Oxygen Therapy Devices

User Manual

July 2021

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Foreword

Oxygen is a life-saving therapeutic medical gas used as an emergency medication. Medical oxygen is used for the management of hypoxaemia – an abnormally low level of oxygen in the blood that is caused by disease, trauma or other health conditions. Since the global pandemic COVID-19 outbreak, medical oxygen has become the most important life-saving commodities in the fight against COVID-19. Medical oxygen plays an essential role when a COVID-19 infected patients develop pneumonia and hypoxaemia – a low blood oxygen level.

In Myanmar, confirmed COVID-19 cases and deaths has reported daily record-breaking numbers under rapidly escalating third wave since early July of 2021. When medical oxygen is used judiciously in the treatment of hypoxaemia due to COVID-19, it undoubtedly saves life. However, oxygen is often used inappropriately and the dangers of over-oxygenation are unappreciated. Having the ability to properly detect and diagnose hypoxaemia, and having a reliable supply of oxygen to treat hypoxaemia, are crucial elements of ending preventable deaths among adults and children from COVID-19 and other hypoxic causes. Achieving this requires a holistic and integrated system of technologies that includes everything from the oxygen source (either produced locally at a health facility or delivered and stored) and devices for flow regulation and conditioning, to consumables for oxygen delivery to the patient. In addition, pulse oximetry is used to detect hypoxaemia and monitor oxygen saturation during oxygen therapy for respiratory diseases, anaesthesia, emergency obstetric care, surgery, trauma or any other cause of respiratory difficulty. Finally, devices for continuity of power and power quality, devices for monitoring oxygen concentration, and spare parts for equipment maintenance, along with the capacity to maintain them, are also essential components of effective oxygen systems.

This booklet aims to increase the availability of good quality, affordable, safe and appropriate oxygen therapy systems at all levels of health facilities. This document does not cover clinical guidance in details. For clinical guidance related to oxygen therapy in adult, children and neonates, please refer to another document of CPI: oxygen therapy for COVID-19 patients: From guidelines to implementation.

Oxygen Sources

Medical oxygen is oxygen used as a medicine in health care center as oxygen therapy, that is (as a minimum) 82% pure oxygen and free from any contamination, generated by an oil-free compressor. In low resource setting, there are three most common sources of medical oxygen in health care facilities. These are-

(1) Compressed gas cylinders,
(2) Oxygen concentrators and
(3) Oxygen plants.
A fourth oxygen source, though less common in low resource setting, is bulk-stored liquid oxygen.

Table 1: Description and comparison of oxygen sources

	Oxygen Cylinder	Oxygen Concentrator	Oxygen Plant	Liquid oxygen
Description	A refillable cylindrical storage vessel used to store and transport oxygen in compressed gas form. Cylinders are refilled at a gas generating plant and thus require transportation to and from the plant.	A self-contained, electrically powered medical device designed to concentrate oxygen from ambient air, using pressure swing adsorption (PSA) technology.	An onsite oxygen generating system using pressure swing adsorption (PSA) technology, which supplies high-pressure oxygen throughout a facility via a central pipeline system, or via cylinders refilled by the plant.	Bulk liquid oxygen generated off-site and stored in a large tank and supplied throughout a health facility via a central pipeline system. Tank requires refilling by liquid oxygen supplier.
Clinical application and/or use case	Can be used for all oxygen needs, including high-pressure supply and in facilities where power supply is intermittent or unreliable. Also used for ambulatory service or patient transport. Used as a backup for other systems.	Used to deliver oxygen at the bedside or within close proximity to patient areas.	Can be used for all oxygen needs, including high-pressure supply.	Can be used for all oxygen needs, including high-pressure supply and in facilities where power supply is intermittent or unreliable.
Appropriate level of health system	All level.	All level.	District hospital level.	Regional, specialized hospital, specialized outpatient clinics.
Electricity requirements	No.	Yes.	Yes.	No.
Costs	Moderate; cylinder, regulator, flowmeter, installation, training.	High; concentrator, spares, installation, training.	Very high; plant and pipeline distribution system, installation, training.	Can be very high; tank, pipeline installation, training.
Ongoing operating costs	Moderate ; cylinder deposit and leasing fees, refill costs, transportation from refilling station to health facility.	Low; electricity and maintenance (spare parts and labour).	Low/moderate; electricity and maintenance (spare parts and labour). May require additional staff to operate/manage if not operated by third party.	High (can be very high if tank is leased); refill costs, maintenance.
Maintenance requirement	Little maintenance required by trained technicians.	Moderate maintenance required by trained technicians.	Significant maintenance of system and piping required by highly trained technician and engineers, can be provided as part of contract.	Significant maintenance of system and piping required by highly trained technician and engineers, can be provided as part of contract.

	Oxygen Cylinder	Oxygen Concentrator	Oxygen Plant	Liquid oxygen

User care	Moderate; regular checks of fittings and connections, regular checks of oxygen levels, cleaning exterior.	Moderate; cleaning of filters and device exterior.	Minimal; at terminal unit only.	Minimal; at terminal unit only.
Merits	No power source needed.	Continuous oxygen supply (if power available) at low running cost.	Can be cost-effective for large facilities and can get continuous oxygen supply.	99% oxygen obtained. High oxygen output for small space requirement.
Drawbacks	• Requires transport/supply chain. • Exhaustible supply. • Highly reliant upon supplier. • Risk of gas leakage. • Risk of unwanted relocation.	• Requires uninterrupted power. • Requires backup cylinder supply. • Requires maintenance. • Low pressure output, usually not suitable for CPAP or ventilators.	• High capital investments. • Requires uninterrupted power. • Needs adequate infrastructure. • High maintenance for piping. • Requires backup cylinder supply. • Risk of gas leakage from piping system.	Requires transport/supply chain. Exhaustible supply. High maintenance for piping. High total cost. Needs adequate infrastructure. Requires backup cylinder supply. Risk of gas leakage from piping system.

The appropriate choice of oxygen source is multifactorial; it is important to take into consideration the amount of oxygen needed at the health facility, available infrastructure, cost, capacity and supply chain for local production (and delivery) of medicinal gases, reliability of electricity, access to maintenance services and spare parts, etc. In addition, the level of the health system at which these different sources might be used will depend on local policy, training and capacity at the different levels of care. This booklet will focus on oxygen cylinders and concentrator in more detail, with technical specifications.

Oxygen Cylinder

- Oxygen gas can be compressed and stored in cylinders. Oxygen gas is produced in manufacturing plants by cooling air until it liquefies, then distilling the liquid to separate pure oxygen, which is then passed through a liquid oxygen pump into cylinders.
- Cylinders 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.

Cylinder sizing

- Oxygen cylinders come in many different sizes.
- Unlike industrial used cylinder, medical cylinders' sizes are named alphabetically.
- The most common used cylinder size in Myanmar are 10 Liters, 20 Liters and 40 Liters. (See details in the following figure)

Figure 1: Common oxygen cylinder type found in Myanmar during COVID-19 third wave outbreak

Cylinders are fitted with customized valves (either pin index or bullnose type) that are opened with valve keys, and with valve guards for safety. The Pin Index Safety System (PISS) is designed to ensure the correct gas is connected to the regulator or other equipment. The arrangement of the pins is unique for each gas, and the positions of the holes on the cylinder valve must correspond with the pins to prevent the use of the wrong gas.

- Some cylinders have built-in, integral pressure regulators, which do not require a separate pressure regulator to be fitted to the cylinder valve before use.

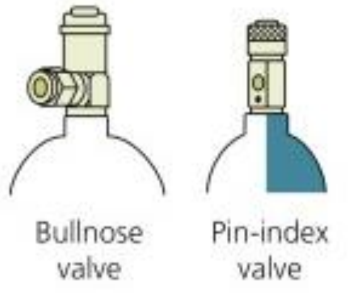


Figure 2: Valves (Bullnose and Pin-index type)

Figure 3: Valve keys

Figure 4: Valve guards/ Valve protection caps

Figure 5: Pressure gauge/ Pressure regulator

Installation and use

When installing an oxygen cylinder:

- Ensure the quality of the oxygen is assured, either by supplier quality certificate, PSA plant logbook or onsite analyzer testing.
- Oxygen cylinders should be prepared for use and set up in a secure position; vigilance by the operator during preparation is of critical importance.
- Tighten all the connections (between the cylinder and the regulator and between the regulator and the flowmeter), so that oxygen does not leak out.
- Before assembling regulators and fittings, it is extremely important to ensure there are no particles of dirt in the cylinder outlet.
- Use clean compressed air or nitrogen to blow out any loose particles of dirt from the valve sockets.
- Where clean compressed air or nitrogen is not available, particles of dirt and residual moisture can be removed by quickly opening and immediately closing the valve (otherwise known as "snifting").
- No one should attempt to connect a regulator and/or accessory equipment using improvised hookups or adapters.
- Plastic tape should not be used on a regulator.

