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INDIA'S COVID-19 CRISIS: CHALLENGES & STRATEGIES

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ABSTRACT

Globally, the coronavirus has now infected 0ver 17 crore people and killed over 3.5 million since the pandemic broke out in December 2019. India is facing an "invisible enemy". The pandemic first struck India over a year ago. Facing the world's worst health crisis, India has reported over four lakh daily infections The Covid-19 pandemic is rapidly spreading in rural areas. Daily infections are shooting up in the Indian countryside in comparison to big towns, where they have slowed after last month's surge Governments should act on a "war footing" to check the second wave of infections and was setting up new hospitals and oxygen generating plants while augmenting supplies of medicines and vaccines. People are required to observe Covid Appropriate Behaviour (CAB). Moreover, states should take action against black-marketing of medicines and essential supplies.

KEYWORDS: *Covid-19 Crisis*

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INTRODUCTION

Some seropositive surveys have been done, indicating that perhaps 20 % to 30 % of the overall population had been exposed. In large cities such as Mumbai and Delhi, in the areas that were surveyed, it appeared that 50 % to 60 % had been exposed. Decades of underinvestment in public health, with inadequate diagnostic capacity and programmatic agility, have created challenges in the implementation of test, trace, and treat strategies at scale.[1]

In mid-February, India's daily caseload was at its lowest: fewer than 11,000 per day. But mutant viruses were already circulating at low levels before then. Sequencing data now tells us that the double-mutant variant (B.1.617) was already seen in December, but it was very minor and received little attention. The January introduction of the UK variant (B.1.1.7) into India led to the surge that started from about the third week of February. The variants are far more infectious and faster-moving than the original. This is a mutant virus that has 15 different changes from the original. Six mutations are in the spike protein, and two of those are in a very critical region called the "receptor-binding motif." This is the region of the spike protein that allows the virus to enter the cell. It is also the region that is targeted by antibodies that neutralize the virus. Thus, any small changes in this region have the potential to increase the ability of the virus to enter cells and evade neutralizing antibodies.

The World Health Organization recommends sequencing about 0.3 % of the confirmed cases, but India was much below that rate. By December 2020, India was only sequencing approximately 0.05 %. But with the establishment of this sequencing consortium of ten labs, the rate has risen to about 1 % since February 2021.

One of the critical errors India made was in vaccine procurement. In January 2021, the government ordered only 11 million doses from Serum Institute of India. Together, Serum Institute and Bharat Biotech can currently produce roughly 90–100 million doses in a month. But those firms also have export commitments, especially to the WHO's COVAX program.

How long it will take for the virus to become endemic depends on how much vaccine coverage we can get and how quickly, as well as how long protection lasts, what proportion of the population gets infected, and what kind of mutant viruses develop.

Crisis and Its Implications

The first red flag ought to have gone up when cases started rising in March 2021. On March 10, nearly 20,000 new cases were reported; on March 24, the number had spiked to 50,000. New daily cases on April 4: 100,000; April 14: 200,000; April 21: 300,000 and May 7: 414,000.

On April 21, India recorded a total of 314,835 new daily cases—the highest single-day tally for any country since the beginning of the pandemic. It overtook the US's single-day January record of 297,430. The rate of progression from 200,000 to 300,000 was far swifter than in the US. There were 2,102 deaths on 21 April. Since then, the numbers have continued to swell.

On April 15, India crossed 200,000 new cases daily, doubling to 400,000 cases on April 30, with a total of 32 million active cases.

Numbers have only continued to explode, and health infrastructure has collapsed, with oxygen shortages leading to deaths in hospitals. The weight of millions of active COVID cases and a severe shortage of logistics have exhausted health professionals. The horror of sweeping infections, severe disease, and staggering death rates have made state shutdowns a popular measure. The surge was brought about mainly by inappropriate messaging, massive political rallies, and large religious events.

India's relative success with the first wave likely led to a sense that vaccines could be rolled out slowly; additionally, the government is now in "emergency mode." India's overwhelming surge of coronavirus infections has revealed complacency and insensitivity after last year's first wave. India is suffering the world's worst outbreak of COVID-19 cases, with deaths hitting a record of more than 4,000 daily.

Emergence of mucormycosis (black fungus) during the Covid Catastrophe is a bigger challenge to India. The Union Health Ministry, on 20 May, urged states to make mucormycosis a notifiable disease under the Epidemic Diseases Act 1897. What is it and how is it caused? Here's all you need to know.

The pandemic threatens the health and well-being of everyone in the planet. The virus will continue to replicate, mutations will continue to occur, and variants of concern will continue to emerge. The emergence of variant strains is a great threat for the control of the pandemic. Investments in scientific research and public health, genomic n disease surveillance are crucial to respond to the future pandemics.

What Went Wrong?

After a drop in cases last year, there was a sense that India had weathered the worst the virus could give her—that the country had come through and it was time to open up.That complacency hurt India's people. People let their guard down

too soon. India should have gathered better-quality scientific data, which it did not. India's relative success against the first wave of infections also likely led to it not swiftly preparing enough vaccines for its own population.

The government did not anticipate such a harsh second wave and has mishandled the vaccine roll-out, which was sluggish and did not encompass the demographic breadth it should have. The government kept private players out of the vaccination drive, massively curtailing its reach. Only 8 % of India's population has received one dose of the vaccine so far, and only 1.3 % has been fully vaccinated. In comparison, the US has fully vaccinated 26 % of its population, and the UK has inoculated 16 %.[2]The government underestimated the number of doses that would be needed if the numbers turned grim and is now scrambling to find the necessary shots. It also failed to strengthen its health infrastructure during the months when the virus appeared to have been tamed.

India needed to administer ten million shots daily, instead of being complacent with three million doses a day. In view of the stocks available and manufacturing capacity, that target seems months away—if it is even possible to achieve at all. Vaccinating a critical mass of the population is the only real solution to this devastating crisis. But in a country as large, diverse and populous as India, that is a challenge of mammoth proportions.

A More Deadly Second Wave

On May 6, India saw the highest daily tally of new SARS-CoV-2 infections ever recorded in the world—414,000—taking its pandemic total to 16 million cases, second only to the US, and recording more than 200,000 deaths. "Official statistics in India are often doctored and there was tremendous pressure to report less," Kutty told *The BMJ*, [*BMJ* 2021; 373:n1124] adding that there is a lack of transparency in the figures for infections and mortality too.

