MINISTRY OF HEALTH
Republic of Liberia

National Roadmap to Increase Access to Medical Oxygen in Liberia

2021 – 2024

Validated October 2021

Foreword

Oxygen is an essential medicine that is key to improving health outcomes of a wide range of patient conditions, including those of life-threatening newborn and maternal emergencies. Access to stable, affordable, and high-quality medical oxygen has long been a challenge in Liberia, impeded by gaps that span across the health system: availability of sustainable oxygen sources, availability of biomedical equipment and supplies; facility infrastructure; availability of trained clinicians and biomedical personnel; and sustainable financing. The COVID-19 pandemic that erupted in 2020 have significantly amplified these challenges and have highlighted an urgent need to scale up oxygen access in the country.

A critical first step to successful resource mobilization and implementation of interventions for oxygen scale-up is the development of national guiding documents; in particular, a national roadmap providing a coordinated activity plan, timeline, and budget is necessary. Led by the Ministry of Health's Health Services Department, this document, the **National Roadmap to Increase Access to Medical Oxygen in Liberia,** serves the purpose as the first-ever national plan focused on oxygen access. This Roadmap outlines prioritized interventions under four main objectives to be implemented over the next three years:

1) Create enabling environment for oxygen access scale-up
2) Increase availability and quality of oxygen technologies and supplies
3) Improve clinical oxygen delivery and maintenance of oxygen technologies
4) Integrate oxygen data into routine health information systems

By the completion of this document, we have accomplished one the cardinal milestones in the managements of medical emergencies and disease conditions requiring medical oxygen therapy and standardized method of administration. Overall, this landmark document would never have been possible without the individual and collective input of the members of the Oxygen Technical Working Group (TWG). The Ministry of Health particularly recognizes with profound gratitude, the technical and financial support from the Clinton Health Access Initiative (CHAI), and contributions from other partners including the World Health Organization (WHO) and UNICEF.

Let me end by emphasizing that the Ministry of Health recognizes that oxygen is an essential medicine, and is committed to ensuring that **no patient in Liberia dies from hypoxemia.**

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Minister of Health

Acknowledgements

The Ministry of Health acknowledges with sincere gratitude and honor for the overwhelming support received from service providers, partners, and donors in completing the drafting and validation process for the **National Roadmap to Increase Access to Medical Oxygen in Liberia.**

We appreciate the very useful inputs from the onset to the final days of the validation process. The process of *developing this Roadmap has been a collaborative and participatory* effort from the start, leveraging on the Ministry's Oxygen Technical Working Group. We recognize the efforts of all Ministry units and partners during this process and would like mention the following:

- Ministry of Health Emergency Medical Response (EMR) Unit; Healthcare Technology Management Unit (HTMU)
- Clinton Health Access Initiative (CHAI); WHO; UNICEF; USAID; GIZ; Partners in Health (PIH); MCAI; Jhpiego; Last Mile Health; Partner Liberia

My sincere thanks and appreciation to the Minister of Health for her unflinching support for response to the COVID-19 pandemic and the strengthening of our health system.

Finally, I want to express my sincere gratitude on behalf of the Ministry of Health to the foundation established by EMR Director, Mr. Mark Luke, and all staff of the EMR Unit, upon which we will increase access to medical oxygen for all patients.

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Chief Medical Officer-RL(CMO)/Deputy Minister

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Executive Summary

Hypoxemia —an abnormally low level of oxygen in blood— is a leading cause of death in Liberia, particularly among mothers, newborns, and children. Hypoxemia can result from a number of underlying causes and complications, and the timely diagnoses and management of hypoxemia is key to preventing mortality.

Oxygen is an essential medicine that is key to improving health outcomes of a wide range of patient conditions, including those of life-threatening maternal and newborn emergencies. The Government of Liberia is committed to reducing maternal, neonatal and child mortality, and oxygen therapy as a key to achieving this goal must be prioritized accordingly. 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 and supplies; facility infrastructure; availability of trained clinicians and biomedical personnel; comprehensive national strategy and sustainable financing. These challenges have been amplified by the current COVID-19 pandemic.