When using an oxygen cylinder:

- All gas cylinders should be equipped with a functioning gas regulator while in use.
- Check the contents gauge on the cylinder before starting to be sure there is enough gas available. Open the regulator and check the amount of oxygen in the cylinder on the pressure gauge. If the arrow in the content gauge is in the red zone, the cylinder is nearly empty and should not be used.
- Valve protection caps are required on all cylinders that are threaded to accommodate a cap, unless the cylinder valve is connected for use to a regulator or manifold.

- When personnel have finished using a compressed gas cylinder, the cylinder valve should be closed and the pressure in the regulator and associated equipment released.

Monitoring and calculation of oxygen cylinder duration

- It is important to monitor the amount of oxygen in the cylinder. Open the regulator, and check the amount of oxygen in the cylinder on the pressure gauge. If the needle of the gauge is in the red zone, the cylinder is nearly empty and should not be used, unless it is the only one you have. You must anticipate the need for oxygen and order more before it runs out.
- Please see more details in **Annex 1** which provides the approximate estimation of oxygen time inside a different type of cyclinder.
- Never allow such a cylinder to be used for a child overnight, as it will run out and the child will become hypoxaemic.
- After starting a child on oxygen, recheck the oxygen saturation with a pulse oximeter and/or check for signs of hypoxaemia. If the child still has an SpO2 < 90% or has cyanosis or severe chest indrawing, increase the oxygen flow to a maximum of 2 L/min for an infant or up to 4 L/min for an older child.
- Do not use flow rates > 2 L/min for neonates or infants, as they can result in distension of the stomach. Any infant who is unable to suck or who needs an oxygen flow of 2 L/min should have a nasogastric tube to decompress the stomach. If the SpO2 remains < 88% or signs of hypoxaemia persist, the child may need a second source of oxygen, such as a high-flow mask, if it is available.

Safe use and handling of oxygen cylinders

Firebreak connectors/ Fire safe cannula

- It is very important not to allow an open flame or a cigarette anywhere several meter apart (at least 3 m) from an oxygen source. Post "No smoking" signs wherever oxygen is used. Firebreak connectors are recommended to stop the oxygen flow in the event of fire.
- The oxygen supply from a cylinder must be connected through a suitable pressure-reducing valve (regulator). Using oxygen from cylinders without a regulator is **extremely dangerous**.
- Never apply grease or oil, as it could catch fire in pure oxygen, especially at high pressure. Aerosols such as hair spray or paint, Oil-based face creams or lotions on your nose or face.
- Oxygen cylinders are dangerous objects. If they fall over, they may injure or even kill people.
- Make sure that cylinders are safely stored and mounted. In storage, they should lie horizontally. In use, they should be securely fixed in the vertical position to a wall or be kept standing secured with a restraining strap or chain.
- Keep your oxygen tanks (cylinders) away from all heat sources, including radiators, heat ducts, stoves, fireplaces, matches, and lighters.
- Always keep oxygen cylinders in a well-ventilated area because it is normal for small amounts of oxygen to leak.
- A reliable system for oxygen cylinder depends on a good source of supply and reliable year-round transportation. (transport cost)
- "Industrial" oxygen and of "medical" oxygen are produced by the same process. good-quality industrial oxygen is perfectly safe for medical use. It may also be easier to obtain and less expensive.

General handling

- Personal protective equipment, such as eye and hand protection, should be worn when handling oxygen cylinders.
- All compressed medical oxygen gas cylinders (regardless of size) should be secured to racks, walls, work benches or hand trolleys by a strong chain or strap, capable of preventing the cylinder from falling or being knocked over.
- Secure in an upright position. Note that small cylinders (e.g. E size), when used for patient transport, may be laid flat, but still need to be firmly secured.
- Do not drop cylinders or allow sharp impacts on cylinders.
- Cover the top of the oxygen cylinder with the cap when it is not in use or when being transported for delivery.
- Set up the cylinder for patient use a safe distance from the patient.
- After connecting the appropriate equipment, turn the flow control off; carefully open the main valve, then turn up the flow slowly to the desired rate.

- Do not place the cylinder on a patient's bed.
- Before moving cylinders, they must be disconnected from any regulators, applying any protective valve caps before the cylinders are released.
- Cylinders should be moved only on a hand truck or other cart designed for handling gas cylinders.
- No more than one cylinder should be handled at a time except on carts designed to transport more than one cylinder.
- All medical gas cylinders should be clearly labelled to identify the contents. A cylinder without a readable product label should not be used and should be returned to the supplier.
- All defective gas cylinders or equipment should be reported immediately to the supplier for correction or replacement.

Storage

- Always physically separate full and empty medical gas cylinders.
- Organizations providing ambulatory care (eg. OPD care, minor emergency care, outpatient birthing centers, etc.) can do this by using separate racks, physical barriers or by colour coding the storage rack.
- Label the cylinders clearly (open/empty or full/unopened), to avoid confusion and delay selecting between full, partial and empty cylinders.
- Store in well-ventilated, clean, dry conditions, not exposed to extremes of heat or cold.
- Protect cylinder and all other fittings from contamination by oil and grease.
- Never use a single-use and/or re-use an industrial gas cylinder for refilling medical oxygen.

Fire safety

- Ensure appropriate fire extinguishers are kept nearby and are regularly inspected.
- Keep oxygen cylinders at least several metres (at least 3 meter) from a heat source, open flames, electrical devices, or other possible sources of ignition.
- Put a "no smoking" sign near oxygen sources in the hospital.
- Check that all nearby electrical circuit breakers and devices are in safe working condition and free from sparking to prevent a serious fire occurrence.

Disposal

- Cylinders and unwanted product should be returned to the vendor, not vented into the environment.
- Obsolete cylinders must be disposed of based on local regulations.

Other

- Use aluminum alloy cylinders with compatible accessories in magnetic resonance imaging (MRI) procedure rooms.

Complete system for using oxygen in cylinders requires:

1. Reliable source of oxygen supply in cylinders
2. Transport to get the cylinders to the hospital
3. Procedures to ensure that the hospital orders the appropriate amount of oxygen
4. Apparatus to deliver oxygen from the cylinder to the patient:
   - Suitable regulator
   - Flow meter
   - Oxygen delivery tubing
   - Humidifier
   - Tube to carry oxygen to the patient's face
   - Nasal catheter (or mask) to deliver the oxygen to the patient's airway
5. Person with clinical training to give the correct amount of oxygen, in the correct manner, to the patients who need it (medical person)
6. Person with technical training to inspect the apparatus, maintain it in good condition and repair it when necessary (Repair place)
7. Adequate budget to ensure the consistent availability of the oxygen supply.

Maintenance

Table – 2 provide daily and weekly guidance for user care and routine maintenance of oxygen cylinders and associated accessories. However, preventive maintenance of the cylinders should be carried out periodically (e.g. every 5–10 years) by the gas supplier, and a coloured cylinder test ring may be fitted around the cylinder neck indicating the next due date for testing.

Table 2: User care and preventive maintenance recommendations for oxygen cylinders (and associated accessories)

Schedule period	Activities	Check
Daily	Cleaning	✓ Ensure delivery tubes and masks are decontaminated. ✓ If humidifier bottle is used, disinfect and refill with clean water.
	Visual checks	✓ Check cylinder is correct type and correctly labelled. ✓ Check all parts are fitted tightly and correctly.
	Function	✓ Before use, ensure cylinder has sufficient pressure. ✓ Ensure flow is sufficient for intended use. ✓ Close cylinder valve after each use.
Weekly	Cleaning	✓ Clean cylinder, valve and flowmeter with damp cloth.
	Visual checks	✓ Check for leakage: hissing sound or reduction in pressure.
	Function	✓ Remove valve dust with brief, fast oxygen flow checks. ✓ Check flow can be varied using flow control.

Source: Adapted from *User care of medical equipment: a first line maintenance guide for end users. Strengthening Specialised Clinical Services in the Pacific*; 2015 (https://bmet.ewh.org/handle/20.500.12091/83, accessed 26 April 2019).