With a reported 0.25 million deaths, the official figures in India are likely to be much lower than the actual numbers. "Testing was limited, and so many who weren't tested were admitted to hospitals. When these patients die, their deaths are not recorded as COVID-19 deaths and that death can also occur much later after discharge."[3]A study in *Lancet Global Health* in February indicated that the first wave infected up to 50 % of people in urban areas.[4]

The second wave seems to be spreading more to rural areas, where people travel far to get to the nearest health centers. In the state of Punjab, health records show that over 80 % of patients have severe symptoms once they arrive, due to the delays caused by travel.[5]

India's surge in cases has implications beyond the subcontinent. The Serum Institute of India, a pharmaceutical company headquartered in Maharashtra, is contracted to produce the bulk of vaccine doses for the developing world via COVAX, the vaccine-sharing scheme spearheaded by the World Health Organization. But the Indian government, confronted by the wave of cases at home, has banned the export of most of the doses meant for other countries, leaving swathes of the Global South facing a shortfall.

The spike is thought to be due to the rise of variants (UK, India double-mutant), relaxation of public health standards as though the pandemic were over, large rallies, super-spreader events, and seasonality (the virus is more effective when humidity levels are low).By early or, at the latest, mid-March, it was clear from the data that India was heading towards trouble. The Kumbh Mela Shahi Snans in March and April, when over six million people gathered without masks or social distancing, may be counted as the largest super-spreader event in the history of this pandemic.

Healthcare workers are stretched beyond all comprehension, and the second wave of cases has been made even more deadly by oxygen shortages in hospitals. The government waited until October 2020—eight months after the pandemic began—to invite bids for a $27 million contract to place oxygen generation systems inside more than 150 district hospitals. Six months later, most still aren't up and running. Hospitals have been issuing distress calls for urgent supplies of oxygen.

Prime Minister Narendra Modi has described the second wave as a "storm" that has "shaken the nation." Citing an acute shortage of medical infrastructure, chief ministers of several states have been expressing helplessness in handling the situation. This is the status more than a full year since the pandemic first struck India. An *India Today* analysis of government data reveals that the number of oxygen-supported beds, ICU beds and ventilators saw a drastic decrease between September 2020 (when India saw the peak of the first COVID-19 wave) and the end of January 2021 (just before the second wave started, around mid-February).[6]

The analysis, based on data collected from Parliament documents and official press releases, reveals: as of September 22 last year, India had 2,47,972 oxygen-supported beds. By January 28 of this year, the number had fallen to 1, 57,344—a decrease of 36.54 %.In the same period, the number of ICU beds for COVID-19 patients saw a decrease of 46 %, falling from 66,638 on September 22 to just 36,008 on January 28.If we combine the number of oxygen-supported beds and ICU beds, there was a 38 % decline in these four months. Furthermore, India had 33,024 ventilators as of September 22. By January 28, the number had fallen to 23,618—a decline of 28 %.[6]

During 2020, when the coronavirus pandemic hit India, the country started rapidly augmenting its health infrastructure. The central and state governments swung into action to meet the rising demand for hospital beds and ventilators. Parliament documents show that from just 62,458 oxygen-supported beds on April 21, 2020, the figure rose to 2, 47,972 by September 22. ICU beds and ventilators also increased from 27,360 to 66,638 and from 13,158 to 33,024, respectively. Between April 21 and September 22, 2020, the number of oxygen-supported beds increased by 297 %; ICU beds by 143 %; and ventilators by 151 %.

This was a substantial augmentation of resources under the constraints of a pandemic. However, despite these advances, there were reports about COVID-19 patients struggling to get hospital beds, indicating that India still needed to enhance its infrastructure in case a second wave hit the country. September was also when India reached the peak of the first wave of coronavirus infections. On September 17, the country reported 97,894 cases, the highest point in the first wave. Thereafter, India's COVID-19 cases started decreasing for nearly four and half months, until mid-February. As of December 29, 2020, India had 2,70,710 oxygen-supported beds, 40,486 ICU beds and 40,627 ventilators.[7]

Despite ample warnings of an impending second wave of coronavirus infections from health experts and a parliamentary committee, this strengthened health infrastructure in India was very short-lived. In just one month, the number of beds plummeted as the central and state governments became relaxed and lowered their guards, possibly because daily cases were reducing. After the first wave, the sense of urgency to ramp up health infrastructure in the country declined.[8]

The scale of decline in India's health infrastructure after the first wave can be gauged from the fact that although there were 2,70,710 oxygen-supported beds on December 29, 2020, by January 28 the figure fell to just 1,57,344—a fall of 42 %. The decline in ICU beds and ventilators was 11 % and 42 %, respectively. On April 9, 2021, the Union Health Ministry in a press statement said the country had substantially ramped up hospital infrastructure for management of COVID-19. It said there were 75,867 ICU beds and 2,55,168 oxygen-supported beds in the country. Although the figure

for ICU beds was higher compared to December 29, 2020, oxygen-supported beds were still lower. The number of ventilators wasn't mentioned.

While states and the central government have made efforts to increase bed availability and the armed forces have been roped in, the efforts came only after hundreds of COVID-19 patients in several states languished outside hospitals pleading for a bed. Many of them died gasping for breath—at their homes, in ambulances, outside hospitals, on roads, in auto-rickshaws, and elsewhere. The challenge ahead won't be just to ensure sufficient oxygen-supported and ICU beds, ventilators and medical oxygen, but also to have a pool of trained personnel to take care of the patients and these facilities. To meet this challenge, the central and state governments ought to start planning now, even as they are in a firefighting mode to tackle the second wave.

Economic Implications

The COVID-19 crisis in India has triggered a fresh wave of unemployment in the country. The unemployment rate reached a four-month high of 8 % in April 2021 as job losses increased sharply due to localized curbs imposed by states that cost more than 7 million jobs compared to March, when the unemployment rate was 6.5 %.

CMIE said that the unemployment outlook remains weak due to restrictions imposed to contain the unprecedented rise in COVID-19 cases. The impact of COVID-19 on various indicators of the economy would depend on how fast cases are contained. At the moment, the situation in India looks grim as the country continues to report over 350,000 cases and 3,400 deaths on a daily basis. CMIE data indicates that the impact of lockdowns has resulted in a higher rate of unemployment in urban areas. The unemployment rate in urban areas edged up to 9.78 % in April, compared to 7.13 % in rural areas.[9]

The rising wave of unemployment in the country could result in a dilemma for the government as cases continue to rise unabated. The labor force shrank by 1.1 million in April 2021 to 424.6 million compared to 425.8 million in March. In spite of this smaller labor force seeking employment, a greater proportion failed to find employment. As a result, the unemployment rate shot up from 6.5 % in March to 8 % in April. India's 63.4 million MSMEs, already battling low demand, are on the brink of forced shutdowns thanks to a second labor exodus, the high cost of inputs, and loan-repayment blues.[9]

Coronavirus Deaths Underreported

The real count of global deaths caused by the coronavirus is more than double the number officially reported, according to one analysis. Researchers at the University of Washington's Institute for Health Metrics and Evaluation analyzed excess mortality numbers and found about 6.9 million global fatalities from the virus.[10] Reasons why countries are underreporting coronavirus deaths include missing cases unintentionally as healthcare systems come under pressure and as well as of adequate testing to identify COVID-19-related deaths.

