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AN EMPIRICAL STUDY TO UNDERSTAND THE FAILURE OF OXYGEN SUPPLY IN INDIA DURING THE 2ND WAVE OF THE COVID-19 VIRUS.

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Abstract:

The shortage of medical oxygen made headlines after the outbreak of Coronavirus pandemic (Covid-19). Medical Oxygen is a critically important component in the treatment of those affected with Covid-19. During the peak of the Covid wave, the medical infrastructure of India battled with the shortage of the oxygen which resulted in an exponential spike in the number of deaths per day. The demand for oxygen cylinders, ventilators etc. increased to such extents that the existing supply (availability) of the same proved to be insufficient. This resulted in a huge unmet demand. Several efforts were made by the Government of India to quickly ramp up the production process so as to ensure that medical oxygen gets delivered to those in urgent need of the same. However due to certain logistical and supply chain hindrances, the medical oxygen couldn't be delivered from the point of manufacturing to the point of consumption. This research paper is an attempt to understand in depth the various reasons for the failure of medical oxygen in India during the second wave of Covid-19 virus.

Keywords:

Supply chain, Covid'19, Lack of medical oxygen, Oxygen cylinder, ventilators, Point of Manufacturing, Point of Consumption, India, Medical infrastructure, Transportation and logistics.

Introduction:

Coronavirus Disease also known as COVID'19 is a name that almost everyone is aware of as it had set panic among the economies of the world. It was first reported to have originated in the city of Wuhan, China. Very little did the world know that Covid-19 would spread like wildfire and eventually turn out to become a test of the medical infrastructure of the world economies. India reported its first case from the state of Kerala in early January 2020. In a matter of a few months, India saw an exponential rise in the number of cases. As a precautionary measure, the Government of India has to announce a nationwide lockdown on March 23, 2020.

Just after the first wave the second wave smashed into the nation and was spread rapidly. The lethality of the second wave became clear as the number of infections increased. Everyone in India was taken aback by the suddenness and ferocity of the second COVID-19 wave. None of us had anticipated the rate of development or the velocity with which it occurred. This time, the pandemic affected everyone; it wasn't just some distant thing that occurred to someone else; every family, every individual was affected. The CT [computed tomography] scans were something we had never seen in the first wave as patients would come with such advanced disease in their lungs.

Historical Data proves that all patients diagnosed with Covid in the second wave faced serious respiratory problems the degree of which differed from patient to patient. Hospital beds were full as the second COVID-19 wave spread, and patients had to be turned away. In a desperate attempt to help individuals in need, nongovernmental organizations had to set up beds in enormous halls. The most immediate concern was a severe oxygen shortage, which resulted in a hustle not only in hospitals but also on the streets, **with black market oxygen prices skyrocketing**, leaving individuals in helpless positions as they struggled to save their loved ones. As individuals fought for oxygen, social media was inundated with desperate pleas for help from both family and professionals. This demanded a continuous supply of medical oxygen. In no time, India saw a sudden spike in the demand for medical oxygen. To add to India's worries, the medical infrastructure wasn't equipped to increase supply at such a short interval. This inconsistency in demand and supply had adverse effects on the production and supply chain of medical oxygen. Supply chain refers to all the activities that an organization is required to undertake/perform to ensure that the products/services get delivered to the customer at the right time and right place. Hence, day after day, the trauma was on vivid display, making headlines around the world.

Despite researchers' warnings and the experience of various other countries, the surge revealed the central government's complete lack of preparedness. The feeble response was exacerbated by the hubris, overconfidence, and denial of reality at the very top of government, and by ignoring superspreader events like large election rallies and religious gatherings.

India had to address two main concerns. Firstly, "How can the medical infrastructure of the country be upgraded?" Secondly, "What improvisations are needed in the supply chain of medical oxygen, oxygen beds, and ventilators to streamline the entire process?"

It was important for India to address the above concerns for the primary reason that, there was a huge unmet demand for medical facilities all over the country. Given the daily exponential rise in the number of cases and the mortality rates, it was in India's best interest to step up the production of the same as quickly as possible as it was a matter of life and death.

The time involved in the production of medical oxygen to the final delivery at the right place was quite high. This was due to the simple fact of various logistical hindrances faced by manufacturers/ vendors etc. Moreover, producing voluminous quantities of medical oxygen demands high purity levels (95-97%) was a challenge in itself because the licenses to do so lie in the hands of very few players worldwide. To sum up, India had to act quickly if they had to streamline the process.

Since India was caught off guard to face such a crisis, it struggled to find various sources from where oxygen could be manufactured and supplied. Moreover oxygen though freely available is technology dependent. Lack of adequate staff training on the use of advanced equipment's further delayed the delivery. Patients admitted to remotely located health care centers were the worst affected due to the uncertainty of electricity to keep the ventilators and other medical requirements working at full capacity.

The next logical step that India should have taken was to reach out to their foreign nations for help. Nations having an excess supply of medical oxygen could supply some to aid India's condition. Since time was a major constraint, airlifting liquid oxygen was another choice available. One of the other options available at India's disposal was the conversion of industrial oxygen to medical oxygen. Had the above steps been thought of at an early stage the severity of the crisis could have been greatly minimized.

