Liberia Oxygen Assessment

January 2021

MINISTRY OF HEALTH
Republic of Liberia

CLINTON HEALTH ACCESS INITIATIVE

Table of Contents

List of Figures

List of Tables

Background

Oxygen therapy (or respiratory care) can be used to treat any form of hypoxemia—abnormally low level of oxygen in the blood—regardless of its underlying cause, and has the potential to reduce disease burden among many patient groups. For example, oxygen can be used to manage a range of complications in newborns, children, and pregnant women, including but not limited to pneumonia, neonatal infections, premature birth, and obstetric emergencies.

The delivery of high-quality oxygen therapy has long been a challenge in Liberia, with access to oxygen impeded by gaps that span across the health system: availability of biomedical equipment (BME) and supplies, and their procurement & supply management (PSM); health facility infrastructure and set-up; human resources for health (including availability of clinicians and biomedical personnel); national strategy and financing; and the overall complexity of integration and coordination. In many low and middle-income countries (LMICs) including Liberia, these challenges have been exacerbated and amplified by the current global pandemic and emergence of COVID-19 – an acute respiratory tract disease that lead to hypoxic respiratory failure, and in the most severe form, Acute Respiratory Distress Syndrome (ARDS).

We are at a critical juncture at which global and country actions must be taken to increase access to oxygen, not only in response to COVID-19 in the immediate term, but also for longer-term planning to scale up oxygen access across Liberia. To support the government's planning, the Clinton Health Access Initiative (CHAI) supported the Ministry of Health (MOH), working closely with the Healthcare Technology Management Unit (HTMU), to conduct an assessment of select facilities to understand current availability of oxygen equipment in Liberia, as well as facility readiness to provide oxygen therapy.

Objectives of facility assessment

The assessment aims to determine the current availability of and readiness for oxygen therapy and respiratory care in select public and private facilities, across all 15 counties in Liberia. Results from the assessment will be used by the MOH and CHAI to inform decision-making on scaling up oxygen access, including but not limited to quantification of oxygen equipment and supplies needs for the country; biomedical equipment procurement, distribution, and maintenance planning; training of health workers and biomedical technicians (BMETs); and resource mobilization. Results from this assessment will also provide baseline data to inform the development of Liberia's national roadmap to scale up oxygen access.

Methodology

Facility selection

Based on consultation with HTMU, the assessment was conducted in 53 facilities in Liberia – both private (6) and public (49) facilities are included, and facilities are either secondary or tertiary facilities (health centers or hospitals). Facilities were selected based on a variety of criteria, such as known inventory of oxygen equipment and supplies, infrastructure for potential scale-up of oxygen access, catchment population, service volume, etc.

Tools

The assessment was conducted using an adaptation of the World Health Organization (WHO) inventory tool for facility readiness and equipment for COVID-19 case management (*Source: Biomedical Equipment for COVID-19 Case Management Interim guidance – Inventory tool for facility readiness and equipment re-allocation, World Health Organization, 04 May 2020*). Adaptations were done to ensure that the tool was suitable for use within Liberia's context, and included all components[1] assessed in the original tool (Appendix 1):

1) Facility identification
2) Facility readiness for oxygen systems (e.g. bed capacity, electricity, voltage stabilizers, emergency transport, trained staff)
3) Clinical monitoring devices: Vital sign monitoring devices; pulse oximeters
4) Oxygen concentrators
5) Oxygen cylinders
6) Cylinder assembly units

[1] Numbering of the Results section below may not correspond directly to the numbering list here, as some related results are grouped together.

7) Flowmeters / Thorpe tubes
8) Flow splitters
9) Oxygen delivery interface: Nasal cannula; mask and bag; Venturi mask
10) BiPAP and CPAP machines
11) High-flow nasal cannula (HFNC)
12) Resuscitation bags and masks (adult, pediatric, neonatal)
13) Suction devices (manual, electric, suction vacuum)
14) Laryngoscope
15) Intubation sets
16) Airways
17) Patient ventilators
18) Autoclave/sterilizer
19) Oxygen terminal bedside wall units
20) Oxygen cylinder manifold
21) Bulk liquid oxygen tank
22) On-site oxygen plant

Responses to the assessment were either self-reported, directly observed, and/or confirmed with an analytical instrument depending on the type of question. The adapted tool was separated into 2 versions: Version 1 for if there are available oxygen analyzers in country to conduct functionality and purity testing of oxygen concentrators; Version 2 for if no oxygen analyzers are available, and other screening criteria will need to be observed to determine concentrator functionality. Due to the long lead time in procurement of analyzers, Version 2 of the tool was ultimately used for all health facilities for the assessment.

Data collection

Data collection was conducted by county BMETs of the HTMU. CHAI's Monitoring & Evaluation (M&E) Associate and Director of the HTMU provided supervisory oversight to all data collectors and carried out data quality checks. Though not directly involved in data collection, county M&E focal persons participated in data collection training where possible to ensure future integration of BME/assessment data into county activities. HTMU also alerted County Health Teams (CHT) ahead of the exercise, and work together with CHTs to communicate this to health facilities to ensure their cooperation.

Data collection was conducted in-person, on-site at each health facility in the assessment sample, with questionnaires administered in English via the SurveyCTO platform on Android tablets. This type of electronic data collection offers better data quality assurance. Uploads/submissions of completed questionnaires were done daily where Internet connectivity allowed, or were otherwise done as soon as a stable connection was available. Daily data quality checks were conducted to address any discrepancies or inconsistencies in the data, and to ensure that data collection schedules were followed.

Data management, analysis, and dissemination

Upon data upload, CHAI staff reviewed and approved each submission on SurveyCTO. Basic data quality checks were performed to ensure accuracy, completeness, and logical consistency in survey responses. Data were analyzed using Stata SE version 14. The complete dataset is owned by CHAI and MOH, and will also be accessible by the WHO globally. Raw data are stored on the SurveyCTO server '*o2therapy*' provided by CHAI and WHO globally for the COVID-19 response; stakeholders who are interested in accessing the raw data can request the dataset from CHAI, WHO, or the MOH. Analyzed data based on key indicators are presented in this assessment report.

Results

This report presents key findings from the oxygen assessment, focused mainly on the county and national-level capacity of oxygen equipment and supplies. The full complete dataset containing facility-level information is available upon request from CHAI or the WHO.

1) Facility distribution

A total of 53 health facilities are included in this assessment, consisting of 45 public facilities and 8 private facilities. All facilities are either secondary or tertiary health facilities (36% are health centers; 64% are hospitals). The facilities assessed represents 57% of the total secondary or tertiary health facilities in the country.

Table 1: Facilities Assessed by County, Region, and Ownership

Region/County	Private	Public	Total
North Central			
Bong	0	3	3
Lofa	0	6	6
Nimba	2	5	7
North Western			
Bomi	0	1	1
Gbarpolu	0	1	1
Grand Cape Mount	0	2	2
South Central			
Grand Bassa	1	1	2
Margibi	0	3	3
Montserrado	5	10	15
South Eastern A			
Grand Gedeh	0	3	3
Rivercess	0	1	1
Sinoe	0	2	2
South Eastern B			
Grand Kru	0	3	3
Maryland	0	2	2
River Gee	0	2	2
Grand Total	8	45	53

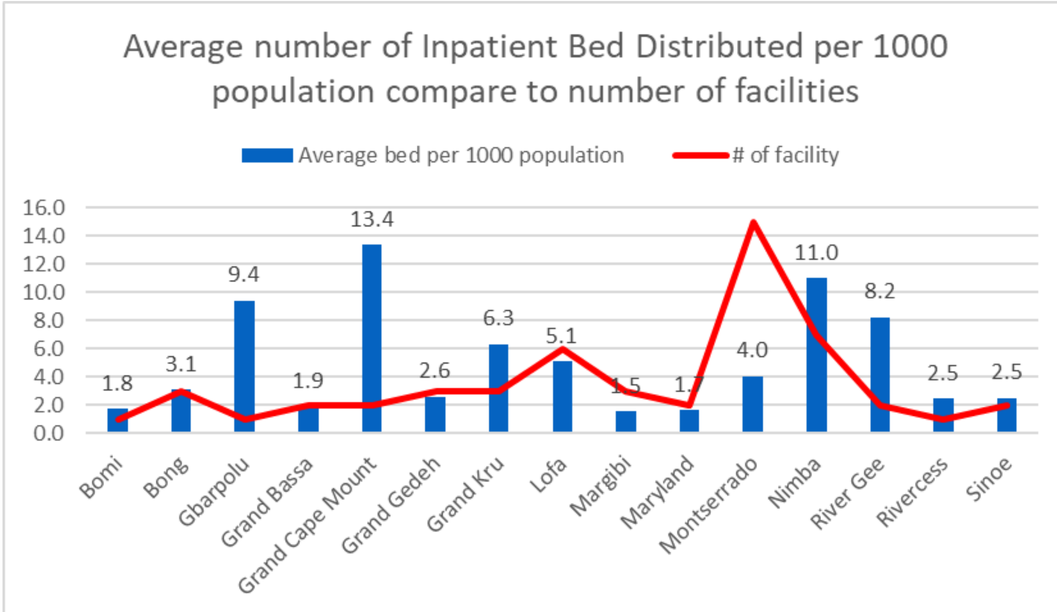
2) General facility infrastructure

Beds

The COVID19 outbreak unveiled serious need for adequate space in hospitals to accommodate the influx of sick people contracting the virus - hospital bed in general and intensive care beds specifically. The number of acute care beds in hospital provides a general indication of the capacity of hospital to deliver acute care to patients. The pandemic overwhelmed the health system; thus creating the need to temporarily convert some of the inpatient beds into flexible intensive care units; however, for COVID19 management, it is of utmost importance that intensive care beds be equipped with respiratory equipment. In this regard, the oxygen assessment included questions about the number of inpatient bed and the number of bed for intensive care. These questions were meant to assess facility readiness to handle patients suffering from hypoxemia or hypoxia as a result of COVID19.

Finding from the assessment showed an average of 5.0 inpatient bed per 1000 population with less than 1 intensive care bed in most of the facilities. Though there are no global standard for the density of bed in relation to 1000 population but considering the high admission rate from COVID19, these figures indicate a substantial shortage of intensive care beds in Liberia

Figure 1: Average Number of Inpatient Beds per 1,000 Population

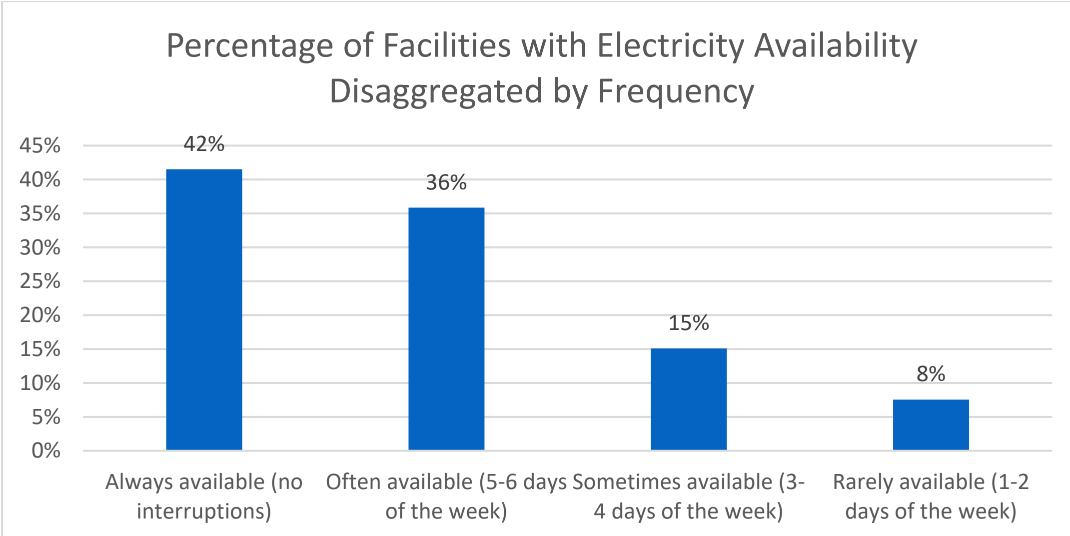


3,853 inpatient beds were counted from 53 health centers and hospitals surveyed, only 442 (11%) were used for intensive care. Forty-two facilities (79%) reported having ICU beds, and 12 facilities (23% of all facilities) reported having a neonatal intensive care unit (NICU).

Electricity

Reliable electricity is an essential aspect of operating hospital equipment, especially respiratory therapies and devices. Problems with electrical grids or power sources such as electrical outages, voltage sags, voltage surges, voltage spikes and frequency deviations can all limit the uptime of any oxygen equipment requiring power by causing outages, reducing the functionality or reliability of the equipment or damaging the circuitry in the equipment itself. The assessment included questions about the availability of electricity in the last 7 days preceding the assessment from either primary or secondary source. The assessment found out that electricity was reported to be always available with no interruptions in 22 of the assessed facilities (42%); always available (5-6 days of the week) in 19 facilities (36%); sometimes available (3-4 days of the week) in 8 facilities (15%); and rarely available (1-2 days of the week) in 4 facilities (7.5%).