Devices for oxygen regulation and conditioning

Figure 6: Parts of Oxygen flowmeter

Figure 7: Ways to connect oxygen cylinder and flowmeter

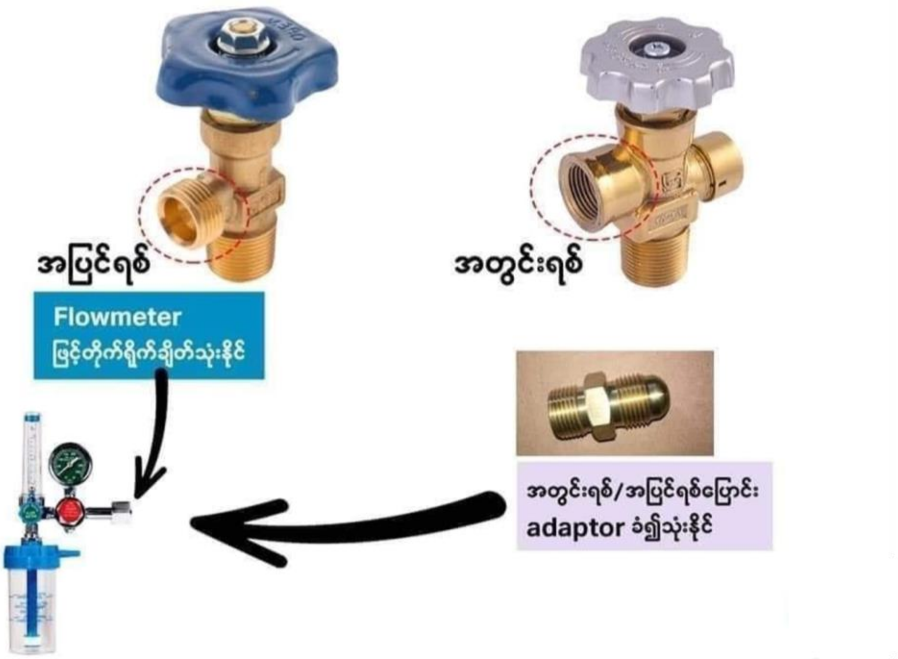


Figure 8: Setting the oxygen cylinder and flowmeter

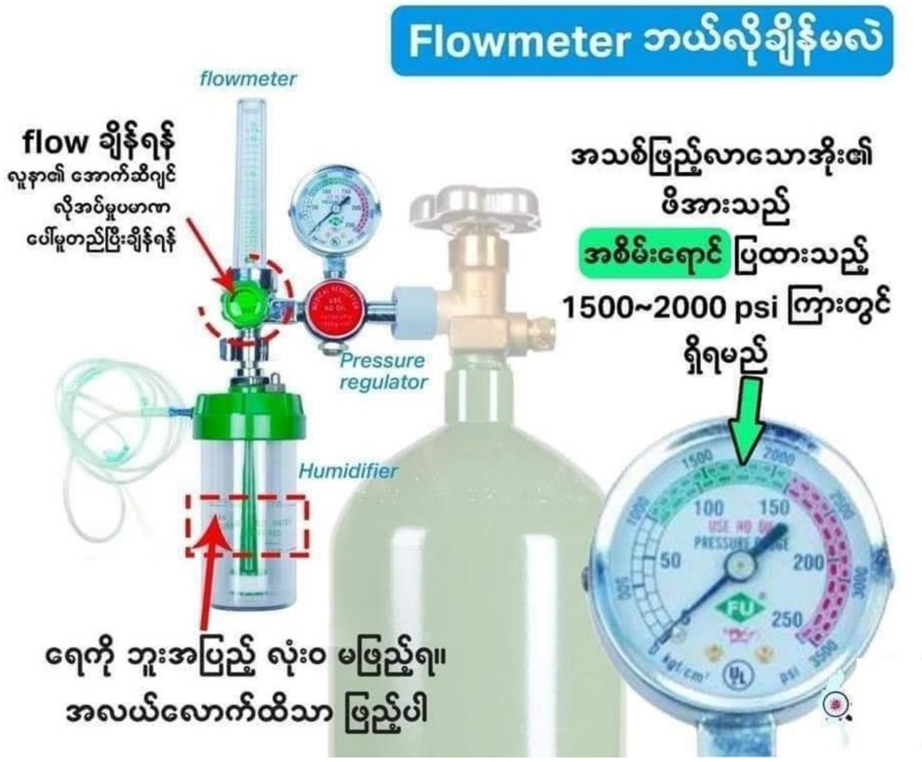
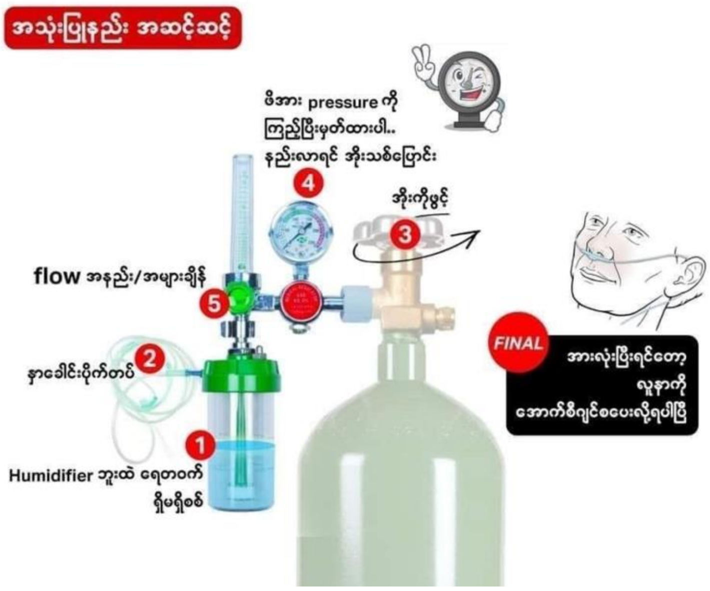


Figure 9: Setting the oxygen cylinder for oxygen therapy



Troubleshooting and corrective maintenance

Table 3 provides some troubleshooting tips for common issues with oxygen cylinders and associated accessories. Refer to user and service manuals for more guidance.

Table 3: Troubleshooting for oxygen cylinders (and associated accessories)

Problem or fault	Possible cause	Solution
No oxygen is flowing	• Empty cylinder.	• Replace cylinder.
	• Flowmeter knob or cylinder flow valve is closed.	• Open valves, and then check meter registers flow.
	• Faulty regulator.	• Close all valves and replace regulator.
Leakage from cylinder or flowmeter	• Cylinder is not connected to pressure regulator properly.	• Tighten all fittings.
	• Faulty or missing washer between regulator and cylinder.	• Replace washer.
	• Flowmeter seal damaged or loose.	• Replace sealing washer and realign flowmeter.
	• Cylinder faulty.	• Label faulty and take appropriate action.
Leakage cannot be located	• Leakage too small to be heard.	• Apply detergent solution (NOT oily soap) to joints. Bubbles will show at leak point. • Clean/replace washer and tighten at that joint.
Flowmeter ball not moving, yet oxygen is flowing	• Faulty flowmeter.	• Close all valves, disconnect flowmeter and clean inside. Reconnect and test. • If problem persists, replace flowmeter.
Pressure gauge does not show pressure, yet oxygen is flowing	• Faulty pressure gauge.	• Replace pressure gauge.

Source: Adapted from *User care of medical equipment: a first line maintenance guide for end users. Strengthening Specialised Clinical Services in the Pacific;* 2015 (https://bmet.ewh.org/handle/20.500.12091/83, accessed 26 April 2019).

