

GASPING FOR AIR

The deadly shortages in medical oxygen for COVID-19 patients

MSF Briefing Paper
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Introduction

Medical oxygen is the single most important medicine for treating patients with COVID-19. Yet this effective and life-saving treatment for critically ill patients has been scarce in many health facilities in countries where MSF has been responding to the pandemic. This is not new. MSF has witnessed these structural issues for some time in places where healthcare is under-resourced.

MSF has responded to the COVID-19 pandemic in both high-income and middle- to low-income countries. Whilst some hospitals in the US and Europe have struggled with a shortage of ventilators for critical patients, oxygen in high-income countries is piped to patients' hospital bedsides, and supply has mostly been able to keep up with demand.

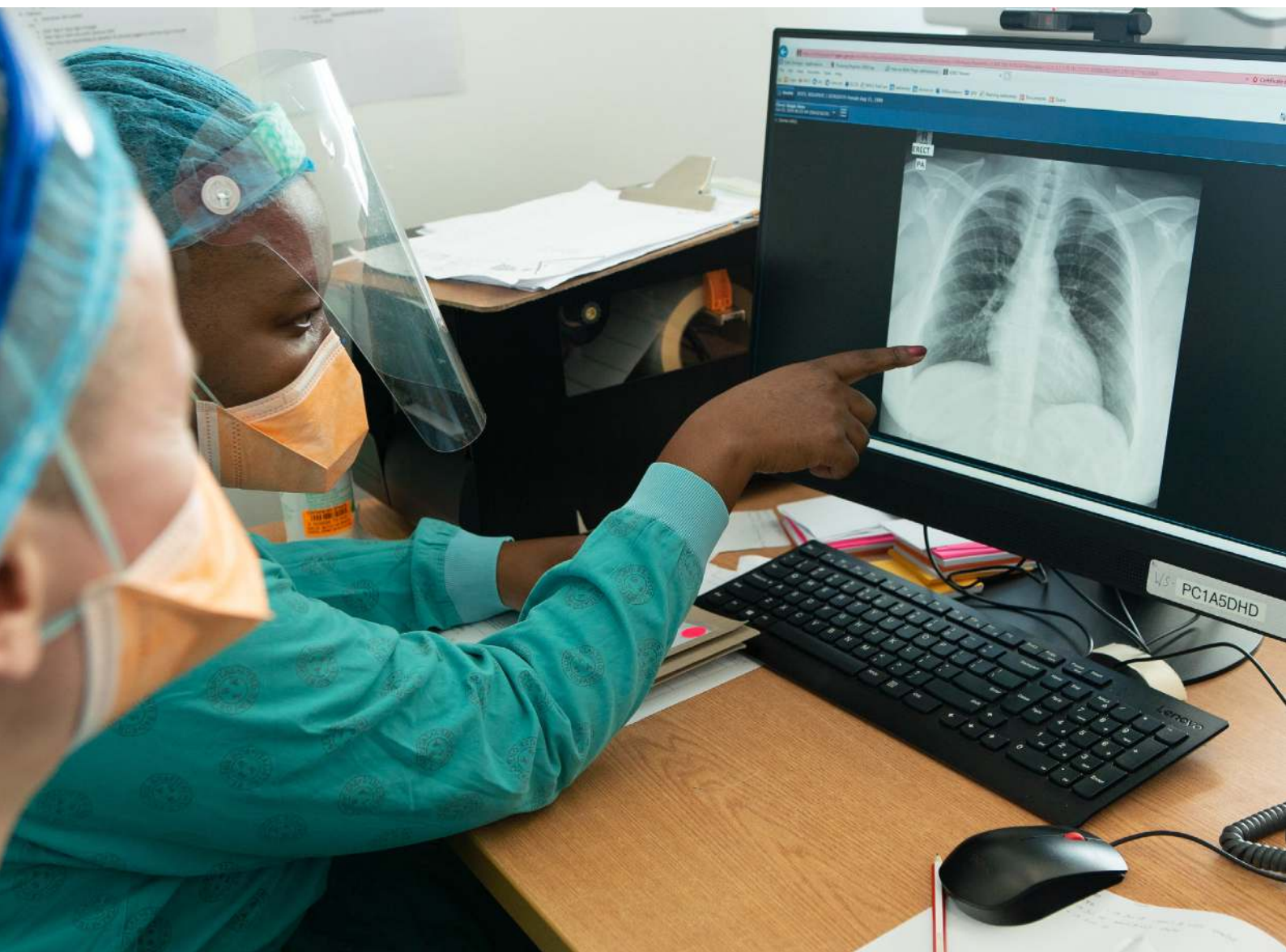
In low and middle-income settings, the lack of medical oxygen and supply shortages during the COVID-19 pandemic have caused patients to face delays in receiving critical assistance. MSF teams have witnessed first-hand the avoidable deaths and complications these delays have led to. Health workers – in desperate attempts to save lives – have had the impossible task of rationing oxygen, leaving them to carry the mental health burden of being unable to provide essential care to all their patients.