Figure 2: Percentage of Facilities with Electricity Available at Assessed Facilities Disaggregated by Frequency

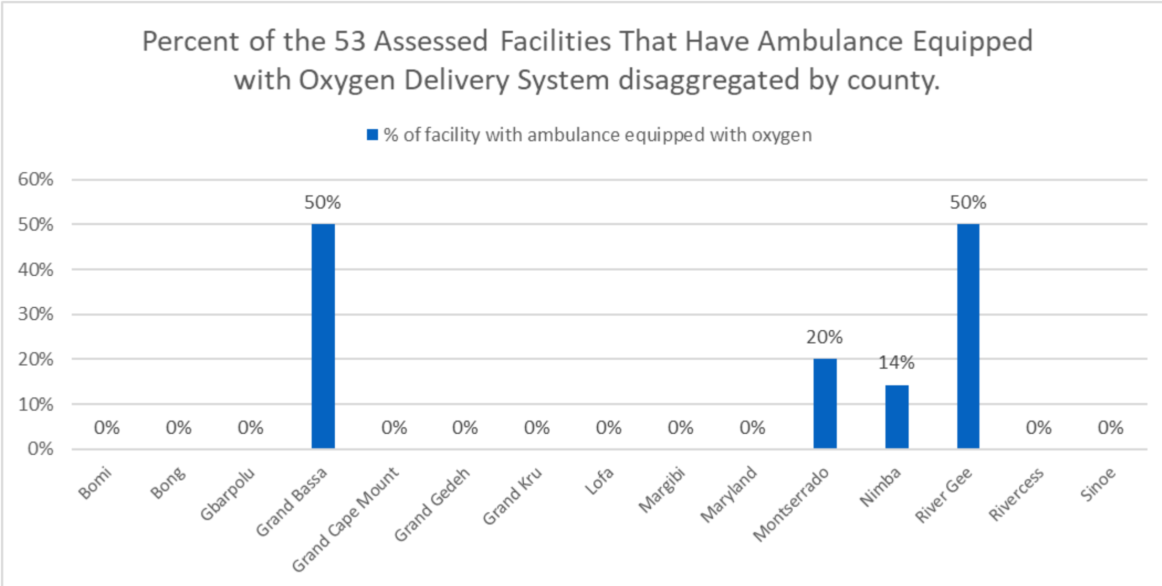


34 of the 41 facilities found to have electricity available reportedly used generators while the other 7 facilities obtained electricity from other sources such as solar panel or national grid. Though generators seem to be the most reliable source for electricity but the running cost is exorbitant. Despite the significant initial investment required for the installation of solar panels at health facilities, solar power remains the most cost-effective and sustainable source of electricity.

Emergency transportation

Transporting critically ill patients with Severe Acute Respiratory Infection associated with COVID19 from community or primary care levels to secondary or tertiary levels is an integral response strategy in mitigating COVID19 death. With the outbreak of COVID19, it became even more important to equip ambulances with oxygen delivery equipment so that patients suffering from hypoxemia could be stabilized while in transit to the health facilities. To know this, the assessment counted the number of ambulances with the capacity to administer oxygen (trained providers, essential devices, etc.) at the assessed facilities. The result showed that majority (85%) of facilities did not have an ambulance with oxygen. The facilities that reported having an ambulance with oxygen were in four (4) counties: Grand Bassa, Montserrado, Nimba and River Gee counties. Five (5) of the facilities were private and 1 public: Arcelol Mittal Hospital, Bardnesville Junction Hospital, JFK Medical Center, St. Joseph Catholic Hospital, Arcelol Mittal Hospital, and Fish Town Hospital. The results show inadequacy in the preparedness of facilities to transport critically ill patients and lack of ability to provide oxygen during transport.

Figure 3: Percent of Facilities with Oxygen-Equipped Ambulances



3) Facility services and providers

Availability of medical equipment continues to increase as technology advances, this poses binding demand on health workers to know how to operate the devices in order to address global health challenges. Clinical service providers at the facility level must work together with biomedical engineers to support utilization and functionality of oxygen equipment in order to strengthen health system capacity in responding to surges in the demand for care associated with pandemics such as COVID19. To better understand the health workforce demand, the assessment asked about number of doctors and nurse anesthetist at the facilities; in addition to questions about the number of bio-medical engineers assigned at the facilities. The assessment result showed that 14 (26%) of the facilities had a dedicated staff assigned as Bio-Medical Engineer; 39 (74%) of the facilities had doctor while 33 (62%) reportedly had a nurse anesthetist. There was average 0.2 physician per 1000 Population across the 53 assessed facilities. This indicates minimal availability of professional health workers to provide care for critically ill patients and to operate hospital equipment.

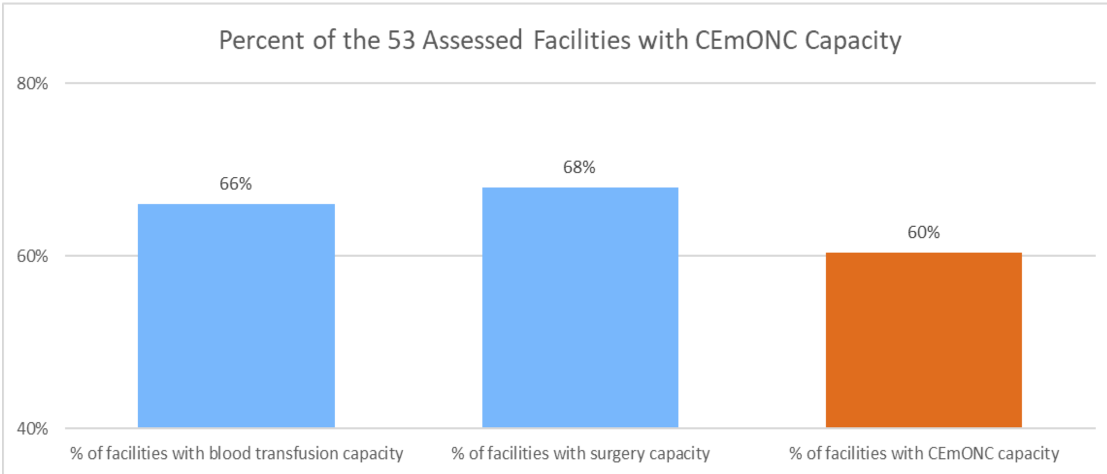
CEmONC capacity

Comprehensive Emergency Obstetric and Newborn Care services (CEmONC) are the interventions provided to pregnant women and newborns experiencing fatal complications, including severe bleeding, infection, prolonged or obstructed labor, eclampsia, and asphyxia in the newborn. CEmONC interventions include safe blood transfusion, providing oxytocin and antibiotics, performing cesarean sections, manual removal of the placenta, assisted vaginal delivery, abortion and resuscitation of the newborn. [2]With this understanding, it became important to assess health facilities readiness to provide these services to pregnant women in case they present pregnancy – related complications as a result of contracting the Coronavirus. Though there are limited data on the clinical presentation on maternal and perinatal outcomes of COVID-19 disease during or after pregnancy[3]. Nevertheless, building on existing recommendations from WHO on pregnancy and infectious diseases, CEmONC services are recommended if medically justified. Against this background, the assessment included questions on facility capacity to perform surgery (cesarean section) and blood transfusion. The results showed that 32 (60%) of the assessed facilities have equipment and supplies needed for blood transfusion, while 31 (58%) of facilities reported surgical capacity. Considering both of these characteristics, only 60% (n=32) of the assessed facilities met criteria to perform CEmONC services. All of the facilities assessed where secondary (health centers, county hospitals) or tertiary

[2] https://wraglobal.medium.com/comprehensive-emergency-obstetric-and-newborn-care-the-proven-approach-in-tanzania-4d7bb4542e3b
[3] https://apps.who.int/iris/rest/bitstreams/1278777/retrieve (WHO interim guidance on Clinical Management of COVID-19 (updated May 27, 2020)

(referral hospitals) health facilities and thus should ideally be CEmONC-ready; there is thus a need to increase the percentage of facilities able to provide comprehensive EmONC services to pregnant women.

Figure 4. Percent of Assessed Facilities with CEmONC Capacity



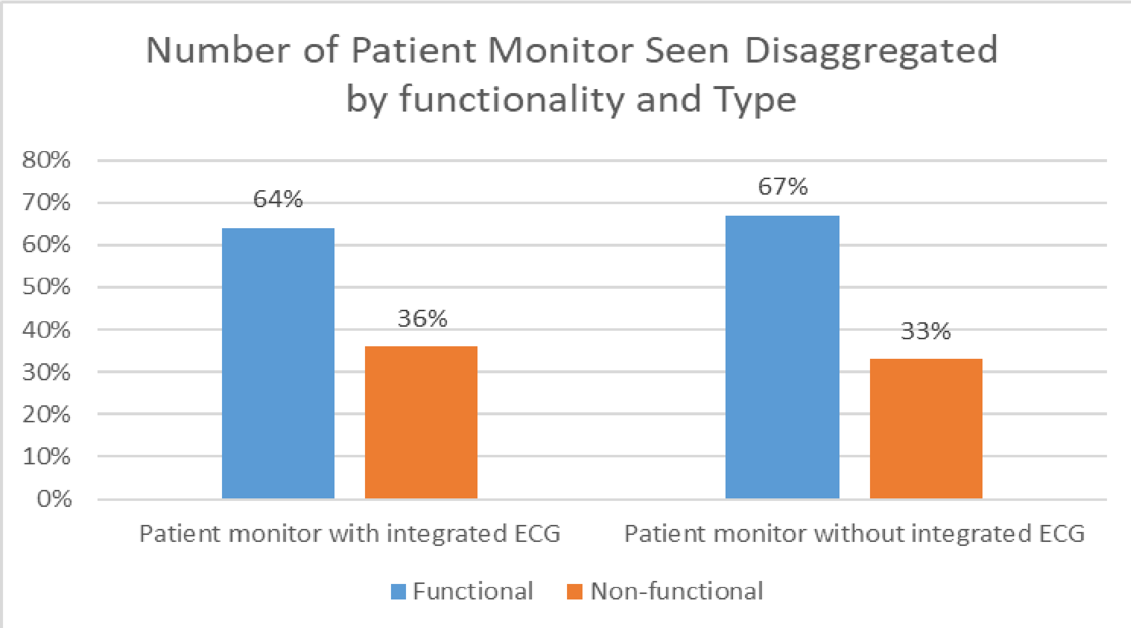
4) Vital sign monitoring devices

Vital sign monitoring devices measure and display a patient's vital signs in inpatient and outpatient conditions. Vital signs monitors give medical personnel an indication about the patient's condition and enable them to evaluate treatment options. The measurements usually consist of pulse oximetry, ECG, noninvasive blood pressure and temperature. With the COVID-19 pandemic, WHO recommended in its Interim guidance for Clinical Management of COVID19 that all persons at the first point of contact be screened in order to identify individuals that have suspected or confirmed COVID-19. In case a patient is confirmed with moderate COVID-19 signs or symptoms, It is recommended for that patients to be closely monitored for disease progression; and as for severe COVID-19 cases; WHO recommended that all areas where severe patients may be cared for should be equipped with equipment including pulse oximeters to allow regular monitoring of vital signs (including pulse oximetry) and, where possible, utilize medical early warning scores (e.g. NEWS2, PEWS) that facilitate early recognition and escalation of treatment of the deteriorating patient. It was against this background that the oxygen assessment asks about patient monitor and pulse oximeter.

Patient monitor

The monitor helps to translate the reading of patient's vital signs. There were two type of patient monitor the assessors were asking about: the first being a monitor with an integrated ECG and the second being a monitor without an integrated ECG. The finding from the assessment showed that there were 150 monitors seen at 31 (58%) facilities assessed; 98 (65%) of these devices were functional while 52 (35%) of the devices were non-functional. 64% of the patient monitor with an integrated ECG was functional but the other 36% was non-functional; while 67% of the ones without an integrated ECG was functional and 33% non-functional. The most frequent reasons given for the non-functional monitors was the lack of spare parts and consumables.