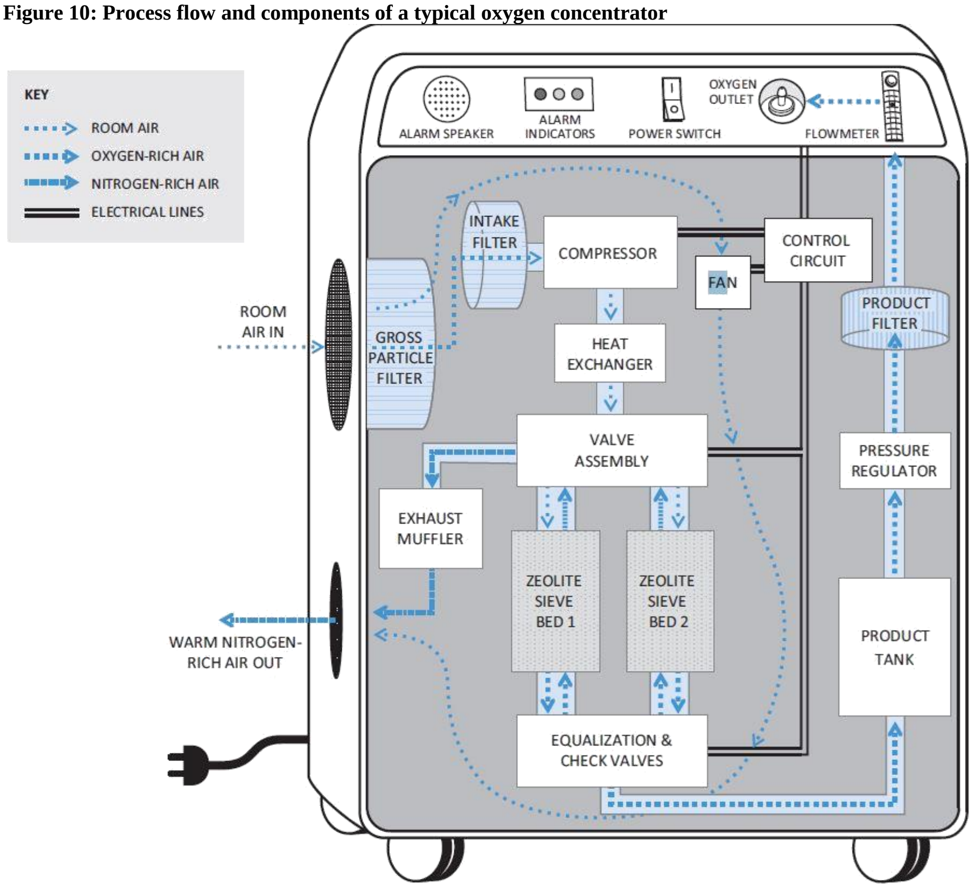
Oxygen Concentrator

- An oxygen concentrator is a self-contained, electrically powered medical device designed to concentrate oxygen from ambient air. Utilizing PSA technology, an oxygen concentrator draws in air from the environment, extracts the nitrogen, and can produce a continuous source of 95.5% concentrated oxygen[1].
- Most concentrators supply oxygen at a concentration of 90–96%. They can provide a continuous supply of oxygen. Oxygen concentrators are portable and can be moved between clinical areas, but they are also often set up to be stationary fixtures in patient areas. Concentrators designed for home care or bedside use are available in models that can deliver maximum flow rates between 5 and 10 L/min.
- Concentrators nevertheless require regular maintenance to ensure proper functioning and a source of continuous power. Concentrators can be run on AC mains power, a power generator or solar power.
- **It is best practice to also have a power-independent oxygen source, such as a cylinder, as a back-up.**
- Most portable oxygen concentrators, however, will last for around **4 to 7 years** or more, depending on how often it was used and how well it was maintained. Maintenance for the average portable oxygen concentrator is very minimal, and usually only consists of cleaning a filter.

How is oxygen concentrator working

Atmospheric air is drawn through a gross particle and intake filter before moving through a compressor. The pressurized air passes through a heat exchanger to reduce the temperature before entering sieve beds that contain zeolite, a mineral material that preferentially adsorbs nitrogen gas (N2) at high pressures. As each sieve bed is depressurized, N2 is released. Valves open to deliver concentrated oxygen into a reservoir where it accumulates, and from which a flowmeter can be used for measured and continuous release of oxygen to the patient at a specified flow rate.

Figure 10: Process flow and components of a typical oxygen concentrator



[1] Note that vacuum pressure swing adsorption (VPSA) is another, newer, technology for oxygen generation that works at much lower pressure and is more energy efficient. Its use in LRS is currently unknown.

Complete system for oxygen delivery based on concentrators requires:

1. Manufacturer and supplier of concentrators
2. Electricity in the hospital: either mains electricity or a generator or solar system to ensure that a sufficient supply of major spare parts is purchased and stored centrally and an adequate supply of minor spare parts, such as air intake filters, is available at each hospital
3. Apparatus to deliver oxygen from the concentrator to the patient, which includes:
   –Flow meter (included in every concentrator)
   –Oxygen delivery tubing
   –Humidifier (Should not use tap water. Use distilled water in the humidifier. Even filtered tap water can still have tiny impurities can cause build up and malfunctions in the oxygen concentrator)
   –Tube to carry oxygen to the patient's face
   –Nasal catheter (or mask) to deliver the oxygen to the patient's airway
4. Person with clinical training to give the correct amount of oxygen, in the correct manner, to the patients who need it (medical person)
5. Person with technical training to maintain the apparatus in good condition and to repair it when necessary (technical person)
6. Adequate budget to ensure the consistent availability of the oxygen supply.

Cleaning and decontamination

Cleaning and decontamination procedures should be followed according to manufacturer recommendations and standard clinical practice. Cleaning can be done easily by the user, including nurses or assistants. No special training is required to clean the oxygen concentrator; the user only needs to be shown how to correctly remove, wash, dry and replace the gross particle filter of the oxygen concentrator. If the environment is particularly dusty or dirty, then the gross particle filter and device exterior must be cleaned more frequently, at least twice per week and following every dust storm.

In general, the filter can be cleaned with a mild detergent, rinsed with clean water, dried and replaced. A spare filter is inserted if the concentrator is being used during cleaning. The gross particle filter may be reused after each cleaning but should be replaced if visible degradation occurs. Users should refer to the manufacturer for cleaning and replacement protocols.

Similarly, the exterior of the oxygen concentrator should be wiped according to the manufacturer's instructions, disconnected from the power supply. Manufacturers generally recommend cleaning using a mild detergent or cleaning agent. Allow the solution to remain on the surface for 10 minutes and then rinse off and dry.

When humidifiers are used, they should have clean water replaced daily and be soaked in dilute bleach for 15 minutes weekly (and between patients), and then dried.

Figure 11: Oxygen concentrator outer side view

Maintenance Steps

- Disconnect the power cord from the electrical outlet before you clean the cabinet.
- Do not operate the concentrator without the filters installed, or while filters are wet. These actions could permanently damage the concentrator.
- Clean the whole body: In the condition of power off, make a clean for the outside body by soft towel with little mild household cleaner, and then wipe it up with dry towel, once or twice per month.
- Clean air filter: It is a critical step for daily maintenance to clean intake air filter, at least twice a month. (Detail steps: should follow the user manual)
- Clean secondary filter (compressor filter) according to user manual guidance.
- Clean the humidifier (if the humidifier is prescribed by a physician)
    - Daily:
        - Empty the water from the humidifier.
        - Rinse the humidifier flask under running water.
        - Fill humidifier up to the mask with pure water or distilled water.
    - Regularly (Once a week):
        - Disinfect the humidifier parts by immersing them in a disinfectant solution (in general, using water containing a small amount of chlorine bleach or solution of water and vinegar 10:1).
        - Rinse and dry.
        - Check that the humidifier lid seal is in good condition.

Not appropriate condition for concentrators

1. Ambient temperature up to 40 °C
2. Relative humidity up to 100%
3. Unstable mains voltage
4. Extremely dusty environment
5. Be incapable of delivering an oxygen concentration of less than 70% O2
6. No comprehensive service manual
7. No supply of spare parts for two years' use
8. Not available oxygen cylinder for emergency use.

Oxygen Plant

- **Oxygen plant is also a central oxygen supply system for district level health facilities.** An oxygen plant is a large, onsite, central source of oxygen that is piped directly to terminal units within patient areas. Plants can generate oxygen using PSA technology (similar to concentrators) or by cryogenic distillation. Plants can also be set up to refill cylinders for oxygen distribution or backup oxygen supply; these cylinders can be connected to sub-central manifold systems at the health facility or transported to neighboring health facilities.

(Note: oxygen plants require a reliable source of power. It is best practice to also have cylinders as a backup supply.)

- Pipeline systems 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. The high cost of installing centralized oxygen sources with copper pipelines and the high level of specialized maintenance required currently make these systems of oxygen delivery unsuitable for many district-level hospitals in low resource setting.

Liquid oxygen Tank

Facilities can be equipped with large bulk liquid oxygen tanks that are refilled periodically by a truck from a supplier. The liquid oxygen tank supplies a centrally piped system throughout the health facility by self-vaporization, meaning that a power supply is not required. Although currently an economical option in some locations, liquid oxygen requires high technical knowledge and large, well-ventilated spaces, and can introduce risks in settings with extreme temperature and humidity. It is best practice to also have cylinders as a backup supply.

