Guidelines

Oxygen Facilities for Covid-19 Patients

Objective
To quantify oxygen demand, to identify oxygen sources that are available, and select appropriate surge sources to best respond to COVID-19 patients’ needs. These guidelines are intended for health facility administrators, clinical decision-makers, procurement officers, planning officers, biomedical engineers, infrastructure engineers and policy-makers.

Rationale
COVID-19 is a public health crisis without parallel in recent history. But it is also an opportunity to turn the spotlight on medical oxygen as one of the defining health equity issues of our age. Oxygen therapy is recommended for all severe and critical COVID-19 patients, with low doses to moderate flow rates or higher flow rates.

Instructions
About 15% of people with Covid-19 have moderate/severe illness requiring oxygen therapy, and 5% will be critically ill requiring intensive care unit treatment. For these reasons, COVID-19 treatment health-care facilities should be equipped with pulse oximeters, functioning oxygen systems including single-use oxygen delivery interfaces.

- Oxygen therapy is recommended for all severe and critical COVID-19 patients, with low doses ranging from 1-2 L/min in children and starting at 5 L/min in adults with nasal cannula, moderate flow rates for use with venturi mask (6-10 L/min); or higher flow rates (10-15 L/min) using a mask with reservoir bag attached as Annexure A.

Oxygen can be delivered at higher flow rates and in higher concentrations using non-invasive ventilation (NIV) and invasive ventilation devices. The high-flow nasal cannula (HFNC) device can be used to deliver oxygen at higher flow rates and in higher concentrations but is not used as a first line of oxygen therapy as this is not a very common device, it will consume more oxygen.

Oxygen sources
Medical oxygen contains at least 82% pure oxygen. Only high quality, medical-grade oxygen should be given to patients. Oxygen systems must consist of an oxygen source, or production combined with storage. Common oxygen sources are: oxygen generating plants and liquid oxygen in bulk storage tanks, and oxygen concentrators. The most common source of oxygen storage used in health-care settings is a cylinder.

The appropriate choice of oxygen source depends on many factors, including: the amount of oxygen needed at the treatment centre; the available infrastructure, cost, capacity and supply chain for local production of medicinal gases; the reliability of electrical supply; and access to maintenance services and spare parts, etc.
**Liquid oxygen plants:** The liquid oxygen tank supplies a centrally piped system throughout the health facility by self-vaporization and for which a power supply is not required. The use of liquid oxygen relies on external supply chain mechanisms and needs a bit more caution with respect to transport and storage due to the risks associated with higher pressures. Extra care should be taken in more extreme environments. It is best practice to also have cylinders as a backup supply.

**PSA oxygen plant:** A pressure swing adsorption (PSA) oxygen plant serves as a large, central source of oxygen generation using PSA technology (similar to concentrators) that can be located on-site at medical facilities. Oxygen from a PSA plant can either be piped directly to bedside terminal units within patient areas or, with a booster compressor, be used to refill cylinders for oxygen distribution (either on-site or to neighbouring health facilities) or for backup oxygen supply. Oxygen plants require a reliable source of power. It is best practice to also have cylinders as a backup supply.

**Oxygen concentrators:** An oxygen concentrator is a self-contained, electrically powered medical device designed to concentrate oxygen from ambient air. An oxygen concentrator uses PSA technology to draw in air from the environment, removing the nitrogen to produce a continuous source of more than 90% concentrated oxygen. It should not be used if the oxygen concentration falls below 82%.

**Oxygen storage and intra-hospital distribution**

**Oxygen cylinders:** Oxygen gas can be compressed and stored in cylinders and can be piped to specific areas of the health facility, even at the ward level. When cylinders are the only source of oxygen in a health facility, a strong supply-chain is required to ensure ongoing availability. Once filled, cylinders themselves do not require electricity, but they do require several accessories and fittings to deliver oxygen, such as pressure gauges, regulators, flowmeters, and in some cases, humidifiers. Cylinders also require periodic maintenance, commonly provided by gas suppliers at the point of refilling. Storage or transportation of medical oxygen in cylinders must be done carefully and by trained personnel as the contents are under extreme pressure.

**Pipeline intra-hospital distribution networks** are helpful to supply oxygen at high pressure to equipment such as anaesthetic machines and ventilators. A key advantage of pipeline systems is that they obviate the need for handling and transporting heavy cylinders between hospital wards. However, the high cost and complexity of installing centralized oxygen sources with copper pipelines and the associated specialized maintenance required for this, makes pipeline systems less accessible for turn-key installations.

**Oxygen needs Estimation**

About 75% of the COVID-19 patients requiring hospitalization will be classified as “moderate or severe”, and 25% as “critical”. Thus, the total supply of medical oxygen required can be estimated based on the recommended flow rates for each patient severity category (Annex B).

Please refer to “Annexure A” for Oxygen flow categories, “Annexure B” for Sample oxygen flow planning per 100 bed facility and “Annexure C” for comparison of oxygen sources and storage.