India's medical infrastructure is believed to be one of the best and finest in the world. However, this crisis should be an eye-opener for India to again reassess its infrastructure and take corrective actions where needed.

The Indian Ministry of Health and Family Welfare is now raising awareness about the new outbreak and is taking the required measures to stop COVID-19 from spreading further. To attain this goal, the federal and state government of India are adopting various measures and developing several wartime protocols.

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. 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.

Literature Review:

The Covid-19 virus which originated from China shifted gears from being initially called an epidemic to being declared as "Pandemic" by the World Health Organization (WHO) in a matter of few months. This pandemic had triggered medical havoc as countries all over the world went into a state of complete lockdown. The situation in India, the world's 2nd largest populated country was no different. The medical infrastructure of the country was put to test. Covid-19 was a test of India's alacrity to respond to such a crisis taking place on a nationwide basis. Experts believe India's medical infrastructure to be one of the best and finest in the world. However, the country saw itself battling for hospitals, medical oxygen, ventilators, etc. as the medical infrastructure was on a brink of collapse.

The importance of medical oxygen has become multifold after the Covid-19 pandemic hit the world. The fact that oxygen is naturally available makes mankind often forget that it is essential lifesaving medicine. It is the timely availability of this medical oxygen that is the deciding factor in the life and death of a patient. The most palpable and visceral crisis in the country currently is a shortage of oxygen in hospitals. This paper apprises on the various reasons for the failure of oxygen supply in India during the 2nd wave of Covid-19. The paper enhances the understanding of the various logistical hindrances India faced while supplying medical oxygen as it battled the pandemic.

In 2021, an opinion that India had achieved herd immunity had sent the country into a state of complete complacency. Post 1st wave of Covid-19, as the daily case count subsided and the mortality rate dropped, the central, as well as the state governments, had scaled back some of the arrangements they had made concerning the medical oxygen containers, ventilators, etc. The government also took a rather brave call of opening up the economy that was already hurting.

Unrestrained public gatherings, political rallies, religious festivals like the Kumbh Mela were observed which triggered an exponential rise in the number of cases. The state government made frenetic attempts to build as many new medical infrastructures as an activity which the experts believe should have been commenced way before the Covid 2nd wave began. Since the government did not prepare for both peak and non-peak scenarios, the country struggled with the logistical problem of ‘flexibility’ as it couldn’t ramp up the supply for oxygen cylinders, ventilators, Covid beds, and other arrangements that they had withdrawn earlier.

Covid exposed major shortcomings in the health infrastructure of the country. It proved that the country was not well equipped to face such a crisis. The stock of oxygen cylinders was insufficient to the ever-increasing demand for the same. To add to the worries, post the second wave of Covid, the Government didn’t crunch the numbers and forecast the demand for the daily consumption and hence the production of the same took a hit. Therefore, the problem arose in the logistics and supply chain, the price for which was borne by the patients battling against Covid.

Investment in infrastructure is already a known cause that affected the supply chain of oxygen and therefore caused the shortage in the supply of medical oxygen. Although the medical and public health professionals were working day and night, the sheer exponential spike in the number of daily cases demanded help from ASHAs (accredited social health workers). These health workers needed to come to aid since only the specialized medical professionals were not enough to help the Covid affected patients. However, these ASHAs weren’t acclimatized with the various equipment and lacked the required training to be able to work at the forefront of Covid stricken India.

Inadequate training and stark differences between primary, secondary healthcare and educational programs caused disruptions in the oxygen supply. Experts concluded that there was ample scope for learning and the problem of lack of knowledge in using the medical oxygen could have been averted had the ASHAs been adequately trained. High volumes of unregulated medical oxygen resulted in overuse of the same thereby furthering India’s worries.

The country not only lacked in the supply of medical oxygen but also in developing the essential infrastructure for its transport and storage since liquid oxygen had to be transported at very low temperatures in cryogenic tankers to distributors. This low-temperature liquid oxygen is then converted into gas for filling cylinders. The shortage of these cryogenic containers led to the shortage in the supply of oxygen as the logistics of refilling them and bringing them to the destination is a severe bottleneck. The oxygen shortage had been a huge problem not only in cities but also in small towns and villages where the health infrastructure was not strong.

Oxygen is also used in industries for welding, cutting, and other chemical and combustion purposes. Given the high requirement for medical oxygen in India, it is not surprising to see that a huge quantity of industrial oxygen was channelized for medical use, the oxygen cylinders used in industries were used to transport oxygen to hospitals and health care facilities. According to the WHO, medical-use oxygen is different from industrial oxygen in terms of purity and quality, and the production, storage, and distribution processes involved with industrial oxygen could result in contamination. For instance, industrial oxygen cylinders are inappropriate for storing medical use oxygen since the probability of it getting contaminated with impurities is high. This can be on account of the use of unclean equipment, unhygienic storage, etc. This calls for the use of more sophisticated and upgraded industrial oxygen cylinders fit for medical use by undergoing a process of deep cleaning and disinfection, sealing micro leaks, replacing valves, and ensuring they are free of any contamination before their use for medical purposes.

