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Review Article

An experimental analysis on India's oxygen failure during the 2nd COVID-19 wave

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ABSTRACT

The most dreaded sickness to have lately spread across the world is thought to be corona virus disease 2019 (COVID-19). During the first wave, India had extremely few COVID-19-positive cases per million people, but during the second wave, even more than 400,000 confirmed cases/day were reported. News of the medical oxygen shortage became more widely publicised following the Corona virus pandemic epidemic (Covid-19). One of the most crucial elements in the care of patients who have Covid-19 is medical oxygen. When the Covid epidemic was at its worst, India's medical system struggled with an oxygen shortage, which caused a sharp increase in the daily death toll. The demand for oxygen cylinders, ventilators, and other medical supplies grew to the point that there was not enough supply (availability). There was a significant unmet demand as a result. The Government of India made several attempts to fast ramp up the production process in order to guarantee that medical oxygen is given to individuals who are in dire need of it. However, the medical oxygen was unable to be transported from the point of production to the point of consumption due to significant logistical and supply chain issues. The goal of this study article is to thoroughly comprehend the numerous factors that contributed to the medical oxygen system failing in India during the second wave of the Covid-19 virus.

1. Introduction

Everyone has found the months of April and May 2021 to be exceedingly difficult, but anesthesiologists in particular. In the second wave of the COVID-19 pandemic, a sizable proportion of patients contracted the disease quickly. The medical facilities were overloaded with patients, which made it difficult to get enough oxygen, COVID beds, intensive care unit (ICU) space, necessary medications, and other supplies (Andrews, et al., 2020). The anesthesiology community during this time was intensely focused on setting up more and more beds and oxygen for COVID patients, delivering oxygen from liquid medical oxygen (LMO) tanks, medical gas cylinders, oxygen concentrators, or dividing the central oxygen supply. This was in addition to taking care of COVID and non-COVID clinical work (only as dire emergency measures). The anesthesiologists handled the clinical, administrative, psychological, and social stresses with skill.[1–5]

The most crucial treatment for COVID-19 patients that are mild to severe is medical oxygen. Patients risk suffocation and death without it. Medical oxygen has been in low supply at hospitals in India for the past one and a half years, both those that treat COVID-19 and those that do not. When the second wave peaked in April and May 2021, the issue reappeared on a far larger scale than it had during the height of the first wave in September 2020. According to some monitors, 512 lives may have been lost nationwide as a result of oxygen deprivation or scarcity. Inadequacy of the tanker distribution network to get liquid oxygen from

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the point of manufacture to the hospitals is the cause, not a dearth of medical oxygen per se. [6–11]

This research paper attempts to understand the intricacies involved in the functioning of the medical infrastructure of the country. The purpose is to have a sound understanding of the various hindrances involved both on the demand as well as the supply side of medical oxygen (Biswas, Bhattacharjee, Chakrabarti, Tewari, Banu, & Dutta, 2020). The inputs, beliefs, ideologies from this paper can be a source of further input for the Government and all other concerned stakeholders to forecast and foresee the demand for medical facilities in the coming future. Though the medical infrastructure of the country is believed to be the best and finest in the world, the ideas from this research paper can be used to reassess the infrastructure and take corrective action like allocating more capital to the medical sector of the country. In this way the number of hospitals could be stepped up quickly so that should India face such a crisis ever again, its response will be better than the previous one. [12–16]

1.1. The second wave's effects, section

All of India has been devastated by the COVID-19 second wave. This wave differs from the first wave in two ways: first, the daily infection rate is significantly higher as a result of the spread of more virus variants that are transmittable and an increase in testing capacity; and second, it has overwhelmed the Indian healthcare system because more infrastructure and medical personnel are required (Forni, Cagliani, Clerici, & Sironi, 2017). In addition to the social and economic destruction, which is more severely felt by the most vulnerable and marginalised members of society, the cumulative effect has resulted in high mortality across the Indian population.

