not at a federal level where it would be considered as an integral part of the pandemic response strategy. Accordingly, the body would have power to enact the Epidemic Diseases Act of 1897 or state-specific variations of the Act, which would empower the government or state-administration to enforce temporary regulations to fight the “outbreak of any dangerous epidemic disease”. Such a body would enable better communication and coordination between the private and public healthcare systems, alleviating the burden on a weak public system whilst incentivizing the private sector to get involved in the pandemic response effort by providing them a chance to give input before government decisions marshalling resources are made.

Creating surge capacity in the human supply chain

At the scale of individual hospitals, to ensure efficient care is provided to patients in the face of the Covid-19 pandemic, whilst protecting hospital care personnel (HCP) from infection, it is vital to rapidly train all HCPs within the hospital (doctors, nurses, sanitation workers and other support staff) (39). The key areas for training must include guidelines on appropriate use of PPEs, steps to prevent infection among HCPs, clinical management of patients both in in-patient and out-patient services and the handling of key equipment necessary to provide oxygen therapy and respiratory support. The implementation of best practices to avoid the spread of infection amongst HCPs is essential as they are the main defence against the pandemic, thus education on the use of PPE must be an integral part of training (40). The aim of such training should be to enable the use of existing human resources to create a virtual Disaster Management Department (41). Thus, the main target audience should be specialized personnel from different departments, ranging from Anesthesiology to Hospital Administration, so as to prepare them to be ready to provide support and function as surge capacity.

Such preparation must be delivered in as narrow a timeframe as possible whilst maintaining high standards. To ensure this is possible, especially in the face of future emergencies, hospitals must prepare a tested plan and programme that is tailored to their structure and the resources at their disposal. For example, training can be designed to be easily scaled up using telemedicine and reliable digital platforms. If the hospital is equipped with experts relevant to the health emergency, the structure of the Disaster Management Department can be designed to consist of smaller teams under the supervision of an experienced HCP, each covering a different area of need. The teams can meet and discuss key challenges being faced in their domain, pool resources and redistribute as deemed fit and develop effective lines of communication through systems in line with infection-prevention guidelines (39). In most scenarios, this would mean adopting the use of digital platforms such as videoconferencing.

As the public healthcare system in many regions may lack sufficient staff to establish a Disaster Management Department, medical colleges can be relied on to support district hospitals, the final referral centres for the primary and secondary levels of the public healthcare system (39). This may result to be vital as the workforce availability is not adequate at the outset. In rural regions specifically, policy designed for use in hospitals may result ineffective in CHCs or any other smaller healthcare body. Hence the pandemic response strategy must focus on investing in ASHAs (26). Medical colleges can be recruited to support ASHAs via training, especially in the key characteristics of the disease, the use of PPE and strategies to prevent the spread of infection. The training must be designed to effectively reach the network of ASHAs, ensuring that the mode of delivery is viable (telemedicine may not always be feasible). Before an emergency can take hold, effective lines of communication must be cemented if possible, allowing for ASHAs to be integrated in the public healthcare system. Given their key role as frontline workers in the prevention and management of outbreaks, including delivery of the vaccine campaign, investments must be made to ensure ASHAs have access to PPE (26) (27). For support in overcoming hurdles such as issues in accessibility, communication and lack of funds, the network of NGOs based in India should be tapped into in a timely manner. Trained volunteers from NGOs can serve as the surge capacity needed to respond to the pandemic in densely populated urban areas.

A through line connecting every policy proposal is the necessity for excellent management and communication. Thus, in preparation for future crises, constant efforts should be made to ensure that communication within departments, individual hospitals, regional healthcare bodies and rural HCPs is effective and well-established. Communication between hospitals, and members of different levels of the public healthcare systems, enables the formation of networks and thus greater reliable sharing of information and resources.

Public Structures

Education

The mode in which various health policies have been communicated and implemented by the Indian government may have contributed to the exacerbation of the COVID-19 pandemic. The Indian Council of Medical Research (ICMR) was conducting trails on the possibility of improving COVID-19 treatments by reciting Gayatri Mantra (42), which is an ancient Hindu prayer as well as performing a set of yoga deep breathing exercises. Such trials have been wildly criticized by scientists due to the design of the trial, as the sample size is small and there were pre-conceived biases in the test populations (43). Such directed research could mislead the public by trying to validate unevidenced practices, with such improper study being typical of pseudoscience.