Unfortunately in India, the oxygen manufacturing industry is an Oligopoly market as there are only a few manufacturers/ vendors for the same. Since supply was scarce and the demand graph continued its activity, the vendors also went out of stock. This disrupted the entire supply chain.

Several large corporations of India like Reliance, Adani group, and TATA group began to produce oxygen from their plants to increase the supply of oxygen. The constraint was to deliver the oxygen to far-off distances in the shortest time possible. Since there was not a direct supply chain, the government of India had to resort to airlifting oxygen tankers from countries like Singapore and running “oxygen Express Trains” frequently to have them delivered to India.

Since the domestic demand was underestimated, India had to reach out to its foreign counterparts for assistance. France, Germany, the US, and the EU said they will do their utmost to help India mobilize oxygen supply and medicines. The Government of India announced that it plans to import 50,000 metric tonnes of medical oxygen to meet its domestic demand.

It was not until Covid, that we realized that oxygen through free and naturally available was dependent upon technology when it came to medical oxygen required to treat those diagnosed for Covid. Since oxygen cylinders were not readily available, hospitals had to resort to concentrators. However, the public hospitals and the hospitals that were not well equipped with the latest technology faced a setback since these concentrators require 24/7 power.

The inferences, observations, and findings from this research paper can prove to be an essential input for the various stakeholders like Government, public and private hospitals, manufacturers, vendors, and all those parties involved in the process of dealing with medical oxygen to streamline the entire process. This will ensure that should India face another such crisis, all the parties involved will be in a better position to approach the same.

Data Collection and Validation:

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.

Objectives of the Study:

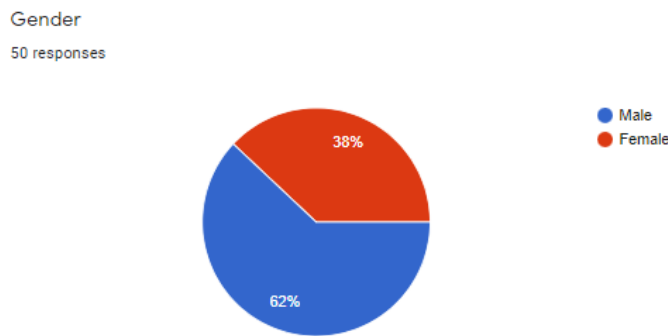
- To find out the reasons for the shortage of medical oxygen in India during the 2nd Wave of Covid.
- To determine whether the deficiency of medical oxygen was due to operational and logistical hindrances or not.
- To understand the major constraints that the medical infrastructure of India faced during the second wave of Covid-19.
- To determine whether the Demand for the medical oxygen could have been predicted beforehand or not.

Research Methodology:

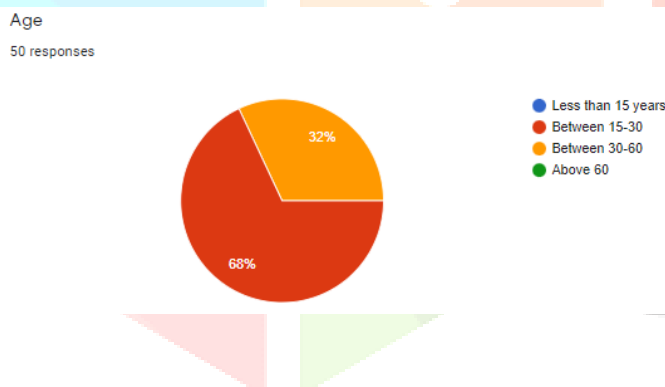
- Primary sources of Data Collection. A Questionnaire consisting of 15 questions was designed. Sample Size of 50 was considered for testing the hypothesis.
- Nominal, Ordinal, Interval and ratio scale was used as a testing technique to approach the data collected to test the above objectives of the research paper.
- Referring to Research Paper written by various researchers on similar topics to gain more insights about the topic at hand.
- 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 50 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 30 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.

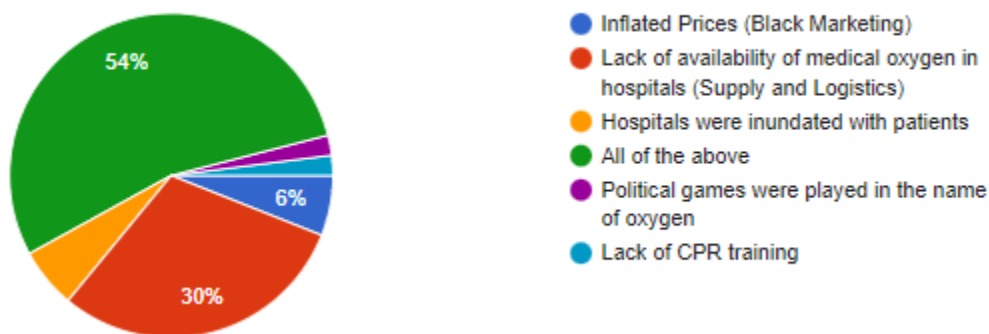
Of the sample Size of 50, 62% of the respondents were males and the remaining were females.