A recent assessment of existing capacity to deliver oxygen therapy in Liberia has revealed gaps in many health facilities. Of all the public and private health centers and hospitals across 15 counties, only half of the facilities qualified as access points for basic oxygen therapy when criteria of trained provider, availability pulse oximetry, availability of functional oxygen source, and available delivery interfaces are considered. Furthermore, only 60% of facilities had any functional oxygen concentrators, and just six functional PSA plants were in place at the time of the assessment to serve the entire country, indicating an urgent need to implement solutions to increase access to oxygen availability at health facilities.

It is the vision of the Ministry of Health that no patient in Liberia dies from hypoxemia, and the government is committed to increasing access to quality, affordable medical oxygen for all patients. To achieve this goal, a coordinated and systems-based approach to oxygen scale-up is required. This document, the National Roadmap to Increase Access to Medical Oxygen in Liberia, outlines priority interventions under four main objectives to be implemented in the next three years to improve access to medical oxygen:

1) Create enabling environment for oxygen access scale-up
2) Increase availability and quality of oxygen technologies and supplies
3) Improve clinical oxygen delivery and maintenance of oxygen technologies
4) Integrate oxygen data into routine health information systems

The Roadmap is intended to guide implementation and coordination of oxygen activities in Liberia, to provide cost estimates for implementation, and to support resource mobilization efforts. The Ministry of Health through the Health Services Division will coordinate and implement this plan, working closely with all relevant Ministry programs, regulatory agencies, professional boards and training institutions, health facilities, donors, and non-government partners to improve oxygen access in Liberia.

Oxygen as an Essential Medicine

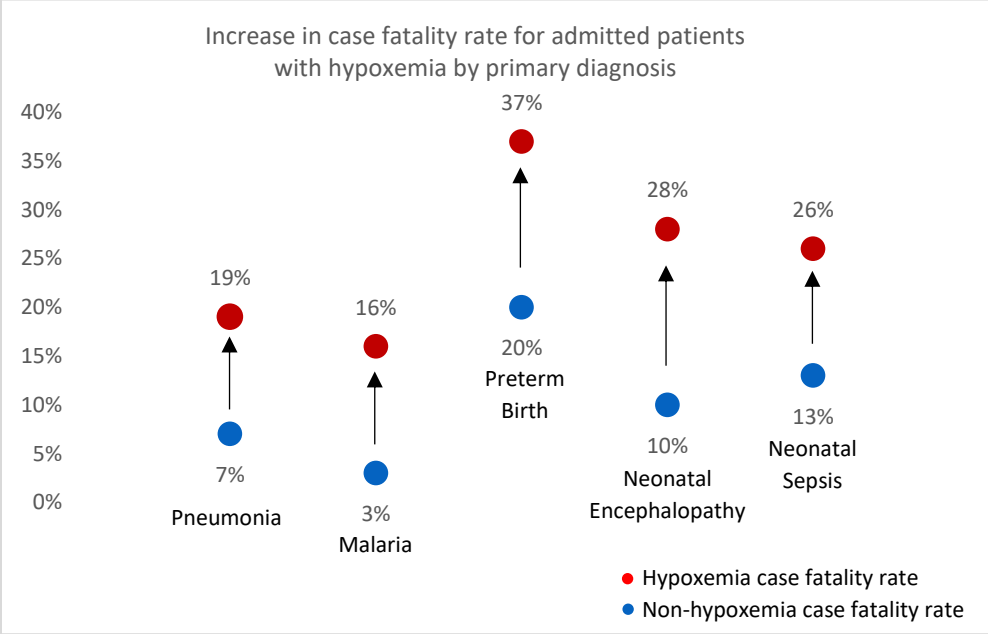
Oxygen therapy (respiratory care; respiratory therapy) can be used to treat any form of **hypoxemia**—abnormally low level of oxygen in the blood—regardless of its underlying cause, and therefore has potential to reduce disease burden among many patient groups. In vulnerable populations such as newborns, children, and pregnant women, hypoxemia can be caused by a range of complications including pneumonia, neonatal infections, premature birth, obstetric emergencies—oxygen therapy is critical for patient care, survival, and recovery in these cases. Oxygen is used across age groups to manage a wide range of conditions, including severe pneumonia, birth asphyxia, sepsis, malaria, asthma, and chronic obstructive pulmonary disease. Oxygen is also essential for safe surgery, anesthesia, and obstetric and emergency care.