Figure 5: Percent of Facility with Patient Monitors

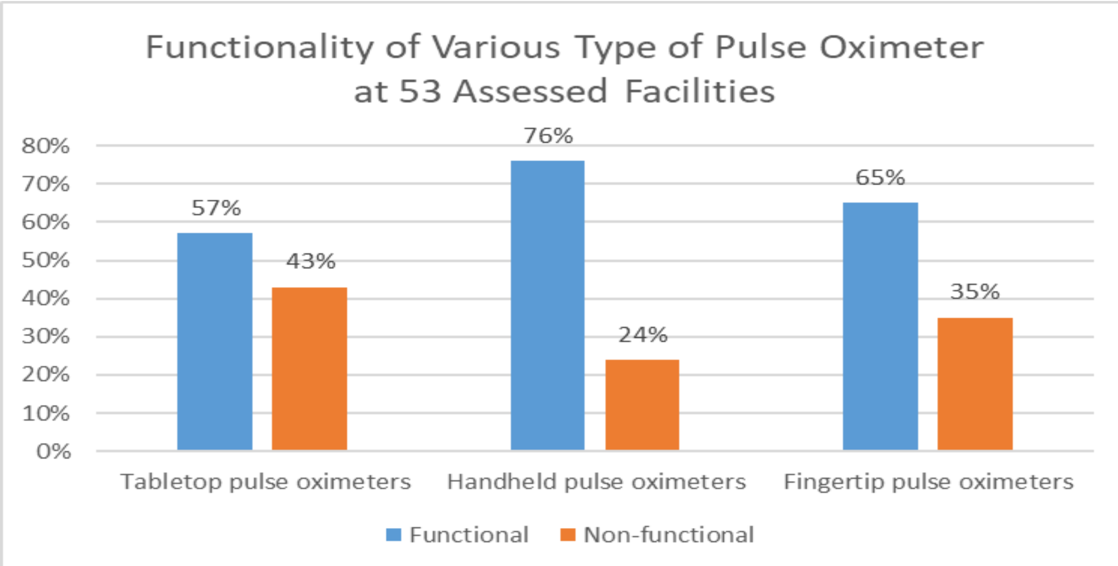


Pulse oximeter

Pulse oximetry is a simple and non-invasive method to indirectly measure the oxygen saturation of hemoglobin in arterial blood. Pulse oximeters are the accepted global standard for detecting and monitoring hypoxemia – an abnormally low level of oxygen in the blood.[4] For clinical management of severe COVID-19, WHO recommended regular monitoring of vital signs including pulse oximetry for hospitalized patients. In this regard, the oxygen assessment team checked for pulse oximeters at the assessed facilities. The results showed that there were 34 (64%) of the facilities assessed with 234 pulse oximeters; of which 158 (68%) were functional while 76 (32%) were non-functional. Assessment of the various type of pulse oximeter showed that 43% of the Tabletop pulse oximeters were not functioning while 24% of the handheld pulse oximeter and 35% fingertip pulse oximeter were not also functioning. The most common reason given for the non-functionality of the oximeters was the lack of spare parts and consumables.

[4] *https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/pulse-oximetry*

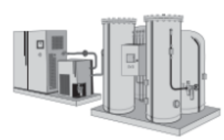
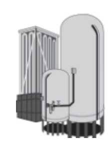
Figure 6: Percent of Pulse Oximeter disaggregated by functionality and type



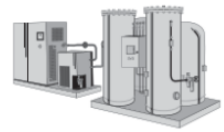
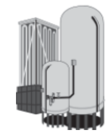
5) Oxygen sources

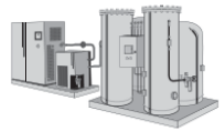
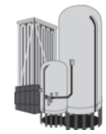
Oxygen therapy, or supplemental oxygen, is the use of medical oxygen as a medicine in health care. Medical oxygen is generated by an oil-free compressor and must be free from any contamination, in addition to having a minimum standard of being 82% pure oxygen. The three most common sources of medical oxygen in health care facilities are: oxygen concentrators, oxygen cylinders, and oxygen plants. A fourth oxygen source, though less common is the bulk-stored liquid oxygen. 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.[5] Only high quality, medical-grade oxygen is recommended to be given to patients.

Table 2: Summary of Common Oxygen Sources

	Cylinder	Concentrator	Oxygen Plant (PSA)	Bulk 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 PSA technology.	Onsite system using PSA technology, which supplies high-pressure oxygen throughout a facility via 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.

[5] WHO *Oxygen sources and distribution for COVID-19 treatment centres*

	Cylinder 	Concentrator 	Oxygen Plant (PSA) 	Bulk Liquid Oxygen 
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. A single concentrator can service several beds with the use of a flowmeter stand to split output flow.	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	Primary, secondary, possibly tertiary (any medical unit requiring oxygen).	Primary, secondary, possibly tertiary (any medical unit requiring oxygen).	Secondary and tertiary.	Secondary and tertiary.
Distribution mechanism	Connected to manifold of central/sub-central pipeline distribution system, or directly connected to patient with flowmeter and tubing.	Direct to patient with tubing or through a flowmeter stand.	Central/ sub-central pipeline distribution system, or can be used to refill cylinders that can be connected to manifold systems in the facility.	Central pipeline distribution system.
Electricity requirement	No	Yes	Yes	No
Initial costs	Moderate; cylinder, regulator, flowmeter, installation, training.	Moderate; concentrator, spares, installation, training.	High; plant and pipeline distribution system, installation, training.	Can be high; tank, pipeline installation, training.
Ongoing operating costs	High; 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 if not operated by third party.	Moderate (can be high if tank is leased); refill costs, maintenance.
Maintenance requirement	Limited maintenance required by trained technicians.	Moderate maintenance required by trained technicians (1), who could be in-house.	Significant maintenance of system and piping required by highly trained technicians and engineers, can be provided as part of contract.	Significant maintenance of system and piping required by highly trained technicians and engineers, can be provided as part of contract.
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.

	Cylinder 	Concentrator 	Oxygen Plant (PSA) 	Bulk Liquid Oxygen 
Merits	• No power source needed.	• • Continuous oxygen supply (if power available) at low running cost. • Output flow can be split among multiple patients.	• Can be cost-effective for large facilities. • 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.	• Low pressure output, usually not suitable for CPAP or ventilators. • Requires uninterrupted power. • Requires backup cylinder supply. • Requires maintenance.	• 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.

Concentrators

Oxygen concentrators provide the cheapest and most consistent source of oxygen in health facilities where the power supply is reliable. An oxygen concentrator is a self-contained, electrically powered medical device designed to concentrate oxygen from ambient air. An oxygen concentrator uses PSA (Pressure Swing Absorption) 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 purity falls below 82%.[6] In WHO Clinical Management for COVID-19 guideline, it is recommended that supplemental oxygen therapy be administered to any patient with emergency signs and to any patient without emergency signs and SpO2 < 90%. Therefore, to know if hospitals and health centers in Liberia are capable of oxygen therapy, the assessment asked if facilities had oxygen concentrators; and if yes, how many.

The result showed that 32 (60%) of the 53 assessed facilities had functional oxygen concentrators. There were 302 concentrators counted – 150 (49.7%) of them were functional. A majority of the non-functional concentrators (n=121 or 72%) were due to the lack of spare parts. The procurement of necessary spare parts and consumables and performance of routine equipment repair and maintenance visits can therefore be a speedy and cost-effective approach to significantly increase the availability of functional patient monitors in the country.

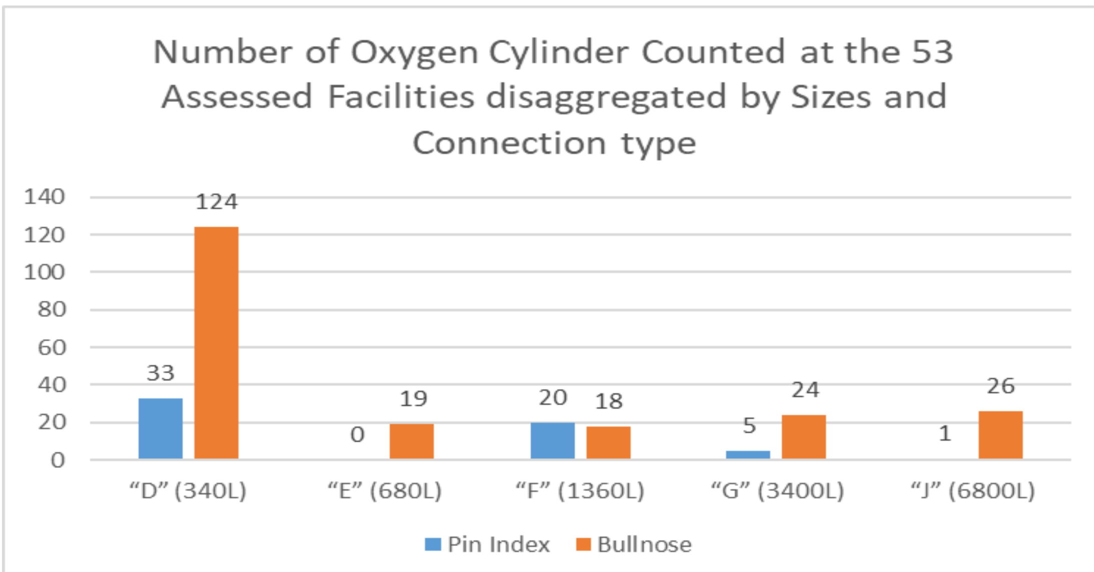
Cylinders

Oxygen gas can be compressed and stored in cylinders. These cylinders are filled at a gas manufacturing plant, either via a cryogenic distillation or a process known as pressure swing adsorption (PSA)and transported to health facilities to be connected to manifold systems (groups of cylinders linked in parallel) that are piped to areas of the health facility; or cylinders can be used directly within patient areas. The use of cylinders typically involves transport to and from the bulk supply depot for regular refilling, which could have logistical challenges and ongoing cost implications, often leading to unreliable supply in many setting. While less common, cylinders can also be filled by a PSA oxygen plant that is co-located

[6] *WHO-UNICEF Technical specifications and guidance for oxygen therapy devices, Page 16*

with a health facility and that has a high-pressure compressor for cylinder filling purposes. As mentioned earlier, a supplemental oxygen therapy is recommended for managing severe COVID-19; so the assessment checked at the facilities for cylinders. The result revealed that 25 (47%) of the assessed facilities had oxygen cylinders. There were total of 270 cylinders counted at the assessed facilities; most of them (60%) were "D" (340 Liters) size with a Bullnose, which is suitable for use at health facilities in case of emergency and also in ambulances.[7] Another suitable type of cylinder for health facility use is the "E" (680L), there were 19 of them across the assessed facilities. The remaining cylinders counted were "F", "G" and "J" sizes, those ones are either stand-alone or use with a manifold; thus not ideal for emergency use. The average refill frequency was reported to be weekly; and the average number of cylinder consumed per week was nine (9) cylinders with an average refill cost of $318 USD. On the question of where facility fill their oxygen cylinders, 49% (26/53) of facilities reported that they refill their cylinders at locations outside the situated county – this is costly in terms of transportation and accommodation for staff responsible for refilling the cylinder.

Figure 7: Breakdown of Oxygen Cylinders by Size and Connection Type



Cylinder assembly units

Cylinder assembly units are valves that regulate the outflow of oxygen from the cylinder (either pin index or bullnose type). These units 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[8]. The assessment asked about these valves, 27 (51%) of the assessed facilities had a total of 234 cylinder-assembly units, of the total cylinder assembly units counted, 151 (65%) of them were functional while the remaining 83 (35%) were non-functional. The most common type of cylinder assembly units was the one with bullnose connection type. The bullnose does not require PISS to regulate the flow of oxygen thus is less complicated and can be easily used.

On-site oxygen plant

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

[7] *WHO-UNICEF Technical Specification and Guidance for Oxygen Therapy Devices, Page 19, Table 3.2*
[8] *WHO-UNICEF Technical specifications and guidance for oxygen therapy devices, Page 19*

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[9]. 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 anesthetic machines and ventilators. In view of this, the assessment checked facilities for an on-site oxygen plant. The result showed that only 6 (11%) of the 53 assessed facilities have an on-site oxygen plant; however only 3 of those plants are functional and the other 3 are non-functional. Lack of spare parts is the most common reason given for why the non – functional plants were down. Among the functional ones, only 1 (JJ Dossen Hospital) was supplying oxygen to other facilities. None of the plants were connected to back-up source of electricity.

Oxygen terminal bedside wall units

Terminal bedside wall units is a pipeline system that enhance delivery of oxygen from a central source such as the onsite oxygen plant to patient wards without moving cylinders around. Key advantage of pipeline systems is that they obviate the need for handling and transporting heavy cylinders between hospital wards. Facilities were surveyed to know if there was a pipeline system installed. The finding showed that ELWA hospital was the only hospital reported to have an oxygen terminal bedside wall units. There were 21 oxygen wall outlets with the pressure 345–425 kPa (50-60 psi) and 1 connection per bed. 15(71%) of the units were seen in the emergency wall while 6 (29%) in the Intensive Care Unit (ICU). All of the connections were reportedly fitted with a valve, pressure gauge, and flow regulator. It is our understanding that 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 county -level hospitals.

Oxygen cylinder manifold

The manifold system is the linking of groups of cylinders in parallel that are piped to areas of the health facility to avoid the use of cylinder directly within patient areas; safety is increased when use of cylinders directly in patient rooms is eliminated. The cylinders are refill from a plant and then connected to this system. This does not mitigate the challenges of transporting the cylinders to and from the bulk supply depot for regular refilling. The result from the assessment showed that 5 (9%) of the facilities had a manifold system. 14 Oxygen cylinder manifolds were counted from 2 facilities in Montserrado, 1 in Nimba, 1 in Maryland, 1 in Bong. Eleven (11) of the manifolds were with manual switch and three (3) with an automatic switch. Among the manual switch manifolds, eight (8) of them had the capacity for 4 cylinders, 2 with 5 cylinders space and 1 with 8 cylinder capacity. As for the automatic switch manifolds, two (2) of the manifolds with 2 cylinders space and 1 with 5 cylinders capacity.