Oxygen delivery devices

Devices for oxygen delivery differ in cost, efficiency of oxygen use, and ability to provide the requisite fraction of inspired oxygen (FiO2) (i.e. the percentage or concentration of oxygen that a patient inhales). The choice of appropriate delivery device will thus depend on clinical needs and device capabilities.

Nasal cannula: Nasal cannulae, also called nasal prongs

Figure 122: Different types of nasal prongs/ nasal cannula

Nasal prongs

- Device that ends in two short tapered tubes (about 1 cm in length) designed to lie just within the nostrils.
- Standard flow rates through nasal prongs are 0.5–1 L/min for neonates, 1–2 L/min for infants, 1–4 L/min for older children.

Benefit

- ➢ no risk of gastric distension at standard flow rates
- ➢ Humidification is not required with standard oxygen flow rates. (natural protection)
- ➢ Safe oxygen compares to non-invasive method

Risk

- ➢ Slight risk that the airway will become obstructed by mucus

Practical application of nasal prongs

- ➢ The distal prong should fit well into the nostril (premature infants: 1 mm, infants weighing up to 10 kg: 2 mm).
- ➢ **Check first oxygen flow rate BEFORE insertion into nostril.**
- ➢ The prongs should be secured with a piece of tape on the cheeks near the nose.
- ➢ The maximum flow rate without humidification is 1 L/min in neonates, 2 L/min in infants, 4 L/min in preschool children and 6 L/min in schoolchildren.
- ➢ Higher flow rates without effective humidification may cause drying of nasal mucosa, with associated bleeding and airway obstruction.
- ➢ Care should be taken to keep the nostrils clear of mucus to avoid blockage.

Nasal catheter

Figure 13: Nasal Oxygen catheter

- A nasal catheter is a thin, flexible tube that is passed into the nose and ends with its tip in the nasal cavity.
- Nasal catheters are usually well tolerated, and they are unlikely to be dislodged.
- Humidification does not need because the tip of the catheter lies in the nasal cavity.
- Catheters can become blocked with mucus.
- Little risk of displacement into the oesophagus, with a consequent risk of gastric distension.

Practical application of nasal catheters

- ➢ In neonates and infants, 8-French (F) size catheters should be used.
- ➢ It passed for a distance equal to the distance from the side of the nostril to the inner margin of the eyebrow usually reaches the posterior part of the nasal cavity. **Check oxygen flow BEFORE insertion.**

- In infants, this is about 2.5 cm. The tip of the catheter should **not** be visible below the uvula.
- A catheter is easily secured with tape above the upper lip. The maximum flow rate should be set at 0.5–1 L/min for neonates and 1–2 L/min for infants and older children.
- A nasogastric tube should be in place at the same time, in the same nostril so as not to obstruct both nostrils. Higher flow rates without effective humidification may cause drying of the nasal mucosa, with associated bleeding and airway obstruction.

Nasopharyngeal catheters

Figure 1413: Different sizes of nasopharyngeal catheters

- It is passed to the pharynx just below the level of the uvula.
- Oxygen delivery through a nasopharyngeal catheter is the most economical of all the methods. Better oxygenation is achieved with a lower oxygen flow.
- As oxygen given through a nasopharyngeal catheter bypasses the humidifying and warming properties of the nose, effective **external humidification is essential to avoid drying of the pharyngeal mucosa** and to reduce the likelihood of thickened secretions blocking the catheter.
- **Nasopharyngeal catheters can be displaced downwards into the oesophagus and cause gagging, vomiting and gastric distension.**
- Therefore, be limited to situations in which nasal prongs are unavailable, staff are familiar with the insertion technique and with supervision, the oxygen supply is limited and in the case of children in whom cyanosis or oxygen desaturation is not relieved by oxygen given via nasal prongs or a nasal catheter. **severe hypoxia and/or apnoea** (associated with prematurity or bronchiolitis).

Practical application of nasopharyngeal catheters

- Nasopharyngeal catheters are inserted into the nose to a depth 1 cm less than the distance from the side of the nose to the front of the ear (tragus). In infants, this distance is about 7 cm.
- Like nasal catheters, nasopharyngeal catheters can easily be secured in place with tape. In neonates and infants, 8-F catheters should be used.
- The maximum flow rate should be set at 0.5 L/min for neonates and 1 L/min for infants.
- Higher flow rates without effective humidification may cause drying of the nasal mucosa, with associated bleeding and airway obstruction.
- Because there is a risk for gastric distension with downward dislodgement of the catheter tip, a nasogastric tube should also always be in place (passed through the same nostril) to permit rapid decompression of the stomach.
- The catheter should be removed and cleaned at least twice a day. **Humidification is always required.**

Head boxes, incubators, tents and face-masks

Benefit

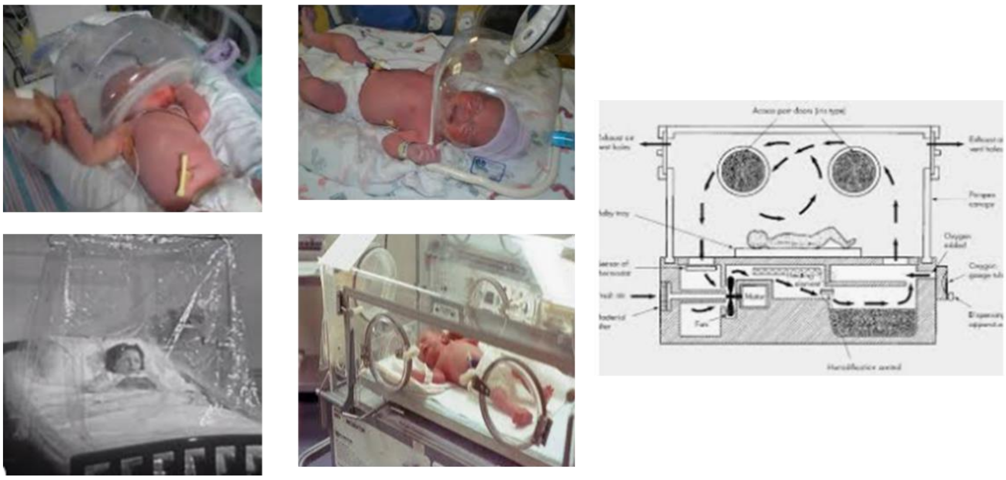
- No risk for airway obstruction by mucus or of gastric distension
- Humidification is not necessary.

Risk / Disadvantage

- **Carbon dioxide toxicity can occur if the flow of oxygen is inadequate**. (due to setting too low, kinking, size of headbox, tube disconnection).
- Flow rate 2–3 L/kg per min is necessary to avoid rebreathing of carbon dioxide in a head box.
- Head boxes, face-masks, incubators and tents all require high oxygen flows to achieve adequate concentrations of oxygen and avoid carbon dioxide accumulation, and they are therefore expensive and wasteful.

- Head boxes and face-masks also interfere with feeding.
- Therefore, these methods are **not recommended for oxygen administration**, especially in settings where oxygen supplies are limited.

Figure 15: Head boxes, incubators, tents



Continuous Positive Airway Pressure (CPAP)

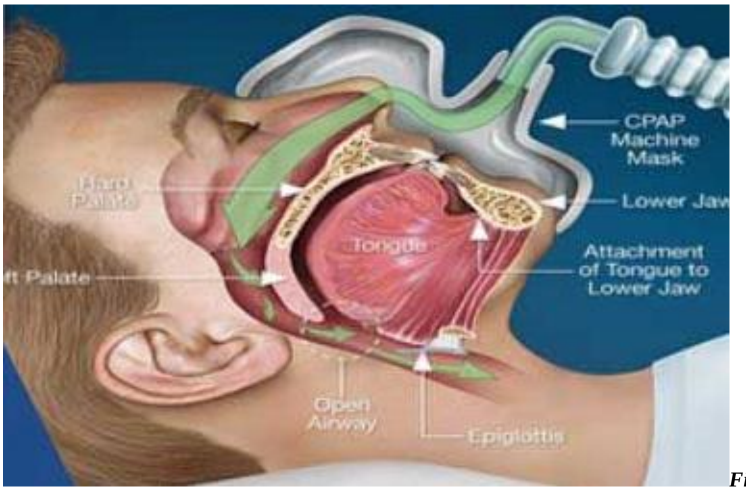


Figure 16: How does CPAP work

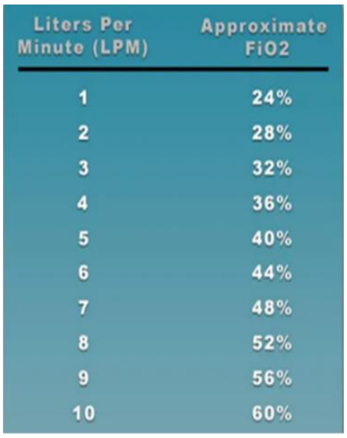
- CPAP consists of delivery of mild air pressure to keep the airways open. CPAP delivers with a variable amount of oxygen to the airway of a spontaneously breathing patient to maintain lung volume during expiration.
- CPAP decreases atelectasis (alveolar and lung segmental collapse) and respiratory fatigue and improves oxygenation.
- Useful for infants with severe respiratory distress, hypoxaemia or apnoea despite receiving oxygen.
- CPAP requires a source of continuous airflow (often an air compressor) and usually requires an oxygen blender connected to an oxygen source.
- CPAP system is available in some hospitals but should be used only when it is reliable, when oxygen systems are in place, where staff are adequately trained and when close monitoring is assured.