In particular, the urgent need for oxygen in the treatment of newborns, children under five and in obstetrics and gynecology is highlighted below.

Oxygen Therapy for Newborn and Child Health

Pneumonia is the leading cause of death in children under 5 years of age and is responsible for an estimated 14% of all deaths in this age category (WHO Global Health Observatory). Hypoxemia (insufficient oxygen in the blood) is a major fatal complication of pneumonia, and the risk of death increases with increasing severity of hypoxemia. A 2019 study in Nigeria found that for a range of primary diagnoses (pneumonia, malaria, preterm birth, neonatal encephalopathy, neonatal sepsis), hypoxemia increases the odds of death by six times in neonates and by seven times in children (Figure 1) (Graham, 2019[1]).

Figure 1. Hypoxemia and odds of death



More than half of all neonatal deaths globally are due to severe respiratory distress syndrome as a complication from pre-term birth (PATH, 2017), neonatal pneumonia, and asphyxia, all of which can cause low blood oxygen

[1] Hypoxemia and non-hypoxemia case fatality rates as reported for patients admitted to hospitals in South West Nigeria in Graham, 2019

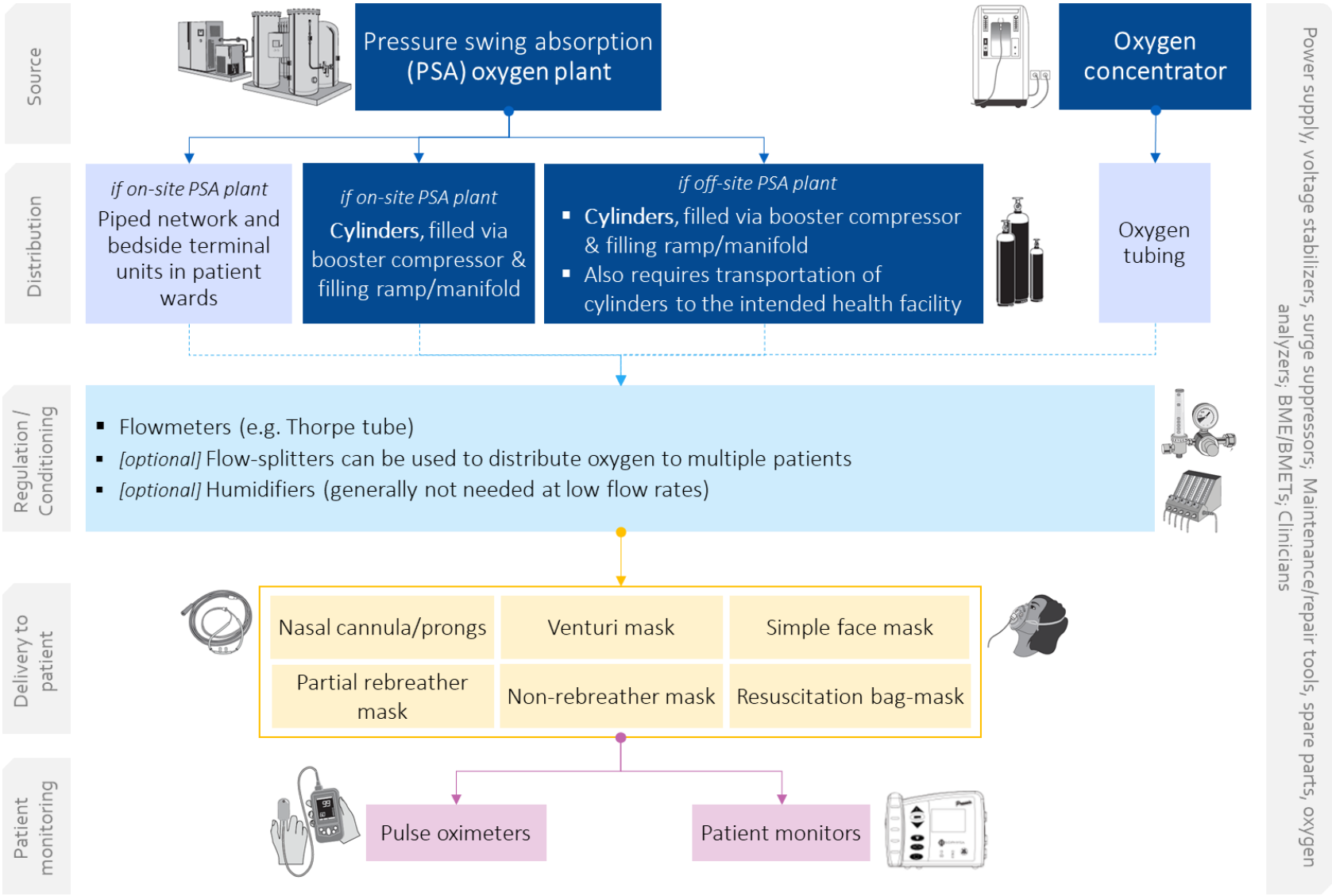
