Guide to SEARO-IMAI oxygen survey at district and regional hospitals

Please note this survey was developed collaboratively by the Health Emergency Programme of the Regional Office for the World Health Organization's South East Asia Region (WHO-SEARO) and the Integrated Management of Adult and Adolescent Illness (IMAI) Alliance, based on previous IMAI tools.

The survey is in Excel so that it can be easily and quickly adapted and administered, with in-built formulae for calculations. Please note there are 8 tabs/sheets in the file (all may not be visible at first).

Adaptation during initial country use

A quick pilot in one district hospital is useful to make sure that there are not changes needed for the available equipment in country, easy to fill out and most effective.

(1) The most likely country adaptation relates to cylinder size as these are not internationally consistent. In Table 1 below, we have reproduced the generic oxygen cylinder table. The lettering may not be consistent and you may have other sizes.

    If you are not sure of what size a common cylinder is, you can measure its height. You can also ask your procurement team or those who refill the cylinders to get the actual liters in each cylinder. Clinicians often do not know this.

    If you add a row with a new cylinder or change the cylinder size, change or add this to the formula for calculating total liters/ward for each column (multiply number of cylinders x number of liters for each size of cylinder; O2 Survey page 2, section 2).

(2) Availability of trained staff for various tasks (O2 Survey page 3). You may need to add or reword the cadre names working at the hospital.

(3) Oxygen concentrator maintenance by a technician (O2 Survey page 3) – there may be other relevant questions based on common type of concentrator and how your concentrators are maintained, that you want to add.

How to carry out the survey- for the hospital surveyor

Who: Ideally pages 1-4 of the survey can be done by the hospital manager or senior administrator, joined by a clinician and/or respiratory therapist.

Pages 5-6 are for a technician to complete.

Page 7 allows calculation of how much oxygen might be required for different numbers of adult patients with COVID-19.

How to administer: Print the first two pages (take out any numbers or x's in the blanks). Each sheet is printed separately from the Excel and should fit on a single A4 page.

Fill out the survey by walking through the ER and all wards, counting oxygen sources and delivery devices. Look at rosters and staff lists to count the number of staff and discuss with the senior clinicians about staff training. Make notes where training or retraining is needed.

Instructions for several specific questions

Page 1: General hospital questions

5.1 If there is piped oxygen from an oxygen plant or liquid oxygen, the litres/day may be hard to find out—contact a technician who has the manufacturer manual.

Page 2: Oxygen (and oxygen administration supplies)

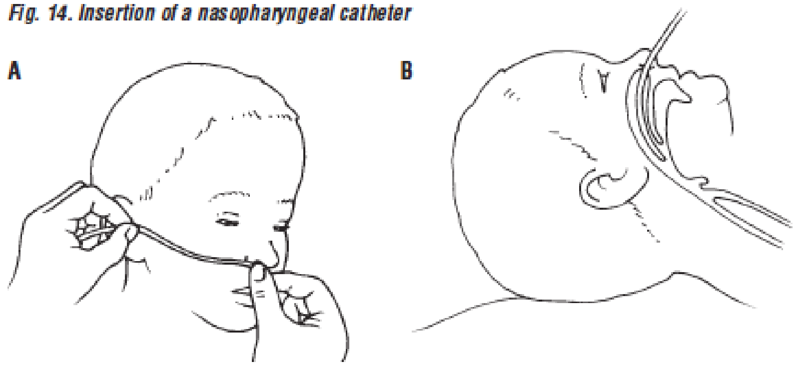
Count only functional equipment.