Four classes of age groups were considered, a) Less than 15 years b) Between 15- 30 years, c) Between 30 – 60 years d) Above 60 years of age. Data Collected showed that the respondents were concentrated mainly between the age bracket of 15- 30 years (Approximately 68%) and the remaining in the age bracket of 30 – 60 years. (32%)



When asked about the constraints that the people faced while obtaining medical oxygen, the data represented was as follows:



Inflated prices, Lack of availability of medical oxygen in hospitals, Hospitals inundated with patients were among the major constraints faced. When asked for the respondent’s opinion, 54% of them believe not one but all of the above were the constraints faced by the people who tested positive for Covid-19.

Around 30% of the respondents were of the opinion that it was the supply chain and logistics that caused the lack of the availability of medical oxygen in hospitals.

6% of the respondents voted for Hospitals been inundated with patients and hence couldn't make room for the huge traffic of Covid patients.

Researchers were also open to study about other factors apart from the above mentioned ones that could have affected the supply of medical oxygen to the audience requiring it.

Data showed that the deficiency of medical oxygen in the country and the urge to obtain the same led to few parties playing dirty politics in the name of obtaining the medical oxygen.

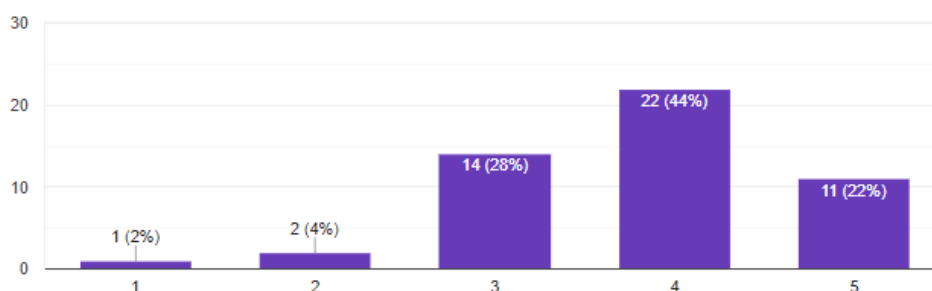
Moreover, a small portion of the respondents opinionated that it was also the Lack of adequate training on CPR that posed a constraint.

Researchers also resorted to the use of psychometric testing in order to measure the attitudes, beliefs and opinions of the respondents. When asked for their opinion if the Government could have forecasted the demand for the supply of medical oxygen post the First Wave of Covid, following were their opinions:



48% of the respondents strongly agreed that the Government could have forecasted the demand for the medical oxygen post the 1st wave of Covid. 34% somewhat agree to the above statement. 12% took a neutral stand on the same. 4% of the respondents voted for somewhat disagree and a minority of 1% was in strong disagreement to the statement.

In order to gain a deep understanding of the extent to which respondents agree that logistics and supply chain hindered the supply of medical oxygen, an interval scale was used (1- Lowest , 5- Highest)

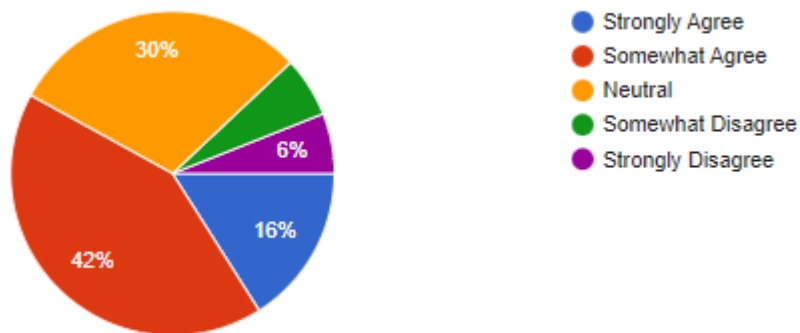


22% of the total sample size showed strong agreement to the statement that logistics and supply chain was one of the major cause hindering the supply of medical oxygen.

44% of the respondents were somewhat agreeing to the above statement.

28% took a rather neutral stand in this regard.

A minority of 4% and 2% respectively voted for somewhat disagree and strongly disagree.



An ordinal scale was used to understand the degree to which the respondents agree that the concentration of medical oxygen manufacturers would have solved most of the problems.

The data collected shows that around 16% of the respondents strongly agree to the above statement.

42% of the sample size somewhat agree to the above mentioned statement.

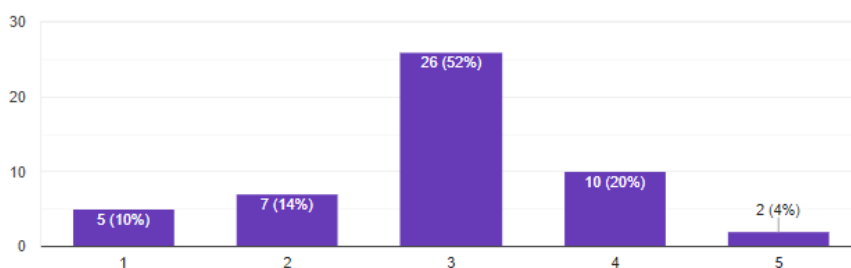
30% took a neutral stand.