1.2. Massive unemployment and escalating economic crisis

The UN has forecast that India's economy will grow by 7.5% with the caveat that the outlook is "highly fragile" because of the brutal COVID-19 second wave.26 The first wave of COVID-19 has already pushed 230 million below the poverty line (Rs. 375 per day) and increased informality, poverty, debt, and inequality in India (see SSHAP brief).12 The second wave has further deepened this distress.

1.3. Informal labourers are more precarious

Similar to the first wave, as soon as authorities began to announce containment measures and lockdowns, migrant workers began to move from cities to towns and villages. 29 Many migrant workers were left stranded in train stations, bus terminals, or at their places of employment as a result of the unexpected rise in COVID-19 cases and lockdown in states like Gujarat, Maharashtra, and Delhi.

1.4. Discrimination against disadvantaged populations

The precarity of marginalised communities in India, including poor women, Dalits, Muslims, and Adivasis, has increased (Gordon & Jang, 2020). These groups and communities have mostly been ignored by the country's development programmes (see SSHAP brief).

1.5. Rural distress

Similar to urban areas, rural communities are under distress due to a dual burden of rising disease rates and limited access to medical care. Due to insufficient testing, infection-related stigma, low disease knowledge, and insufficient testing, there has been a significant under reporting of cases. In India, villages that have mostly been cut off from testing and medical care have reported cases of mortality caused by COVID-like symptoms.

1.6. An emergency situation brought on by an oxygen shortage

India's second wave of Wuhan virus infections started in the middle of March 21. According to the Indian Prime Minister, "it has rocked the country." The majority of media headlines began to flash "oxygen crisis" by the third week of April 21. Several of the elected authorities made political statements as patients were dying, people were in agony, the judiciary was distraught, and hospital administrations were in a helpless panic (Huang & Yang, 2020). These are a few examples of headlines.

Every hour, the city hospital gasps for oxygen. Sharing O2 cylinders and stopping admissions: a horror story. Four people pass away at Gurgaon Hospital as Delhi NCR remains under a chokehold. Eight patients in Gurgaon and Rewari pass away from a lack of oxygen. National Health Emergency: Supreme Court requests a plan from the centre immediately; how will you increase the supply of oxygen; ensure that the flow of oxygen or risk criminal prosecution (Delhi High Court to authorities). Anybody blocking oxygen supplies would be hanged, the Delhi High Court warns. Delhi-NCR hospitals start asking patients to leave when the oxygen supply runs out.

2. Objectives of the Study

1. To ascertain the causes of the second wave of Covid's shortage of medical oxygen in India.
2. To investigate whether or not operational and logistical challenges were to blame for the lack of medicinal oxygen.

3. Review of Litrearture

According to Adiga et al. (2020), the COVID-19 pandemic is the worst worldwide health crisis in the past 100 years. Its effects on the economy, society, and health are still being

felt, and it was predicted to rank among the worst worldwide catastrophes since the 1918 pandemic and the World Wars. With the ongoing crises, mathematical models have been crucial in informing governmental policies and informing many of the social segregation programmes that have been implemented globally (Magro, 2020). They have covered a few of the significant mathematical models that help the current planning and response operations in this article. The applications, mathematical structures, and application areas of these models vary.

In order to estimate the number of new cases and make the necessary preparations, Bhatnagar (2020) looked into the issue of mathematical modelling of the novel corona virus (COVID19) spread in a number of nations, notably in India, the USA, and Italy. We suggest a fresh mathematical formulation of the COVID-19 spread. The analytical and available data demonstrate that the USA and Italy are at the third stage of COVID19, while India is in the second stage (Approves, 2021). The proposed approach makes it simple to do an approximation of new scenarios. The paper also takes lock-impact down's into account. The findings make it clear that lock-down is crucial in stopping the COVID-19 spread.