Some illustrations or explanations to clarify several items:

1.1-Nasal cannula

1.2-Neonate/ Infant nasopharyngeal catheters—8 French catheter[1]

Fig. 14. Insertion of a nasopharyngeal catheter

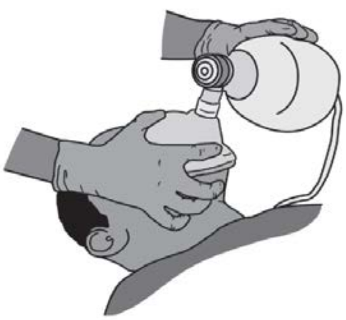


1.3-Face masks

[1] Illustration from WHO: Oxygen therapy for children, 2016

1.4-Face masks with reservoir bag

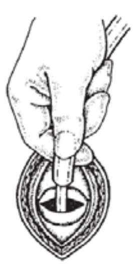
1.5- Bag-valve mask adult



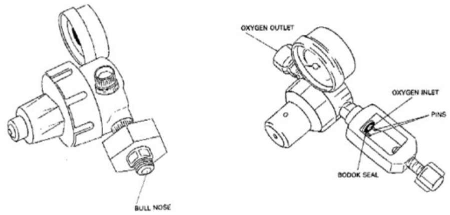
1.7-Endotracheal tube within intubation set

1.10-Cricothyroidotomy tray

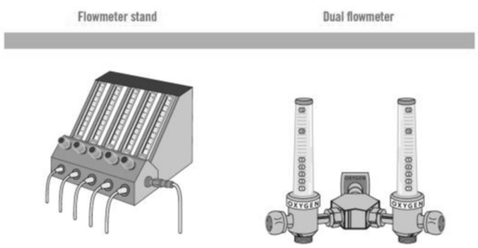
Tray with all the equipment to perform a surgical cricothyroidotomy (in a patient with life threatening upper airway obstruction- includes #22 or #23 scalpel blade, curved artery forceps, thin introducer (or nasogastric tube), or endotracheal tube.



1.11;1.12-Regulator (bull nose; pin index)



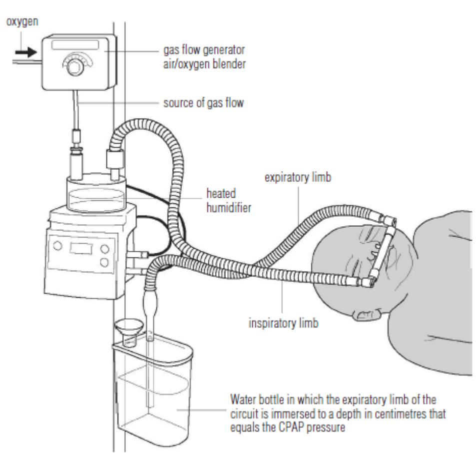
1.13-Flow splitter



1.14;1.15;1.16-Mechanical ventilator

Transportable, portable   Intensive Care

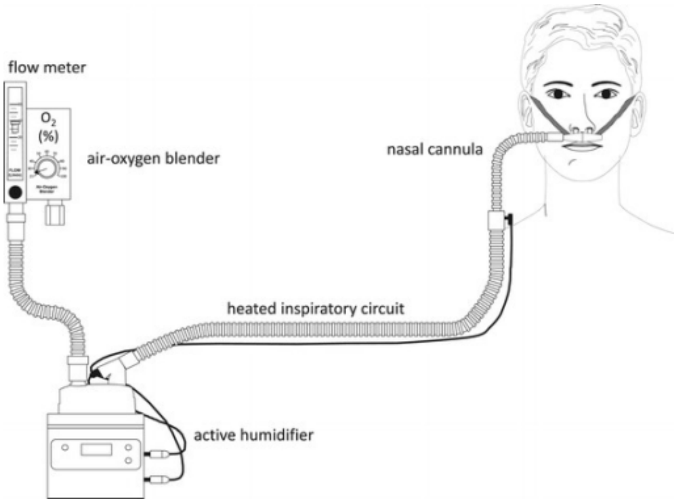
1.17-BubbleCPAP[2]



[2] Illustration from WHO: Oxygen therapy for children, 2016

1.18;1.19-CPAP/BiPAP

1.17-High flow nasal oxygen-adult, with humidifier



Page 8:1h-CPAP/BiPAP hose

Page 8:1h-CPAP/BiPAP side connector for oxygen addition to hose

Page 3: Maintenance and training

1.2 Concentrator maintenance by a technician and whether there are spare parts may be difficult for clinicians assisting with the survey to determine. The hospital manager or person in charge of equipment may know.