Data Collected showed only 6% respondents were somewhat and strongly disagreeing to the statement asked.

Respondents were also asked to assess the Govt. success in their approach towards managing the medical crisis on a scale of 1 to 5. (1- Poor, 5 – Excellent)

How successful was the Govt. in their approach towards managing the medical crisis?

50 responses



Data collected shows that more than 50% of the respondents marked 3 that suggest that the Govt. approach was neither poor nor excellent.

Around 10% of the respondents were not satisfied with the approach taken by the gov. and hence rated 1.

14% of the sample size marked rated “2” indicating a little satisfaction in terms of how the Govt. approached and managed the crisis.

On the other hand, 20% of the respondents were fairly satisfied with approach taken by the Govt. and hence marked 4 on a 5 pointer scale.

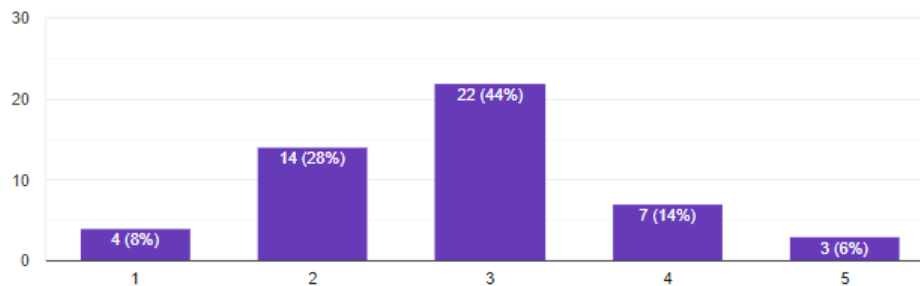
Lastly, 4% of the sample size considered for the study marked “5” as they were highly satisfied with the approach taken by Govt. in managing the Covid crisis.

On a pointer scale of 1 – 5, the respondents were asked to rate the efficiency of the medical infrastructure of India. (1-Poor, 5-Excellent)

Following is the data representation:

How would you rate the efficiency of the medical Infrastructure of India?

50 responses



8% of the respondents rated the efficiency of the medical infrastructure of the country as “1” implying poor efficiency.

28% of the respondents voted “2” as they felt the efficiency of the same below the required standard.

A vast majority of the respondents believe the medical efficiency of the country to be average and hence marked 3 as their response.

14% of the respondents believe the efficiency of the medical infrastructure of the country to be fairly good in terms of the crisis were managed and hence marked “4” as their response when asked with the above question.

6% of the respondents rated the medical efficiency of the country to be “5” implying excellence.

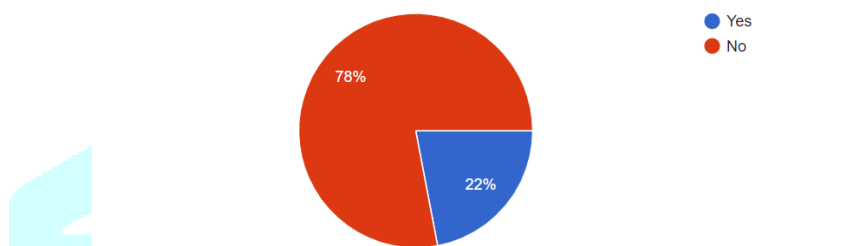
A blend of varied as well as similar views were collected from the sample when asked the reasons for the deficiency of medical oxygen in India during the 2nd wave of Covid-19. The reasons are as follows:

- 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.
- India produced more than 7,000 metric tonnes of liquid oxygen per day, which was enough to support the requirement of medical oxygen. However, uneven supply and logistical issues have led to an oxygen crisis in some states
- 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.
- 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.
- Point of Manufacturing was quite far away from the point on consumption, thus increasing the delay.

- Uneven distribution of the manufacturing plants which made transportation of the oxygen even more difficult.
- Respondents pointed out the supply chain to be the main cause of concern as they believe the same was not streamlined.
- The ever increasing population plus casual attitude of the people led to the exponential spike.
- Few respondents believe that the health infrastructure was improper due to less Government infrastructure in this sector.
- Some state governments blew the problem out of proportion only for cheap politics.
- 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
- Lack of CPR training
- Improper Allocation and Utilization of the already scare availability of medical oxygen.

Do you think the medical infrastructure and the technology in India was enough?

50 responses



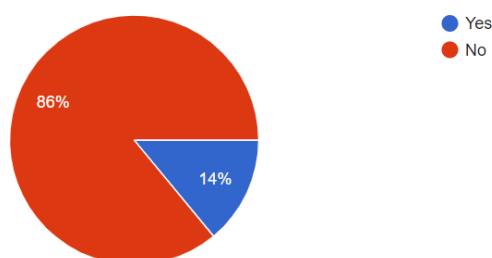
We further collected data on the medical infrastructure and technology available in India and it was observed that 78% of the individuals stated that the medical facilities in India are not enough for tackling the pandemic.