Venturi Mask / Venturi devices

- Venturi mask looks like Face Mask but has different function.
- The venturi mask is a medical device to deliver a known oxygen concentration to patients on controlled oxygen therapy. A Venturi mask mixes oxygen with room air, creating high-flow enriched oxygen of a **desired concentration**. It provides an accurate and constant FiO_2.

- The Venturi mask is ideal for a patient with COPD who has a low to moderate oxygen requirement but is at risk for hypercarbia with uncontrolled oxygen therapy. A Venturi mask can deliver accurate oxygen concentrations from 24% to 50% with flow rates from 4 to 10 L/min. This is the most accurate form of oxygen delivery. The addition of humidification is not necessary with this device.

Figure 17: Venturi devices



Liters Per Minute (LPM)	Approximate FiO2
1	24%
2	28%
3	32%
4	36%
5	40%
6	44%
7	48%
8	52%
9	56%
10	60%

Rebreathing Mask: Simple Mask

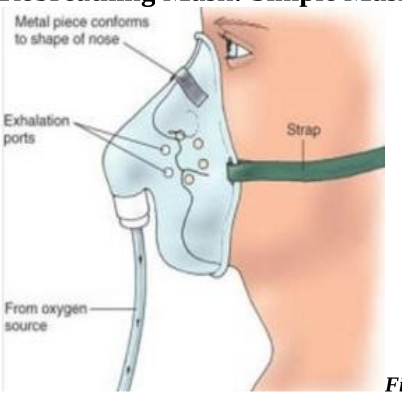


Figure 18: Simple face mask

Components

- **Face mask –** The face mask covers both nose and mouth. There are no valves to limit the flow of air. The exhaled air passes through the exhalation ports on the mask.
- **Elastic cord-** This helps in fixing the mask over the patient's face to cover the nose and mouth.
- **Oxygen supply tube-** Connects the main oxygen supply to mask

Purpose

- The purpose of such a mask is to deliver low flow of oxygen continuously. A simple mask can deliver oxygen at a concentration of about 28-50% [10] at a flow rate of 5- 10 LPM (Litres per minute).

Indication

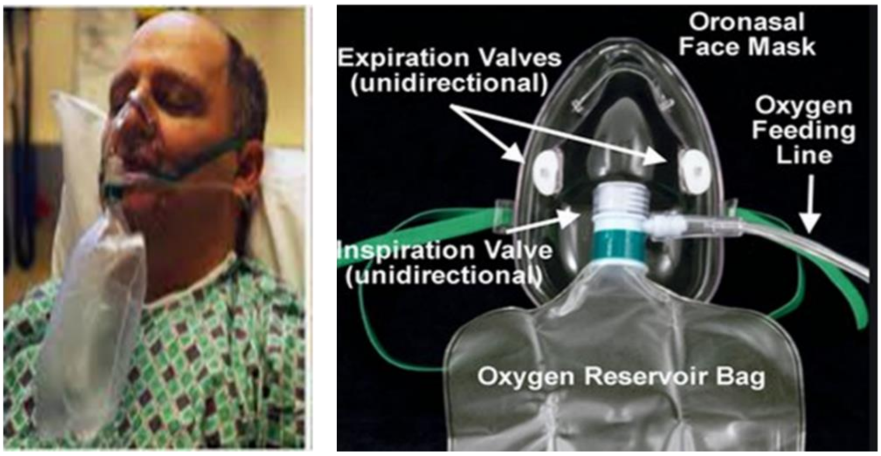
- Mild to moderate respiratory distress

Non-Rebreathing Mask

- A *non-rebreathing mask* is a medical device that helps deliver **oxygen in emergency situations**. It consists of a face *mask* connected to a reservoir bag that's filled with a high concentration of oxygen. The reservoir bag is connected to an oxygen tank. The *mask* covers both your nose and mouth. Non-rebreathing mask has a reservoir bag that is filled with oxygen and as the oxygen depletes due to the breathing, it gets filled up from the oxygen tank.
- This mask is called "non-rebreathing" because, when you're using it, you're unable to inhale anything you exhale. It allows you to breathe only pure oxygen. A **non-rebreathing mask typically delivers 70 to 100**

percent oxygen. Give **10 – 15 Litres per minute**. Pre-fill the reservoir on the mask prior to placing the mask on the patient.

Figure 19: Non-rebreathing mask



Non-rebreathing mask (Hudson mask)

Components

- **Face mask with 2 one-way valves-** The face mask covers both nose and mouth. A one-way valve is present between the reservoir bag and the face mask. Oxygen can only flow from the reservoir bag to the mask. The valve prevents entry of exhaled air into the bag. Another one-way valve is present on the mask which lets the exhaled air to flow out to the atmosphere but prevents atmospheric air entering in. Hence, there is no re-breathing.
- **Elastic cord-** This helps in fixing the mask over the patient's face to cover the nose and mouth with a sufficient sealing so that atmospheric air does not get mixed with the oxygen in the mask.
- **Reservoir bag-** The bag is connected to the main supply of oxygen, an oxygen tank or a central oxygen supply, by an oxygen supply tube. The oxygen received from the tank is collected in the bag and delivered to the patient as he/she inhales, through a one-way valve. Usually the bag is around 1 litre in capacity. With each breath being inhaled, around 1/3rd of the bag gets deflated, and is replaced from the main oxygen supply. Remember that if the bag gets fully deflated, the patient will not have any source of oxygen for inhalation.
- **Oxygen supply tube-** Connects the main oxygen supply to the reservoir bag.

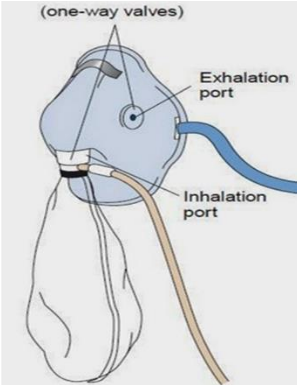
Purpose

- The purpose of such a mask is to deliver high concentration of oxygen without it getting diluted by exhaled air or the atmospheric air which has lower concentrations of oxygen. A non-rebreathing mask can deliver oxygen close to concentration of 80-100%. Generally, an expected concentration of 60-80% is surely delivered to the patient

Indication

- A non-rebreathing mask is only used in patients who can breathe unassisted. The recommended flow rate of oxygen with a non-rebreathing mask is around 12- 15 LPM (Litres per minute). Those who require assistance in breathing should be given mechanical ventilation.
  - Physical trauma
  - Cluster headache
  - Carbon monoxide poisoning
  - Smoke inhalation
  - Chronic airway obstruction

Figure 20: Non-rebreathing mask



Partial Rebreathing Mask

Components

- Face mask with **1 two-way valve-** This is similar to a non-rebreathing mask. The difference is in the valve that connects between the reservoir bag and the face mask. Here, the valve is a two-way valve. This allows the first 1/3rd of breathe that is exhaled to get into the reservoir bag.
- Remaining exhaled air flows out to the atmosphere through the exhalation ports on the mask. The first part of exhaled air is inhaled again from the reservoir bag. The first 1/3rd of exhaled air is the air held in the dead space (space where there is no exchange of air in the lungs), that is the trachea. Since it is the air from the dead space, it contains unused oxygen.
- **Elastic cord-** This helps in fixing the mask over the patient's face to cover the nose and mouth with a sufficient sealing.
- **Reservoir bag-** The bag is connected to the main supply of oxygen, an oxygen tank or a central oxygen supply, by an oxygen supply tube. The oxygen received from the tank along with the first 1/3rd of exhaled air is collected in the bag and delivered to the patient as he/she inhales, through a two-way valve. Usually the bag is around 1 litre in capacity. With each breath being inhaled, around 1/3rd of the bag gets deflated, and is replaced from the main oxygen supply.
- **Oxygen supply tube-** Connects the main oxygen supply to the reservoir bag.

