

## **Demand for Oxygen Therapy During the COVID-19 Pandemic: A Literature Review**

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### **Abstract**

*The demand for oxygen during the COVID-19 has no equivalent in the past and caused a lot of strain on the hospital infrastructure as well as raised concerns about the ability of oxygen systems to meet the escalating needs of patients. This is a literature review on the demand for oxygen therapy during the COVID-19 pandemic. The purpose of this study is to conduct an in-depth evaluation of previous studies on the demand for oxygen therapy during the COVID-19 pandemic. The study assesses the current understanding of the topic because of its relevance and influence on the health of different populations around the world. Pub Med, Science Direct, Google Scholar, the Lancet and EBSCO were searched using a series of combinations of the following keywords: oxygen demand during the COVID-19 pandemic, oxygen therapy, COVID-19 pandemic, access to oxygen therapy during the COVID-19 pandemic, challenges of oxygen services delivery and medical oxygen. The findings revealed that the COVID-19 pandemic led to a substantial increase in the demand for oxygen therapy around the world due to the respiratory complications associated with the disease. The average monthly utilization of oxygen has increased due to the persistent increase in demand. Many health systems struggled to deliver oxygen therapy however, their efforts were futile due to the sudden increase in the number of patients that require oxygen therapy; problems related to the medical oxygen supply chain; lack of capacity to deliver oxygen therapy due to limits in infrastructure as well as other challenges.*

**Keywords:** *COVID-19 Pandemic, Demand for Oxygen Therapy, Health Infrastructure, Medical Oxygen, Respiratory Complications, Supply Chain.*

### **Introduction**

The onset of the COVID-19 pandemic has led to a substantial increase in the demand for oxygen therapy due to the respiratory complications associated with the virus. Studies have reported a surge in hospital admissions with severe hypoxemia, necessitating higher volumes of medical-grade oxygen. The demand for oxygen during COVID-19 has no equivalent in the past and caused a lot of strain on the hospital infrastructure as well as raised concerns about the ability of oxygen systems to meet the escalating needs of patients.

As hospitalization for COVID-19 complications continued to increase in different regions of the world so did the requirement for oxygen therapy increased and the challenges in meeting the demand for oxygen therapy. During the COVID-19 pandemic, many health systems faced several challenges as regards the demand for oxygen therapy and these include a sudden increase in the number of patients that require oxygen therapy; problems related to the medical oxygen supply chain; lack of capacity to deliver oxygen therapy due to limits in infrastructure; increased competition for

resources; quality control problems and staff training.

The purpose of this study is to conduct an in-depth evaluation of previous studies on the demand for oxygen therapy during the COVID-19 pandemic. The study would like to answer the following research question: what is the existing evidence of knowledge about the demand for oxygen therapy during the COVID-19 pandemic? The study assesses the current understanding of the topic because of its relevance and influence on the health of the population around the world.

The study will contribute to increasing the level of understanding of the demand for oxygen therapy especially during pandemics and other emergencies as well as highlight areas that require further investigation to improve the health outcomes of the populations around the world.

## **Methods**

### **Search Strategy**

The author searched Pub Med, Science Direct, Google Scholar, the Lancet and EBSCO using a series of combinations of the following keywords: oxygen demand during the COVID-19 pandemic, oxygen therapy, COVID-19 pandemic, access to oxygen therapy during the COVID-19 pandemic, challenges of oxygen services delivery and medical oxygen.

The search was limited to articles published in English. Also, related articles were searched for, and the references of qualified articles were examined for further sources of information.

## **Evaluation of the Literature**

### **The COVID-19 Pandemic**

The World Health Organization (WHO) declared the COVID-19 pandemic in March 2020 [1, 2]. The COVID-19 pandemic has unleashed terror throughout the world leading to the hospitalization and deaths of millions of people [1, 2, 3 & 4]. Earlier, in December 2019, cases of viral pneumonia were reported in Wuhan, China and were found to be caused by

SARS-CoV-2 [1, 5]. The disease later spread from Wuhan China to other parts of the world [1]. The update on the pandemic in June 2021 revealed that globally there were over 178 million COVID-19 cases that have been confirmed and greater than 3.8 million cases of mortality [6, 7]. The morbidity and mortality from the severe acute respiratory syndrome caused by COVID-19 infection were high and many countries had their health systems overwhelmed [8]. There was a disparity in the pattern of mortality from COVID-19 as observed by scholars which was based on country, racial background, age, chronic health condition in the individual, socioeconomic status as well as immune status [9, 10]. The serious effect of the disease on the elderly and those with pre-morbid conditions has been noted by clinicians [1, 11].