Atangana and Araz (2021) have given a statistical analysis of estimating the future number of daily fatalities and infections up to 10th September, 2020 utilising the data already obtained from European and African countries. They have also used a variety of statistical theories to give several statistical analyses of data gathered from both continents. Under the worst-case scenario, the forecasts indicated that a second wave of spread may hit Europe, and that the number of illnesses in Africa would increase exponentially. We introduce an enhanced well-blancmange function to better represent the spread with fractal qualities as a result of statistical analysis's projection (Mokhtari, 2020). In order to illustrate the existence and uniqueness, a mathematical model representing the spread with nine subclasses was first converted to a stochastic system. A redesigned numerical approach was proposed and utilised to show the numerical simulations after the model was expanded to include the idea of nonlocal operators due to nonlinearity. Two to three waves of the spread shortly were predicted by the given mathematical model.

Discernment that India had accomplished group resistance in 2021 had dove the country into complete carelessness. The national government and the state legislatures had dialed down a portion of the game plans they had made for the clinical oxygen canisters, ventilators, and other hardware following the primary wave of Covid-19 as the day to day case count diminished and the casualty rate fell. Unreasonable public get-togethers, political meetings, and strict festivals like the Kumbh Mela were seen, and these occasions prompted a remarkable spike in the quantity of cases (Commission, 2021). The state government made unhinged attempts to develop however many new clinical foundations as could be expected under the circumstances, not with standing the way that experts concur that this movement ought to have begun far sooner than the Covid 2nd wave. The public authority struggled with the strategic issue of "adaptability" since it couldn't expand the stockpile of oxygen chambers, ventilators, Covid beds, and different courses of action that they had before removed on the grounds that they had not made arrangements for both pinnacle and non-top situations.

4. Research Methdology

1. Primary sources of Data Collection. A Questionnaire consisting of 15 questions was designed. Sample Size of 50 was considered for testing the hypothesis.
2. Nominal, Ordinal, Interval and ratio scale was used as a testing technique to approach the data collected to test the above objectives of the research paper.
3. Referring to Research Paper written by various researchers on similar topics to gain more insights about the topic at hand.
4. Secondary Sources of Data Collection. A few questions were asked informally by meeting people to capture the qualitative factors that may have affected the objective of the study.

A questionnaire was designed and a sample of 100 respondents was taken as the scope of study. Responses were collected from individuals residing in various demographics of the country. Data Collected showed more than 40 respondents residing in the state of Maharashtra. The reason for emphasizing more on the above state was that it was one of the worst affected state and a hotspot for Covid during the second wave. Responses of individuals residing in states such as Madhya Pradesh, Assam, Gujarat, Karnataka, Rajasthan, and Uttar Pradesh were collected in order to get a holistic view of the scenario at hand.

4.1. Data Collection

In order to test the belief of the researchers, we have resorted to primary sources of data collection. Researchers claim that the deficiency of medical oxygen during the second wave of Covid-19 was due to supply chain and logistical hindrances. This forms the Alternate Hypothesis of the problem undertaken to study. Likewise, the contradictory belief or the Null Hypothesis would be the deficiency of medical oxygen during the second wave of Covid-19 was not because of supply chain and logistical barriers but due to some other factors coming into play.[16–20]

60% percent of the respondents in the example size of 100 were men, and the leftover respondents were ladies. There were four classifications old enough gatherings thought about: less than 20, somewhere in the range of 20 and 30, somewhere in the range of 30 and 50 or more 50 As

Table 1: Demographical profile

Variable	Frequency	Percentage
Gender		
Female	60	60%
Male	40	40%
Total	100	100%
Age		
20-30	30	30%
30-40	25	25%
40-50	20	20%
50 above	25	25%
Total	100	100%

per the information accumulated, most respondents (around 68%) were inside the age scope of 15 to 30 years, with the rest of inside the scope of 20 to 50 years. (20%)

At the point when gotten some information about the requirements that individuals looked while getting clinical oxygen, the information addressed was as per the following.