Technology is going to play a key role in India’s roadmap to health infrastructure. The regulatory policies regarding the health have evolved drastically over the last year. The use of technology and to gather to make data more accessible and usable is one of the biggest changes in the Indian healthcare system. To address the pertinent challenges in the medical infrastructure the Indian health care system need to be driven by R&D, design thinking, and smart technology based on a foundation of smarter, safer, and sustainable labs.

When asked about the assistance that the people received while obtaining oxygen from the government, the data represented was as follows:

Did you receive any government help in getting an oxygen cylinder?

50 responses



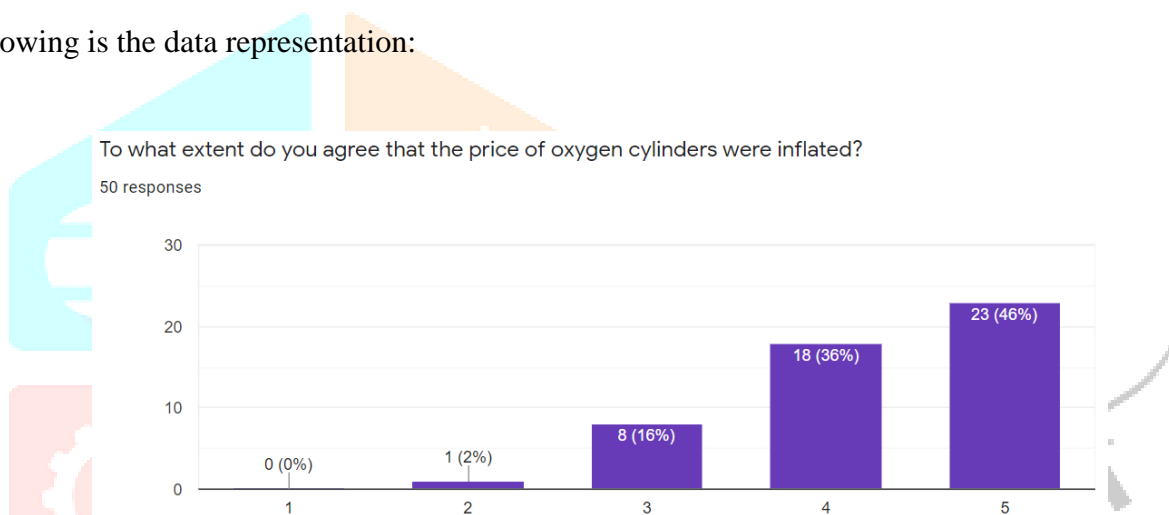
The data shows that 86% individuals received the oxygen cylinder whereas the 14% found it difficult to obtain oxygen cylinders on time due to the extreme shortage of the supply of oxygen during the pandemic. Hospitals were battling around the country and have exhausted their supplies of oxygen cylinders. Amid this gloom and anguish many Ngo's and government organisations came forward and helped in reducing the scarcity of oxygen.

The biggest challenge that was faced was the distribution and transportation of the oxygen cylinders to the hospitals. Cryogenic containers cannot be manufactured overnight to transport compressed liquid oxygen. The millions of high pressure steel cylinders, regulators, and non-sparking valves and connectors needed to transport the surplus from steel plants and actually into the lungs of gasping patients cannot be created overnight.

The data clearly shows that the government of India was more or less successful in providing oxygen cylinders initially but faced major challenges afterwards.

Respondents were asked about the inflated price of oxygen cylinder and were required to rate On a pointer scale of 1 – 5 (1-Poor, 5-Excellent).

Following is the data representation:



The majority of the respondent i.e. 46% voted “5” as they agreed that the price of the oxygen cylinders were inflated, implying it one the significant reason in failure of the supply of the oxygen cylinders to the hospitals.

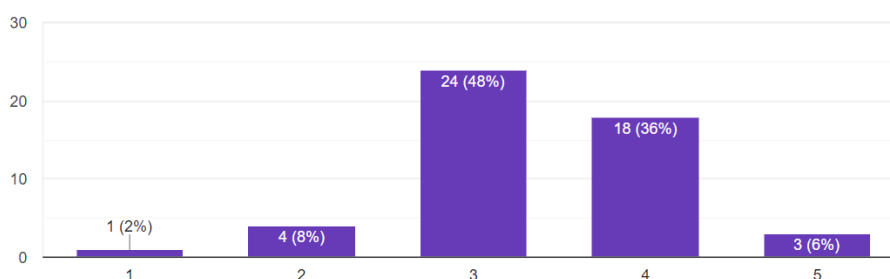
36% respondents marked “4” and somewhat agreed to the above statement.

According to the research Black markets aren't the only reason for a price hike. Transportation and infrastructure also contribute to the increase.

In order to further understand the efficiency and effectiveness of the Ngo's like ASHA in providing medical aid to the patients the respondents were required to rate on the pointer scale of 1 to 5.

How successful were the NGOs like ASHA in providing medical aid to the patients?

50 responses



2% of the respondents rated the capability of the medical aid of the Ngo's as "1" implying poor performance.

8% of the respondents voted "2" as they felt the efficiency of the same below the required standard.

A vast majority of the respondents believe the medical efficiency of the NGO's to be average and hence marked 3 as their response.