Initial reports from China said that about 15% of COVID-19 patients had a severe illness and needed oxygen therapy, and up to 5% of the patients had to be admitted to the intensive care unit (ICU) [12]. COVID-19 pneumonia leads to inadequate oxygen in the blood circulation (hypoxemia) which is a life-threatening complication and requires oxygen therapy for treatment [12, 13].

### **Demand for Oxygen Therapy during the COVID-19 Pandemic**

The onset of the COVID-19 pandemic has led to a substantial increase in the demand for oxygen therapy due to the respiratory complications associated with the virus (See Table 1 below). Studies have reported a surge in hospital admissions with severe hypoxemia, necessitating higher volumes of medical-grade oxygen [12, 14]. The demand for oxygen during COVID-19 has no equivalent in the past and caused a lot of strain on the hospital infrastructure as well as raised concerns about the ability of oxygen systems to meet the escalating needs of patients.

Oxygen therapy is a form of treatment used in the management of different types of health

problems [12]. High-flow oxygen therapy has been shown to improve clinical outcomes in patients with respiratory failure due to COVID-19 [13]. Medical grade oxygen is made up of at least 82% pure oxygen and is administered as a non-invasive intervention through a nasal cannula or facemask as well as mechanical ventilation in patients with severe hypoxia [12, 13]. The COVID-19 pandemic has led to an exponential increase in demand for oxygen in India and other regions of the world which caused the ‘Oxygen Crisis’ during the second wave of the pandemic [12, 13]. For example, reports have put the daily requirement for medical oxygen in India before COVID-19 at about 700 metric tons (MT) however, the situation suddenly changed during the first wave to a daily requirement of 3,100 MT and 8900 MT during the second wave [12, 15]. This situation brought a lot of strain on the health system leading to an increase in daily production of medical oxygen to 9400 MT to meet the rising demand [12]. However, reports have shown that the daily production of medical oxygen in India surpassed 11,000 MT over time as events continue to unfold [12].

The COVID-19 pandemic has led to changes in clinical practice patterns that created variations in medical oxygen demand [13] (see Table 1 below). These persistent changes in the oxygen demand translated into an increase in the average monthly oxygen utilization [13]. The provision of oxygen therapy became a heavy responsibility that many health systems were struggling to deliver [16]. The need for every hospital to create a strategy for oxygen therapy became more obvious. The hospital must understand its oxygen requirement and its peak average daily consumption. The oxygen requirement of a healthcare facility is influenced by factors such as the hospitalization rate of the facility as well as its capacity to provide ICU and ventilation services [16].

### **Challenges in Meeting the Demand for Oxygen Therapy during the COVID-19 Pandemic**

Meeting the demand for oxygen therapy during the COVID-19 pandemic has presented several challenges, these include a sudden increase in the number of patients that require oxygen therapy; problems related to the medical oxygen supply chain; lack of capacity to deliver oxygen therapy due to limited in infrastructure; increased competition for resources; quality control problems and staff training (see Table 2 below).

Generally, hospital admissions dropped significantly for non-COVID-19 patients after the COVID-19 pandemic was declared by the WHO [17]. On the other hand, hospitalization for COVID-19 complications continued to increase in different regions of the world. The hospitalization rate related to patients with COVID-19 was reported as 4.6 per 100,000 population in March 2020 [18]. The rate of hospitalization and the requirement for oxygen therapy in COVID-19 patients is influenced by several factors such as the severity of the illness, age, pre-morbid medical conditions, and the capacity of the healthcare facility to provide the required interventions [18, 19 & 20]. The most common underlying medical condition in hospitalized COVID-19 patients was obesity, especially among 18 – 64-year-olds [18, 19]. COVID-19 patients with severe respiratory symptoms such as difficulty in breathing or low peripheral oxygen saturation (SPO2) require hospitalization and oxygen therapy. Reports have shown that up to 15% of COVID-19 patients require hospitalization due to the severity of symptoms and 5% of the patients become critical and would need mechanical ventilation [18, 19 & 20]. Other factors that affect the rate of hospitalization include the emergence of new variants of the COVID-19 virus, vaccination rates, and public health measures implemented by different countries [17].