More than a year since COVID-19 first swept the globe, attention and hopes are pinned on the roll-out of COVID-19 vaccines. However, the countries most affected by the lack of medical oxygen are also the ones with the least access to vaccines. This is why it is critical to ensure the sufficient supply of medical oxygen for those people who will still become ill.

Governments must not only consider oxygen supply when patients are gasping for air in overflowing hospital beds when cases peak. Long-term solutions are needed to secure supply. But, in the meantime, medical oxygen supplies must be urgently made available to health facilities battling COVID-19, particularly when the virus surges.

This briefing paper describes MSF's experience of the critical role of medical oxygen in treating COVID-19; the challenges of accessing it, particularly in rural settings, and of ensuring its proper use; and the impact oxygen shortages have on patients and healthcare workers.

Khayelitsha, South Africa - ©Rowan Pybus/MSF





Aden, Yemen - ©Hareth Mohammed/MSF

The pre-existing problems of oxygen provision

The lack of medical oxygen in many low- to middle-income countries is not a new problem. Prior to the pandemic, oxygen supply in sub-Saharan Africa met only half of patients' needs¹. In many cases, it was – and still is – only available in urban areas, leaving gaps in oxygen supply in rural settings.

Oxygen therapy is used for pneumonia and other respiratory illnesses. Oxygen is also needed for medical conditions where the body's metabolic demands are high, such as in sepsis, severe malaria, epilepsy, trauma, obstetric and neonatal conditions (respiratory distress, apnea, asphyxia, sepsis). Additionally, oxygen is routinely provided with surgical care and anesthesia.

Oxygen shortages are particularly evident in neonatal care, since more than half of all neonatal deaths globally are due to conditions that cause dangerously low blood oxygen levels. Global estimates suggest that one in five sick newborns have hypoxemia upon admission to a hospital. Administering oxygen therapy, antibiotics, and other supportive care practices for severe neonatal infections could save the lives of more than 400,000 babies each year².

A recent study published in the Lancet³ found that of facilities treating respiratory infections in sub-Saharan Africa, only around one in five had access to oxygen in Mauritania and one in 10 in Niger. Ethiopia and Nigeria are the only two African countries to have national oxygen policy roadmaps, which include plans for large-scale oxygen production⁴.

The COVID-19 pandemic has exposed pre-existing shortages of medical oxygen, and the inequalities in access to what WHO considers an 'essential medicine'. Not every COVID-19 patient has the same chance of survival, in part based on their ability to access oxygen – the most essential of treatments.



Sana'a, Yemen - ©Maya Abu Ata/MSF

MSF and Covid-19

MSF began responding to COVID-19 in January 2020, more than a month before the pandemic was declared. Over the course of the pandemic, MSF has worked in 60 countries on COVID-19 projects, providing technical training to healthcare staff and health promotion activities. In many places MSF has been directly involved in patient care, including for critically ill patients requiring oxygen therapy.