Purpose

- This bag is also used to deliver higher concentrations of oxygen which is more than that could be received through a simple mask. Further, this also reduces the oxygen consumption as the unused oxygen within the dead space can be reused. The partial rebreathing can deliver oxygen up to a concentration of 40-70% at a flow rate of 5-15 LPM (litres per minute)

Indication

- Hypoxia
- Respiratory disease
- Cardiac disease
- Shock
- Trauma
- Severe blood loss
- Seizures

Figure 141: Non-rebreathing mask Vs Partial rebreathing

Table 4: Non-rebreathing mask Vs Partial rebreathing mask Vs Simple Mask (Re-breathing)

TYPE OF MASK	ADVANTAGES	DISADVANTAGES	FLOW RATE	OXYGEN ACHIEVED
Simple Mask	**Less Expensive Less chance of non- availability of air to breath**	**Low concentrations of oxygen Interferes with eating or talking.**	5-10 LPM	28-50%
Non-rebreathing mask	**Highest concentration of oxygen can be delivered. Can be used in severe hypoxia**	**Expensive Can be uncomfortable Malfunction can lead to suffocation.**	12-15 LPM	80-100%
Partial rebreathing mask	**High oxygen concentration can be delivered**	**Can interfere with eating and talking**	5-15 LPM	40-70%

Figure 22: Oxygen delivery devices and the oxygen flow rate

Titrate O_2 flow with SpO_2. Do not waste oxygen.

Nasal prongs O_2 1 – 5 L/min	→	Fi O_2 28% - 40% child and adult
Nasopharyngeal catheter O_2 1 – 2 L/min	→	Fi O_2 45% - 60% infant and child
Oxygen face mask O_2 6 – 10 L/min	→	Fi O_2 44% - 60% child and adult
Oxygen face mask reservoir bag O_2 10 – 15 L/min	→	Fi O_2 60% - 95%
Venturi oxygen face mask O_2 4 – 15 L/min *(for Venturi O_2 flow rate Fi O_2 device specifc)*	→	Fi O_2 24% - 60%

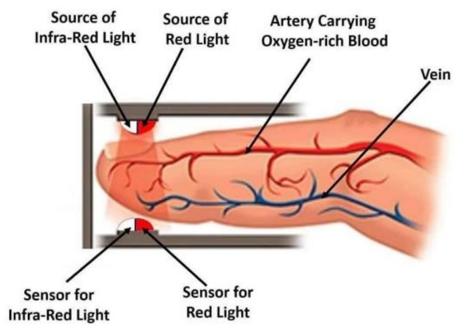
Management of oxygen saturation

Pulse oximeter

- Pulse oximeter is the most accurate, non-invasive and cost effective method for detecting hypoxaemia.
- Pulse oximeters are the accepted global standard for detecting and monitoring hypoxaemia, which is an abnormally low level of oxygen in the blood.
- It is used to measure the percentage of oxygenated haemoglobin in arterial blood (SpO2).

How is pulse oximeter working

- Pulse oximeters use the principle of differential light absorption to determine SpO2.
- A sensor (also called a probe) is applied to an area of the body (e.g. a finger, toe or earlobe) and transmits different wavelengths of light from light-emitting diodes (LEDs) through the skin and into the tissue. These wavelengths are differentially absorbed by the blood's oxyhaemoglobin (HbO2), which is red, and deoxyhaemoglobin, which is blue.
- A photodetector in the sensor (opposite to the LED) converts the transmitted light into electrical signals proportional to the absorbance.
- The pulse oximeter's microprocessor processes these signals and derives a SpO2 reading

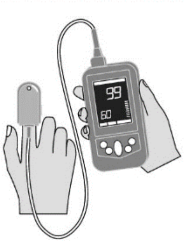


Types of pulse oximeter

Pulse oximeter probes should be chosen appropriately for the desired mode of use. Based on application and design sophistication, pulse oximeters fall into three distinct groups:

(1) Self-contained fingertip or finger clip oximeter

Fingertip oximeters are ultra-compact, battery powered pulse oximeters integrated into a finger/toe clip mounted directly on the patient, typically intended for personal use. Fingertip oximeters have the lowest upfront cost of the three types and are suitable for spot checking.



(2) Portable handheld oximeter

This is a portable unit with a display screen and attached cable and probes, which come in varied sizes for neonates, infants, children and adults. The display screen typically shows a numeric digital display and a waveform and may include alarm settings. Handheld pulse oximeters can be used for spot checking or continuous monitoring. If used for continuous monitoring the alarm function must be activated.

(3) Tabletop or stand-alone oximeter

A stationary (e.g. tabletop, wall- or pole-mounted) device that may monitor oxygen saturation only or may incorporate other physiological parameters such as capnography, blood pressure monitoring and temperature. Well suited for a variety of applications, these devices normally include alarm settings and trends and are normally used for continuous monitoring in secondary and tertiary health care settings.

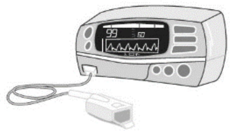
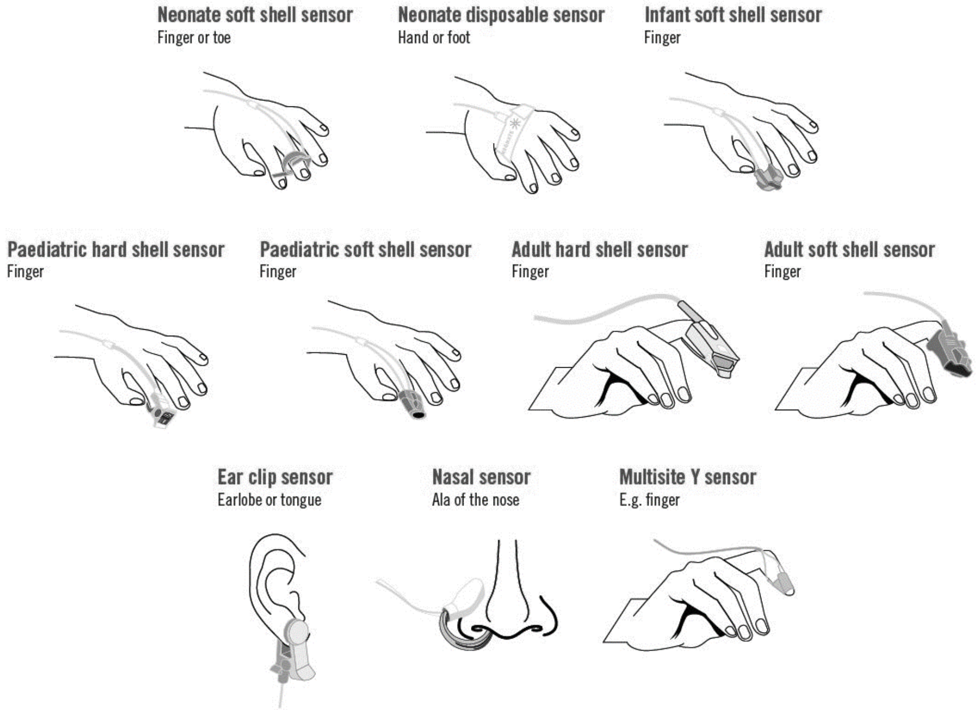


Figure 153: Different types of pulse oximeter

Features of pulse oximeter

- Alarm: A low-battery alarm is essential to alert health workers when the machine should be plugged into a power supply.
- Sensors: A wide range of probes is available in different sizes. It is important to choose a sensor probe that is appropriate to the size of the patient.
- Probe: sensor house

Different types of SpO_2 sensor/probe cable types



Effect of pulse oximetry reading

- Blood pressure generally needs to be >80 SBP
- Disturbance of vascular flow from any cause
- Elevation with respect to the heart
- Compression by the probe
- Bright light interferes the probe
- Heart Rate extremes <30 or >200
- Cold
- Fear (Endogenous catecholamine)
- Medications

Daily monitoring

- At least once/twice a day, all children who are receiving oxygen should be tested by pulse oximetry.
- Take the child off oxygen (unless he or she has severe respiratory distress).
- Monitor oxygen using pulse oximeter.
- If the SpO2 is > 90% 10–15 min after the child has been taken off oxygen, leave the oxygen off.
- Check the SpO2 again in 1 hr (to detect late desaturation)
- If the SpO2 is < 90%, resume oxygen.
- Each day, record the SpO2 and pulse rate on the patient's monitoring chart, and record beside it whether there is a sufficient supply of oxygen.
- Use pulse oximetry regularly to monitor all children who show worsening respiratory distress, apnoea, any deterioration in consciousness or any other clinical sign of deterioration.