Variants Vs Vaccines

In December, scientists detected a new variant, known as B.1.617, in India, although it's not known whether this is driving the local outbreak, owing to a lack of genomic surveillance. There is a correlation, however, between the rising prevalence of variants and the surge in Indian case numbers. As Maharashtra saw the prevalence of B.1.617 rise, they also saw an outbreak. It is on the rise in Delhi, where people are also seeing an outbreak. These are very important epidemiological correlations. In Delhi and in northern India, another variant—first identified in the UK and known as B.1.1.7—was more dominant than B.1.617. The B.1.1.7 variant is known to be more transmissible.

Recent data showed that India's homegrown COVID-19 vaccine, COVAXIN, neutralized the B.1.617 variant, suggesting that vaccination may be effective against it. Other variants, first identified by scientists in South Africa and Brazil, are also believed to be more transmissible than the original strain and have already made their way into several other countries.

More than 60 % of American adults have received their first dose of vaccine and 48 % of the US population is fully vaccinated. More than 33 million people aged 18 and over in the UK have received at least one dose of aCOVID-19 vaccine—around 43 % and 64 % of the eligible population, respectively.[11] In contrast, around 19 million people in India had received at least one dose of the vaccine, as of May 19, the Indian health ministry reported. That's just over 9 % of India's total population. Experts have blamed a slow vaccine rollout and shortage of supply for this poor showing. India would need to administer 10 million doses a day to vaccinate all adults within the next five to six months—and that is assuming enough doses are available.[12]Funds should not be a constraint. At an assumed average price of INR 250 per dose, the cost of administering two doses to every one of the 70 crore adults will require INR 35,000 crore.

Impact

Hundreds of millions of poor people remain easy targets for a highly contagious virus. India has long neglected public health, spending less than USD 100 per capita per year, according to the World Bank—less than many other developing nations. After the government eased many restrictions during Phase I, infections rose, reaching almost 100,000 per day in September, but the healthcare system held. By the beginning of 2021, when infections had ebbed and the economy began to sputter to life, government made a concerted effort to signal that India was back. Many Indians shed their masks. They returned to markets and socialized. Even more restrictions were lifted. COVID-19 centers that had been set up during the first wave were dismantled.

A recent World Bank report estimates that the level of both schooling and learning will fall due to COVID-19, resulting in a loss of between 0.3 and 0.9 years of schooling, adjusted for quality. Measures taken to contain the pandemic are also unleashing severe consequences for livelihoods and food security, and the stress of insecurity, isolation, and quarantine are associated with an increase in depression and domestic violence. These effects are exacerbating pre-existing inequalities, especially for vulnerable populations, including women and girls, who bear a disproportionate impact from disruptions in core services.[13]

Vaccine deployment will require a national-level “whole-of-society” approach, including mobilizing financing, leveraging private and public actors within the health system, infrastructure support for vaccine delivery including energy solutions for cold chains, digital information systems to monitor delivery, civil society support for delivery, communication, and setting behavioral norms.

A fierce and deadly second wave of COVID has left many children orphaned and helpless across India. While some have lost their both parents, others are in a situation where a single surviving parent is unable to take care of them financially and psychologically. Millions of children are out of school. On the whole,COVID has traumatized children deeply.

Consequences

For six of the seven days beginning on April 21, India set new global records for daily COVID-19 infections, repeatedly surpassing the 300,000-case record previously set by the US. India’s total of confirmed cases—more than 18 million—are

second only to that of the US. By official counts, more than 200,000 have now died, and over 3,000 are dying per day. The true daily death toll is at least two times higher, from a caseload likely at least ten times higher, based on modelling of data from the first wave.

India's total healthcare spending is a mere 3.5 % of GDP, far lower than in other countries ranging from the world's wealthiest, like France (11.3 %) and the UK (10 %), to other emerging economies like Brazil (9.5 %) and South Africa (8.3 %). Furthermore, only a third of India's healthcare spending comes from the government, with the rest mostly coming out of citizens' pockets. This effectively means that those who can afford to purchase health can have it, while citizens of lesser means must fend for themselves.[14]

For all those vulnerabilities, the current crisis could have been avoided if the government had acted earlier. The virus is the root cause of the crisis, but the extent of the crisis is due to so much more. It's equal parts complacency and insensitivity. Many Indians who took strict precautions last year abandoned their masks and gathered indoors when the broader public messaging implied that India had conquered the virus.

In the longer term, vaccinations are desperately needed to prevent a third wave. Only 9 % of Indians have had at least one vaccine dose, and the current pace of vaccination is too slow. It's also not realistic for India to attempt to rapidly vaccinate 1 billion people. With limited vaccine supply, the most effective way to reduce transmission may be to target hot-spot areas and higher-risk people—which means India needs better data, fast. For the "pharmacy of the world," which produced 60 % of the vaccines for global use before the pandemic, supply was never going to be a problem. India already had the world's largest immunization program, delivering 390 million doses annually to protect against diseases like tuberculosis and measles, and an existing infrastructure that would have made COVID-19 vaccine distribution easier. In early January, India announced a goal to inoculate 300 million people by August. [15]

India now has over 23 million confirmed cases, compared to the US total of 33.5 million. The country is currently in the midst of a second wave of the virus, with confirmed daily infections reaching an all-time high of 414,000. But the official numbers only tell part of the story, according to multiple studies. The Indian government says that the national recovery rate has reached 77 % and the case fatality rate is down to 1.8 %, due to "timely and effective clinical management of the patients in critical care" according to an official statement on August 30. However, experts who spoke with *The Lancet* have pointed to several sources of uncertainty in India's COVID-19 mortality data. Public pressure and media reports about alleged undercounting have begun to push many states to review their COVID-19 mortality data. "In several states, many of the 'missing' deaths were added later on to the tally after audits."[16]

In rural areas, where most of India's population lives, most deaths occur outside the hospital, which can delay registration. "Among the deaths registered under the civil registration system, only 22 % are medically certified nationally with cause of death. The Integrated Disease Surveillance System is collecting the data on deaths due to Covid-19 from testing laboratories and hospitals, but miss's deaths due to COVID-19 among those who were not tested." Babu told *The Lancet* that "verification of data and detailed examination of the death numbers from several hospitals and field offices needs to be done." "From what has been reported, I think India definitely has the most infections in the world," says Ramanan Laxminarayan, director of the Washington, DC-based Center for Disease Dynamics, Economics and Policy.[15]