Table 2: Consequences confronted by respondents for obtaining medical oxygen

Variable	Frequency	Percentage
Inflated Prices (Black Marketing)	20	20%
Lack of availability of Medical oxygen in hospitals (Supply and Logistics)	30	30%
Hospitals were inculcated with Patient	20	20%
All of the Above	15	15%
Lack of CPR training	15	15%
Total	100	100%

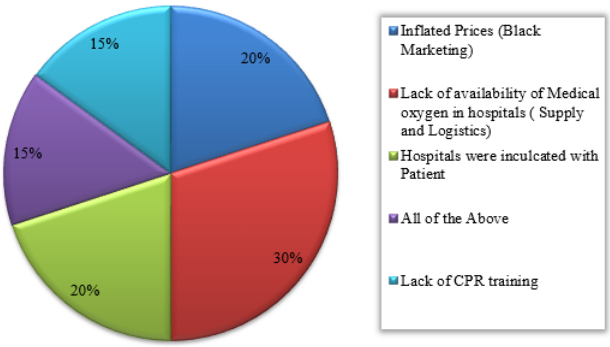

Fig. 1: Graphical representations of the percentage of consequences confronted by respondents for obtaining medical oxygen

Significant difficulties were expanded expenses, an absence of clinical oxygen in medical clinics and spilling over clinics with patients. Whenever allowed the opportunity to offer their viewpoints, 54% of respondents said they trusted all of the previously mentioned limitations applied to the individuals who tried positive for Covid-19, not only one. Around 30% of those overviewed accepted that the planned operations and inventory network were at fault for the emergency clinics' absence of admittance to clinical oxygen. 6% of the respondents said that clinics were spilling over with patients and couldn't oblige the enormous number of Covid patients. Analysts were likewise ready to take a gander at components other than those generally referenced that could have impacted the accessibility of clinical oxygen to the crowd who required it. The absence of clinical oxygen in the country and the craving to acquire it prompted a few gatherings participating in untrustworthy governmental issues for the sake of getting the clinical oxygen, as per information. Furthermore, a minuscule level of the respondents felt that a hindrance was the shortfall of legitimate CPR preparing.

To measure the mentalities, convictions, and perspectives on the respondents, analysts likewise utilized psychometric testing. Following were their reactions when inquired as to whether they naturally suspected the public authority might have anticipated the interest for the stock of clinical oxygen following the Primary Wave of Covid.

Table 3: Respondent's answers to the question of whether they believed the government could have foreseen the need for the supply of medical oxygen

Variable	Frequency	Percentage
Strongly Agree	25	25%
Somewhat Agree	25	25%
Neutral	20	20%
Somewhat Disagree	20	20%
Strongly Disagree	10	10%
Total	100	100%

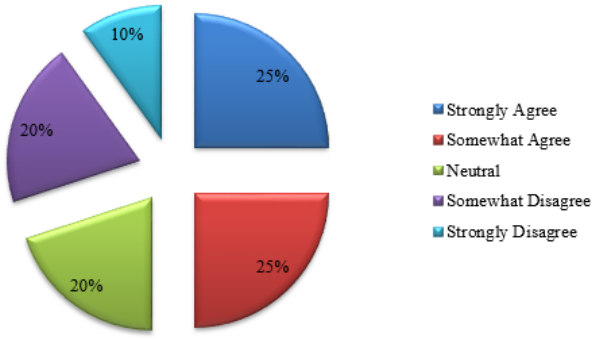

Fig. 2: Graphical representation of the answers to the question of whether they believed the government could have foreseen the need for the supply of medical oxygen

The requirement for clinical oxygen after the primary wave of Covid could have been anticipated, as indicated by 48% of the individuals who firmly concurred. 34% of individuals concur with the previously mentioned assertion just somewhat. 12% offered no viewpoint regarding the matter. A minority of 1% respondents, or 4%, said that they emphatically contradicted the explanation.

5. Data Analysis and Result

To decide how much boundaries as free factors have impacted the public authority's help with getting oxygen chambers as the reliant variable, a relationship and relapse test was led. Here, we've picked Y (Did the public authority offer you any help with acquiring an oxygen chamber) as the reliant variable. Furthermore, autonomous variable as X (Do you accept India's mechanical and clinical foundation was adequate?) Relapse investigation was directed again. The information was changed over completely to a paired number utilizing twofold answers, where "yes" was addressed by 1 and "no" by 0.