India's Ayush ministry put great emphasis on alternative medicine, such as Ayurveda, yoga, and unani. They also implemented a nationwide campaign which promotes the use of polyherbal drugs for patients even when lacking any peer-viewed scientific evidence (44).

The science and health minister of India, Harsh Vardhan, who is a physician himself, supported the use of "Coronil" (45), which contains herbal medicine. Coronil was formulated and manufactured by Patanjali, whose owner made false claims regarding the verification of Coronil by World Health Organization (WHO). The Indian Medical Association then refuted the claim that Coronil could be used as prophylactics and therapeutics for COVID-19, calling that a "false and fabricated projection" and "unscientific medicine" (45).

From the above examples, it is evident that the Indian government or government officials were irresponsible in terms of the educating the public and promoting COVID-19 treatments by actively supporting unscientific claims and pseudoscience.

Hospital capacity

One of New Delhi's best equipped private hospital, Holy Family Hospital, has the capacity to treat 275 adults but was treating 390 (46). In the intensive care unit (ICU), patients were placed on trolleys between beds and ventilators and oxygen supplied were lacking. This hospital is a private hospital, but the situation was still devastatingly bad, which suggests that the situation in public hospitals and in less-equipped hospitals could be even worse.

According to Indian government data, less than a third of the population rely on public healthcare system for treatment (46), which suggests that the actual situation could be far worse. Furthermore, available and accurate data on the situation e.g., number of hospitals needed, is lacking since the vast majority of the population do not rely on public healthcare systems and actual data e.g., number of people infected, could be very hard to retrieve.

At the same time, it was estimated that there were at least 300,000 new infections every day (47) and over 31.5 million cases registered (48). Oxygen supplies were critically low, and some people had to rely on the black market to procure health supplies.

Transport accessibility

The sudden enforcement of lockdown in March 2020 resulted in a reverse-mass migration from Delhi and Maharashtra to the countryside (49). More than 10 million people had left their hometowns to look for work in these major cities, and the lockdown forced them to return. Due to an absence of transport facilities, vulnerable people including pregnant women, the

elderly, and infants were forced to walk many kilometers, and prominent psychosocial issues were described amongst these people (50).

People living in rural areas are also facing difficulty accessing medical care due to transportation and access challenges. In some rural areas in India, 1 doctor serves as many as 10,000 people whereas 1,000 is the recommendation by the WHO (51). Lack of transport systems to reach hospitals exacerbates this issue as it becomes increasingly difficult to reach the hospitals which already face dwindling medical supplies. Due to the increased consumption of medical oxygen, the government has been using trains and military aircraft to speed up oxygen supply, but this still is not enough to supply rural areas, where other more direct means of transport are limited.
Data has shown that around half of the population of India and roughly three sixths of the rural population need to travel over 5km for access to healthcare. While this is primarily due to the lack of qualified medical personnel in these areas, the issue is aggravated due to reduced transport accessibility to these places (52)

Recommendations

Educating the public via Broadcast radio

According to a statistical study published on Statista, the internet penetration rate in India is 45% in 2021 (53), which means that over 50% of people living in India do not have access to the internet. Also, a study conducted by Learning Spiral, which is an online examination solution provider concluded that only 27% of Indian households have access to the internet and 47% have access to the internet and or a computing device (54). Considering that it is likely that the wealthier population might have higher chances of having access to the internet, if COVID-19 related promotion and education were focused mainly on the internet, they might not be able to reach the whole Indian population. Therefore, even though in India there are over 560 million internet users (55), it might not be a very effective way for promotion and education on COVID-19 in order to raise awareness. Other conventional ways of education, such as posters, might not be very effective given that the mobility of the population is much lower due to social distancing restrictions.
A study showed that broadcast radio reaches 99% of the Indian population (56). This suggests that reaching out to the Indian population via radio is very efficient. First, broadcasting via the radio does not require a lot of manpower, which is in shortage in COVID-19 times. Secondly, radio broadcasting has a relatively low cost, so more resources can be allocated to other matters. Lastly, radio broadcasting also allows illiterate people to be educated and informed on the COVID-19 pandemic policies. In 2021, the literacy rate of India was around 74% (57), which means that around 26% of the population is illiterate. Considering that the illiterate might not be privileged enough to have access to the internet or capable of reading information on posters or leaflets, other means of education may leave these people uninformed and unaware.