The reason is that even now, testing is only detecting a fraction of the cases that actually occur in India's massive population of 1.4 billion people. A serological survey conducted between August and September 2020, which measured the presence of the virus in a sample group of the Indian population, estimated that there were between 26 and 32 infections for

every reported case of the virus. The first national SARS-CoV-2 serosurvey in India, done in May–June, 2020 among adults aged 18 years or older from 21 states, found a SARS-CoV-2 IgG antibody sero prevalence of 0.73 % (95 % CI 0.34–1.13). The study aimed to assess the more recent nationwide seroprevalence in the general population in India.[17]

For every 30 infections, only one was being picked up as a case, a similar disparity likely still exists now—even though India's testing capacity is higher than it was last year—because of the signs pointing to the fact that the virus is running rampant in the population. Experts argue that we need to apply the 30-fold undercount even now. Therefore, the real number of COVID-19 infections to date in India could be somewhere around 400 million—still, that means a billion people are not infected. There is thus plenty of room for infection, even with many people already infected.

The number of confirmed COVID-19 deaths in India stands at just over 0.25 million, the second-highest in the world, behind the US. But those numbers may not tell the whole story. Even before the pandemic, as few as 21 % of deaths in India were recorded by a medical professional along with a cause of death, according to the World Health Organization. India has almost one sixth of world's population, with an estimated 26 million births and 8 million deaths every year.[18]If we are undercounting cases by a factor of 30, is it possible that we are undercounting deaths as well. For 80 % of deaths, we have no medically identified cause of death at any given time.

As a percentage of the total number of cases, the official death numbers put India's case fatality rate at around 1.25 %, lower than that of the US (1.8 %), Brazil (2.6 %) and others. The Indian government has focused on these numbers in public pronouncements as evidence of success in tackling the virus. Just as the country's second wave began to take off in March, a report by India's health ministry cast the situation in positive terms. "Today we have the least number of COVID-19 cases, highest recovery rate, least number of deaths due to COVID-19 and now moving towards a greater win by developing vaccines against the dreaded disease," it said.[19] Part of the reason for India's low death rate is its young population, more than half of whom are under the age of 25. Younger people are less likely to suffer severe reactions to COVID-19 or to die from the disease.

How the Pandemic is Reshaping India

India will have more cases than any other country in the world. With a population of 1.4 billion, there is plenty of room for exponential growth. The pandemic has already reshaped India beyond imagination. Its economy was faltering even before the lockdown, and the International Monetary Fund now predicts it will shrink by 4.5 % this year. Many of the hundreds of millions of people lifted out of extreme poverty by decades of growth are now at risk in more ways than one. Gaps in India's welfare system meant millions of internal migrant workers were unable to receive government welfare payments or food. Hundreds died, and many more burned through the meager savings they had built up over years of work.

Now, with India's economy reopening even as the virus shows no sign of slowing, economists are worried about how fast India can recover—and what happens to the poorest in the meantime. "The best-case scenario is two years of very deep economic decline. "There are at least 100 million people just above the poverty line. All of them will fall below it.[20]

Although Indian policymakers have long been aware of the extent to which the economy relies on informal migrant labor, there are an estimated 40 million people who regularly travel within the country for work. Migrant labor a source of dynamism and an escalator for many people to escape poverty. In order to get that income improvement for the poor back, we must ensure that the social safety net works better for them.

The wide-scale economic disruption caused by the lockdown has disproportionately affected women. Because 95 % employed women work in India's informal economy, many lost their jobs, even as the burden remained on them to take care of household responsibilities. Many signed up for India's rural employment scheme, which guarantees a set number of hours of unskilled manual labor. Others sold jewelry or took on debts to pay for meals. The COVID situation multiplied the burden on women both as economic earners and as caregivers. They are the frontline defenders of the family.

As COVID-19 moved from early hot spots in cities toward rural areas of the country where healthcare facilities are less well equipped, public-health experts expressed concern, noting that India has only 0.55 hospital beds per 1,000 people, far below Brazil's 2.15 and the US's 2.80. Much of India's health infrastructure exists only in urban areas. As the pandemic unfolds, it is moving into states that have very low levels of testing and rural areas where the public-health infrastructure is weak.

When the virus is spreading exponentially as it is currently in India, cases increase sharply, but deaths, which lag weeks behind, stay low, skewing the ratio to make it appear that a low percentage are dying. No serious public-health expert believes this is an important statistic. On the contrary, it may give people false optimism, increasing the risk of transmission. India's case fatality rate (the percentage of infected people who have died from the disease) stands at 3.4 %, even with the added deaths from Wednesday. That number is lower than the 5.4 % global average, as well as the rates in both the US and Brazil. Scientists argue about why India's case fatality rate appears lower than in much of the rest of the world.

Cause and Effect

Despite this surge, as of now, India's COVID mortality rate is 140 dead per 1 million people. This compares to 401 for the world average, 1,762 for the US, and 1,869 for the UK. It puts India 119th in the world in this measurement, which is the most important statistic for comparison purposes.

The lack of a robust and dependable public health infrastructure as well as medical supplies of equipment and drugs is a matter of grave concern. Poverty is the world's biggest killer, which is why a strong economy is not an optional luxury but rather an essential requirement for good health. By far the biggest killer is heart disease, with 1.54 million killed per year—or 4,200 each day—which has not unduly worried HMG or our domestic press in the past. Based on India's population of 1.4 billion people, it means they have an IFR of 0.0003 %, fantastic, has to be the best in the world.

Overconfidence, complacency and missteps contributed to the country's devastating second wave. The COVID-19 task force didn't meet for months. Each day, cremation grounds burn thousands of bodies, sending up never-ending plumes of ash that are turning the skies grey over some of India's biggest cities. Congested burial sites and corpses spotted floating in rivers are a testimony to a nightmare. Officials dismissed warnings by scientists that India's population remained vulnerable and had not achieved "herd immunity" as some in this administration were suggesting, according to people familiar with those conversations.