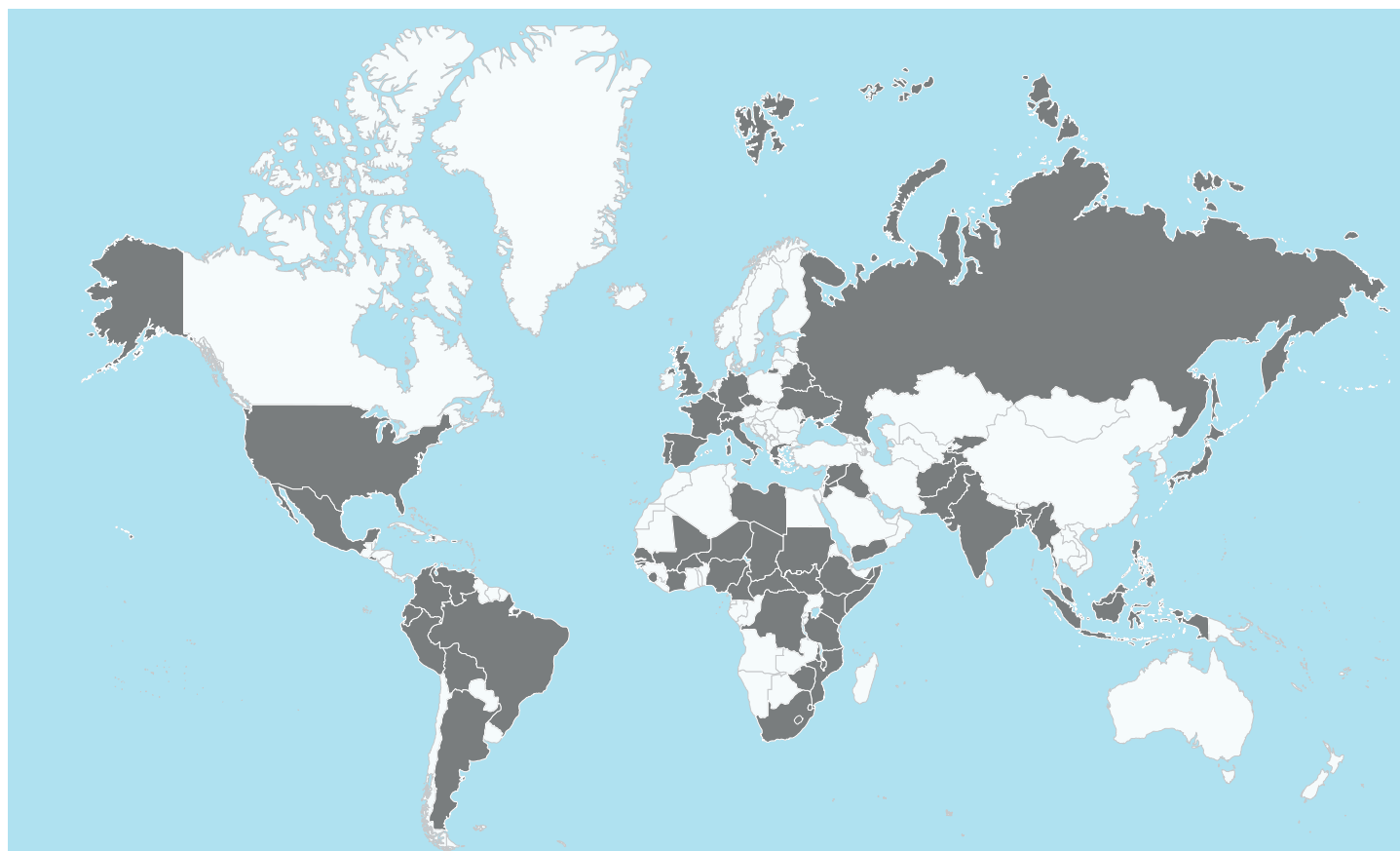
This paper draws mainly on our experiences in five countries: Brazil, Democratic Republic of the Congo (DRC), Lesotho, Yemen and South Africa. It also draws on examples from MSF's work in India. In each of these countries, MSF was or is engaged in substantial activities related to oxygen therapy, and encountered considerable challenges.

1 <https://apnews.com/article/oxygen-crisis-africa-latin-america-eb0d2731a8613c1ae218db7d32a227a6>

2 https://path.azureedge.net/media/documents/DRG_Oxygen_Primer.pdf

3 [https://www.thelancet.com/journals/langlo/article/PIIS2214-109X\(20\)30298-9/fulltext](https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(20)30298-9/fulltext)

4 <https://gh.bmj.com/content/5/6/e002786>



302

70

40%



Health facilities

778

156

4,360



Other facilities

983

221

Protective equipment and health promotion

3.21 million

301,000

376,000

Care for suspect and confirmed cases

112,000

15,400

6,000

93,000

COVID-19 tests conducted

The importance of oxygen for COVID-19 patients

Oxygen is of vital importance for the human body. The lungs filter oxygen from the air, which is then transported throughout the body via the bloodstream. Human body cells need this constant supply of oxygen to remain functional. If a person can no longer absorb enough oxygen, their cells will quickly stop functioning and they will die within a matter of minutes. In people with severe COVID-19, the viral infection of the lungs and the subsequent inflammatory reaction by the immune system can greatly reduce the capacity of the lungs to filter oxygen.