References

1. Manual for Ethnic Health Clinic Service Providers, Community Partners International, May 2021.

2. Clinical management of suspected or confirmed Covid-19 disease Version 5 (24th August 2020) by Department of Health, Republic of South Africa and National Institute for Communicable Diseases, Division of the National Health Laboratory Services.

3. World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected 2020 [Available from: https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratoryinfection-when-novel-coronavirus-(ncov)-infection-is-suspected.

4. COVID-19 Brief Guideline by Medical Action Myanmar, July 2021.

5. WHO-UNICEF technical specifications and guidance for oxygen therapy devices. Geneva: World Health Organization and the United Nations Children's Fund (UNICEF), 2019 (WHO medical device technical series). Licence: CC BY-NC-SA 3.0 IGO.

6. https://www.tgh.org/sites/default/files/oxygen-duration-nugget-.pdf

7. Oxygen Therapy with Limited Resources: COVID-19 Severe Acute Respiratory Infection (SARI) and Pneumonia. 2020

8. Oxygen for life. Oxygen System: Installation Guide: Setting up a ward oxygen system: Installation Guide. Version 2.1 April 2020.

9. BTS guideline for emergency oxygen use in adult patients. British Thoracic Society. June 2008.
10. https://www.rch.org.au/rchcpg/hospital_clinical_guideline_index/Oxygen_delivery/#Indications

11. Oxygen therapy for children. WHO. 2016

12. Oxygen-delivery-devices_Hemanth_Oct-2017

13. High Flow Nasal Cannula (HFNC) – Part 1: How It Works. Frank Lodeserto MD REBEL CME, REBEL Crit Medical Category: Thoracic and Respiratory. 2018

14. https://www.easycalculation.com/medical/oxygen-delivery-flow-rate-chart.php

15. World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected 2020 [Available from: https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected.

16. International Journal of Infectious Diseases Volume 98

Annex 1: Estimation of oxygen time available while using oxygen cylinder

Important note: The following tables shows the estimated time of the usage of oxygen cyclinder based on the tank pressure. The time available is calculated mainly based on practical experiences and the authors cannot provide the references and clear formulas and conversion factors currently.

OXYGEN AVAILABLE TIME TABLE										
Cylinder Size : 40 L										
Tank Pressure (psi)	**Flow rate (L/min)**									
	1 L/min	**2 L/min**	**3 L/min**	**4 L/min**	**5 L/min**	**6 L/min**	**7 L/min**	**8 L/min**	**9 L/min**	**10 L/min**
2000 psi	3:03:33	1:13:46	1:01:11	18:53	15:06	12:35	10:47	9:26	8:23	7:33
1800 psi	2:18:40	1:09:20	22:13	16:40	13:20	11:06	9:31	8:20	7:24	6:40
1500 psi	2:05:20	1:02:40	17:46	13:20	10:40	8:53	7:37	6:40	5:55	5:20
1400 psi	2:00:53	1:00:26	16:17	12:13	9:46	8:08	6:59	6:06	5:25	4:53
1200 psi	1:16:00	20:00	13:20	10:00	8:00	6:40	5:42	5:00	4:26	4:00
1000 psi	1:07:06	15:33	10:22	7:46	6:13	5:11	4:26	3:53	3:27	3:06
800 psi	22:13	11:06	7:24	5:33	4:26	3:42	3:10	2:46	2:28	2:13
600 psi	13:20	6:40	4:26	3:20	2:40	2:13	1:54	1:40	1:28	1:20
Note: The available time is [(day) : hour : minutes] format										
Note: This chart shows approximate time available for the use of oxygen cylinder but it has some variation on the real situation. So, you have to check on the flow meter, if the PSI value arrive to 400 psi, you have to prepare another oxygen cylinder.										

OXYGEN AVAILABLE TIME TABLE										
Cylinder Size : 20 L										
Tank Pressure (psi)	Flow rate (L/min)									
	1 L/min	2 L/min	3 L/min	4 L/min	5 L/min	6 L/min	7 L/min	8 L/min	9 L/min	10 L/min
2000 psi	1:13:46	18:53	12:35	9:26	7:33	6:17	5:23	4:43	4:11	3:46
1800 psi	1:09:20	16:40	11:06	8:20	6:40	5:33	4:45	4:10	3:42	3:20
1500 psi	1:02:40	13:20	8:53	6:40	5:20	4:26	3:48	3:20	2:57	2:40
1400 psi	1:00:26	12:13	8:08	6:06	4:53	4:04	3:29	3:03	2:42	2:26
1200 psi	20:00	10:00	6:40	5:00	4:00	3:20	2:51	2:30	2:13	2:00
1000 psi	15:33	7:46	5:11	3:53	3:06	2:35	2:13	1:56	1:43	1:33
800 psi	11:06	5:33	3:42	2:46	2:13	1:51	1:35	1:23	1:14	1:06
600 psi	6:40	3:20	2:13	1:40	1:20	1:06	0:57	0:50	0:44	0:40
Note: The available time is [(day) : hour : minutes] format										
Note: This chart shows approximate time available for the use of oxygen cylinder but it has some variation on the real situation. So, you have to check on the flow meter, if the PSI value arrive to 400 psi, you have to prepare another oxygen cylinder.										

OXYGEN AVAILABLE TIME TABLE										
Cylinder Size : 15 L										
Tank Pressure (psi)	**Flow rate (L/min)**									
	1 L/min	**2 L/min**	**3 L/min**	**4 L/min**	**5 L/min**	**6 L/min**	**7 L/min**	**8 L/min**	**9 L/min**	**10 L/min**
2000 psi	1:04:20	14:10	9:26	7:05	5:40	4:43	4:02	3:32	3:08	2:50
1800 psi	1:01:00	12:30	8:20	6:15	5:00	4:10	3:34	3:07	2:46	2:30
1500 psi	20:00	10:00	6:40	5:00	4:00	3:20	2:51	2:30	2:13	2:00
1400 psi	18:20	9:10	6:06	4:35	3:40	3:03	2:37	2:17	2:02	1:50
1200 psi	15:00	7:30	5:00	3:45	3:00	2:30	2:08	1:52	1:40	1:30
1000 psi	11:40	5:50	3:53	2:55	2:20	1:56	1:40	1:27	1:17	1:10
800 psi	8:20	4:10	2:46	2:05	1:40	1:23	1:11	1:02	0:55	0:50
600 psi	5:00	2:30	1:40	1:15	1:00	0:50	0:42	0:37	0:33	0:30
Note: The available time is [(day) : hour : minutes] format										
Note: This chart shows approximate time available for the use of oxygen cylinder but it has some variation on the real situation. So, you have to check on the flow meter, if the PSI value arrive to 400 psi, you have to prepare another oxygen cylinder.										

OXYGEN AVAILABLE TIME TABLE										
Cylinder Size : 10 L										
Tank Pressure (psi)	**Flow rate (L/min)**									
	1 L/min	**2 L/min**	**3 L/min**	**4 L/min**	**5 L/min**	**6 L/min**	**7 L/min**	**8 L/min**	**9 L/min**	**10 L/min**
2000 psi	18:53	9:26	6:17	4:43	3:46	3:08	2:41	2:21	2:05	1:53
1800 psi	16:40	8:20	5:33	4:10	3:20	2:46	2:22	2:05	1:51	1:40
1500 psi	13:20	6:40	4:26	3:20	2:40	2:13	1:54	1:40	1:28	1:20
1400 psi	12:13	6:06	4:04	3:03	2:26	2:02	1:44	1:31	1:21	1:13
1200 psi	10:00	5:00	3:20	2:30	2:00	1:40	1:25	1:15	1:06	1:00
1000 psi	7:46	3:53	2:35	1:56	1:33	1:17	1:06	0:58	0:51	0:46
800 psi	5:33	2:46	1:51	1:23	1:06	0:55	0:47	0:41	0:37	0:33
600 psi	3:20	1:40	1:06	0:50	0:40	0:33	0:28	0:25	0:22	0:20
Note: The available time is [hour : minutes] format										
Note: This chart shows approximate time available for the use of oxygen cylinder but it has some variation on the real situation. So, you have to check on the flow meter, if the PSI value arrive to 400 psi, you have to prepare another oxygen cylinder.										

Annex 2: Maintenance of Oxygen Concentrator