Although India is a vaccine powerhouse that produces vaccines to protect the world, it didn't purchase enough doses to protect itself. Instead, while vaccination rates remained low at home, India exported over 60 million shots to bolster its standing on the world stage. Any Indian leader would have faced challenges. In India, hundreds of millions of poor people live cheek by jowl—easy targets for a highly contagious virus. India has long neglected public health, spending less than USD 100 per capita per year, according to the World Bank—less than many other developing nations.[21]

India started its immunization program on January 16, with healthcare workers at the front of the line and a target of reaching 300 million people by July–August. It is using a vaccine developed at home by Bharat Biotech and the Indian Council of Medical Research, as well as another licensed from AstraZeneca. Antibody tests done on more than 700,000 people by Diagnostics Company Thyrocare Technologies showed that 55 % of India's population may have already been infected. The World Health Organization says at least 60 % to 70 % of the population needs to have immunity to break the chain of transmission. The government has cherry-picked results that suggested a move toward herd immunity. Though several factors are at play and new, more dangerous virus variants may also be involved, many people blame the elections.[22]

The B.1.617 variant of COVID-19 was first detected in India in October 2020. The strain involves two variants of the virus. The E484Q mutation has characteristics of a previously detected variant—E484K—which was seen in the fast-spreading Brazilian and South African variants, making it highly transmissible. The L452R mutation, on the other hand, helps the virus evade the body's immune response. The double-mutation strain was subsequently named B.1.617. The WHO's chief scientist says that the variant spreading in India is more contagious and has some mutations that potentially could make it resistant to antibodies that are generated by vaccines. These factors contributed to the massive outbreak of the infection in the second wave. Tweaking of existing vaccines should be done at the earliest opportunity; otherwise, the Pfizer or Moderna vaccines must be allowed in India.[23]

Health Infrastructure

Health services across states are on the verge of a breakdown. Patients are struggling to get hospital beds, COVID test reports are delayed by days, and there is an acute scarcity of oxygen and vital drugs. India has a chronic shortage of space on its intensive care wards, with many patients' families forced to drive for miles to try to find a bed for their loved one. In Delhi—a region of about 20 million people—hospitals are full and are turning away new patients. People are dying on the streets outside hospitals as the country struggles to cope.

Some streets outside medical facilities have become crowded with the seriously ill, their loved ones trying to arrange stretchers and oxygen supplies for them as they plead with hospital authorities for a place inside.The government announced that military medical infrastructure would be made available to civilians and that retired medical military personnel would be helping out in COVID treatment facilities. But the COVID-19 pandemic is only going to get worse. India will need an extra 500,000 ICU beds, 200,000 nurses and 150,000 doctors in the next few months to respond to the challenge. At present, India has only 75,000 to 90,000 ICU beds and almost all are already occupied, when the second wave of the pandemic has not even reached its peak yet.

For every patient who tests positive, there are 5 to 10 people who are positive but not tested. That means over 2 million people are getting infected every day in India, even now. Statistically, 5 % of the positive patients need an ICU bed, irrespective of their age. On average, a patient in ICU spends at least 10 days there. India needs to create at least 0.5 million additional ICU beds now.

Hospitals need nurses, doctors and paramedics in that order. India needs to produce at least 0.2 million nurses and at least 0.15 million doctors in the next few months who are dedicated to managing COVID for the next year. India has about 0.22 million nursing students who have finished their three-year nursing training course who are preparing for their exams. The government can consider these students as graduates and deploy them to work in COVID wards/ICU wards for one year. There are also 0.13 million young doctors today preparing for NEET examinations to get into post-graduate

courses against 35,000 positions. Nearly 100,000 young doctors can be offered jobs to meet the immediate need. India must be prepared for the third wave.

Court Interventions

Courts have been proactive with their timely intervention, advising the government to safeguard the lives of India's people. On May 9, 2021, the Supreme Court of India convened an independent task force of experts on the COVID crisis to study and recommend, on a scientific and rational basis, the allocation of oxygen, medicines, medical resources and vaccines across the country. The government had failed us. During the course of hearing, it was suggested by the Court that an "expert body" involving national experts with experience in health institutions be set up as a National Task Force that will be responsible for providing public health responses based upon a scientific approach to the issues concerning the pandemic situation. It is necessary that an effective and transparent mechanism be set up within the Union Government for the purpose of allocating medical oxygen to all states and UTs for use during the COVID-19 pandemic. The Union Government has agreed to set up a National Task Force to streamline the process. This Task Force would be tasked inter alia with formulating a methodology for the scientific allocation of oxygen to the states and UTs.[24]

Critical Analysis of the COVID Catastrophe

When the first wave of COVID came to India and then subsided last year, the government and its supportive commentariat were triumphant. However, the number of COVID-protocol funerals from graveyards and crematoriums in small towns and cities suggest a death toll up to 30 times higher than the official count. Doctors who are working outside the metropolitan areas can tell you how it is. If Delhi and Mumbai are breaking down, what must be happening in villages in Bihar, in Uttar Pradesh, in Madhya Pradesh? What is happening in places where tens of millions of workers from the cities, carrying the virus with them, are fleeing home to their families, traumatized by their memory of national lockdown in 2020?

This time around, although there is no national lockdown, the workers have left while transport is still available, while trains and buses are still running. They have left because they know that even though they make up the engine of the economy in this huge country, when a crisis comes, in the eyes of this administration, they simply don't exist. These are villages where people die of easily treatable diseases like diarrhea and tuberculosis. How are they to cope with COVID?

India spends about 1.25 % of its gross domestic product (GDP) on health, far lower than most countries in the world, even the poorest ones. The real figure is estimated to be closer to 0.34 %, excluding the private sector. The Union health budget still remains at about 0.34 % of GDP—a slight increase from 0.31 % last year (BE). To attain the goal of 2.5 % of GDP as stated in the NHP, the Finance Commission estimated that the Union budget for 2021–2022 should be 0.68 % of GDP. Thus, the massive gap still remains.

Three quarters of healthcare facilities are in the private sector; only one fourth are in public sector. The 2021 Economic Survey set out the importance of increasing public health spending and also discussed market failures in health in detail. It showed that an increase in public health expenditure from the current levels in India to 3 % of the GDP can reduce out-of-pocket expenses (OoPE) from the current level of 60 % to about 30 %. As is well known, the OoPE on healthcare burden not only the poor but also the middle class of this country. The Economic Survey therefore makes a case for increasing public spending on health from 1 % to 2.5–3 % of GDP, as the National Health Policy (NHP) 2017 states. This is necessary to improve India's poor standing on various indicators of health, such as share of OoPE, equitable and good quality access to healthcare, availability of infrastructure, and human resources for healthcare.[25]

The tragedy is that in this devastatingly poor country, as a 2016 *Lancet* study shows, 78 % of the healthcare in urban areas and 71 % in rural areas is now handled by the private sector. The resources that remain in the public sector are systematically siphoned into the private sector by a nexus of corrupt administrators and medical practitioners, corrupt referrals and insurance rackets.[26]Healthcare is a fundamental right. The private sector will not cater to starving, sick, dying people who don't have money. This massive privatization of India's healthcare is a crime.