levels. In Liberia, 25% of neonatal deaths are caused by preterm birth complications (Liu, 2015). Pneumonia is the leading infectious cause of death in children under five globally; at least 13% of those admitted with severe pneumonia have hypoxemia. In Liberia, 34% of under-five deaths from pneumonia result from hypoxemia, indicating a need for increased access to oxygen. Furthermore, there is an estimated annual 1,467 preventable deaths from hypoxemia annually in neonatal and pediatric patients under 5 years (estimates made using IHME case data for Liberia and estimated hypoxemia prevalence and fatality rates from similar contexts: Subhi, 2009; IHME, 2018; Orimadegun, 2014).

Oxygen in Obstetrics and Gynecology

Liberia has a high maternal mortality rate (MMR) at 1,072 deaths per 100,000 live births (LISGIS et al., 2014) Many obstetric conditions (obstetric shock including hemorrhagic, anaphylactic shock and septic shock, preeclampsia and eclampsia, and cesarean sections) and gynecological conditions (comprehensive abortion care and post-abortion care complications, ectopic pregnancy, and fistula) require the use of oxygen. The management of both emergency and chronic conditions require surgical interventions with a pure source of oxygen at the time of operation and post-surgery in the recovery or Intensive Care Units (ICUs). For women in labor and delivery in low and middle-income countries, obstetric emergencies such as hemorrhage, pulmonary embolism, and eclampsia with hypoxemia may go undiagnosed (PATH, 2017). Having the means to detect hypoxemia (e.g. pulse oximetry) and to manage hypoxemia is critical in preventing maternal deaths.