Bulk liquid oxygen tank

Bulk liquid oxygen tank are storage for oxygen generated off-site and kept in a large tank for distribution throughout a health facility via a central pipeline system. The tank requires refilling by liquid oxygen supplier. Facilities can be equipped with large bulk liquid oxygen tanks that are refilled periodically by a truck from a supplier[10]. 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 it could be 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. Result from the assessment showed that none of the assessed facilities has bulk liquid oxygen tank. This could be because of the many drawbacks listed in Table 1 above.

6) Oxygen Regulation and Conditioning

The regulation and conditioning of oxygen gas for the delivery of oxygen therapy to patients is done using three different devices – flowmeters, flow-splitting devices and humidifiers. These devices play different roles depending on either high-pressure cylinders, oxygen concentrators or from the terminal unit (i.e. medical gas outlet) of a central piped system.

---

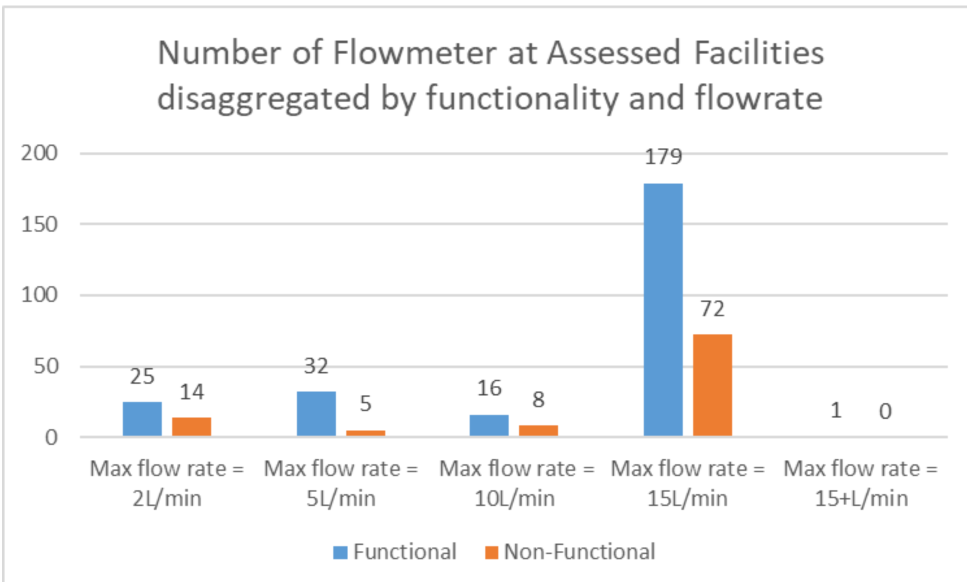
[9] *WHO-UNICEF Technical specifications and guidance for oxygen therapy devices, Page 19*

[10] *WHO-UNICEF Technical specifications and guidance for oxygen therapy devices, Page 18-19*

Flowmeters

Flowmeters are needed to measure and control the rate of oxygen flow to a patient, either from a concentrator, a high-pressure cylinder or a terminal unit of a piped system[11]. Considering the need for regulated oxygen therapy (i.e. low doses ranging from 1-2 L/min in children and starting at 5 L/min in adults) as described in the WHO Clinical Management guideline for COVID-19, it is important for facilities to have flowmeters to measure the quantity of oxygen deliver to patients. Against this background, the assessment asked questions about the number of flowmeters at each of the assessed facilities and categorized them by the different flowrates. Findings from the assessment revealed there were 253 functional flowmeters of the total 352 flowmeters counted from 29 (55%) of the 53 assessed. Most (67%) of the functional flowmeters was the type with the maximum flow rate of 15L/min. This type of flowmeter is versatile and can be used for low to high flow application; whereas, the ones with lower maximum flowrate are suitable for only neonates and pediatric care.[12] Therefore, the type with 15L/min is appropriate for COVID-19 oxygen therapy.

Figure 8: Number of Flowmeter disaggregated by Functionality and Maximum Flowrate



Flow splitters

Flow-splitter is a device that provide an effective and efficient means of economically administering medical oxygen to multiple patients from a single source, and therefore was important to include in this assessment. Flow-splitting devices may be used with concentrators, cylinders and centralized systems for both pediatric and adult patients. The two main devices for splitting oxygen flow are the flowmeter stand and the dual flowmeter. The results showed that there were 30 functional flowmeter stand seen at 10 (19%) of the 53 assessed facilities; 21 (70%) of the splitters were the type with 5 outlets and the flowrate of 2L/min; 7 (23%) of them were with 2 outlets and the flow rate of 2L/min while the remaining 2 (7%) were 3 outlets with flowrate of 1L/min.

7) Oxygen delivery interface (consumables)

Oxygen delivery interface are devices that connect an oxygen source to a patient, for the delivery of oxygen therapy. These delivery methods can be used regardless of what source of oxygen is used (cylinder, concentrator or piped system). 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

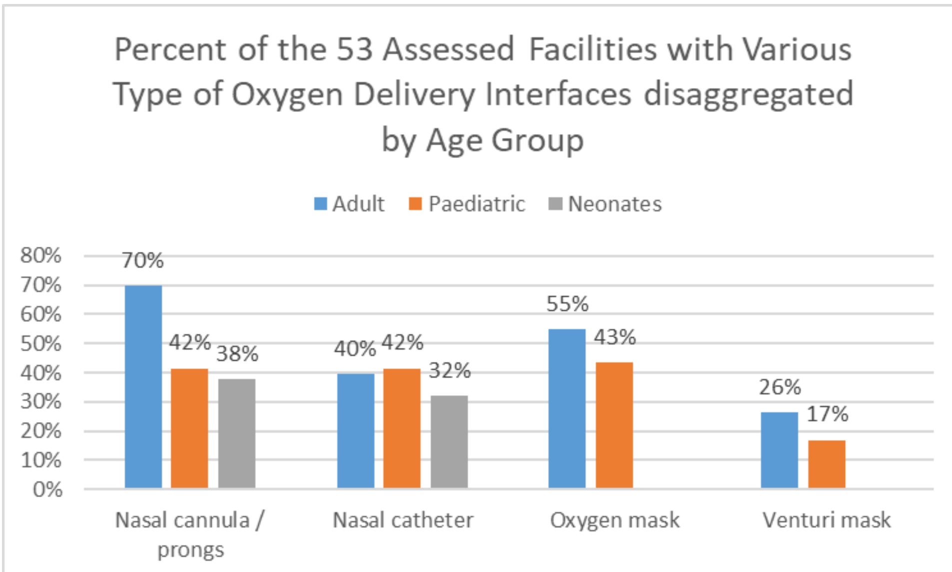
[11] *WHO-UNICEF Technical Specification and Guidance for Oxygen Therapy Devices, Page 28*
[12] *WHO-UNICEF Technical Specification and Guidance for Oxygen Therapy Devices, Page 17*

thus depend on clinical needs and device capabilities. The assessment checked for four kinds of the delivery interface – Nasal Cannula, nasal catheter, oxygen mask and the venture mask.

Nasal Cannula

Nasal cannula (nasal prongs) are the preferred method for delivering oxygen to infants and children under 5 years of age with hypoxemia, according to the WHO[13]. Nasal cannula consists of plastic tubes that end in two short tapered prongs that are placed in the nostrils. When delivering standard flow rates with this delivery method, the flow of oxygen typically does not meet the patient's full inspiratory demand so ambient air mixes with the delivered oxygen. The assessment result showed that nasal cannula was the most available type of oxygen delivery interface seen at the facilities, constituting 45% of the oxygen delivery devices available at the assessed facilities. The total of 11340 cannulae were counted for the different age categories. The ones for neonatal and pediatric use constituted 71% while the adult use was 29%.

Figure 9: Percent of the Assessed Facilities with Oxygen Delivery Interface disaggregated by Type and Age Group



Nasal catheter

A thin, flexible tube that is passed into the nose and ends with its tip in the nasal cavity. Catheters are sized according to the French gauge system (Fr), also known as Charrière (Ch), where the gauge is three times the external tubing diameter. Nasal catheters are less costly than nasal cannula and are recommended as an alternative where nasal cannula are not available. Nasal catheters are usually well tolerated, and they are unlikely to be dislodged. The assessment result showed that nasal catheter made up of 36% of the oxygen delivery devices at the facilities. The ones for neonate and pediatrics are 66% and the adult ones constitute 34%.

Non-invasive methods (Oxygen mask and Venturi mask)

Non-invasive methods of oxygen delivery include head boxes, face masks (simple, partial rebreathing and non-rebreathing), incubators and tents. With these methods, the FiO2 can be determined more precisely by an oxygen analyzer placed near the patient's mouth[14]. For neonates, infants and children, however, the use of head boxes, face masks, incubators and tents to deliver oxygen is generally discouraged, as they are wasteful of oxygen and potentially harmful due to the risk of carbon dioxide accumulation. The assessment asked for two types of non-invasive methods of oxygen delivery interface: oxygen mask and venturi mask, the finding was that 17% of the oxygen delivery interface was the oxygen mask for both adults and

[13] *WHO. Oxygen therapy for children: a manual for health workers. Geneva: World Health Organization; 2016 (http://www.who.int/maternal_child_adolescent/documents/child-oxygen-therapy/en/, accessed 25 April 2019).*
[14] WHO. Oxygen therapy for children; 2016; p. 27.

neonates. The most rarely seen delivery interface at the facilities is the Venturi mask constituting only 2% of the devices. Venturi masks are often used in Chronic obstructive pulmonary disease (COPD), where it is important not to over-oxygenate the patient.[15]

High Flow Nasal Cannula (HFNC)

High-flow nasal cannula oxygenation has distinct advantages over other oxygen devices because of its unique effects on respiratory physiology. In particular, adjustable oxygen delivery and flow-dependent carbon dioxide clearance reduce work of breathing and better match inspiratory demand during respiratory distress. High-flow nasal cannula oxygenation has been shown to have similar, and in some cases superior clinical efficacy compared with conventional low-flow oxygen supplementation and noninvasive positive pressure ventilation in acute hypoxemic respiratory failure. [16] Based on this information, the assessment counted the number of HFNC at the facilities and the result showed 5 of the assessed facilities have HFNC. There were 193 HFNCs for all age category, 108 (56%) for adults and 85 (44%) for pediatrics. There are 10 other counties that don't have HFNC. 155 (80%) of HFNCs were reported from the Pleebo Health Center in Maryland County.

8) BiPAP and CPAP

BiPAP and CPAP machines are very similar in function and design in that they are a non-invasive form of therapy for those suffering from sleep apnea. Like CPAP treatments, BPAP treatments are designed to keep the airway from collapsing and allow users to breathe easily and regularly during sleep. The main difference between BiPAP and CPAP devices is that BiPAP machines have two pressure settings: one pressure for inhalation (IPAP), and a lower pressure for exhalation (EPAP)[17]

BiPAP

The BiPAP machine is designed to increase the pressure when you inhale to keep the airways in the nose and throat from closing while you are sleeping, and provide a lower pressure during exhalation that continues to maintain an open airway. Many patients find BiPAP more comfortable than the single pressure delivered by CPAP machines. Data gathered from the facility assessment showed that five (5) of the 53 assessed facilities had BiPAP machines. There were 29 BiPAP machines counted; of which, 9 (31%) were functional. 5 (56%) of the functional BiPAP machines were for adults while 4 (44%) for neonates. No pediatric BiPAP machine was seen, which is a concern for the facility to manage pediatric patients. There was 20 non-functional adult BiPAP machines reported from the ELWA hospital.

CPAP

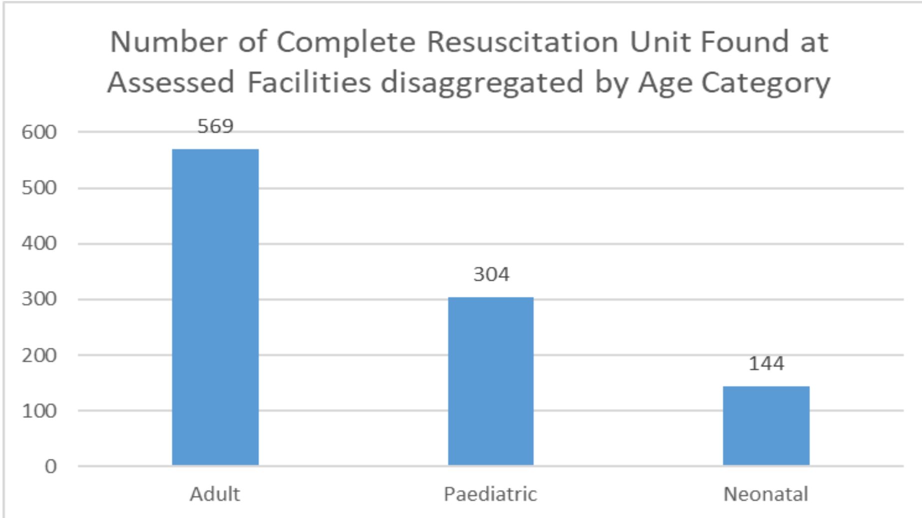
The CPAP machine is usually used to treat mild to moderate sleep apnea. But depending on the severity of sleep apnea, doctors may recommend a BiPAP machine instead. Patients requiring high levels of CPAP pressure are often more comfortable using BiPAP. The assessment found 14 CPAP machines at 6 (11%) of the assessed facilities – 5 adults; 5 pediatrics; and 4 neonates. All of the machines were functional.