Table 4: Regression statistics

Multiple R	0.46589
R square	0.36526
Adjusted R Square	0.256355
Standard Error	0.28945
Observation	70

5.1. ANOVA Testing

Analysis of variance, or ANOVA, is a statistical and analytical tool that is used for comparing mean values of more than two groups simultaneously. In order to learn more about the link between the dependent and independent variables among three or more groups of data, a one-way ANOVA test will be utilised in this study. The ANOVA test was conducted to interpret the variation.

Table 5: ANOVA

	df	**SS**	**MS**	**F**	**Significance F**
Regression	60	1.25632	1.48956	15.26320	0.005597
Residual	40	3.56955	0.58954		
Total	100	6.56236			

5.2. Descriptive analysis

Additionally, the basic concepts of the database will be understood through the descriptive analysis of the data that was gathered. We conducted the descriptive analysis using the following 5 variables:

1. *Column 1* - Do you agree that the Govt., could have forecasted the demand for oxygen supply post 1st Wave of Covid?
2. *Column 2* – Do you think that the concentration of medical oxygen manufacturers would have solved most of the problems?
3. *Column 3* - To what extent do you agree that the price of oxygen cylinders were inflated?

Data was gathered for these variables based on how each of the aforementioned variables was rated. A Likert scale with the values 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (agree) was used to test the engagement criterion and effects of factors (strongly agree).

Table 6: Results of the first column

Column 1	
Mean	0.2365
Standard Error	0.2875
Median	0.3251
Mode	0.3595
Standard Deviation	0.3888
Sample Variance	0.4123
Kurtosis	0.4356
Skewness	0.4525
Range	0.3569
Minimum	0.3652
Maximum	0.4233
Sum	0.4853
Count	0.5862

Table 7: Results of the second column

Column 2	
Mean	0.1523
Standard Error	0.1165
Median	0.2365
Mode	0.2658
Standard Deviation	0.2777
Sample Variance	0.3256
Kurtosis	0.3888
Skewness	0.3412
Range	0.3562
Minimum	0.3986
Maximum	0.4132
Sum	0.4552
Count	0.5325

The expression "mean worth" alludes to the typical rating that individuals gave the trouble they experienced in getting oxygen, which is generally 3.5 overall. This demonstrates that, out of 5, around 68% of individuals in clinics experienced hardships in getting oxygen. The example we chose has a sensibly high circulation of the mean, as indicated by the standard mistake of 0.13. The focal point of any perception is known as the middle.

A middle worth of 3 to 4 signifies the utilization of the middle instead of the mean to represent the likelihood that

Table 8: Results of the third column

Column 3	
Mean	0.1523
Standard Error	0.2415
Median	0.2856
Mode	0.2895
Standard Deviation	0.3256
Sample Variance	0.3885
Kurtosis	0.4235
Skewness	0.4856
Range	0.5123
Minimum	0.5365
Maximum	0.5896
Sum	0.6312
Count	0.7562

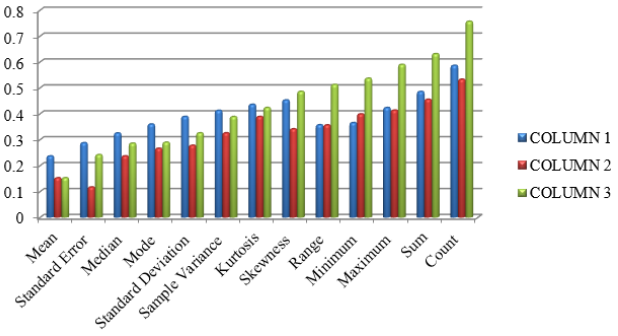

Fig. 3: Comparison of the results of the columns

exceptions could contort the normal of the information.

The example's skewness goes from - 0.23 to 0.96. We can deduce that the information prone to be left-slanted on the grounds that the skewness number is more modest than nothing.