36% of the respondents believe the efficiency of the medical aid of the NGO's to be fairly good in terms of the crisis were managed and hence marked "4" as their response when asked with the above question.

6% of the respondents rated the medical efficiency of the country to be "5" implying excellence.

Interpretation:

Correlation and Regression test was performed to find out the extent to which parameters as independent variables have affected the government help in getting oxygen cylinders as the dependent variable. Here we have taken the **Dependent variable as Y** (Did you receive any government help in getting an oxygen cylinder?) and **independent variable as X** (Do you think the medical infrastructure and the technology in India was enough?) Further regression Analysis was done. With binary responses, the data was converted to a binary number as "Yes" indicated as 1 and "no" as 0.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.4835243
R Square	0.23379575 23.37957497
Adjusted R Square	0.21815893
Standard Error	0.30730138
Observations	51

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	1.411942959	1.41194	14.9516	0.000325176
Residual	49	4.627272727	0.09443		
Total	50	6.039215686			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	0.05	0.048588614	1.02905	0.30851	-0.047642476	0.147642476	-0.04764248	0.147642476
X Variable 1	0.40454545	0.104622058	3.86673	0.00033	0.194299558	0.614791351	0.19429956	0.614791351

- Multiple R is the correlation coefficient which determines the strength and direction of the dependent and independent variables considered In the model it can be seen from the above model that correlation coefficient between X and Y is positively correlated. Since the value of multiple R is less than 0.5, it can be implied that it is relatively weak positive correlation.
- R square which is the coefficient of determination is just 23% which implies that the deployability of the model is just 23% .This further means that only 23% changes in y is explained by X.
- The rest 77% changes in Y can be explained by factors other than infrastructure and technology.
- The model so considered for the study is overall significant since the Significance F value is less than 0.05. This implies that the medical infrastructure of the country was not good enough which caused delay and further hindered the supply chain of medical oxygen cylinders.

Further, **The descriptive analysis** of the data collected will be comprehended about the fundamentals of the database. We did the descriptive analysis on the basis of the 5 variables which are as follows -

Column 1 - Do you agree that the Govt., could have forecasted the demand for oxygen supply post 1st Wave of Covid?

Column 2 – Do you think that the concentration of medical oxygen manufacturers would have solved most of the problems?

Column 3 - To what extent do you agree that the delay caused in the supply of medical oxygen was due to Supply Chain and Logistical Constraints?

Column 4 - How successful was the Govt. in their approach towards managing the medical crisis?

Column 5 - How would you rate the efficiency of the medical Infrastructure of India?

Column 6 - To what extent do you agree that the price of oxygen cylinders were inflated?

Column 7 - How successful were the NGOs like ASHA in providing medical aid to the patients?

For these variable, the data was collected on the basis of the rating to each of the above variable. The engagement criteria and effects of variables were measured in a Likert scale ranging from 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree) and 5 (strongly agree).

Column1	
Mean	4.2156863
Standard Error	0.1262233
Median	4
Mode	5
Standard Deviation	0.901415
Sample Variance	0.812549
Kurtosis	0.1144655
Skewness	-0.9606107
Range	3
Minimum	2
Maximum	5
Sum	215
Count	51

Column2	
Mean	3.588235294
Standard Error	0.137702352
Median	4
Mode	4
Standard Deviation	0.98339149
Sample Variance	0.967058824
Kurtosis	0.414056613
Skewness	-0.650306051
Range	4
Minimum	1
Maximum	5
Sum	183
Count	51

Column3	
Mean	3.784313725
Standard Error	0.126223349
Median	4
Mode	4
Standard Deviation	0.90141501
Sample Variance	0.81254902
Kurtosis	0.572557784
Skewness	-0.574089299
Range	4
Minimum	1
Maximum	5
Sum	193
Count	51

Column4	
Mean	2.941176471
Standard Error	0.132581502
Median	3
Mode	3
Standard Deviation	0.946821307
Sample Variance	0.896470588
Kurtosis	0.318530909
Skewness	-0.320770174
Range	4
Minimum	1
Maximum	5
Sum	150
Count	51

Column5	
Mean	2.823529412
Standard Error	0.136355597
Median	3
Mode	3
Standard Deviation	0.973773739
Sample Variance	0.948235294
Kurtosis	0.10726415
Skewness	0.234020191
Range	4
Minimum	1
Maximum	5
Sum	144
Count	51

Column6	
Mean	4.2352941
Standard Error	0.1140631
Median	4
Mode	5
Standard Deviation	0.8145731
Sample Variance	0.6635294
Kurtosis	-0.430925
Skewness	-0.6964427
Range	3
Minimum	2
Maximum	5
Sum	216
Count	51

Column7	
Mean	3.372549
Standard Error	0.111885
Median	3
Mode	3
Standard Deviation	0.799019
Sample Variance	0.6384314
Kurtosis	0.7026063
Skewness	-0.2984656
Range	4
Minimum	1
Maximum	5
Sum	172
Count	51



Mean value describes the average rating that the individuals have given to the difficulties faced by them in receiving the oxygen which are around 3.5 on an average, which means that out of 5 approx. 68% challenges were faced by the individuals in the hospitals to get the oxygen. The 0.13 of Standard error indicates that the sample we chose has a fairly high distribution of the mean. Median is the middle point of any observation.