By allowing a patient to breathe air with a higher percentage of oxygen (normal air contains 21% oxygen), their loss of lung capacity can be compensated. This does not address the viral infection itself, but it can keep the patient alive while their immune system tries to eliminate the virus. Oxygen requirements vary amongst patients: giving too much or too little oxygen can both cause harm, so the therapy has to be uniquely adapted for each person. The key parameter is oxygen saturation of the blood, which must be carefully monitored.

COVID-19 is different to other respiratory diseases because some patients can have very low oxygen saturation without feeling short of breath: this is why it is so important to have oxygen saturation monitoring available. Saturation does not need to be monitored continuously for most patients on oxygen, but it is important that saturation is monitored regularly and that action is taken if oxygen saturation is falling.

The therapy must then balance several factors, such as the percentage of pure oxygen, the quantity administered per minute (or flow), and the pressure at which the air is given. Medical staff have to be trained in oxygen therapy to be able to provide this treatment in an optimal way.

Data on people infected with SARS-CoV-2 indicate that about 80% are asymptomatic or have mild disease; 15% develop severe disease, including pneumonia; and 5% become critically ill. Critically ill patients can experience respiratory failure, septic shock and/or multi-organ system failure.

Only one in five people with COVID-19 symptoms suffers respiratory distress sufficient to require oxygen therapy. As COVID-19 patient-care protocols have evolved, medical oxygen is considered essential for the treatment of these patients. They can receive oxygen through normal and high flow oxygen therapies and/or through invasive ventilation. Studies show that early and adequate access to oxygen



Aden, Yemen - ©Athmar Mohammed/MSF

(i.e. before a ventilator is required) results in better outcomes, reducing mortality and severity of the disease⁵.

Providing oxygen to patients includes several other elements such as having sufficiently trained staff able to manage critical patients, ensuring good practice in the efficiency of oxygen use avoiding misuse of oxygen supplies and contributing toward the avoidance of shortages. Essential clinical practices include ensuring that the masks that are used to provide oxygen are properly fitted for patients and kept in place, ensuring that patients are prone⁶ where necessary, and that saturation is frequently checked to adjust the oxygen levels according to the patient's needs reducing oxygen waste.

Most patients with COVID-19 who need hospitalisation require oxygen via a face mask or nasal prongs (or both), and do not need enhanced respiratory support. Patients that do require ventilators need ICU trained nurses and doctors, and a high healthcare worker to patient ratio.

Invasive ventilation requires a level of critical care that is simply not available in many of the settings in which MSF works. The challenge faced by MSF teams responding to COVID-19 outbreaks was to provide alternative methods of enhanced respiratory support given the additional resources that invasive ventilation entails. MSF teams working in the COVID-19 response found that the provision of high flow nasal oxygen (HFNO) and non-invasive ventilation (NIV) could be safely applied to COVID-19 patients in MSF settings.

⁵ <https://bmcmmedicine.biomedcentral.com/articles/10.1186/s12916-020-01735-2>

⁶ Proning (where patient lies on their front) has long been used in ICUs for patients with Adult Respiratory Distress Syndrome who are on ventilators and sedated. Turning patients from lying on their back to lying on the front is complex and needs 4-5 people to perform turning. Proning a patient that is awake has been widely implemented during COVID-19 for patients receiving oxygen who are not on ventilators: this is a simple procedure, and is estimated to improve oxygen saturation up to 10%.



Porto Velho, Brazil - ©Diego Baravelli/MSF

Consequences of the lack of oxygen

Without the correct treatment, patients quickly deteriorate to critical status and, in some extreme cases, all patients are dying once hospitalised. Several factors can influence high mortality such as late arrivals to healthcare, self-medication, and conditions in the health system. For example, in Amazonas state in Brazil, when MSF arrived at the rural hospital in Tefé in June 2020, local medical staff told our teams that almost all patients requiring intensive care had died. This was due to the severity of their condition combined with staff shortages, lack of appropriate equipment and other hurdles to effective critical care.