A sudden increase in the number of patients requiring oxygen therapy during the COVID-19 pandemic has overpowered the healthcare system and strained the resources of hospitals

and healthcare providers to the limit [20]. The medical oxygen supply chain was put to the test during the pandemic due to the sudden and widespread demand for oxygen therapy. Reports have highlighted supply chain issues such as transportation constraints, distribution challenges, and shortages of oxygen cylinders and concentrators which contributed to worsening oxygen therapy delivery to COVID-19 patients [18, 19 & 20]. On the other hand, the lack of capacity to deliver oxygen therapy due to limits in infrastructure has also been reported [20]. The number of hospital beds, oxygen delivery systems, and the availability of trained medical personnel, may be insufficient to meet the escalating demand [20, 21]. Challenges due to logistics also contributed to preventing hospitals from meeting their oxygen demand. Also, due to the fact the pandemic was a global phenomenon competition for healthcare resources increased and this led to shortages of medical supplies such as oxygen and vaccines, especially for some low- and medium-income countries [18, 19 & 20]. Another issue was that the sudden increase in demand for oxygen creates quality control challenges for oxygen production and distribution which in turn limits the availability of the resource [18, 19 & 20]. Accurate prediction of the requirement of essential resources such as medical oxygen during the pandemic is a basic necessity to avoid catastrophe [20]. A mode that predicts the COVID-19 patient that may require oxygen therapy has been described by some scholars [22]. This was done by assessing the risk for oxygenation by using clinical and laboratory

variables such as C - reactive protein (CRP), underlying medical condition and lymphocyte count [22]. Artificial intelligence (AI) has also been used to predict the need for mechanical ventilation for COVID-19 patients by the assessment of the patient's blood, heart rate and blood pressure [20]. The need for professionals to be trained to handle many patients with respiratory complications presenting at the same time also posed a challenge during the pandemic. This was due to the rapid influx of COVID-19 patients that require oxygen therapy. It was necessary to train the staff because not all professionals have extensive experience with respiratory care [20].

## **Findings**

The findings revealed that the COVID-19 pandemic led to a substantial increase in the demand for oxygen therapy around the world due to the respiratory complications associated with the disease. The average monthly utilization of oxygen has increased due to the persistent increase in demand. Many health systems struggled to deliver oxygen therapy however, their efforts were futile due to the sudden increase in the number of patients that require oxygen therapy; problems related to the medical oxygen supply chain; lack of capacity to deliver oxygen therapy due to limits in infrastructure; increased competition for resources; quality control problems and staff training. The evidence from the review has led to the generation of the following themes: the demand for oxygen therapy during the COVID-19 pandemic and the challenges in meeting this demand (Tables 1 and 2 below).

**Table 1.** Literature Summary on the Demand for Oxygen Therapy During the COVID-19 Pandemic

<b>Concept</b>	<b>Author, Title, Year, Place</b>	<b>Argument Structure</b>	<b>Contribution</b>
Respiratory complications and respiratory failure.	White et al., “Oxygen Supply and Demand during the COVID-19 Pandemic: An Integrated Health System Perspective”, 2023	COVID-19 virus led to respiratory complications and respiratory failure which require oxygen therapy as a form of treatment.	Described the relationship between increased in number of patients with respiratory complications from COVID-19 disease and the increase in demand for oxygen therapy.
	Ismail J. & Bansal A., “Medical Oxygen: A Lifesaving Drug during the COVID-19 Pandemic”, 2022	COVID-19 lead to an exponential increase in demand for oxygen therapy due to number of patients that require the treatment.	Asserted the notion that COVID-19 brought about a surge in patients with complications in the respiratory tract which requires treatment with medical oxygen.
Changes in clinical practice pattern.	White et al., “Oxygen Supply and Demand during the COVID-19 Pandemic: An Integrated Health System Perspective”, 2023	COVID-19 has led to changes in clinical practice pattern which created an increase in demand for oxygen therapy/	Describe the changes in clinical practice patterns during the COVID-19 pandemic that led to increase in demand for oxygen therapy.