9) Resuscitation devices

Resuscitation devices are used to initiate spontaneous breathing by mechanically ventilating the lungs. These devices are needed for emergency airway management for patients with severe COVID-19 signs (obstructed or absent breathing, severe respiratory distress, central cyanosis, shock, coma and/or convulsions) according to WHO guideline for clinical management of COVID-19,[18]. The guideline provides that both adults and children with emergency signs should receive emergency airway management and oxygen therapy during resuscitation to target $SpO2 \geqslant 94\%$. Therefore, the assessment asked for resuscitation devices for various age groups. Findings from the assessment showed there were 1017 resuscitation bags and masks counted acrossed the assessed facilities – 569 (56%) adults; 304 (30%) pediatrics and 144 (14%) neonates. Ganta Methodist Hospital had the highest (20%) stock of resuscitation bags and mask.

[15] https://www.oxfordmedicaleducation.com/prescribing/oxygen-delivery/
[16] https://www.atsjournals.org/doi/10.1513/AnnalsATS.201707-548FR
[17] https://www.aastweb.org/blog/bipap-biphasic-positive-airway-pressure-vs.-cpap-therapy
[18] WHO Clinical Management of COVID-19 – Interim guidance P 20

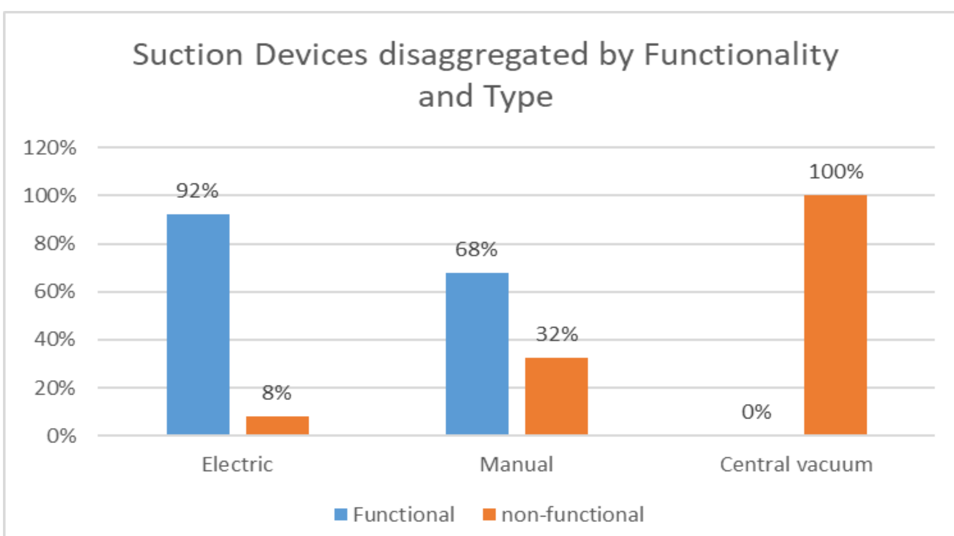
Figure 10: Number of Complete Resuscitation devices At the Assessed Facilities by Age Category



10) Suction devices

Suction machines are used to gently suction and clear excessive mucus from the airway passages of a newborn or an infant, in order to facilitate easier breathing. They can be electrical, manual or foot operated. When a newborn is unable to breathe enough in the first few minutes of life, birth asphyxia may occur. One way that this occurs is when the infant still has fluid in the airway. Suction can, therefore, in this case assist in removing the fluid and clear the airway to allow the newborn to breathe easily or to decrease respiratory resistance.[19] To check facility's preparedness to manage would-be COVID-19 cases in children, question was asked about the availability of suction machines. The result showed there were suction machine at 46 (87%) of the assessed facilities. The team counted 742 suction devices; of which, 637 (86%) were functional. 515 (81%) of the functional suction devices were electric; 121 (19%) were manual and none was a central vacuum suction device. For the non-functional suction devices, 45 (42%) were electric while 58(55%) manual. The lack of spare parts and consumables was the most frequent reason for the suction devices being non-functional. Montserrado County had most of the non-functional suction devices.

Figure 11: Percent of Suction Devices at the facilities disaggregated by Functionality



[19] WHO Technical specifications of Neonatal Resuscitation Devices

11) Laryngoscope, Intubation sets, Airways

WHO recommends that, for all suspected COVID-19 cases, there should be collection of upper respiratory tract (URT) specimens (nasopharyngeal and oropharyngeal) for testing by reverse transcription polymerase chain reaction (RT-PCR) and, where clinical suspicion remains and URT specimens are negative, to collect specimens from the lower respiratory tract (LRT) when readily available (expectorated sputum, or endotracheal aspirate/bronchoalveolar lavage in ventilated patient). In addition, testing for other respiratory viruses and bacteria should be considered when clinically indicated.[20] To do these screening and specimen collection, health workers use various devices including Laryngoscope, intubation sets and airways.

Laryngoscope

This is a small device use to look into the throat and larynx, or voice box. This procedure is called laryngoscopy. This is done to figure out why you have a cough or sore throat and to find and remove something that's stuck in there, or to take samples of your tissue to look at later. The assessment found out that 26 (49%) of the assessed facilities had thes devices. There were 316 Laryngoscopes; of which, 208 (66%) were the Macintosh (Curved blade) and 108 (34%) were Miller (Straight blade). Most (17%) of the reported laryngoscope was seen at the ELWA hospital. A study comparing the Miller and Macintosh laryngoscope conducted by researchers from Poland concluded that endotracheal intubation with the use of the Miller laryngoscope in trauma pediatric patients is associated with higher first attempt success rates than the Macintosh laryngoscope.[21] They explained that their results suggest that for patients with cervical spine immobilization, the Miller laryngoscope should be the preferred method of intubation in emergency medicine conditions. With this information, there are lesser of this preferred method available at the assessed facilities.

Intubation sets

Intubation sets are used to assist patients who cannot maintain their airway, cannot breathe on their own without assistance, or both. They may be going under anesthesia and will be unable to breathe on their own during surgery, or they may be too sick or injured to provide enough oxygen to the body without assistance. The endotracheal tube is inserted through the mouth and then into the airway. This is done so that a patient can be placed on a ventilator to assist with breathing during anesthesia, sedation or severe illness such as COVID-19. The tube is then connected to a ventilator, which pushes air into the lungs to deliver a breath to the patient. The WHO recommend in its guideline for clinical management of COVID-19 that endotracheal intubation be performed in the management of critical COVID-19 cases with acute respiratory distress syndrome (ARDS). In this regard, the oxygen assessment counted the number of intubation sets for two different age groups – Adults and Pediatrics. The result showed that 21 (40%) of the 53 assessed facilities had complete intubation sets (i.e. endotracheal tube set (tube + guide "Stylet" or "Bougie"), laryngeal mask, AND colorimetric end tidal CO_2 detector). Total of 877 intubation sets were counted – 504(57%) for adults and 373 (43%) for pediatrics. With less than half of the facilities having a complete intubation set, this establishes a clear gap in facility readiness at the health center and hospital level.

Airway

Oropharyngeal and nasopharyngeal airways are adjuncts that can be used to obtain/maintain an open airway. An oropharyngeal airway (OPA) is also known as an oral airway or Guedel airway. The nasopharyngeal airway (NPA) is also called a nasal airway[22]. Either device can be used depending on the indications for use and patient circumstances. WHO recommends in the management of severe COVID-19, mechanical ventilation should be implemented using lower tidal volumes (4–8 mL/kg predicted body weight [PBW]) and lower inspiratory pressures (plateau pressure < 30 cmH2O). Patients, both adults and children with emergency signs (obstructed or absent breathing, severe respiratory distress, central cyanosis, shock, coma and/or convulsions) should receive emergency airway management and oxygen therapy during resuscitation to target SpO2 ≥ 94%.[23] To determine if the assessed facilities were ready to support airway management, the team checked facilities for various types of airways and gauged their reusability. The results showed that 38 (72%) of the assessed facilities had airways. There were 1325 airway devices, of which 571 (43%) of the devices were reusable

[20] Clinical Management of COVID-19: Interim guidance, page 17

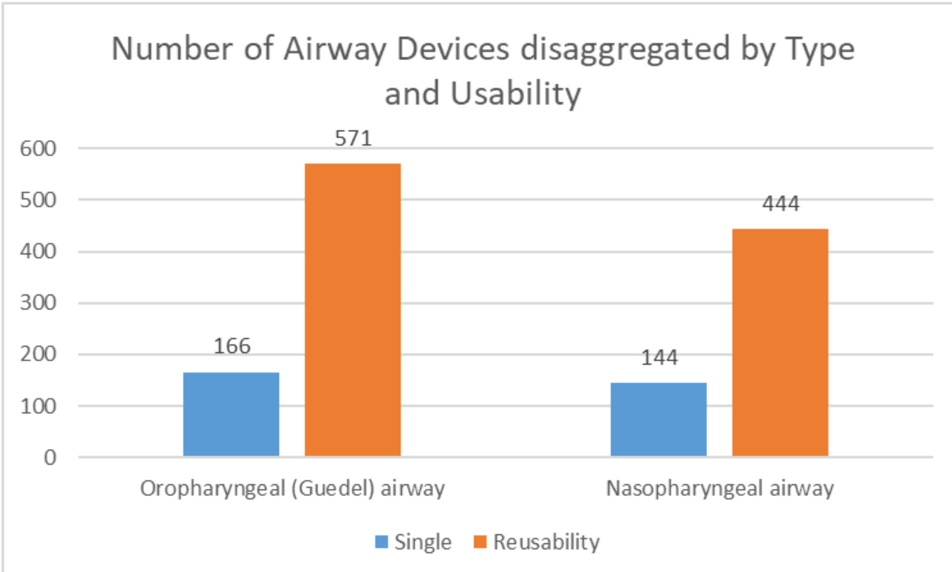
[21] https://www.researchgate.net/publication/315778825_Comparison_of_the_Miller_and_Macintosh_laryngoscopes_in_simulated_pediatric_trauma_patient_a_pilot_study - Conclusion page 9

[22] *https://www.careercert.com/articles/airway-management-ventilation/nasopharyngeal-oropharyngeal-airways/*

[23] *Clinical management of COVID-19: interim guidance, page 21*

Oropharyngeal (Guedel) airways; 444 (34%) reusable Nasopharyngeal airways; 166(13%) single-use Oropharyngeal (Guedel) airways and 144 (11%) single-use Nasopharyngeal airways. The reusable airways require appropriate Infection Prevention and Control measures to avoid transmission of infection from one patient to another; however an ideal situation for Liberia would be to have significantly more single-use airway devices to be disposed after use.

Figure 12: Number of Airway Devices by Type and Usability



12) Ventilators

Ventilators are used to provide mechanical ventilation by moving breathable air into and out of the lungs to deliver breaths to patient who are physically unable to breathe independently. When your lungs inhale and exhale air normally, they take in oxygen your cells need to survive and expel carbon dioxide. Because COVID-19 is a respiratory infection that inflame the airways and essentially drown your lungs in fluids, WHO recommends the administration of supplemental oxygen therapy to patient with emergency signs and to any patient without emergency signs and SpO2 < 90%. Implementation of mechanical ventilation is recommended for patients with Acute Respiratory Distress Syndrome using lower tidal volumes (4–8 mL/kg predicted body weight [PBW]) and lower inspiratory pressures (plateau pressure < 30 cmH2O) is recommended. [24] In this regard, the assessment counted number of patient ventilators at the assessed facilities by type. The result showed that only 13(25%) of the 53 assessed facilities had ventilators. There were total of 58 ventilators counted; of which, 42 (72%) were functional. 24 of the functional ventilators were transportable type; 15 intensive care for adults and 3 intensive care for pediatrics; whereas, for the non-functional ones, the count showed 8 transportable type; 7 intensive care for adults and 1 intensive care for pediatrics. The common reason given for why some ventilators were not functional was the lack of spare parts and consumables such as cables, batteries and sensors.

There are no ventilators in some of the dedicated COVID-19 treatment facilities and even the centers equipped with ventilators lack the various types needed for different age categories. There is a need for additional ventilators to adequately support mechanical ventilation of patients.