Collaborating with religious leaders

India is one of the most religious countries, with around 90% of its population being religious (58). This shows that religious leaders have a substantial role in the Indian society and are highly regarded. According to a report from UNICEF, they have reached out to faith-based organizations and religious leaders in India in order to build relationships across social and economic groups. They reported that they have extensive collaboration and engagement with religious leaders which enabled support for immunization and polio eradication (59).

They have emphasized the importance of Muslim leaders in marginalized communities, which suggests that the government should reach out to leaders of Hinduism, which is the largest religion in India and comprises 81% of the adult population (58), but also reach out to the leaders of the religious minorities (59). UNICEF's experience with religious leaders in India was successful, as religious leaders came together to embrace the campaign and urged parents to immunize their children. Collaborating with religious leaders as influencers in the communities helped implement behavioral and social changes efficiently.
UNICEF's success suggests that it is indeed effective and feasible to ask religious leaders to be advocates and help educate the public on COVID-19 awareness.

Temporary hospitals

To cope with the growing number of COVID-19 patients and reducing numbers of available hospital beds in early 2020, the Chinese government decided to build temporary hospitals for COVID-19 patients with mild symptoms starting from early February (60). Many mild cases were left to wait and resulted in exacerbation of the pandemic. In India, the limitation of hospital bed spaces would only lead to worsening of the cases, with the medical system becoming more stretched. The Indian government could learn from China's experience and build temporary hospitals for patients with mild symptoms by converting large buildings like exhibition centers to hospitals with medical function units, ward units and technical support units as seen with the China model (60). This directly increases the number of hospital beds available, which allows for more patients to be admitted and treated on time and prevents exacerbation of the COVID-19 pandemic. This would prevent further burdening and straining of the medical system, as treating patients with more serious diseases and conditions becomes a secondary priority in a pandemic – eventually leading to greater costs incurred in the long-term. This also prevents the transmission of COVID-19 from individuals with mild symptoms, as patients who are not serious enough to be admitted will likely to travel back home or continue to travel in public, which will speed up the transmission of disease. China's success in eradicating COVID-19 owes largely to these temporary hospitals and its resulting lower levels of COVID-19 transmission.

Teleconsultation platforms

The government recognized that populations living in rural areas lacked adequate access to healthcare due to shortages of specialist staff and limited transport accessibility. As a result, in April 2020, during the nationwide lockdown, the Ministry of Health and Family Welfare of India launched the national teleconsultation platform, e-Sanjeevani OPD. This greatly increased healthcare access for patients in rural areas - those who had COVID-19 and had to social distance, or those with other illnesses who were unable to travel due to nationwide restrictions (61). Approximately 5 million individuals used the e-Sanjeevani system in 2020, which gives an estimation of the potential benefits such telecommunication systems could have if they were to be scaled (62).

While this teleconsultation platform has provided the opportunity for millions around India to access healthcare, there were still difficulties with monitoring patients' status over longer periods of time, as this required frequent visits to healthcare centers. This can be solved by increasing the usage of apps and home-based monitoring equipment. For example, patients with cardiovascular diseases are at risk of developing greater complications if infected with SARS-CoV-2. iRhythm, a UK based medical equipment supplier, launched a service to allow patients to apply single-use cardiac monitors by themselves at home. This enabled health care professionals to identify patients who required greater support, while reducing the need to be physically present in the health centers (63). Such monitoring technology can be

delivered to the doors of patients and has the potential to connect doctors with patients over long distances. It also reduces the need for patients relying on transport infrastructure for adequate access to healthcare. Implementing monitoring technology alongside the teleconsultation platforms that the Indian government has begun rolling out would help to mitigate the effects of COVID-19 on the most vulnerable demographics.