Recognizing this, in 2017, the World Health Organization identified oxygen as an essential medicine in its Model List of Essential Medicines (EML) for the management of hypoxemia. Previously, the Model EML only listed oxygen as an inhalation medicine in general anesthesia, thereby excluding recognition of its broader use in the management of hypoxemia. Oxygen medical gas as an ‘essential medicine’ must be considered in a markedly different way compared to other commodities. For health facilities to effectively deliver oxygen therapy, all components of a functional oxygen system must exist (Figure 2); however, there is no one-size-fits-all approach (additional detail on common oxygen sources and delivery interfaces in Appendices 1 and 2). Factors such as availability of human resources, health facility infrastructure and geography must be considered when planning for the optimal mix of oxygen sources and delivery approaches for the country. Therefore, Liberia’s national roadmap to scale-up oxygen access must also consider resources and interventions needed across all these different components.

Figure 2. Components of a functioning oxygen system



Oxygen Access in Liberia: Situation Analysis

Ownership and Coordination

Historically, there has been no mechanism to coordinate oxygen activities, and there is no single designated Ministry of Health (MOH) unit or department responsible for implementing all components of oxygen delivery systems. Thus, various vertical programs often discuss oxygen access challenges and solutions within their own respective working groups. As a result, support to oxygen activities have been fragmented. Given that oxygen access is critical and relevant across various diseases and conditions, a functional oxygen system must involve interventions in all health system building blocks, there is significant benefit in establishing a coordination mechanism that links all ministry programs, support units, and partners working in oxygen-related activities.

In September 2020, driven by the national COVID-19 response and to prepare for longer-term planning to scale up oxygen access in Liberia, the Ministry of Health established the Oxygen Technical Working Group (TWG) (see Appendix 3 for TWG Terms of Reference). It is expected that the TWG will meet regularly and provide a platform for the implementation of all oxygen priorities in the country, and for the coordination of resources and support between government and partners. The TWG will report to the national Health Sector Coordination Committee (HSCC) which is a high-level decision-making body chaired by the Minister of Health which oversees TWG activities.

Policies, Strategies, Guidelines

There is currently no policy framework at the national level to delineate the roles and responsibilities within the health sector as they relate to oxygen access. While oxygen access is mentioned briefly in some existing national documents, there are no specific details to guide implementation (Figure 3).

The lack of national strategy is a key factor driving the fragmentation in both government and partner technical and financial support, resulting in inefficient use of resources and lack of sustained progress in oxygen scale-up (e.g. lack of knowledge sharing and transfer between individual partner projects and initiatives). Where government and/or partner resources are available, no validated set of national priorities are available to guide resource allocation; this sometimes results in activities being implemented out of order or not in an evidence-based fashion (e.g. donation or procurement of oxygen equipment that is not informed by national oxygen demand). Where technical or financial resources are not yet available, the lack of a national roadmap poses a significant challenge to resource mobilization efforts.

Figure 3. Existing national documents related to oxygen

Liberia RMNCAH Investment Case (2016-2022)

The Reproductive, Maternal, Neonatal, Child and Adolescent Health (RMNCAH) Investment Case (IC) (Liberia MOH, 2016) identifies key bottlenecks and prioritized geographies and interventions in the area of RMNCAH. However, oxygen access is not explicitly prioritized for the current IC period of 2016-2020; oxygen is briefly mentioned as it relates to existing in-service training programs for skilled birth attendants (SBAs). The IC identifies the need for a coordinated and harmonized training approach that covers all emergency obstetric and neonatal care signal functions, inclusive of oxygen training initiatives such as:

1) *Life Saving Skills (LSS)* – Course developed by the American College of Nurse Midwives (ACNM), includes a module on adult and newborn resuscitation
2) *Helping Babies Breathe (HBB)* – Course developed by the American Academy of Pediatrics (AAP)

While these in-service training initiatives have successfully trained SBAs in Liberia in the past (mainly through donor-supported trainings), there is no nationally validated repository of Liberia-specific training material, nor are there routine reviews and updates of any nationally validated training curriculum for oxygen.