Experts predict that the number of cases in India will grow exponentially to more than 500,000 a day. They predict the death of many hundreds of thousands in the coming months, perhaps more. Cases started rising in February, when India reported an average of about 10,000 infections a day. The situation progressively worsened in April, and India ended the month by repeatedly setting new global records for daily cases. As per The World Health Organization, one in every three new coronavirus cases globally is being reported in India. Nearly 7 million cases were reported for the month of April, a huge share of the more than 19 million India has recorded during the entire pandemic.

Scientists say the spike in cases is partially due to variants of the coronavirus circulating in India at the moment. At least two important dominant variants have emerged: one is a UK variant, and the other is an Indian variant. Last month, the Indian government reported that 80 % of cases in Punjab were due to the highly contagious UK variant, which is known as B.1.1.7.[27] Mean while, the Indian variant (known as B.1.617) has multiple sub-lineages with slightly different characteristic mutations. The WHO classified it as a variant of interest in its epidemiological update on the pandemic last week.[28]

Maharashtra, which is home to India's financial capital Mumbai, is the hardest hit state and also the epicenter for the second wave.

Since launching its mass inoculation drive in January, India has administered over 160 million vaccine doses as of April 30, according to government data. These include 94,12,140 HCWs who have taken the first dose and 62,41,915 HCWs who have taken the second dose.[29]This implies that a little over 10 % of the population has received at least one of the two shots required. But the percentage of people who have completed their vaccination is only about 2 % of the total population—around 27.9 million as of April 2021.Starting in May, India is opening vaccinations to anyone age 18 and older. The kind of herd immunity India needs to reduce transmission can only be achieved through vaccination. It will take many months beforea critical mass is vaccinated against COVID.

India is presently facing vaccine shortages, and several states have reportedly run out of supply, exacerbating a dire second wave of infections that has left hospitals and morgues overflowing while families scramble for increasingly scarce medicines and oxygen.[30]The supply crunch is expected to last through July, according to Adar Poonawalla, CEO of India's top vaccine maker, Serum Institute, which is producing AstraZeneca's shot.[31]He recently told the *Financial Times* that his firm is set to increase vaccine production capacity from about 60–70 million doses a month to 100 million.[32] Furthermore, New Delhi has recently approved the Russia-developed Sputnik V and authorized foreign-made vaccines that have been granted emergency approval by the US, UK, European Union, Japan and World Health Organization-listed agencies.[33]

Public Health Concerns

India's second coronavirus wave is rapidly sliding into a devastating crisis, with hospitals unbearably full, oxygen supplies running low, desperate people dying in line waiting to see doctors—and mounting evidence that the actual death toll is far higher than officially reported.

Interviews from cremation grounds across the country, where the fires never stop, show an extensive pattern of deaths far exceeding the official figures. Nervous politicians and hospital administrators may be undercounting or overlooking large numbers of dead, analysts say, and grieving families may be hiding COVID connections as well, out of shame, adding to the confusion in this enormous nation of 1.4 billion.[34] The true numbers of cases and deaths are likely to be higher than the numbers provided by authorities, with many people avoiding testing or struggling to access it. Many deaths in rural areas also go unregistered.

Last year, the World Health Organization advised that countries needed to get the positive test rate below 5 % for at least two weeks before considering easing restrictions. The rate in India is now around 20 %. A high percentage of positive tests suggest high infection rates and the likelihood that many more people in the community with coronavirus are going undetected. The Indian Council of Medical Research (ICMR) noted that 21.4 % of the 28,589 people—aged 18 years and above—surveyed during the period showed evidence of past exposure to the coronavirus infection. 25.3 % of children aged 10 to 17 years from the same number of surveyed population have had the disease.[36] A large part of the population is still vulnerable to COVID-19.

We can cross-check under-reporting of infections directly with serosurveys carried out in India. The third serosurvey conducted by the Indian Council of Medical Research (from December 17, 2020 to January 8, 2021) reports that 21.5 % of all Indians above the age of 18 have antibodies present that indicate past SARS-CoV-2 infection. Approximately 59 % of India's 1.36 billion citizens are above the age of 18. This implies nearly 173 million adults infected. Factoring in the nearly 11 million COVID-19 cases reported by January 8 (assuming most cases are adults), this points to an implied under-reporting factor of roughly 16 for infections. In other words, only 6 % of India's COVID-19 infections are reported. Hence, the issue of "missing infections" in India is undeniable and not contingent on a belief in the legitimacy of mathematical models—it is evident based on figures released by the Indian government and institutions alone.

Preparedness for a Third Wave

Given the high levels at which this virus is circulating, India may see a third wave of the coronavirus pandemic. Vaccines will need to be updated to deal with new strains that have accelerated contagion in India, overwhelming hospitals and killing thousands. India must prepare for Phase3, and surveillance is the priority of the hour.

The public health measures that work best are those that the people voluntarily adopt because they see them to be in their own best interests, drastically reducing transmission. A study found that countries where masks were widely used (either because of government orders or cultural norms) had lower per-capita mortality from COVID than countries where there was no universal masking. A smaller study of transmission among family members in Beijing households found that face masks were 79 % effective in preventing transmission when they were used by all household members.[37]

A comprehensive review of the scientific evidence for the use of face masks, published in January of this year in the *Proceedings of the National Academy of Sciences* (PNAS), concluded that "near-universal adoption of nonmedical masks when out in public, in combination with complementary public health measures" could reduce community spread, provided the measures were sustained. Mask wearing by itself will not be enough: it must be part of a package of measures that include rigorous social distancing, hand hygiene and avoiding mass gatherings.[38]

As stated above, the public health measures that work best are those that the public voluntarily adopts because they see it as being in their best interests. There is evidence from an experimental study in Bangladesh indicating that people will use masks enthusiastically if they are provided free, are comfortable, and accompanied by appropriate instructional materials. Mask usage tripled when masks were given away free and accompanied by well-designed instructional material, as well as reminders from religious and community leaders and volunteers.

Having volunteers in public spaces such as markets to remind people to wear masks and distribute masks to those who did not have them, as well as frequent messages from religious and community leaders, saw an increase in mask usage from 13 %—when none of these interventions existed—to over 40 % with them. One key to success was mask quality: masks needed to be comfortable to wear in hot and humid conditions, as well as being effective filters. Importantly, those who wore masks were also more likely to maintain social distancing.

Communication at the community level is the key to getting people to protect themselves this way. People need to be educated on the reasons for mask wearing as well as the proper way to wear a mask. Imaginative and creative communication campaigns are essential.