3b. *Cleaning: warm soapy water, dried with absorbent towel.*

3c. *Soak in a mild antiseptic solution for 15 minutes, rinse with clean water, air dry.*

3d*. The water should be either distilled or tap or other clean water that has been boiled- so that it is sterile.*

4. Enter data on number of staff with appropriate training for delivering oxygen therapy

5. Determine if the hospital has enough electrical power and whether there is back-up power (generator, solar panel + batteries) to support current and increasing oxygen capacity at the facility e.g. concentrators

Data entry

Enter your hospital's data into the soft copy of the excel.

Yes/no questions: Where there is a check under Yes, enter 1. Where there is a check under No, enter 0.

Questions asking for numbers of items: these will be automatically added up by row.

Page 2 will automatically calculate the total oxygen available by concentrators and in cylinders.

If there is piped oxygen from an oxygen plant, liquid oxygen or manifold cylinders, the total oxygen available is based on the daily capacity of that system plus the total from any other concentrators and cylinders.

What does the oxygen total at the bottom of page 2 of the survey mean for capacity to treat adult severely ill patients?

See table on page 7 of the survey, and oxygen requirements for adults in Annex A of this Guide.

The summary total at the bottom of page 2 of the survey can be used to estimate how many adults in respiratory distress can be treated for one day.

> This is based on the oxygen flow rate, with the current oxygen sources in your hospital- **if** all cylinders full, all concentrators working or a functional oxygen plant or other large source for piped oxygen.
>
> After cylinders are used up, calculations for subsequent days rely on concentrators and refilled cylinders, factoring in time to refill (in the absence of piped oxygen from an oxygen plant, liquid oxygen etc).

The first table on page 7 shows calculations for the one-day requirement of a patient receiving various liters/minute, where this is known. Enter an estimate of the number of patients at various flow rates to estimate total oxygen required, then compare this with the total oxygen available. Divide the total oxygen available by the total required for the day to determine how many days the oxygen supply could last for this number of patients with these oxygen flow requirements.

The second table on page 7 allows estimation of how much oxygen would be required for possible numbers of adults in your area diagnosed with COVID-19. Entering a predicted total number of adults under 'Patients' will automatically estimate the number with severe and critical COVID-19, and total oxygen requirements. See Annex A of this Guide for a summary of assumptions and calculations used to inform these figures.

The oxygen cylinder table presents duration of oxygen from each full single cylinder for various liters/minute needed by a patient in respiratory distress.

What can be done about very limited oxygen supply, inadequate maintenance or lack of trained staff?

Keep the results from each district hospital separate. Summarize the results for each surveyed hospital, in terms of total available oxygen, oxygen-giving equipment, maintenance of concentrators and humidifiers, etc.

Summarize deficiencies which:

- Require more total oxygen capacity (in liters/day for concentrators and plants; in total liters available for cylinders)
- Require more cylinders/concentrators (not just to increase total liters/day)
- Requires functional generator (or solar panel + battery) so capacity is sufficient for prolonged, substantial use- e.g. for increased number of concentrators
- Can be corrected by more regular maintenance
- Can be corrected by more training

etc

These can then be summarized regionally and/or nationally and a plan developed to solve these. If not all district hospitals have been surveyed, one could extrapolate the results to cover the likely requirements of additional district hospitals expected to handle cases of COVID-19 or other SARI.

Actions following this assessment could include:

- Proposals to acquire more oxygen or oxygen-delivery equipment, such as more concentrators or cylinders.
- Arranging maintenance or repair of existing equipment.
- Training/re-training of staff to address gaps in competency identified.

- Reallocation of oxygen cylinders or concentrators from one hospital to another that is more likely, or has been designated, to see patients with COVID-19, or to a new/temporary SARI treatment center.
- Deciding on a proposed maximum number of COVID-19 patients to be admitted – especially if one hospital is a primary COVID/SARI center, with specified backup hospitals.
- Deciding on how many days patients with critical disease should be kept in a hospital, before considering transfer to a central or regional hospital (though this will also depend on other factors).