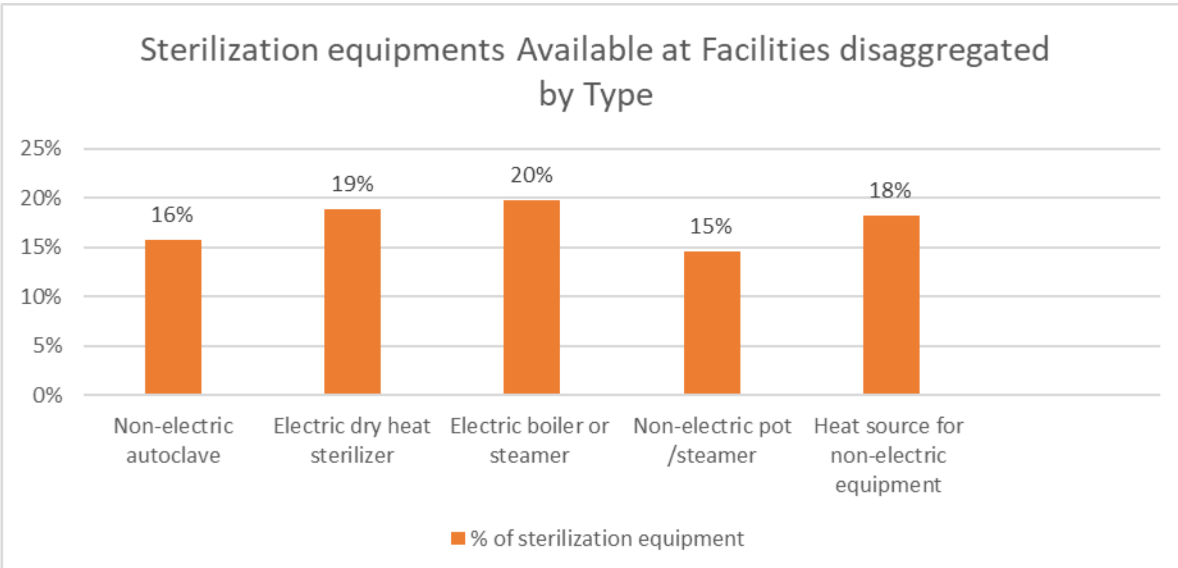
13) Sterilization methods

Infection prevention and control is a critical and integral part of clinical management of COVID-19 patients. The WHO recommend several precautionary measures in the guideline for Clinical Management of COVID-19[25]to avoid the transmission of the virus. These measures include the cleaning and disinfection of equipment. The team checked the facilities for availability of autoclaving/sterilizing equipment/methods to disinfect used equipment. The result showed that

[24] *Clinical management of COVID-19: interim guidance, page 20*
[25] *Clinical management of COVID-19:interim guidance, page 16*

all of the facilities have some sort of equipment or method for disinfection. There were 743 different functional equipment available for autoclaving and sterilizing. 147 (20%) were electric boiler or steamer; 140 (19%) electric dry heat sterilizer; 135 (18%) heat source for non-electric equipment; 117 (16%) non-electric autoclave; 108 (15%) non-electric pot with cover for boiling/steam, and 96 (13%) electric autoclave (pressure & wet heat). Considering interruption in electricity supply, it is suitable to have non-electric autoclaving/sterilization equipment so that power shortage will not be reason for not disinfecting equipment.

Figure 13: Percent of Sterilization Equipment by Type



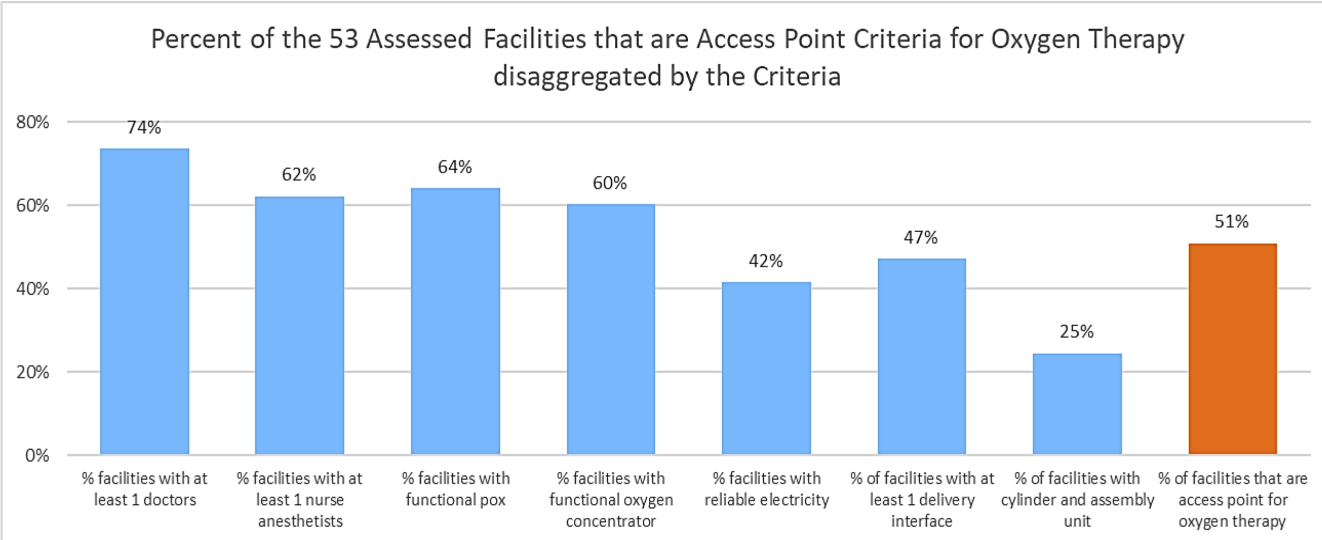
14) Access point for oxygen services

A single-centered, retrospective, observational study conducted in Wuhan, China revealed that although majority of COVID – 19 patients are diagnosed with mild or moderate illness, about 15% of them have severe illness requiring oxygen therapy and 5% are critically ill requiring intensive care unit treatment.[26] Most critically ill COVID-19 patients require mechanical ventilation. For these reasons, COVID-19 treatment health care facilities, even to provide basic oxygen therapy, should be equipped with pulse oximeters, functioning oxygen systems including single-use oxygen delivery interfaces.[27] Select criteria collected from this assessment were analyzed in order to determine which facilities are currently equipped to deliver basic/non-invasive oxygen therapy. The results showed that only a little over half (51% or 27 facilities) of the assessed facilities met all criteria to be considered as an access point; there is therefore a significant gap in the country's ability to offer basic oxygen therapy for hypoxemic patients.

Figure 14. Percent of Facilities that are Access Point for Oxygen Therapy

[26] Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir. 2020. doi:10.1016/S2213-2600(20)30079-5

[27] Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected; Geneva: World Health Organization; 2020 (https://www.who.int/docs/default-source/coronaviruse/clinical-management-of-novel-cov.pdf, accessed 10 April 2020)



Conclusion

This is the first-ever comprehensive survey aimed at assessing existing oxygen delivery capacity and oxygen systems in health facilities in Liberia. Overall, the assessment findings highlight significant shortcomings in the country's capacity to manage hypoxemia and deliver medical oxygen.

At the level of basic facility infrastructure, there is little stability in availability of power and electricity, which is essential for the operation of many oxygen devices. Many facilities are also not staffed with providers who have received training on diagnosis of hypoxemia and oxygen delivery. Many key oxygen technologies are either not present in health facilities, or are present but non-functional. For example, just a little over half of the facilities (64%) have any pulse oximeter (whether functional or non-functional), and only 68% of all pulse oximeters in the country can be deemed functional. Only 60% of assessed facilities have at least one functional oxygen concentrator, which is the key oxygen source in Liberia given the scarcity of oxygen plants and the geographic spread between functioning plants (3 out of 6 plants are currently functional) and health facilities. Across all types of oxygen devices assessed (pulse oximeters, concentrators, patient monitors, etc.), the most frequently cited reasons for non-functional were lack of spare parts and consumables, and the devices not being installed (for example, due to incompatibility in power source, lack of biomedical technician support). For facilities that use oxygen cylinders, the cost of refill and transportation of the cylinders is very high – average $318 USD; this is a significant deterrent to regular oxygen availability due to the already limited budget of most hospitals in the country.

When provider capacity, power availability, oxygen source, and availability of key consumables are considered together, only 51% of facilities can be considered access points of basic oxygen therapy – there is thus a need to implement holistic interventions to ensure that all components of a functional oxygen system are present and functional in a facility.

Based on the results presented here, there is a clear need for coordinated efforts to scale up oxygen access in Liberia, beginning with secondary and tertiary health facilities. To do so, MOH, implementing partners and donors should use these assessments result to:

- ❑ Develop national strategies and interventions to scale up oxygen access
- ❑ Prioritize health facilities for implementation of oxygen interventions
- ❑ Conduct gap analysis by comparing national oxygen demand (quantification) with existing oxygen supply
- ❑ Plan for repair and maintenance of existing oxygen technologies
- ❑ Inform quantity and type of oxygen technologies for procurement

Appendix 1: Oxygen Assessment Tool

INSTRUCTIONS: Please discuss the following questions on facility readiness and availability of devices/equipment for oxygen therapy with the facility Medical Director or OIC. If possible, please also have the person(s) most knowledgeable about biomedical equipment and/or oxygen therapy from the facility present for the assessment.

SECTION 1: FACILITY IDENTIFICATION	
Country (select “Liberia”)	
County name	☐ Bomi ☐ Bong ☐ Gbarpolu ☐ Grand Bassa ☐ Grand Cape Mount ☐ Grand Gedeh ☐ Grand Kru ☐ Lofa ☐ Margibi ☐ Maryland ☐ Montserrado ☐ Nimba ☐ River Gee ☐ Rivercess ☐ Sinoe
Facility name **District name, facility ownership, facility level will be added during data analysis based on MOH registries*	
Name of Facility Medical Director or Officer-In-Charge (OIC) *If the Acting Director/OIC is present on the day of data collection, put their name then put “Acting”*	
Phone number of Medical Director or OIC	
Email address of Medical Director or OIC	
Date of data collection (MM/DD/YYYY)	
Name of data collector	

SECTION 2: FACILITY READINESS CHARACTERISTICS FOR OXYGEN SUPPLY SYSTEMS	
Instructions: Ask for the following information regarding the facility’s overall readiness for oxygen therapy.	
What is the total number of inpatient beds in this facility? *Hint: Include adult and paediatric beds, but exclude delivery beds.*	
Of the total inpatient beds, how many can be used for intensive care?	
Does this facility have the capacity to perform surgeries? *Hint: For example, having operating theater, surgeon, anaesthetist, etc.*	☐ Yes ☐ No
Does this facility have the capacity to perform blood transfusions? *Hint: For example, having a blood bank, blood testing equipment, etc.*	☐ Yes ☐ No
Does this facility have a neonatal intensive care unit (NICU)?	☐ Yes ☐ No

Does the facility have access to clean running water (piped, bucket with tap or pour pitcher)	☐ Yes ☐ No
Does the facility have a wall pipe network of medical gases?	☐ Yes, Oxygen, Air and Vacuum ☐ Yes, Oxygen and Air ☐ Yes, Oxygen ☐ No
What is the primary source of electricity for this facility?	☐ National grid (LEC) ☐ Generator (fuel or battery operated) → answer generator questions below ☐ Solar system ☐ Other (specify)____
What is the secondary/back-up source of electricity for this facility? *Hint: If solar power is used only for the vaccine fridge and not for the rest of the facility, do not count it as the back-up source*	☐ National grid (LEC) ☐ Generator (fuel or battery operated) → answer generator questions below ☐ Solar system ☐ Other (specify)____ ☐ No secondary/back-up source
During the past 7 days, was electricity available from either the primary or secondary source, during all hours when facility was open for service?	☐ Always available (no interruptions) ☐ Often available (5-6 days of the week) ☐ Sometimes available (3-4 days of the week) ☐ Rarely available (1-2 days of the week)
If 'Generator' selected as primary or secondary source → How many FUNCTIONAL generators are available at this facility? 	Number______________
If electrical generator(s) at the facility, please complete the following details for <u>each</u> generator: 	

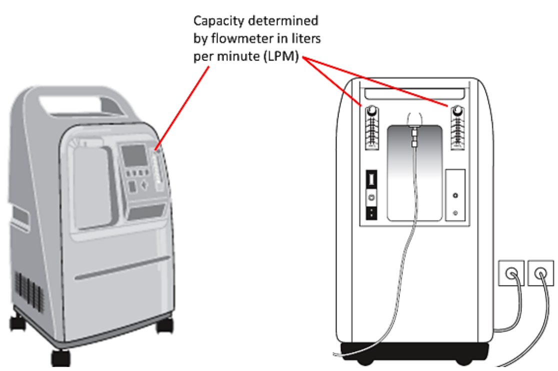
Generator capacity (kVa)	Stabilizer Yes	Stabilizer No	UPS capacity (Watts)

Is there an inverter in the facility for DC current?	☐ Yes ☐ No
Please select all wards/departments that have dependable voltage stabilization AND double conversion uninterruptible power supply	☐ Emergency room ☐ Intensive care ☐ Surgery ☐ Inpatient ☐ Laboratory ☐ Imaging ☐ Other (specify)____
Does facility have any emergency transport vehicles or ambulances stationed at this facility?	☐ Yes, with oxygen → how many vehicles are with oxygen ________ ☐ Yes, but without oxygen → how many vehicles are without oxygen _______ ☐ No
Is there a staff at your facility dedicated to the management, installation, and maintenance of medical equipment? *Hint: Count only staff dedicated to this facility, not Health Technology Management staff who oversee multiple facilities*	☐ Yes → ☐ No If yes, provide contact details for the most senior person at the facility dedicated to management of medical equipment: Title____ Phone number________________________________
How many doctors are at this facility?	Number______________________
How many nurse anaesthetists are at this facility?	Number______________________