In January 2021, oxygen production plants in Manaus, the state capital of Amazonas, came under strain due to the rapid increase in number of patients. This affected the oxygen supply of the whole region. Health workers, supported by MSF, in hospitals in the towns of Tefé and Sao Gabriel, had to ration oxygen for COVID-19 patients. Other hospitals in the region reported they had run out of oxygen altogether, with patients dying as a direct result.

Health workers in places where MSF encountered shortages in medical oxygen expressed their high levels of distress at having to ration oxygen, which has included deciding who should be prioritised for treatment. Their distress is compounded by the fact that oxygen is an essential medicine.



Khayelitsha, South Africa - ©Rowan Pybus/MSF

In Manaus, Brazil, another COVID-19 surge hit its peak in January 2021. An MSF psychologist heard reports of a single oxygen cylinder being divided between five patients. Health workers felt a sense of powerlessness at being unable to provide essential treatment. Family members of the sick slept outside hospital buildings and searched for oxygen cylinders on their own in the markets. The patients whose family members were able to obtain oxygen reported how they watched other patients die without oxygen. At the peak of the surge, the morgue was full and bodies lined the hospital corridors.

The logistical challenges of oxygen supply

Regions such as North America and Western Europe have relatively mature and sound medical-oxygen infrastructures. The increased demand due to COVID-19 posed less threat to their supply chains, although even these systems sometimes had trouble coping with the massive influx of critically ill COVID-19 patients. To provide continuous oxygen supplies, they redistributed medical oxygen from nonessential or underutilised healthcare facilities.

In countries with less-developed medical oxygen infrastructures, which were already struggling with oxygen shortages before the COVID-19 pandemic, oxygen needed to be delivered via tanks or concentrators.

Even when a hospital has its own oxygen facilities, there are no guarantees that supply will be uninterrupted. In Mumbai, India, the BKC hospital that MSF is supporting has an oxygen plant. However, if it stops working, there is no back-up plan or buffer stock to ensure that patients who need oxygen will receive it.

Cylinders are heavy, must be refilled at central stations and transported by truck. They carry the risk of explosion and fire if not handled properly.

The process of transporting oxygen cylinders can be even more logistically complex in rural settings where central oxygen production plants are far away, and in places with poor road infrastructure. In the Amazonas region of Brazil, oxygen cylinders were refilled in the state capital

of Manaus. It would take a further week to transport them by boat to Tefé. During a surge of the epidemic in January 2021, the hospital was more than 100% full and MSF teams had to increase the number of beds from 27 to 67. This huge increase in demand prompted the health authorities to send oxygen by speed boat and plane. At the most critical point in the crisis, the hospital in Tefé was left with a buffer of only 12 hours of oxygen. Medical staff at the hospital were confronted with the ethical dilemma of rationing oxygen provision or choosing which patients had more probability of surviving.

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Aden, Yemen ©Hareth Mohammed/MSF



Khayelitsha, South Africa - ©Rowan Pybus/MSF

In Lesotho, the lack of oxygen plants led to similar challenges during the second wave in January 2021. Medical staff were forced to share devices with more than one patient. This limited the amount of oxygen they could provide to each patient and reduced the capacity of medical teams to increase the oxygen flow if necessary.

In the Yemeni city of Aden, MSF teams have also confronted the challenges of oxygen. In April 2021, the MSF team responding to the second wave of the pandemic saw three times the number of patients than in the first wave at the hospital it supports. The bed occupancy rate was 202% and the team reached a situation of having only two hours of buffer supply. MSF teams managed to secure access to 600 oxygen cylinders per day, but this is often not enough, and there has been a need to borrow oxygen cylinders from other health facilities, or make do with receiving multiple small amounts from different places. The team is dependent on a single supplier for the cylinders. If this plant breaks down or faces difficulties in maintaining the level of supply, the hospital supported by MSF will face a catastrophic situation.

Once the challenge of accessing oxygen cylinders is met in the different contexts where MSF teams provide oxygen therapy, using them appropriately presents another set of issues. Oxygen cylinders have no warning mechanism to indicate the tank is running low. In settings where health workers are already overstretched, this can lead to errors such as patients being left with empty cylinders.

MSF teams also found that transporting and refilling oxygen cylinders was not a feasible long-term solution to oxygen shortages in many healthcare settings. However, innovative solutions can be found to the challenges of oxygen cylinder supply.