The survey can also be conducted in central and regional/provincial hospitals but will be more complex in those with ICUs; total oxygen available can still be calculated. Additionally, there are additional essential equipment and supplies for an ICU that are not included in this survey. This survey was designed for the district hospital without an ICU.

Table 1 (from the WHO IMAI Quick Check and emergency treatments): Cylinder size and run-time according to flow rate

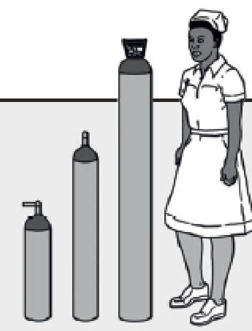
LITRES IN FULL O_2 TANK

BY HEIGHT OF TANK/CYLINDER LETTER

Rate of oxygen administration:

Top row: How long will a tank of this size last.

Bottom row: How many tanks required for 24 hours of oxygen administration.



Rate of oxygen administration for one patient	O_2 tank **C** 170 litres 36 cm	O_2 tank **D** 340 litres 49 cm	O_2 tank **E** 680 litres variable	O_2 tank **F** 1360 litres 1 meter	O_2 tank **G** 3400 litres 1.5 meter	O_2 tank **H** 4100 litres 1.5 meter	O_2 tank **J** 6800 litres 1.45 meter
2 litres/min	1 hr 25 min	2 hr 50 min	5 hr 40 min	11 hr 20 min	28 hr 20 min	34 hr 10 min	56 hr
	16 tanks	8 ½ tanks	4 tanks	2 tanks	1 tank	0.7 tanks	½ tank
5 litres/min	34 min	1 hr 8 min	2 hr 16 min	4 hr 30 min	11 hr 20 min	13 hr 40 min	23 hr
	48 tanks	21 tanks	10 tanks	5 tanks	2 tanks	1.8 tanks	1 tank
8 litres/min	21 min	42 min	1 hr 24 min	2 hr 50 min	7 hr	8 hr 32 min	14 hr
	72 tanks	34 tanks	17 tanks	8 tanks	4 tanks	2 .8 tanks	2 tanks
10 litres/min	17 min	34 min	1 hr 8 min	2 hr 16 min	5 hr 40 min	6 hr 50 min	11 hr
	96 tanks	42 tanks	21 tanks	10 tanks	4 tanks	3.5 tanks	2.2 tanks

Annex A: Calculation of oxygen requirement estimates for patients with COVID-19

Estimation

The table below shows estimates of oxygen requirements per patient of each clinical severity group. The total daily and overall supply of oxygen in your hospital (from page 2 of the survey) can be used to estimate how many patients could be managed per day, and for the duration of their stay in hospital. This estimation uses several assumptions: see below.

COVID-19 severity	Oxygen required per minute	Oxygen required per day (minute x1440)	Oxygen required per admission (day x10)
Non-severe	0	0	0
Severe	5 liters	7,200 liters	72,000 liters
Critical	50%: 15 liters 50%: 48 liters	50%: 21,600 liters 50%: 69,120 liters Mean = 90,720/2 = 45,360 liters	453,600 liters

Calculation

If 100 adults are confirmed to have COVID-19 in a given area, available data suggest that 20 will have severe COVID-19 (20% of confirmed cases), and a further 5 will have critical disease (5% of confirmed cases). NOTE: this is **not** 20 or 5 of 100 admitted to hospital, but of 100 **receiving a confirmed COVID-19 diagnosis in a part of your country,** eg a district or state.

So, in the table below, if the total number of adults in your area with confirmed COVID-19 (N_T) are entered into the top left cell, other cell values can be calculated from this, to give an expected number of patients admitted with severe COVID-19 (N_S), number with critical COVID-19 (N_C) and then daily and per-admission oxygen requirements for these, and the total.

Page 7 in the Excel file contains a similar table, which allows automated calculation using formulae.