Social attitudes

Vaccine hesitancy and lack of confidence in the Indian Government

There is no strong anti-vaccine sentiment in India, partially due to the country's exemplary drive against polio, measles, and tuberculosis. However, the situation with COVID-19 is different. This is largely attributed to distrust of the government and a loss of faith in the country's immunization program. In January 2021, various pharmaceutical players started announcing the clinical successes of several vaccines. Yet, out of a survey involving 8312 individuals, 61% said they were skeptical about the vaccines and would not rush to take them even if they are widely available. In another study, 17% of all analyzed social media posts took a negative view towards the vaccines (64;65).

From the beginning of the vaccine design effort, many individuals described the race towards immunity as a "big game to make money". Approximately 50% of all vaccines produced in India, mainly by the Serum Institute, are reserved for free distribution through public health facilities while the rest is designated for sale to private hospitals or state governments (66). As a direct consequence, companies possess the monopoly to decide the prices these vaccines will be sold for to these entities. As such, wealthier states may be able to acquire more doses. Despite much controversy, the government decided to proceed with the vaccine rollout before a digital vaccine tracking platform was ready. Again, the majority (65%) opposed this move, believing there is a high risk that distributing the vaccine without a working digital platform could lead to doses being lost in black-market scenarios or perhaps replaced with counterfeit vaccines (64).

Certain regulatory measures taken by the government were received negatively by the public and have contributed to vaccine hesitancy. The Indian government approved a domestically developed vaccine - Covaxin by Indian drugmaker Bharat Biotech - before its safety and efficacy trials had been completed. Whilst preliminary findings since then have suggested the vaccine provides good protection and is safe for use, the lack of transparency and rushed nature of the approval process harmed public opinion on COVID-19 vaccines.

Since then, the government has attempted to address vaccine hesitancy through data transparency. During India’s devastating second COVID-19 wave, numerous individuals who were fully vaccinated were still getting infected. This is a normal occurrence given that no vaccine offers 100% protection. India’s health ministry attempted to be transparent by publishing data on breakthrough infections (infections that break through the vaccine's defenses). However, the government claimed a breakthrough infection rate of a mere 0.02-0.04%- a figure far below those submitted by the manufacturers themselves (65). Furthermore, no methodology was disclosed, and no standardized approach exists to track the outcomes of those that receive a vaccine. This incomplete and at times inaccurate communication of vaccine data has fueled vaccine skeptics and failed to convince much of the public of the government’s capabilities in vaccine monitoring.

Besides these data gaps, India's healthcare system must manage the digital divide present in the country. Until recently, no individuals between the ages of 18-45 were allowed to walk in at vaccination centers (66). Anyone in this age range who wishes to receive a vaccine must

first register on the government's Co-WIN website. However, nearly 50% of the Indian population has no access to the internet. To add to this, there is already extensive reluctance to share sensitive information needed for basic services like healthcare. This has created significant barriers to cultivating a data-driven approach to pandemic management.

General apathy among Indian citizens regarding the pandemic

Equally, the mismanagement of public attitudes towards the pandemic lead to a wave of apathy among the Indian population, who were led to believe the pandemic had been overcome. As infection numbers started to decrease at the beginning of January 2021, Indian politicians began proclaiming their efficiency in controlling the virus. On April 27, 2021, the Union health minister Harsh Vardhan stated: "India was better prepared mentally and physically this year with more experience to beat the COVID-19 pandemic as compared to 2020". On the same day, however, Tedros Adhanom Ghebreyesus, the World Health Organization (WHO) chief, proclaimed "The situation in India is beyond heart-breaking." (71). Numerous political figures were communicating in a manner that was not aligned with the view that external governing bodies had of the situation in India. Similarly, little attention was paid to the ravaging second waves in other countries, including Brazil and the UK. Instead of buttressing the public health defenses, politicians then proceeded to commit another fatal error.