*Note: The above recommendations are being regularly reviewed by the Ministry of National Health Services, Regulations & Coordination and will be updated based on the international & national recommendations and best practices.*

*The Ministry acknowledges the contribution of Ms Javeria Yousaf, Mr Quadri and HSA/ HPSIU/ NIH team to compile these guidelines.*
References


For more information, please contact:

HSA/ HPSIU/ NIH, PM National Health Complex, Islamabad

http://www.hsa.edu.pk/  https://twitter.com/nhsrcofficial
https://www.nih.org.pk/  https://www.youtube.com/channel/UCdYuzeSP4Ug1f__ZZ
Proposed Bed Categories/Treatment options

| Oxygen beds for low flow oxygen | • Low flow Oxygen with Mask (up to 5-6 liters/min)  
• Additional flow with by adding Bag to mask |
|---------------------------------|-------------------------------------------------|
| High Dependency Unit (HDU) /Non-invasive high flow oxygen | • High Flow Nasal Canula (HFNC uses more oxygen and not recommended for first line use)  
• CPAP Machine  
• BPAP Machine |
| ICU/Mechanical Ventilation | • Mechanical ventilation with intubation |

*Proposed ratio for planning purpose of any COVID-19 facility is 3:3:1

Annex ‘B’

Sample Oxygen Flow Planning per 100 Bed Facility

<table>
<thead>
<tr>
<th>Hypothetical 100 bed COVID-19 treatment facility</th>
<th>Avg. O₂ flow rate per patient</th>
<th>Size of solutions of scale*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease severity</td>
<td>Total</td>
<td>PSA Plant</td>
</tr>
<tr>
<td>Severe patients</td>
<td>10 L/min</td>
<td>75 * 10 * 60 = 45,000 L/hr</td>
</tr>
<tr>
<td>Critical patients</td>
<td>30 L/min</td>
<td>25 x 30 x 60 = 45,000 L/hr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 90 m³/hr</td>
</tr>
</tbody>
</table>
## Comparison of Oxygen Sources and Storage

<table>
<thead>
<tr>
<th>General characteristic</th>
<th>Cylinders</th>
<th>Concentrators (PSA)</th>
<th>Oxygen plant (PSA)</th>
<th>Liquid oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image</strong></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
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<tr>
<td><strong>Description</strong></td>
<td>A refillable cylindrical storage vessel used to store and transport oxygen in compressed gas form. Cylinders are refilled at a gas generating plant and then require transportation to and from the plant.</td>
<td>A self-contained, electrically powered medical device designed to concentrate oxygen immediately, using PSA technology.</td>
<td>An on-site oxygen generating system using PSA technology, which supplies high-pressure oxygen throughout a facility via a central pipeline system, or via cylinders refilled by the plant.</td>
<td>Bulk liquid oxygen generated off-site and stored in a large tank and supplied throughout a health facility pipeline system. Tank requires refilling by liquid oxygen supplier.</td>
</tr>
<tr>
<td><strong>Clinical application and use case</strong></td>
<td>Can be used for all oxygen needs, including high-pressure supply and in facilities where power supply is intermittent or unavailable. Also used for ambulatory service or patient transport. Used as a backup for other systems.</td>
<td>Used to deliver oxygen at the bedside or within close proximity to the patient area. A single concentrator can service several beds with the use of a flowmeter and stand to split output flow.</td>
<td>Can be used for all oxygen needs, including high-pressure supply.</td>
<td>Can be used for all oxygen needs, including high-pressure supply and in facilities where power supply is intermittent or unavailable.</td>
</tr>
<tr>
<td><strong>Distribution mechanism</strong></td>
<td>Connected to manifold of central/sub-central pipeline distribution system, or directly connected to patient with flowmeter and tubing.</td>
<td>Direct to patient with tubing or through a flowmeter stand.</td>
<td>Central sub-central pipeline distribution system, or can be used to refill cylinders that can be connected to manifold systems in the facility.</td>
<td>Central pipeline distribution system.</td>
</tr>
<tr>
<td><strong>Electricity requirement</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Maintenance requirement</strong></td>
<td>Limited maintenance required by trained technicians.</td>
<td>Maintenance required by trained technicians, who could be in-house.</td>
<td>Significant maintenance of system and piping required by highly trained technicians and engineers, who could be provided as part of contract.</td>
<td>Significant maintenance of system and piping required by highly trained technicians and engineers, who could be provided as part of contract.</td>
</tr>
<tr>
<td><strong>User care</strong></td>
<td>Moderately, regular checks of fittings and connections, regular checks of oxygen lines, cleaning exterior.</td>
<td>Moderately; cleaning of filters and device exterior.</td>
<td>Minimal; at terminal unit only.</td>
<td>Minimal; at terminal unit only.</td>
</tr>
<tr>
<td><strong>Merits</strong></td>
<td>- No power source.</td>
<td>- Continuous oxygen supply (if power available) at low running cost.</td>
<td>- Can be cost-effective for large facilities.</td>
<td>- High capital investment.</td>
</tr>
<tr>
<td><strong>Drawbacks</strong></td>
<td>- Requires transport/supply chain.</td>
<td>- Low pressure output, usually not suitable for CPAP or ventilators.</td>
<td>- Requires maintenance.</td>
<td>- Requires transport/supply chain.</td>
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</tbody>
</table>

### References