Patient severity	Patients	Estimated O_2 liters per day	Estimated O_2 liters per admission
Total adults with COVID-19 in your area	N_T	$Oxygen_{DT} = Oxygen_{DS} + Oxygen_{DC}$	$Oxygen_{AT} = Oxygen_{AS} + Oxygen_{AC}$
Estimated number with severe COVID-19	$N_S = N_T \times 0.2$	$Oxygen_{DS} = N_S \times 7200$	$Oxygen_{AS} = N_S \times 72000$
Estimated number with critical COVID-19	$N_C = N_T \times 0.05$	$Oxygen_{DC} = N_C \times 45360$	$Oxygen_{AC} = N_C \times 453600$

Examples

The tables below show example scenarios.

Example 1: 100 adults in a district have confirmed COVID-19 in 1 week.

Patient severity	Patients	O2 liters per day	O2 liters per admission
Total adults with COVID-19 in your area	**100**	144,000 + 230,400 = **370,800**	1,440,000 + 2,304,000 = **3,708,000**
Estimated number with severe COVID-19	100 x 0.2 = **20**	20 x 7200 = **144,000**	20 x 72,000 = **1,440,000**
Estimated number with critical COVID-19	100 x 0.05 = **5**	5 x 45360 = **226,800**	5 x 453,600 = **2,268,000**

Example 2: 5000 adults in a district have confirmed COVID-19 in 2 weeks.

Patient severity	Patients	O2 liters per day	O2 liters per admission
Total adults with COVID-19 in your area	**5000**	7,200,000 + 11,520,000 = **18,540,000**	7,200,000 + 11,520,000 = **185,400,000**
Estimated number with severe COVID-19	5000 x 0.2 = **1000**	1000 x 7200 = **7,200,000**	1000 x 72,000 = **72,000,000**
Estimated number with critical COVID-19	5000 x 0.05 = **250**	250 x 45360 = **11,340,000**	250 x 453,600 = **113,400,000**

Assumptions

Proportion of patients with COVID-19 requiring oxygen therapy

Data from China suggest 14% of patients with COVID-19 have severe disease [Wu JAMA 2020], whereas Italy's figures suggest 22% [https://www.epicentro.iss.it/coronavirus/sars-cov-2-sorveglianza-dati; accessed 29th March 2020]. We could assume that 20% of adults will have severe disease. Critical disease was observed in 5% in the large Chinese cohort, and 3% in Italy.

Non-severe COVID-19

Non-severe disease is characterized by lack of oxygen requirement, so in theory such patients should not need oxygen, unless they deteriorate after presentation/admission to hospital.

Severe COVID-19

Severe COVID-19 pneumonia is defined for adults as "fever or suspected respiratory infection, plus one of the following: respiratory rate > 30 breaths/min; severe respiratory distress; or SpO2 ≤ 93% on room air". For adults without chronic respiratory disease, oxygen therapy at 5-10 liters/minute would be appropriate. Assuming an average of 5 liters/minute [WHO Essential supplies calculator- COVID-unpublished April 2020], **each patient will on average require 7,200 liters of oxygen per day**.

Length of stay for severe disease was reported in China as 10 days by Zhou et al [Lancet 2020] and 13 days by Guan et al [NEJM 2020]. Assuming 10 days, to allow for variable oxygen requirement during the admission, **each patient may require 10 x 7,200 = 72,000 liters of oxygen per admission**.

Critical COVID-19

Critical COVID-19 can manifest as acute respiratory distress syndrome, sepsis or septic shock. Many of these patients will require high-flow oxygen. Duration of stay in the ICU was 8 days in the Zhou et al cohort, so we assume these patients will need oxygen for 10 days. These patients need significant oxygen support: around 50% will need an average of 15L/minute, but the 50% requiring mechanical ventilation and high-flow oxygen, this will increase to an average of 48L/minute [WHO Essential supplies calculator- COVID- unpublished April 2020]. This would equate to 50% requiring 21,600 liters and 50%: 69,120 liters, with a mean average of **~45,360 liters per day, and 453,600 liters for a 10-day admission**.