Despite the ongoing pandemic, election rallies with thousands of attendees resume - shoulder to shoulder, with no social distancing. In larger states, such as West Bengal, two substantial political rallies were held in Kolkata, a city of 15 million individuals. Crowds in excess of 500,000 gathered with little regard for ongoing COVID-19 protocols in February 2021 (70). Assembly polls in regions such as Tamil Nadu, Assam, Kerala and Puducherry were also going through campaigning and electioneering at the same time. The hosting of these events added to the complacency among the public that coronavirus had been beaten for good. Even as new mutated strains were appearing in the other parts of the world, the coronavirus was a thing of the past in India.

Srinath Reddy, president of the Public Health Foundation of India summarizes the government's failures: "Leadership across the country did not adequately convey that this was an epidemic which had not gone away... Victory was declared prematurely, and that ebullient mood was communicated across the country, especially by politicians who wanted to get the economy going and wanted to get back to campaigning. And that gave the virus the chance to rise again." (72) Ultimately, the false confidence given by government officials fueled by political agendas has created an atmosphere of ignorance and complacency. As authoritative figures within their communities, these individuals misused their power and the trust of the general public to boost their individual gains. These actions have now backfired, with the public now aware of the misuse of power and ill-practice displayed by many policymakers and politicians. Rejuvenated mistrust of the government and a surge in COVID-19 cases at the time of writing are now adding fuel to this simmering crisis. The government must now tread carefully to mitigate these consequences, and we propose the interventions below.

Recommendations

Given that immunity following COVID-19 infection persists for 8 months (67), it is of utmost importance for the Indian government and policymakers to invest in educating the public on

the necessity of vaccinations. Particular emphasis must be placed on addressing all hoaxes and insecurities as well as ensuring data transparency to regain the confidence of the public and motivate individuals to take the vaccines. Evidence from one nature study (68) suggests intense conspiracy/hesitancy rebuttal from the government is particularly impactful among audiences with prior beliefs or an ideology that renders them vulnerable to science deniers and misinformation.

Working in collaboration with prominent social figures

The government should further seek to work closely with civic and faith leaders, or even admired athletes. These figures can have a tremendous influence on the views of the general public and the attitudes adopted towards vaccination. It has been shown that celebrities can catalyze herd behavior to distinguish endorsed products from competitors – they can act as 'influencers' of social behavior. The same holds true for public opinion and habits. Hoffman et al (2017) (73) suggest this is indeed the case by alluding to neuroscience research that suggests brain regions involved in positive association (or reward), including the prefrontal cortex, were activated upon hearing or viewing endorsements by a familiar celebrity. The general public is conditioned to have a positive perception of these endorsements and is subconsciously pushed to follow their advice to avoid cognitive dissonance. This is exemplified by Angelina Jolie's announcement of her double mastectomy in 2013. In the 6-24 months following this, the number of high-risk screenings for the BRCA1 gene associated with breast cancer increased 2.5-fold (74). This approach has also been utilized to prevent the spread of HIV/AIDS among homosexual men, with such endeavors decreasing transmission by 15-29% (69).

A so-called Popular Opinion Leader (POL) program could help identify, train and enlist the help of opinion leaders to change social attitudes among various communities. The program is based on diffusion of innovation/social influence principles, which states that trends and innovations are often initiated by a relatively small segment of opinion leaders in the population. Once innovations are visibly modelled and accepted, they then diffuse throughout a population, influencing others. A cadre of trusted, well-liked figures should be trained to endorse safe vaccine opinions and practices in workshop settings or one-on-one conversations. Here, the "popular opinion leader" could correct misperceptions, discuss the importance of vaccination preventative measures and recommend that their peers adopt safer behaviors (such as social distancing). The immunization of thought leaders and celebrities could also play a role in compelling members of the public to vaccinate – it is important, though, that these vaccine promotion messengers should be trusted, credible, and consistent.

This approach should include the following elements:

1. Identifying and enlisting the support of popular and well-liked opinion leaders to take on risk reduction advocacy roles
2. Training cadres of opinion leaders to disseminate risk-reduction endorsement messages within their social networks
3. Supporting and reinforcing successive waves of opinion leaders to help reshape social norms to encourage vaccination

Authoritative or influential figures can serve as cues for positive social change, managing to erase the stigma of a certain disease or decision and promoting information-seeking and preventive habits, both of which are particularly relevant for India's crisis of COVID-19 vaccine skepticism.