Liberia Every Newborn Action Plan (LENAP) (2019-2023)

The HBB training and initiative is listed as a key intervention package under the action plan (Liberia MOH, 2019), and neonatal resuscitation materials including self-inflating bag and mask, suction devices, and training manikins/simulators are listed as key items for implementation. One national indicator in the action plan targets "at least half of babies who do not spontaneously at birth after thorough drying and stimulation will be resuscitated with bag and mask ventilation"; this indicator could be incorporated into any future national oxygen strategy for harmonization. The LENAP also discuss a potential research topic to explore training of community health assistants (CHAs) on basic newborn resuscitation.

Liberia National Standard Therapeutic Guidelines / Essential Medicines List (STG/EML)

The latest version of the national STG/EML (2nd edition) was updated in 2017. Oxygen is included as an essential medicine and indicated for management of hypoxemia (does not specific underlying causes). However, there may be an opportunity during the STG/EML revision to provide further guidance on pulse oximetry use, flowrate specifics, and management of acute respiratory distress syndrome (ARDS) as a result of diseases such as COVID-19. Furthermore, the EML does not consider requisite equipment and supplies oxygen delivery, such as oxygen concentrators, pulse oximeters, nasal cannulae and prongs, masks, etc.

Financing

Financing for oxygen activities is fragmented across relevant MOH units and departments, and it is not guaranteed that each department's annual budget includes activities explicitly targeted to increasing oxygen access. The Healthcare Technology Management Unit (HTMU), responsible for the maintenance and repair of biomedical equipment (and responsible for advising on any procurement and/or donations of BME), has a limited operational budget. As a result, HTMU has challenges completing activities within their current mandate, such as routine facility visits and planned preventive maintenance (PPM).

All oxygen equipment and devices in country, such as concentrators, pulse oximeters, and CPAP machines, have been procured through donor funding or donated directly by partners. However, this procurement or donation is not guided by nationally validated technical specifications to ensure suitability, nor are quantities or types of devices informed by the national oxygen demand (as no quantification exercise had ever been conducted prior to 2021).

Current Oxygen Availability

Between July and December 2020, the Clinton Health Access Initiative (CHAI) supported the MOH Healthcare Technology Management Unit to conduct the first-ever comprehensive assessment of oxygen delivery capacity in Liberia. The assessment examined the availability of oxygen equipment, devices, supplies, and consumables; infrastructure and power supply; and human resources.

A total of 53 public and private facilities (19 health centers and 34 hospitals, listed in Appendix 4) across all 15 counties in Liberia were visited for the assessment. The facility selection was done in consultation with HTMU, based on factors such as catchment population, admission volume, known infrastructure capacity; based on country context, these facilities are the priorities for scaling up oxygen access.

Key findings at the national and county level are described below to set the baseline scenario for Liberia's oxygen scale-up plan; detailed assessment results can be found in the full assessment report that was conducted by the Ministry of Health with support from CHAI (Liberia Ministry of Health, 2021).

Table 1. Availability of trained providers and oxygen equipment across 15 counties (N=53 facilities)