A COVID-Adaptive Future

While describing future trends, Tabish says:"stepping into the year 2021 is not without burden of inheritance. During the first half of 2020 SARS-CoV-2 rendered the entire human population speechless, motionless and helpless. It exposed the weak public health systems, fragile disaster management mechanisms, complacency of governments and lack of effective leadership in many countries. Globally, these are the unprecedented times, unimagined and unthought-of. The deadly virus around is forcing people all over the world to make unexpected and drastic shifts in their way of life to keep themselves safe. We are living on the edge. COVID 19 will stay for decades. It has left scars on all humans."[39] Tabish further states that the COVID-19 pandemic is exponentially growing. It is the defining global health crisis of our time and the greatest challenge since World War II. Countries are racing to slow the spread of the virus by testing and treating patients, carrying out contact tracing, limiting travel, quarantining citizens, and cancelling large gatherings such as sporting events, concerts, and school classes. The pandemic is moving like a wave. Some countries have effectively contained the pandemic, while others have been slow to react, and the consequences of such delay in responding to the challenge are obvious.[40] Elaborating further, he states that the modern world is becoming a viral superhighway. Left unchecked, today's emerging diseases can become the endemic diseases of tomorrow. The world still has a window of opportunity to prevent the virus from becoming endemic. The best way to seize this opportunity is for governments to act swiftly and forcefully to isolate the virus.[41]

Genomic sequencing must be integrated with routine epidemiologic surveillance. India needs to vaccinate approximately 800 million adults with two doses. At a rate of ten million doses a day, it will take India five to six months to vaccinate the adults. Rapid vaccination is crucial. There is also need forassessing the effectiveness of vaccines against variants. Containment measures and messaging must be intensified, interstate mobility must be restricted, ban large gatherings must be banned. A national mask mandate in public places and transportation must be issued, and the capacity for testing and COVID-care capacity must be scaled up. Public-private partnership is key. India needs strong data to understand the interplay of vaccines and variants. Post-marketing surveillance studies for safety and real-world effectiveness of multiple vaccines need to be carefully set up for a decentralized health system.

India needs a richer health data infrastructure moving forward. Additionally, a social safety net must be provided to the poor, to the vulnerable, to the daily wage earners; they need incentives to comply with public health guidelines. The virus and variants will remain a part of our lives for the foreseeable future. The value of every human life should be equal across the world. No one in the world will be safe until everyone in the world is safe. Our health is interconnected.

Health infrastructure has collapsed in several cities. State governments are scrambling to build up new infrastructure, making announcements this month about suddenly commencing the construction of new healthcare facilities or oxygen plants. However, this frenetic activity comes in the middle of an ongoing and exponential rise in cases, whereas it should have come before, say experts.[42]

Act Faster, Act Now

Containing biological and social contagions requires credible reassurance to quell panic, and for people to wear masks and obey rules of physical distancing. Government should engage with experts to determine how to uphold restrictions and manage the harsh second and third waves scientifically.

India must make COVID vaccination free and compulsory for all Indians. Start a mass vaccination program and achieve this target at the earliest. Import vaccines to the extent necessary. Next-generation COVID-19 vaccines are supposed to be better. Furthermore, Variant of Interest Genomic analysis is needed (presently at less than 1 % in India). Triple mutations of COVID have been detected in some samples. Previously, double mutations were seen. As the virus replicates faster, transmission rates increase and the chances of mutations become high. It should be possible to tweak existing COVID-19 vaccines, should new variants emerge that escape the immunity such vaccines confer.

The so-called "neighborhood concept" can be useful. Create small setups in local areas with home oxygen concentrators under the supervision of a qualified physician through help lines for treating COVID patients. It is nearly 30 % of patients presently admitted in hospitals to make beds available for patients with high oxygen demand. India has limited time, as COVID moves faster than its ability. Policy adjustments and innovations (efforts to address social protection gaps and expand support in the immediate instance) are crucial. India's best shot at tackling the outbreak is by stepping up its vaccination efforts. Furthermore, social protection must be strengthened in the long-term.

The Way Forward

In India, the number of daily infections has risen to a new high of 0.41 million. India is contributing over 40 % to the number of daily new infections worldwide. Currently, the most palpable and visceral crisis in the country is a shortage of oxygen, ICU beds, and admission to hospitals. The more the virus spreads, the more chances it has to mutate and create variants that may eventually resist current vaccines, threatening to undermine other countries' progress in containing the pandemic. Although the immediate priority is saving the lives of those already sick, vaccinating all is considered crucial to stop the virus from spreading. An equitable distribution of the vaccine around the world is essential. If the Indian outbreak can't be contained and spreads to neighboring countries with low vaccine supplies and weak health systems, the world risks replicating scenes witnessed in India, especially if newer, potentially more contagious variants are allowed to take hold. Because India has a leading role in making vaccines for other nations, failing to stop the spread of the virus there could endanger the vaccine rollout worldwide. There is a need to make COVID vaccination free and compulsory for all Indians.

Start a mass vaccination program and achieve this target at the earliest. Import vaccines to the extent necessary. The vaccination drive must be sustained over months; and the number of doses administered daily must far exceed the number of daily cases. Only then can India reverse the surge.

REFERENCES

1. *Jacob John and Gagandeep Kang. Tracking SARS-CoV-2 infection in India with serology. Lancet. Vol 9, Issue 3, E219-E220, March 01, 2021 Published January 27, 2021.DOI:https://doi.org/10.1016/S2214-109X(20)30546-5*
2. *Hannah Ritchie, Esteban Ortiz-Ospina, Diana Beltekian, Edouard Mathieu, Joe Hasell, et al. One World Data: India: Coronavirus Pandemic Country Profile.*
3. *https://ourworldindata.org/coronavirus/country/india*
4. *Pulla P. What counts as a covid-19 death?BMJ2020;370:m2859. doi:10.1136/bmj.m2859 pmid:32680851]*
5. *Malani A. Seroprevalence of SARS-CoV-2 in slums versus non-slums in Mumbai, India. Lancet Glob Health2020;(Nov). doi:10.1016/S2214-109X(20)30467-8. pmid:33197394*
6. *Indian Express. https://indianexpress.com/article/india/punjab-covid-deaths-rural-urban-7293303*
7. *Ministry of Health, Government of India. Lok Sabha Questions. 23 September 2020. http://164.100.24.220/loksabhaquestions/annex/174/AU2205.pdf*
8. *Ministry of Health, Government of India. Steps taken by the Government of India for COVID-19 containment and management.30 Dec 2020. https://pib.gov.in/PressReleasePage.aspx?PRID=1684546*
9. *Prabhash K, Dutta. India Today. Covid-19 possible second wave as India unlocks: How ready is healthcare system?https://www.indiatoday.in/news-analysis/story/covid-19-second-wave-india-unlock-healthcare-1719372-2020-09-07*
10. *CMIE. Job losses mount in April. https://unemploymentinindia.cmie.com/kommon/bin/sr.php?kall=wtabnav&tab=4080*
11. *Cecelia Smith-Schoenwalder. Analysis: Half of Global Coronavirus Deaths Unreported May 6, 2021.https://www.msn.com/en-us/health/medical/analysis-half-of-global-coronavirus-deaths-unreported/ar-BB1gqSQ8?ocid=msedgntp*
12. *CDC. Covid 19 Vaccinations in the US. https://covid.cdc.gov/covid-data-tracker/#vaccinations] / Vaccination in the UK. https://coronavirus.data.gov.uk/details/vaccinations 7 May2021*
13. *Ministry of Health & FW, Government of India. Total Vaccinations. https://www.mohfw.gov.in/*
14. *Laura Rawlings, Ramesh Govindaraj, David Wilson. World Bak.COVID-19 vaccines – A path for recovering human capital. Investing in Health.|JANUARY 21, 2021. https://blogs.worldbank.org/health/covid-19-vaccines-path-recovering-human-capital*
15. *The World Bank. Current Health Expenditure (% of GDP) https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS*