The best appraising for the trouble level individuals have in getting oxygen is scored at 3-4, with 1-2 being the least and 5 being the most noteworthy potential appraisals for oxygen conveyance.

6. Discussion

A blend of varied as well as similar views were collected from the sample when asked the reasons for the deficiency of medical oxygen in India during the 2nd wave of Covid-19. The reasons are as follows:

1. Exponential rise in the number of cases resulted in a sudden spike in the demand and the infrastructure was the same was not sufficient to match the unexpected demand.
2. India produced enough liquid oxygen each day—more than 7,000 metric tonnes—to meet the demand for medicinal oxygen. Yet, an oxygen crisis has developed in several areas as a result of an uneven supply and logistical problems.
3. Respondents believe that the lack of anticipation of the demand, politics leading to hoarding of medical oxygen as well as some qualitative factors like the lack of humanity were also responsible for the same.
4. Complacency by the Govt. as well as the public due to elation, lack of awareness both by the Government as well as the general public and lack of medical infrastructure of the country were among the other reasons cited.
5. Point of Manufacturing was quite far away from the point on consumption, thus increasing the delay.
6. Uneven distribution of the manufacturing plants which made transportation of the oxygen even more difficult.
7. Respondents pointed out the supply chain to be the main cause of concern as they believe the same was not streamlined.
8. The ever increasing population plus casual attitude of the people led to the exponential spike.
9. Few respondents believe that the health infrastructure was improper due to less Government infrastructure in this sector.
10. Some state governments blew the problem out of proportion only for cheap politics.
11. Lack of planning during lockdowns. Lockdowns before the 2nd wave gave ample time for government to plan better and forecast the second wave, especially in terms of oxygen supply in tier 1 and tier 2 cities.
12. Lack of CPR training
13. Improper Allocation and Utilization of the already scare availability of medical oxygen.

The Ministry of Health and Family Welfare, Government of India, Directorate General of Health Services, and Central Drugs Standard Control Organization (CDSCO) in India oversee the production and application of medical gases. Medical grade IP 2010 oxygen that has been approved for human consumption should be used for medical purposes. Medical oxygen is produced by an oil-free compressor, is odourless, and is devoid of any contaminants. It has carbon dioxide levels of no more than 300 PPM and carbon monoxide levels of no more than 5 PPM. Halogen, polymers, oxidising agents, and moisture must not be present. The materials of the cylinders, gas pipeline, anaesthesia apparatus, ventilators, and most importantly the patients should not be harmed in any way.

7. Conclusion

We seem to have developed a tendency of finding easy scapegoats to blame on the "system," suggesting new structures and laws, and occasionally making negative remarks about ourselves, our country, and our culture. The second wave of Covid-19 was the most severe one experienced so far. It affected all the sectors of the

economy, some of which are yet to recover from the damage left behind (Paul C, 2020). The medical sector of India especially was the most affected one. The country saw its frontline workers, doctors, nurses, young graduate professionals work 24/7 serving those diagnosed with Covid-19. It is evident that the delay caused in the supply of medical oxygen was a key driver of the number of daily deaths caused. The pandemic was an eye-opener for the Government, and all those involved/associated directly or indirectly in the field of medicine (Rambaut, Holmes, O'Toole, Hill, & McCrone, 2020). The corrective measures calls for more allocation of funds towards the medical infrastructure of the country. Medical care units in the tier-3 and villages to be equipped with sophisticated machines. Use of artificial intelligence and machine learning to forecast how long a lockdown will last as a result of a surge in Covid-19 instances. The oxygen manufacturing units should be set up in areas in and around medical health care centres. As far as the transportation of medical oxygen is concerned, the authorities involved should decide on a fixed route and a backup route for each route so decided. This shall ensure that the delivery won't be hindered due to transportation and logistics (Sasaki, Uemura, Sato, Toba, & Sanaki, 2021). Hence, the research paper covers all the measures that should be taken in order to tackle the problem of supply of oxygen amidst future pandemic in the country.

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None.

9. Conflict of Interest

None.

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