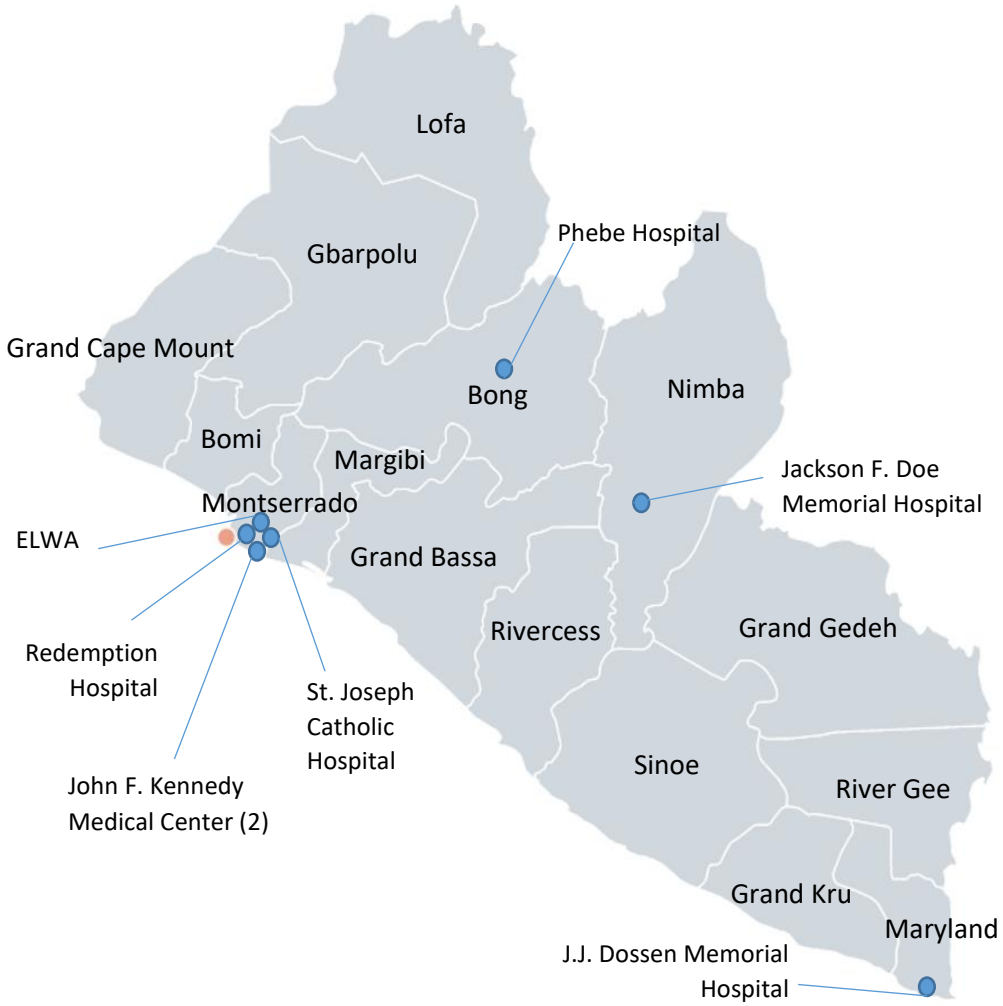
Cadre	Number of health workers in cadre	Percentage (and number) of facilities with at least one health worker in cadre
Biomedical engineering technicians (BMET)	16[2]	26% (14)
Doctors	169	74% (39)
Nurse Anesthetists	103	62% (33)
Equipment	**Number of functional units**	**Percentage (and number) of facilities with at least one functional unit**
Pulse oximeters	158	64% (34)
Oxygen concentrators	134	60% (32)
Flowmeter	253	55% (29)
BiPAP	9	9% (5)
CPAP	14	13% (7)
Patient ventilator	42	25% (13)
Suction device	637	87% (46)

Oxygen plants

At the time of assessment, six (11%) of the 53 assessed facilities had an on-site oxygen plant[3]: Phebe Hospital, JJ Dossen Hospital, ELWA Hospital, Redemption Hospital, St. Joseph Catholic Hospital, Jackson F. Doe Memorial Hospital. However, at the time of assessment, only 3 (50%) of those plants were functional and the other 3 were non-functional. Lack of spare parts was the most commonly cited reason given for why the non-functional plants were down. Among the functional ones, only 1 plant (JJ Dossen Hospital) was supplying oxygen to other facilities. None of the plants were connected to back-up source of electricity.

[2] Number currently deployed in health facilities.
[3] JFK Medical Center was not included in the oxygen assessment, and has 2 oxygen plants on-site.

Figure 4: Map of oxygen plant presence in Liberia



Pulse oximeters

More than half (64%) of the facilities assessed had pulse oximeters (functional or non-functional). These 34 facilities had a total of 234 pulse oximeters, of which only 158 (68%) were functional. Assessment of the types of pulse oximeters showed that 43% of the tabletop pulse oximeters, 24% of the handheld pulse oximeters, and 35% of the fingertip pulse oximeters were not functioning. The most commonly given reason for the not functioning pulse oximeters was the lack of spare parts and consumables.