16. *Time. India's Vaccine Rollout Stumbles as COVID-19 Cases Decline. That's Bad News for the Rest of the World.https://time.com/5940963/india-covid-19-vaccine-rollout/*
17. *Patralekha Chatterjee. Is India missing COVID-19 deaths? WORLD REPORT| The Lancet VOLUME 396, ISSUE 10252, P657, SEPTEMBER 05, 2020*
18. *Manoj V Murhekar,Tarun Bhatnagar,Sriram Selvaraju,V Saravanakumar, Jeromie Wesley Vivian Thangaraj, Naman Shah, et al. SARS-CoV-2 antibody seroprevalence in India, August–September, 2020: findings from the second nationwide household serosurvey. Lancet. Vol 9, Issue 3, E257-E266, March 01, 2021. Published: January 27, 2021DOI:https://doi.org/10.1016/S2214-109X(20)30544-1*
19. *WHO. Civil Registration & Vital Statistics.https://www.who.int/india/health-topics/civil-registration.*
20. *Ministry of Health, Government of India. Annual Report 2020-2021.https://main.mohfw.gov.in/sites/default/files/Annual%20Report%202020-21%20English.pdf*
21. *Billy Perrigo.Time. JUNE 18, 2020. Indian Coronavirus Death Toll Is Rising. https://time.com/5855555/india-coronavirus/*
22. *The World Bank. Current Health expenditure per capita (USD) https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD*
23. *Krishna N. Das, Neha Arora. India says COVID contained, but vaccine campaign stutters. January 28, 2021. https://www.reuters.com/article/health-coronavirus-india-idUSKBN29X0YY*
24. *Double mutant strain in India potentially resistant to vaccine protection, WHO scientist. https://scroll.in/latest/994455/covid-19-double-mutant-strain-might-be-evading-vaccine-protection-in-india-says-top-who-scientist*
25. *Supreme Court ruling regarding setting up a National task Force. https://www.livelaw.in/top-stories/supreme-court-constitutes-national-task-force-for-formulating-methodology-for-scientific-allocation-of-oxygen-to-all-states-uts-173842*
26. *Science: The Wire. Economic survey 2020-2021. https://science.thewire.in/health/union-health-budget-nirmala-sitharaman-covid-19-pmasby-allocation-gdp-expert-analysis/*
27. *The Lancet. Global Burden of Disease. https://www.thelancet.com/gbd*
28. *Mint. Union Health Minister's Statement: In Punjab, 80% of cases are due to the UK variant of Covid-19. https://www.livemint.com/news/india/in-punjab-80-of-cases-are-due-to-the-uk-variant-of-covid-19-harsh-vardhan-11617764417579.html*
29. *WHO. https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19---27-april-2021*
30. *Ministry of Health, Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1715267 1 May 2021*
31. *Tanvi Mehta Chandini, Monnappa Shilpa, Jamkhandikar Adnan, Abidi. Overwhelmed India running short of COVID-19 vaccines. https://www.reuters.com/world/india/indias-posts-record-daily-rise-covid-19-cases-386452-2021-04-30/]April 30, 2021*

32. *CNBC. CEO of Serum Institute on Vaccine Supply Crunch. https://www.cnbc.com/quotes/AZN-GB*
33. *Financial Times. India's vaccine shortage will last months, biggest manufacturer warnshttps://www.ft.com/content/01784671-3834-49d8-9640-fc5d95f92eaf*
34. *Ministry of Health, Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1711558. 13 Apr 2021*
35. *Jeffrey Gettleman, Sameer Yasir, Hari Kumar and Suhasini Raj. As Covid-19 Devastates India, Deaths Go Undercounted The New York Times.April 24, 2021*
36. *Hazhir Rahmandad, Tse Yang Lim and John Sterman. Behavioral dynamics of COVID□19: estimating underreporting, multiple waves, and adherence fatigue across 92 nations.16 March 2021.https://onlinelibrary.wiley.com/doi/full/10.1002/sdr.1673*
37. *DNA. The Indian Council of Medical Research (ICMR) third national serosurvey conducted between December 7 last year and January 8. https://www.dnaindia.com/health/report-icmr-third-national-serosurvey-28-crore-indians-had-been-infected-by-covid-2873212*
38. *Christopher T. Leffler, Edsel Ing, Joseph D. Lykins , Matthew C. Hogan, Craig A. McKeown, and Andrzej Grzybowski. Association of Country-wide Coronavirus Mortality with Demographics, Testing, Lockdowns, and Public Wearing of Masks. American Journal of Tropical Medicine and Hygiene.26 Oct 2020;9(103):6*
39. *Jeremy Howard, Austin Huang, Zhiyuan Li, Zeynep Tufekci, Vladimir Zdimal, Helene-Mari van der Westhuizen, Arne von Delft, et al. An evidence review of face masks against COVID-19. PNAS January 26, 2021 118 (4) e2014564118; https://doi.org/10.1073/pnas.2014564118*
40. *Tabish SA. SARS-CoV-2 Pandemic: From Despair to Hope. Anaesth Critic Care Med J 2021, 6(1): 000188*
41. *Tabish SA. COVID-19 Pandemic: the crisis and the longer-term perspectives. J CardiolCurr Res. 2020;13(2):41–44. DOI: 10.15406/jccr.2020.13.00472*
42. *Tabish SA (2020) COVID-19: An unprecedented crisis that needs an extraordinary response. Arch Community Med Public Health 6(1): 053-054. DOI: https://dx.doi.org/10.17352/2455-5479.000075*
43. *AnooBhuyan. Experts criticise India's complacency over COVID-19.WORLD REPORT. THE LANCET. VOLUME 397, ISSUE 10285, P1611-1612, MAY 01, 2021*