**Table 2.** Literature Summary on Challenges in Meeting the Demand for Oxygen Therapy during the COVID-19 Pandemic

<b>Concept</b>	<b>Author, Title, Year, Place</b>	<b>Argument Structure</b>	<b>Challenge</b>
Rate of hospitalization.	Shikha et al., “Hospitalization Rates and Characteristics of Patients Hospitalized with Laboratory-Confirmed Coronavirus Disease 2019 — COVID-NET, 14 States, March 1–30”, 2020, USA	The demand for oxygen therapy was influenced by the severity of illness, age and the pre-morbid medical condition of the patient as well as the capacity of the healthcare facility to provide the required intervention.	Increased rate of hospitalization and low capacity to provide oxygen therapy.
	Soares, Mattos & Raposo, “Risk Factors for Hospitalization and Mortality due to COVID-19 in Esp’irito Santo State, Brazil”, 2020, Espirito Santo	Many hospitalized COVID-19 patients with pre-morbid conditions such as obesity require oxygen therapy.	Increased hospitalization with increased demand for oxygen therapy.
	Saadatmand et al., “Predicting the necessity of oxygen therapy in the early stage of COVID-19	COVID-19 patients with severe respiratory symptoms such as difficulty in breathing or low peripheral oxygen	Increased hospitalization with increased

	using machine learning”, 2022, Iran	saturation (SPO2) require hospitalization and oxygen therapy.	demand for oxygen therapy.
	Birkmeyer et al., “The Impact of the COVID-19 Pandemic on Hospital Admissions in the United States”, 2020, USA	The rate of hospitalization of COVID-19 patients is affected by new variant of the virus, vaccination status of the patient as well as the public health measures implemented.	Increased hospitalization with increased demand for oxygen therapy
Supply chain challenges	Shikha et al., “Hospitalization Rates and Characteristics of Patients Hospitalized with Laboratory-Confirmed Coronavirus Disease 2019 — COVID-NET, 14 States, March 1–30”, 2020, USA.	Supply chain issues such as transportation constraints, distribution challenges, and shortages of oxygen cylinders and concentrators have contributed to worsen oxygen therapy delivery to COVID-19 patients.	Supply chain inadequacies hinder oxygen therapy delivery to COVID-19 patients.
	Soares, Mattos & Raposo, “Risk Factors for Hospitalization and Mortality due to COVID-19 in Esp’rito Santo State, Brazil”, 2020, Espirito Santo	Supply chain issues such as transportation constraints, distribution challenges, and shortages of oxygen cylinders and concentrators have contributed to worsen oxygen therapy delivery to COVID-19 patients.	Supply chain inadequacies hinder oxygen therapy delivery to COVID-19 patients.
	Saadatmand et al., “Predicting the necessity of oxygen therapy in the early stage of COVID-19 using machine learning”, 2022, Iran	Supply chain issues such as transportation constraints, distribution challenges, and shortages of oxygen cylinders and concentrators have contributed to worsen oxygen therapy delivery to COVID-19 patients.	Supply chain inadequacies hinder oxygen therapy delivery to COVID-19 patients.
Lack of capacity due to infrastructural limitations	Saadatmand et al., “Predicting the necessity of oxygen therapy in the early stage of COVID-19 using machine learning”, 2022, Iran	The number of hospital beds, oxygen delivery systems, and the availability of trained medical personnel, may be insufficient to meet the escalating demand.	Inadequate infrastructural capacity.
Staff training issues	Saadatmand et al. “Predicting the necessity of oxygen therapy in the early stage of COVID-19 using machine learning”, 2022, Iran	The need for professionals to be trained to handle many patients with respiratory complications presenting at the same time had also posed a challenge during the pandemic	Lack of trained professionals.

## Conclusion

This literature review has been carried out and a critical assessment of the current understanding of the demand for oxygen therapy during the COVID-19 pandemic was done. The review identified the level of the demand for oxygen therapy in healthcare facilities during the COVID-19 pandemic and the reasons for the demand as well as the

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challenges faced in meeting the demand. This is a call to action for more studies that could guide policymakers as well as managers of healthcare systems around the world on emergency preparedness and pandemic management. The review has defined the need for healthcare organizations to evaluate their oxygen delivery systems strategies to prevent the occurrence of negative health outcomes during emergencies.

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