In the DRC city of Kinshasa, where MSF was working in a COVID-19 ward of 10 ICU beds in the first quarter of 2021, the team realised how time consuming it was to change

the cylinders at each patient's bed. The team implemented an 'oxygen bank' system by putting several cylinders together. By having a centralized system there was no longer a need to monitor and replace each individual cylinder next to the patients bed, and it was possible to build a buffer stock. However, the logistical burden of the system was immense, as the tanks needed to be regularly refilled.

The Kinshasa team was able to identify multiple suppliers of oxygen. This was necessary to avoid being dependent of one oxygen plant, which, if it broke down, would have left them without an oxygen source. This was the experience of MSF teams in Brazil, where a private company provided oxygen to multiple states via its three plants in Manaus. When state authorities reported that two of the plants had broken down, supplies were affected across multiple states in the region.

Kinshasa, DRC - ©MSF



Though reliance on oxygen plants is not without complications, facilities that have access to them are the lucky ones. The solution of the 'oxygen bank' that MSF teams devised in urban Kinshasa was only possible because the capital city had an oxygen plant available. This is not the case in Masisi in the east of the country where MSF is supporting the general hospital. Masisi has no oxygen plants nearby and oxygen is far scarcer (although no oxygen shortages have occurred in Masisi so far).

Many of the oxygen plants in countries where MSF has been working are controlled by the private sector. In some instances, the rise in demand for oxygen has led to an increase in the price, which in turn has created a barrier in access to sufficient supplies. For example, in Haiti MSF witnessed how filling an oxygen bottle went up from nine to 18 dollars.

An important alternative to oxygen cylinders are oxygen concentrators, which produce oxygen by extracting it from the air. Concentrators were originally designed to provide home based care to chronic patients and not to be used to critical care or hospital care. However, due to the COVID-19 emergency several facilities have been using them. A machine is around the size of a suitcase and it requires an electricity source (direct, generators or batteries), that is not always available. Concentrators are not suitable for critically ill people, since they do not deliver oxygen under pressure and to a high flow, but they can provide enough oxygen for patients who present early enough before they have deteriorated.

In South Africa, where MSF teams ran COVID-19 hospitals in the Western Cape and KwaZulu Natal, health workers increased the oxygen flow from concentrators by using the well established practice of connecting two together. This enabled health workers to deliver twice the volume of oxygen to patients. However, these concentrators often break down, highlighting the need for bio-technicians to be available in locations where concentrators are in use.

Other equipment such as oxygen concentrators with an added compressor to increase the flow (up to 30-40 liters per minute as opposed to the 10 liters per minute of the standard concentrator) can produce the desired flow and pressure, but they are bigger, heavier and much more expensive. They also require more power and technical expertise for maintenance.

The solutions to ensuring oxygen supply vary according to different situations and needs. MSF teams have seen that, with sufficient resources, it is possible to successfully implement adapted solutions and save more lives with the tools at our disposal today. These solutions include innovations to ease the logistical burden of oxygen supply and ensure that adapted delivery solutions are available in rural settings. They need resourcing right now, alongside investment in longer term oxygen supply infrastructure to address systematic problems.

Supplying medical oxygen itself is not the only challenge. Medical materials required to deliver oxygen to the patient can also undergo stock disruptions. In Lesotho, the hospital supported by MSF faced shortages of tank regulators

(manometers), nasal cannulas and prongs. Measures to increase oxygen supply must also take into consideration the medical materials needed to effectively deliver oxygen to the patient, including oximeters to monitor them and skilled staff to maintain or repair the devices if they break.



Mumbai, India - ©Abhinav Chatterjee/MSF

The need for appropriately trained staff for oxygen therapy

Not all facilities in which MSF has worked have enough trained staff to provide effective oxygen therapy. In Zimbabwe, for example, there are no oxygen treatment protocols, making it complex for medical staff to decide on how best to provide treatment.

In India, the BKC hospital in Mumbai currently has two wings for treating COVID patients. Each of these wings can host up to 1,000 patients, and staff are stretched to the maximum. MSF teams supporting doctors and nurses at the hospital have found that medical workers lack training on oxygen therapy. This lack of adequate knowledge can result in excess and underuse of oxygen, both leading to detrimental outcomes for patients.

Staff training is essential to the success of the response to COVID-19, as witnessed in South Africa. MSF teams delivered bedside training for medical officers and nurses and provided formal sessions focusing on oxygen policy and management of co-morbidities.