Median value of 3-4 refers to the median being used as opposed to the mean that the outliers might skew the average of the values.

The Skewness of the sample is between -0.23 to 0.96. As the skewness value is less than zero, we can conclude that the data tends to be left inclined or left-skewed.

The highest rating or we say that the difficulty level faced by the individuals in getting oxygen is rated to 3-4, where the minimum rating to oxygen supply can be given as 1 or 2 and maximum of 5.

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 this paper, a one-way ANOVA test will be used which helps to gain information about the relationship between the dependent and independent variables among three or more groups of data. In order to interpret the variation the ANOVA test was performed.

To achieve the result of the hypothesis that is to accept or reject the null hypothesis, the following factors will be taken into consideration:

Sum of Squares It is defined as the variation produced in the response variable. It is divided into two parts, the sum of squares of regression (SSR) and the sum of squares of residuals (SSE). The sum of squares of regression is the amount of variation caused in the dependent variable that can be explained by the predictor variables and the sum of squares of residuals is the amount of variation caused by the independent variable that cannot be explained by the predictor variables.

Mean Squares of Regression (MSR) and residuals (MSE) They are obtained by dividing the values of SSR and SSE by their respective degrees of freedom. The statistical significance of the overall relationship between the dependent variable and the collection of independent variables can be tested using a Ftest based on the ratio MSR/MSE. The conclusion that the overall association is statistically significant is supported by large values of F calculated = MSR/MSE in general.

The significance of F It is a measure of the probability of whether or not the null hypothesis, $\beta_1 = 0$, will be true. If the probability of the null hypothesis being true is less than 5% or 0.05, we deem the value of significance F to be non significant and hence reject the null hypothesis, stating that at least one of the independent variables has a significant impact on the dependent variable. This measure is used to determine whether the overall model is deployable.

The P-value It is the measure of the probability that the null hypothesis will be true for the individual tests of variables. Just as significance F, if the probability of the null hypothesis being true is less than 5% or 0.05, we deem the p-value to be non significant and hence reject the null hypothesis, stating that the concerned independent variable has a significant impact on a dependent variable.

The analysis was done on the basis of the responses of the two variables given below -

To what extent do you agree that the delay caused in the supply of medical oxygen was due to Supply Chain and Logistical Constraints?

How would you rate the efficiency of the medical Infrastructure of India?

Null Hypothesis: H_0 :	$U_1=U_2=U_K$
Alternate Hypothesis: H_a :	Not all U are equal

K		2
N1		50
N2		50
U1		3.8
U2		2.82
Sample Average		3.31
SSB		24.01
MSB		24.01
SSW		87.38
MSW		0.891632653
F stat		26.92813001
F critical		3.938111078

Since F stat is higher than F critical we reject the null hypothesis and accept the alternate hypothesis.

Conclusion:

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. 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. 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. Deployment of machine of Machine Learning and Artificial Intelligence for predicting the time period of extension of lockdown due to increase in rate of Covid-19 cases. Setting up of decentralized oxygen manufacturing units with more licensed entities involved in the process shall be a welcomed move for tackling should this problem arise in the future? Effective training of the frontline workers on use advanced machineries should now form a part of the Standard Operating Procedures (SOPs) of all hospitals. 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. 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.

Road Ahead:

The analysis, conclusion, summary of this research paper can serve as a good input for the various stakeholders involved in the various processes right from manufacturing to final delivery of the same at the right time and right place. This research paper is an attempt to understand the reasons for the deficiency of medical oxygen in the country during the second wave of Covid. The learnings, outcomes, interpretations of the same can serve as effective future references for the Government, public and private hospitals, medical oxygen vendors who can possibly implement the same should the country face a crisis

similar to this. Post pandemic corrective measures calls for setting up of more Covid hospitals, concentration of oxygen manufacturing units and basic training on the use of medical oxygen cylinders. Oxygen though freely and natural available is a technology dependent variable and hence effective training of the personnel on the administration of the same should assume top priority going forward.

The Government of India should take steps to ensure that the licenses to manufacture medical oxygen should lie in the hands of many so that unexpected demand can be met. This will further ensure that the widespread problem of black-marketing gets curtailed and reduced to a large extent.

The Government of India should look out for back up oxygen manufacturing units that are just enough, should there be any crisis as a result of vast unmet demand.

The suggestions provided in this research paper can be used as a reference for further improving and streamlining the overall supply chain and logistics of delivery of medical oxygen.

Thus in conclusion, the Covid pandemic that struck India was a wakeup call to upgrade the medical infrastructure that is believed to be one of the finest in the world. The author of this research paper hope that the readers benefit from the same and the concerned stakeholders and authorities take the necessary preventive and precautions measures to ensure that the medical infrastructure of the is not affected due to any supply chain hindrances as it is the backbone of the country. This will not only send an assurance signal to the people of the country but also can be looked upon by many nations as an example on how to approach a nationwide crisis and manage it effectively.

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