SECTION 3a: VITAL SIGN MONITORING DEVICES		
Instructions: Count the number of patient vital sign monitoring devices at the facility by functionality and type. *Hint: New devices that are still in box at the time of assessment are considered "non-functional or not-in-use"*		
Type	Number Functional and In-Use	Number Non-functional or Not-In-Use
Patient monitor with integrated ECG 		
Patient monitor without integrated ECG		
If non-functional for any type is >0, please indicate the reason(s) the devices are non-functional.	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No consumables (cables, sensors) ☐ Not installed ☐ No distributor in country ☐ Other (specify)____	

SECTION 3b: PULSE OXIMETERS		
Instructions: Count the number of pulse oximeters at the facility by functionality and type. *Hint: New devices that are still in box at the time of assessment are considered "non-functional or not-in-use"*		
Type	Number Functional and In-Use	Number Non-functional or Not-In-Use
Table-top pulse oximeter 		
Portable handheld pulse oximeter 		
Self-contained fingertip pulse oximeter 		
If non-functional for any type is >0, please indicate the reason(s) the devices are non-functional.	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No consumables (cables, sensors) ☐ Not installed ☐ No distributor in country ☐ Other (specify)____	

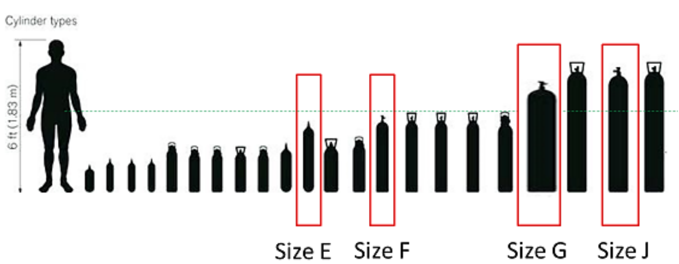
SECTION 4: OXYGEN CONCENTRATORS	
Instructions: Count the total number of oxygen concentrators in this facility (functional and non-functional/not installed). Then for each concentrator, you will answer a series of questions including functionality.	
How many oxygen concentrators are at this facility? Count both functional/in-use and non-functional/not-in-use.	Number_______________



Answer the following questions for EACH oxygen concentrator at this facility:				
Oxygen concentrator 1	*Oxygen concentrator 2*	*Oxygen concentrator 3*	*Oxygen concentrator 4*	*Oxygen concentrator 5*
Who is the manufacturer? ☐ AirSep ☐ DeVilbiss ☐ Diamedica ☐ Invacare ☐ Longfian Scitech ☐ Narang Medical ☐ Nidek Medical Products ☐ Philips Respironics ☐ Yuwell-Jiangsu Yuyue ☐ Other (specify)______________	Who is the manufacturer? ☐ AirSep ☐ DeVilbiss ☐ Diamedica ☐ Invacare ☐ Longfian Scitech ☐ Narang Medical ☐ Nidek Medical Products ☐ Philips Respironics ☐ Yuwell-Jiangsu Yuyue ☐ Other (specify)______________	Who is the manufacturer? ☐ AirSep ☐ DeVilbiss ☐ Diamedica ☐ Invacare ☐ Longfian Scitech ☐ Narang Medical ☐ Nidek Medical Products ☐ Philips Respironics ☐ Yuwell-Jiangsu Yuyue ☐ Other (specify)______________	Who is the manufacturer? ☐ AirSep ☐ DeVilbiss ☐ Diamedica ☐ Invacare ☐ Longfian Scitech ☐ Narang Medical ☐ Nidek Medical Products ☐ Philips Respironics ☐ Yuwell-Jiangsu Yuyue ☐ Other (specify)______________	Who is the manufacturer? ☐ AirSep ☐ DeVilbiss ☐ Diamedica ☐ Invacare ☐ Longfian Scitech ☐ Narang Medical ☐ Nidek Medical Products ☐ Philips Respironics ☐ Yuwell-Jiangsu Yuyue ☐ Other (specify)______________
What is the maximum flow rate capacity of this oxygen concentrator? ☐ Up to 3L/min ☐ Up to 5L/min ☐ Up to 8L/min ☐ Up to 10L/min ☐ > 10L/min	What is the maximum flow rate capacity of this oxygen concentrator? ☐ Up to 3L/min ☐ Up to 5L/min ☐ Up to 8L/min ☐ Up to 10L/min ☐ > 10L/min	What is the maximum flow rate capacity of this oxygen concentrator? ☐ Up to 3L/min ☐ Up to 5L/min ☐ Up to 8L/min ☐ Up to 10L/min ☐ > 10L/min	What is the maximum flow rate capacity of this oxygen concentrator? ☐ Up to 3L/min ☐ Up to 5L/min ☐ Up to 8L/min ☐ Up to 10L/min ☐ > 10L/min	What is the maximum flow rate capacity of this oxygen concentrator? ☐ Up to 3L/min ☐ Up to 5L/min ☐ Up to 8L/min ☐ Up to 10L/min ☐ > 10L/min
What is the functional status of this oxygen concentrator? *[select all that apply]* ☐ Still in box/not installed ☐ Concentrator powers on and has no other evident issues ☐ Concentrator powers on but is missing parts (e.g. humidifier bottles, tubing, etc.) for ongoing function ☐ Concentrator powers on but requires voltage stabilizer for ongoing function ☐ Concentrator powers on but compressor does not start (no action from the unit) ☐ Concentrator powers on but there is no product flow from the unit ☐ Concentrator powers on but there is audible alarm sound that persists ☐ Concentrator DOES NOT power on, even when there is available power supply ☐ Other (specify)______	What is the functional status of this oxygen concentrator? *[select all that apply]* ☐ Still in box/not installed ☐ Concentrator powers on and has no other evident issues ☐ Concentrator powers on but is missing parts (e.g. humidifier bottles, tubing, etc.) for ongoing function ☐ Concentrator powers on but requires voltage stabilizer for ongoing function ☐ Concentrator powers on but compressor does not start (no action from the unit) ☐ Concentrator powers on but there is no product flow from the unit ☐ Concentrator powers on but there is audible alarm sound that persists ☐ Concentrator DOES NOT power on, even when there is available power supply ☐ Other (specify)______	What is the functional status of this oxygen concentrator? *[select all that apply]* ☐ Still in box/not installed ☐ Concentrator powers on and has no other evident issues ☐ Concentrator powers on but is missing parts (e.g. humidifier bottles, tubing, etc.) for ongoing function ☐ Concentrator powers on but requires voltage stabilizer for ongoing function ☐ Concentrator powers on but compressor does not start (no action from the unit) ☐ Concentrator powers on but there is no product flow from the unit ☐ Concentrator powers on but there is audible alarm sound that persists ☐ Concentrator DOES NOT power on, even when there is available power supply ☐ Other (specify)______	What is the functional status of this oxygen concentrator? *[select all that apply]* ☐ Still in box/not installed ☐ Concentrator powers on and has no other evident issues ☐ Concentrator powers on but is missing parts (e.g. humidifier bottles, tubing, etc.) for ongoing function ☐ Concentrator powers on but requires voltage stabilizer for ongoing function ☐ Concentrator powers on but compressor does not start (no action from the unit) ☐ Concentrator powers on but there is no product flow from the unit ☐ Concentrator powers on but there is audible alarm sound that persists ☐ Concentrator DOES NOT power on, even when there is available power supply ☐ Other (specify)______	What is the functional status of this oxygen concentrator? *[select all that apply]* ☐ Still in box/not installed ☐ Concentrator powers on and has no other evident issues ☐ Concentrator powers on but is missing parts (e.g. humidifier bottles, tubing, etc.) for ongoing function ☐ Concentrator powers on but requires voltage stabilizer for ongoing function ☐ Concentrator powers on but compressor does not start (no action from the unit) ☐ Concentrator powers on but there is no product flow from the unit ☐ Concentrator powers on but there is audible alarm sound that persists ☐ Concentrator DOES NOT power on, even when there is available power supply ☐ Other (specify)______

If any of the oxygen concentrators are non-functional or not-in-use, please indicate any additional reason(s) the devices are non-functional.	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No distributor in country ☐ Other (specify)____

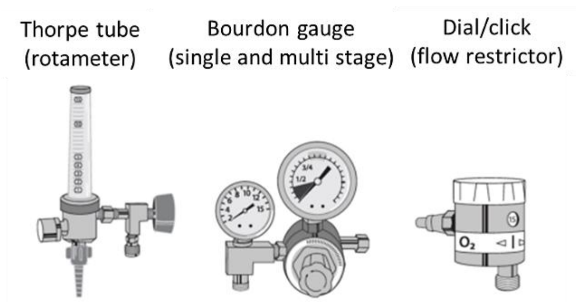
SECTION 5: OXYGEN CYLINDERS		
Instructions: For each cylinder size and connection type, count the number of cylinders available at the facility.		
Cylinder size (nominal content/oxygen capacity in Litres)	Pin-index 	Bull-nose 
"D" (340L)		
"E" (680L)		
"F" (1360L)		
"G" (3400L)		
"J" (6800L)		
Other size (specify size ___________)		



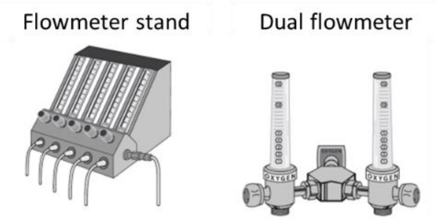
What is the average number of oxygen cylinders consumed per week?	Number____________________
What is the total cost of cylinders/week?	☐ Price ($USD) _____________ ☐ Don't know
Where do you fill the oxygen cylinders at this facility?	☐ Bomi ☐ Bong ☐ Gbarpolu ☐ Grand Bassa ☐ Grand Cape Mount ☐ Grand Gedeh ☐ Grand Kru ☐ Lofa ☐ Margibi ☐ Maryland ☐ Montserrado ☐ Nimba ☐ River Gee ☐ Rivercess ☐ Sinoe
What is the average refill frequency for the oxygen cylinders at this facility?	☐ Daily ☐ Monthly ☐ Quarterly ☐ Other (specify)___________________________

SECTION 6: CYLINDER ASSEMBLY UNITS		
Instructions: Count the number of cylinder assembly units at the facility by functionality and connection type. A cylinder assembly unit is a pressure regulator and gauge.		
Functionality	Pin-index	Bull-nose
Functional		
Non-functional		

SECTION 7: FLOWMETER, THORPE TUBE		
Instructions: Count the number of flowmeters at the facility by maximum flow rate and functionality.		



Maximum flow rate capacity	Number Functional	Number Non-functional
Up to 2L/min		
Up to 5L/min		
Up to 10L/min		
Up to 15L/min		
Greater than 15L/min		

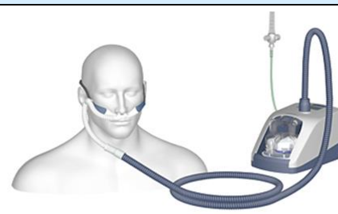
SECTION 8: FLOW-SPLITTER		
Instructions: Count the number of functional flow-splitters at the facility by number of outlets and maximum flow rate		
		
Total number of outlets	Up to 1L/min	Up to 2L/min
2 outlets		
3 outlets		
4 outlets		
5 outlets		
Number of functional flow-splitters with other specifications (specify # of outlets and maximum flow rate):		

SECTION 9: OXYGEN DELIVERY INTERFACE			
Instructions: Count the number of type of oxygen delivery interface, by age category, available at the facility.			
Type	Adult	Paediatric	Neonate
Nasal cannula (nasal prongs) 			
Nasal catheters 			
Oxygen mask 			
Venturi mask 			

SECTION 10: BiPAP & CPAP MACHINES
Instructions: Count the number of BiPAP machines and CPAP machines at the facility by size and functionality. *Hint: New devices that are still in box at the time of assessment are considered "non-functional or not-in-use"*

BiPAP Machines Maintains continuous positive airway pressure (PAP) with *differing pressures* for inhalation vs. exhalation			CPAP Machines Maintains continuous positive airway pressure (PAP) with *same pressure* for inhalation and exhalation		
Size	Number Functional and In-Use	Number Non-functional or Not-In-Use	Size	Number Functional and In-Use	Number Non-functional or Not-In-Use
Adult			Adult		
Paediatric			Paediatric		
Neonatal			Neonatal		

SECTION 11: HIGH-FLOW NASAL CANNULA (HFNC)
Instructions: Count the number of high-flow nasal cannula (HFNC) oxygen delivery interface, by type, available at the facility.



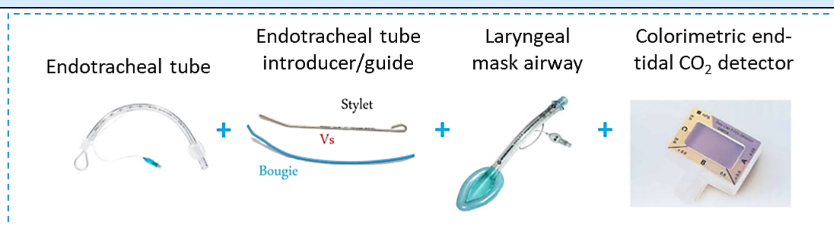
Size	Total number at facility
Adult	
Paediatric	

SECTION 12: RESUSCITATION BAGS AND MASKS
Instructions: Count the number of complete resuscitation bag and mask units at the facility by size.