Ibb, Yemen - ©Majd Aljunaid/MSF

Conclusion

Medical oxygen is an essential life-saving tool, recognised as such in the list of WHO's essential medicines and particularly important for critically ill COVID-19 patients. To date, international and national COVID-19 responses have neglected the need to scale up oxygen supplies. This has left a gap in the treatment of the critically ill. It is often only when a surge in cases occurs that the limitations on oxygen supplies are confronted. By then, it can be too late.

The countries most affected by the lack of access to medical oxygen are also the ones struggling to access vaccines. Patients in these countries will continue to face the twin threat of being less likely to avoid infection in the first place, and less able to access treatment when they are sick. These vulnerable patients will continue to die due to a lack of oxygen, whilst people in richer countries receive protection through expanded vaccination programmes.

Faced with such a reality, access to medical oxygen must be increased to ensure that all critically ill COVID-19 patients receive the care they need to survive. Oxygen plants are the ideal solution, but are not always available, especially in rural locations. In cities, plants are often controlled by the private sector, which means that as demand rises, so do prices. Where oxygen plants are available, government price controls should be implemented during surges in COVID-19 cases. Governments should also look into temporarily re-purposing private sector industrial oxygen plants during times of greatest need.

Oxygen concentrators are viable alternatives to oxygen cylinders for COVID-19 patients who are not critically ill. If COVID-19 care – including oxygen provision – happened faster to avoid patients deteriorating to a critical state, there would be less need for oxygen from plants.

Other essential tools such as oxymeters, manometers and devices to set up oxygen provision should also be made accessible wherever oxygen provision is needed. Sufficient resources must be made available by governments and international donors to ensure that this is possible. In order to provide adequate oxygen therapy, clinical guidelines must be put in place and health workers and oxygen device maintenance teams must be trained.

COVID-19 international mechanisms, including the WHO led Biomedical consortium and the recently launched COVID-19 Oxygen Emergency Taskforce should ramp up efforts to support countries to access available funds and procure the necessary tools for oxygen provision.⁷

Oxygen is the single most important treatment for COVID-19 patients. This disease, and the many other conditions that require oxygen, are not going to disappear. The appropriate resources must be made available to ensure that the disparities between wealthy and resource limited countries do not result in preventable deaths from COVID-19.

These resources must address the long-term solutions needing to solve the shortages of medical oxygen, including innovations in oxygen supply. However, it is imperative that short-term emergency steps are also taken to save lives today. While this paper focused on oxygen supply challenges, innovations are also needed in how oxygen is given to patients.

With so many lives at stake, health care workers and patients in low-income settings should not be forced to 'make do' with the insufficient resources they have available.



Mumbai, India - ©Abhinav Chatterjee/MSF

Recommendations

- 1.** Access to oxygen concentrators must urgently be scaled up with the support of donors.
- 2.** Governments need to calculate the oxygen needs for different scenarios and map their oxygen resources before a surge of cases takes place and hospitals are overwhelmed. Governments and global health donors should not wait for waves of infections to overwhelm available oxygen supply, but rather anticipate what could be needed.
- 3.** In countries where private suppliers of oxygen play an important role, governments should keep oxygen prices in check. Oxygen should never become out of reach for some patients due to price increases.
- 4.** Oxygen is not only produced for medical use, but also for industrial purposes. In place where shortages of oxygen for treatment of COVID-19 patients loom, industrial oxygen producers and governments should find ways to agree to use their capacity for patient treatment.
- 5.** When there is not enough oxygen during a wave of COVID-19, there is often also a lack of adequately trained staff to administer it. Donors and governments must invest in ensuring medical staff have the right skills.
- 6.** Hospitals and medical facilities must have back-up mechanisms for their oxygen supply. Many facilities are dependent on one source of oxygen. If this source fails, it immediately threatens the lives of critically ill COVID-19 patients. Back-up systems are crucial to saving lives.
- 7.** Patients with COVID-19 in need of oxygen therapy must be admitted to hospital earlier. While this is not a guarantee of survival, it does result in better outcomes for some patients. Those who deteriorate fast will need to be moved quickly from low flow to high flow oxygen provision, which is only possible in a hospital. It is important that patients seek medical help early, and that medical staff in the first line of care can refer patients early.
- 8.** Oxygen is a crucial therapy for critically ill COVID-19 patients, yet it seems to be given less attention by governments, global health organisations and donors than pharmaceutical treatments or vaccines. This needs to change. Oxygen saves lives.