Tackling belief in alternative Covid-19 therapies by public information campaigns

Politicians and businesspeople of influence have begun to sell therapeutic products that claim to counteract the symptoms of COVID-19. Whilst most confirm that the vaccine should still be taken, the marketing strategies tend to exploit vaccine-critical beliefs. This contributes to Vaccine hesitancy and is exacerbated by vaccine shortages. Notable examples of these therapeutic products include

1) nasal sprays and oils to prevent COVID-19 infections
2) use of steam with traditional herbs to supposedly prevent the virus binding to receptors on cells in the nose and throat
3) Baba RamDev Covid Tablets – a concoction of traditional herbs that supposedly boost immunity (69).

Many of these products have not been approved by any regulatory scientific regulatory body and have not been shown to be effective in clinical trials. However, the use of traditional herbs and medicine appeals to people, especially when they are more readily available. This means that many people are more relaxed with following through with their vaccine appointments – which sometimes requires queuing outside in the sweltering heat / monsoon rains (70).
It is particularly alarming that many individuals who are educated also hold these traditional methods in high regard, especially those with a commerce/ IT background, perhaps linked to the teaching of science stopping at the age of 16. This generated a population that is open to being commercially exploited.

This problem can be addressed with both a long term and short term approach:

<u>Short term Approach</u>

The short-term immediate response involves expanding the outreach of healthcare professionals to encourage vaccine uptake and discourage the use of other scientifically unvalidated methods.

This could, within 2 months, increase the vaccine uptake and decrease the reliance on traditional methods. Potential problems involve the risk of facing government lobbying by big Ayurveda companies and officials facing incentives from such companies to cave into this pressure.

<u>Long Term Approach</u>

The long-term approach involves improving the diversity of the education system to ensure students learn about basic scientific methods. This would also involve the improvement of critical thinking, such that the population is more aware of marketing ploys and disingenuous snake oil type treatments.

Accepting government failings and re-structuring government bodies to manage tensions between various Indian demographics

The Indian Media has been accused of attempting to convince the public of a controlled pandemic situation, instead of reporting the actual situation. Critics claim this is in part due to their alliance with the government – with the media not willing to tarnish the name of the incumbent prime minister Narendra Modi. Naturally, this leads to the population being less aware of the consequences of poor pandemic management - until it spreads to their kin/area/city. Even when this does, a false sense of optimism is often seen, where people expect normal recoveries. Whilst this may be the case most of the time, very often the elderly and vulnerable do not recover.

India's highly economically divided society has presented further obstacles to social co-ordination. Some are of the view that the upper and middle classes are indifferent towards the consequences of COVID-19 for the working classes. The more affluent families and individuals shelter themselves when infection rates are high and are confident that they will not be affected by COVID-19. This is damaging for a pandemic scenario, where co-ordination of social behaviors throughout a population is critical to impactful mitigation of the health and economic consequences of an infectious virus, such as SARS-CoV-2.

In order to solve this pressing issue, the government once again needs to change the perception of the pandemic situation. Some approaches to this are as follows:

1. Management of tensions between Indian citizens of different economic backgrounds. These deeply rooted social issues are a core blockade to unified action in a pandemic scenario.
    - This will require a re-structuring of governing bodies at the local level, in order to facilitate impactful communication between various demographics. Integration of a 'town hall' style of local governing, which allows people of different background to hear the concerns of all members of their community will move to increase inter-demographic co-operation.
2. Accepting government failings in the handling of the pandemic (prior to widespread public criticism) and reassuring the public that the correct approaches are being taken. This can be carried out through public addresses on live TV.
    - This approach is accompanied with the risk of media-wars between political parties – as such, media communication that utilizes bipartisan political figures should be considered in developing clear pandemic communication. This cross-party combined influence could be enough to change the minds of those resistant to public health measures designed to counter COVID-19 spread, such as social distancing.

Concluding remarks

The management of COVID-19 in India requires consideration of many factors, the most prominent of which have been explored briefly in this report.