Size	Total number of complete units at facility
Adult	
Paediatric	
Neonatal	

SECTION 13: SUCTION DEVICES		
Instructions: Count the number of complete suction devices at the facility by type. *Hint: New devices that are still in box at the time of assessment are considered “non-functional or not-in-use”*		
Type	Number Functional and In-Use	Number Non-functional or Not-In-Use
Manual 		
Electric 		
Central vacuum		
If non-functional for any type is >0, please indicate the reason(s) the devices are non-functional.	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No consumables (cables, sensors) ☐ Not installed ☐ No distributor in country ☐ Other (specify)____	

SECTION 14: LARYNGOSCOPE	
Instructions: Count the number of laryngoscopes at the facility	
Type	Total number at facility
Macintosh (Curved blade) 	
Miller (Straight blade) 	

SECTION 15: INTUBATION SETS	
Instructions: Count the complete intubation sets at the facility. To be considered as a complete set, must contain all of the following – endotracheal tube set (tube + guide “Stylet” or “Bougie”), laryngeal mask, AND colorimetric end tidal CO_2 detector	
	
Adult	Number of complete intubation sets_______________
Paediatric	Number of complete intubation sets_______________

SECTION 16: AIRWAYS		
Instructions: Count the number of airway devices by type and re-usability.		
Type	Single-use (# of pieces)	Reusable (# of pieces)
Oropharyngeal (Guedel) airway 		
Nasopharyngeal airway 		

SECTION 17: PATIENT VENTILATOR		
Instructions: Count the number of functional patient ventilators at the facility by type. *Hint: New devices that are still in box at the time of assessment are considered "non-functional or not-in-use"*		
Type	Number Functional and In-Use	Number Non-functional or Not-In-Use
Transport, portable 		
Intensive care – Adult 		
Intensive care – Paediatric		
If non-functional for any type is >0, please indicate the reason(s) the devices are non-functional.	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No consumables (cables, sensors) ☐ Not installed ☐ No distributor in country ☐ Other (specify)________________________________	

SECTION 18: AUTOCLAVE / STERILIZER			
Instructions: Observe whether the following equipment/methods for autoclaving and sterilizing are available at this facility.			
Type	Available and functional	Available but not functional	Not available
Electric autoclave (pressure & wet heat)			
Non-electric autoclave			
Electric dry heat sterilizer			
Electric boiler or steamer (no pressure)			
Non-electric pot with cover for boiling/steam			
Heat source for non-electric equipment (e.g. dry wood, gas burner, charcoal)			

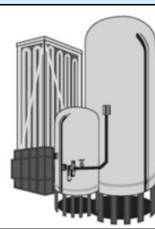
SECTION 19: OXYGEN TERMINAL BEDSIDE WALL OUTLETS	
Are there ANY oxygen terminal bedside wall outlets available at this facility, whose pressure is between 345-425 kPa (50-60 psi)? 	☐ Yes → proceed to questions below ☐ No

Instructions: Count the number of oxygen terminal bedside wall outlets whose pressure is between 345 – 425 kPa (50-60 psi), for EACH ward/department below (Emergency Room; Intensive Care Unit; IPD; Other)

Ward/Department	Total number of oxygen wall outlets	Number of connections per bed	Fitted with a valve and a pressure and flow regulator
Emergency Room		☐ 1 per bed ☐ 2 per bed	☐ Yes ☐ No
Intensive Care Unit (ICU)		☐ 1 per bed ☐ 2 per bed	☐ Yes ☐ No
Inpatient Department		☐ 1 per bed ☐ 2 per bed	☐ Yes ☐ No
Are there any other wards/departments with oxygen wall outlets? *Hint: DO NOT count terminal units in operating theatres (OT) or X-ray / imaging department*	☐ Yes → Specify name of other unit: ______________________________ ☐ No		
In this other unit:	Total number of oxygen wall outlets	Number of connections per bed	Fitted with a valve and a pressure and flow regulator
		☐ 1 per bed ☐ 2 per bed	☐ Yes ☐ No

Are there bedside oxygen wall outlets with pressures other than 345-425 kPa (50-60 psi)	☐ Yes → ☐ No	Pressure: _________ (kPa or psi [circle one])	Total number: __________	☐ 1 per bed ☐ 2 per bed

SECTION 20: OXYGEN CYLINDER MANIFOLD		
Instructions: Count the number of oxygen cylinder manifolds at the facility by size (e.g. number of cylinders that it can fit) and switching mechanism (e.g. manual or automatic).		
		
Number of cylinders that can fit in the manifold	Manual switch	Automatic switch
2 cylinders		
3 cylinders		
4 cylinders		
5 cylinders		
6 cylinders		
7 cylinders		
8 cylinders		

SECTION XXI: BULK LIQUID OXYGEN TANK	
Instructions: Ask for the following information about the facility's bulk liquid oxygen tank.	
Does the facility have a bulk liquid oxygen tank? 	☐ Yes → proceed to questions below ☐ No
What is the tank capacity in M^3. if other unit, please indicate.	
What is the refill frequency?	☐ Daily ☐ Weekly ☐ Monthly ☐ Quarterly ☐ Other (specify)____________________________
How much, price per m3?	☐ Price ($USD) ____________ ☐ Don't know

SECTION XXII: ON-SITE OXYGEN PLANT (PSA)	
Instructions: Ask for the following information about the facility's PSA oxygen plant.	
Does this facility have a pressure swing absorption (PSA) oxygen plant? 	☐ Yes → proceed to questions below ☐ No
What is the manufacturer and model of the plant?	
What is the maximum production capacity of this plant in m^3/hr? *Change units if not familiar*	☐ ___ ___ ___ m^3/hr ☐ Other (specify):__________
What is the average oxygen consumption in m^3/per month? *Change units if not familiar*	☐ ___ ___ ___ m^3/month ☐ Other (specify):__________
Does this oxygen plant currently provide oxygen for other health facilities?	☐ Yes ☐ No
Is the oxygen plant functional and operational?	☐ Yes ☐ No → proceed to reasons why
If oxygen plant is not functional / not operational, what is the reason?	☐ No spare parts ☐ No funds for maintenance ☐ No training to use ☐ No training to repair ☐ No consumables (cables, sensors) ☐ Not installed ☐ No distributor in country ☐ Other (specify)____________________________
On average, this oxygen plant produces oxygen for how many days per week?	Number of days per week_______________
On average, this oxygen plant produces oxygen for how many hours per day?	Number of hours per day_______________
What is the percent concentration of oxygen being produced by the plant? Or put "Don't Know"	☐ Percent concentration ___ ___. ___% ☐ Don't know
Is the oxygen plant connected to a back-up source of electricity, such as a fuel generator?	☐ Yes ☐ No
Is the back-up source of electricity dedicated to the oxygen plant?	☐ Yes ☐ No
Is there a surge suppressor for the oxygen plant?	☐ Yes ☐ No
Is there a voltage stabilizer for the oxygen plant?	☐ Yes ☐ No
Does the oxygen plant have a filling ramp or manifold for filling cylinders?	☐ Yes ☐ No

<table>
<tr><td>How many cylinder connections of the following type are on the ramp/manifold? Enter quantity.</td><td><table><tr><td>Type</td><td>Quantity</td></tr><tr><td>Bullnose</td><td></td></tr><tr><td>Pin-index</td><td></td></tr></table></td></tr>
<tr><td>To what pressure do you fill the cylinders?

Only fill in unit of use</td><td>Bar ___ ___ ___
or
kPa ___ ___ ___
or
psi ___ ___ ___</td></tr>
<tr><td>Approximately, how many cylinders did the oxygen plant fill in the last month?</td><td><table><tr><td>Type</td><td>Nominal content/ O_2 capacity (L)</td><td>Number of cylinders filled in the last month</td></tr><tr><td>“D”</td><td>340</td><td></td></tr><tr><td>“E”</td><td>680</td><td></td></tr><tr><td>“F”</td><td>1,360</td><td></td></tr><tr><td>“G”</td><td>3,400</td><td></td></tr><tr><td>“J”</td><td>6,800</td><td></td></tr><tr><td>Other</td><td>Specify:</td><td></td></tr></table></td></tr>
<tr><td>Is there direct piping from the oxygen plant to other wards/departments within this facility?</td><td>☐ Yes
☐ No</td></tr>
</table>

FINAL COMMENTS
You have reached the end of the Oxygen Equipment Assessment. Please ensure all sections of the assessment have been completed. Please enter any additional comments you have about the facility, the respondents, or the assessment.
Additional comments:

Appendix 2: List of facilities assessed

No	County	Facility name	Facility type	Ownership	Region
1	Bomi	Liberia Government Hospital (Bomi)	Hospital	Public	North Western
2	Bong	Bong Mines Hospital	Hospital	Public	North Central
3	Bong	C.B. Dunbar Maternity Hospital	Hospital	Public	North Central
4	Bong	Phebe Hospital	Hospital	Public	North Central
5	Gbarpolu	Chief Jallahlon Medical Center	Hospital	Public	North Western
6	Grand Bassa	Liberia Government Hospital (Buchanan)	Hospital	Public	South Central
7	Grand Bassa	Arcelol Mittal Hospital	Hospital	Private	South Central
8	Grand Cape Mount	St. Timothy Hospital	Hospital	Public	North Western
9	Grand Cape Mount	Sinje Health Center	Health Center	Public	North Western
10	Grand Gedeh	Gbarzon Health Center	Health Center	Public	South Eastern A
11	Grand Gedeh	Konobo Health Center	Health Center	Public	South Eastern A
12	Grand Gedeh	Martha Tubman Memorial Hospital	Hospital	Public	South Eastern A
13	Grand Kru	Rally Time Hospital	Hospital	Public	South Eastern B
14	Grand Kru	Buah Health Center	Health Center	Public	South Eastern B
15	Grand Kru	Sass Town Health Center (Domo Nimene Maternity Hospital)	Health Center	Public	South Eastern B
16	Lofa	Foya Boma Hospital	Hospital	Public	North Central
17	Lofa	Bolahun Health Center	Health Center	Public	North Central
18	Lofa	Kolahun Hospital	Hospital	Public	North Central
19	Lofa	Vahun Health Center	Health Center	Public	North Central
20	Lofa	Curran Lutheran Hospital	Hospital	Public	North Central
21	Lofa	Tellewoyan Memorial Hospital	Hospital	Public	North Central
22	Margibi	Salala Rubber Corporation (SRC) Health Center	Health Center	Public	South Central
23	Margibi	C.H. Rennie Hospital	Hospital	Public	South Central
24	Margibi	Unification Town Health Center	Health Center	Public	South Central
25	Maryland	J.J. Dossen Hospital	Health Center	Public	South Eastern B
26	Maryland	Pleebo Health Center	Health Center	Public	South Eastern B
27	Montserrado	14 Military Hospital	Hospital	Public	South Central
28	Montserrado	Redemption Hospital	Hospital	Public	South Central
29	Montserrado	Bensonville Hospital	Hospital	Public	South Central
30	Montserrado	JFK Medical Center	Hospital	Public	South Central
31	Montserrado	SDA Cooper Memorial Hospital	Hospital	Private	South Central
32	Montserrado	St. Joseph Catholic Hospital	Hospital	Public	South Central
33	Montserrado	Benson Hospital	Hospital	Private	South Central
34	Montserrado	Duport Road Health Center	Health Center	Public	South Central
35	Montserrado	ELWA Hospital	Hospital	Public	South Central
36	Montserrado	Pipeline Health Center	Health Center	Public	South Central
37	Montserrado	Barnersville Health Center	Health Center	Public	South Central
38	Montserrado	James N. David Memorial Hospital	Hospital	Public	South Central
39	Montserrado	Bardnesville Junction Hospital	Hospital	Private	South Central
40	Montserrado	TB Annex Hospital	Hospital	Public	South Central

No	County	Facility name	Facility type	Ownership	Region
41	Montserrado	Nyehn Health Center	Health Center	Public	South Central
42	Nimba	Karnplay Health Center	Health Center	Public	North Central
43	Nimba	Saclepea Comprehensive Health Center	Health Center	Public	North Central
44	Nimba	Arcelol Mittal Hospital	Hospital	Private	North Central
45	Nimba	G.W. Harley Hospital	Hospital	Public	North Central
46	Nimba	Ganta Methodist Hospital	Hospital	Public	North Central
47	Nimba	Jackson F. Doe Memorial Hospital	Hospital	Public	North Central
48	Nimba	Zoe Geh Medical Center	Health Center	Public	North Central
49	River Gee	Gbeapo Health Center	Health Center	Public	South Eastern B
50	River Gee	Fish Town Hospital	Hospital	Public	South Eastern B
51	Rivercess	St. Francis Hospital	Hospital	Public	South Eastern A
52	Sinoe	F.J. Grante Hospital	Hospital	Public	South Eastern A
53	Sinoe	Karquekpo Clinic	Health Center	Public	South Eastern A