A complete list of the recommended interventions is provided here:

Vaccination strategies:

- Sufficient and effective protective, sterile equipment should be provided
- Provide security, health insurance, and transport for healthcare workers
- Healthcare workers should have ongoing training of administration methods of different COVID vaccines, use of ASHA-Software, and management of common COVID vaccination side effects.
- Implementation of a comprehensive healthcare database to track the extent of the pandemic's spread, hotspots, and priority regions of vaccination
- Research into varied vaccine regimens including heterogeneous vaccination regimens to afford a more flexibility

Resources and Supply chain:

- Patent and technology-transfer buyouts for widespread vaccine manufacturing 'know-how' and capitalisation of latent vaccine capacity
- Deployment of data tools for holistic and improved resource allocation strategies
- Policies for greater government control in marshalling private sector resources
- Creation of surge capacity in the human supply chain to withstand high-demand situations

Public structures:

- Broadcast appropriate medical information via radio, the media source that most of the population has access to, for more efficient and complete communication
- Optimize hospital capacity levels via temporary and specialist hospitals
- Increase the usage of at-home monitoring devices and teleconsultation platforms to reduce the need for in-person consultations

Social attitudes:

- Governmental transparency and action to rectify damaged public approval by compensating disadvantaged communities
- Recruitment of influential figures to sway public opinion in favour of vaccination, despite previous government setbacks and failures that have soured public opinion

The SARS-CoV-2 pandemic has brought novel obstacles to long-established vaccination efforts. Combining a historical perspective with assessment of the current vaccination program allows identification of routes for improvement which will allow for a return to pre-pandemic life. The first major group of suitable interventions regards the ASHAs and all healthcare workers involved. Healthcare workers are the main fighting force in a pandemic situation and require support ranging from equipment upgrades, curated training, and aid if

they were to be infected. These vital workers should not be overlooked, but rather should be supported with the utmost care. Another category of interventions regards the vaccine itself. The manufacturing and production aspect should be carefully considered in addition to whether alternative vaccination regimens can be implemented for a more flexible timeline. Lastly, is the implementation of a coordinated, comprehensive healthcare database to provide India with updated analytics on the pandemic. With the pandemic putting the world to a halt all interventions should be carefully considered and advocated for.

Despite most countries facing similar issues with resource shortages and vaccine supplies, India has a unique manufacturing position that should be capitalized on. The strength of the pharmaceutical industry in India should allow for rapid production and distribution of vaccines for SARS-CoV-2 to the Indian population. Patent buyouts within India, supported by the government, can increase the intensity of the vaccine roll-out. Whilst patent buyouts are valuable, these should also be accompanied with the transfer of the technical know-how to produce vaccines at scale - this should be incentivized by the Indian government. Improving the capacity for rapid scaling of critical resources must be accompanied with government policies for optimizing a combination of private and public resources. However, this also requires consideration of market impacts – the private sector should not be so damaged that incentives for scaling resources are lost. To face future medical emergencies, it is critical to build surge capacity in both human and medical supply resources within the public healthcare system. This would entail long-term investments aimed at equipping hospitals based both in urban and more impoverished rural areas, with hospital care personnel, amount of basic medical supplies (such as number of beds) to not only meet normal demand but hold surge capacity in the event of a pandemic.

Current strategies to resolve the Covid-19 situation in India have been largely ineffective due to medical information being disseminated via the internet which is mostly inaccessible by rural India. In addition, ICU capacities were not high enough to cope with the situation, and the private system of healthcare meant that the most vulnerable could not access medical attention when necessary. The difficulty with transportation and physical access to the healthcare centers also contributed to the soar in Covid-19 cases. Thus, the strategies to manage Covid-19 should focus on rural India, with measures such as setting up temporary hospitals, using the radio to broadcast medical information, and increasing the use of remote patient monitoring. These strategies have proven effective in other countries, and their application in India could significantly reduce the fatalities associated with future Covid outbreaks.

Overall, the situation can be rectified by an honest government acceptance of the mistakes and strong yet appropriate methods to change the perception of covid and its dangers.

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