Concentrators

Thirty-two (60%) of the 53 assessed facilities had functional oxygen concentrators. There were 302 concentrators counted, with 150 (49.7%) of them functional. A majority of the non-functional concentrators (72%) were not functioning due to lack of spare parts.

Ventilators

One-quarter (n=13) of the 53 assessed facilities had ventilators. Of the 58 ventilators that were counted, 42 (72%) were functional. 24 of the functional ventilators were transportable, 15 were intensive care for adults and 3 were intensive care for pediatrics. A common reason given for why some ventilators were not functional was lack of spare parts and consumables such as cables, batteries and sensors. There were no ventilators in some of the dedicated COVID-19 treatment facilities, and those that do have ventilators lacked the various types needed for different patient groups.

Resuscitation bag-mask (Ambu-bags)

A total of 1,017 resuscitation bag-masks were counted across the assessed facilities, with 56% for adults, 30% for pediatrics and 14% for neonates. Ganta Methodist Hospital had the highest stock of resuscitation bag-masks, accounting for 20% of the total stock.

Consumables and other supplies

Of the types of oxygen delivery interfaces, the preponderance (45%) at the assessed facilities were nasal cannulae, with a total of 11,340 cannulae recorded. Of these cannulae, 71% were for neonatal and pediatric use, and 29% were for adult use. Nasal catheters, which are generally less costly than nasal cannulae, made up 36% of all oxygen delivery devices at facilities, with 66% for neonates and pediatrics and 34% for adults. Non-invasive methods of oxygen delivery (oxygen masks and Venturi masks) made up 19% of all oxygen delivery devices, with 17% being oxygen masks and 2% being Venturi masks. High-flow nasal cannula (HFNC) were found at five of the 53 assessed facilities, with 193 HFNCs available in total.

Clinicians and biomedical engineering technicians

Among the assessed facilities, 169 doctors and 203 nurse anesthetists were accounted for; 74% of facilities had at least one doctor, and 62% of facilities had at least one nurse anesthetist. Only 26% of facilities had biomedical engineering technician staff who are trained and certified to be dedicated to the management, installation, and maintenance of medical equipment. When taken together with availability and functionality of oxygen technologies, there is evidence of mismatch between supply and provider training, thus reinforcing the need for holistic interventions across all components of an oxygen system.

Oxygen access points

An analysis was done to determine whether the facilities assessed had capacity for basic oxygen delivery when we consider, in combination, factors of human resource and oxygen technologies and supplies. In order for a facility to qualify as an oxygen access point, analysis of the BME assessment considered a combination of the availability of providers, pulse oximetry, oxygen sources, and oxygen delivery interfaces:

- Trained provider
    - At least one doctor, OR
    - At least one nurse anesthetist in facility
- Pulse oximetry
    - At least one functional pulse oximeter (finger-tip, hand-held, or table-top)
- Oxygen source
    - At least one functional concentrator and electricity always available (i.e. no interruptions) or often available (5-6 days of the week), OR
    - At least one cylinder (any size) and cylinder assembly unit

- Oxygen delivery interface
    - At least one of either Venturi mask, OR
    - Oxygen mask, OR
    - Nasal catheter, OR
    - Nasal cannulae/prongs

Under these considerations, only 51% of facilities qualified as access points of basic oxygen therapy, demonstrating a need to implement holistic interventions to ensure that all components of a functional oxygen system are present and functional in a facility.

Oxygen production in private sector

There are currently two private oxygen PSA plants in Liberia, both of which are located in Montserrado – Pan Oxygen Factory in Freeport of Monrovia, and the Jeety/Sethi Brothers oxygen plant. At their current capacity, these plants produce between 170-240 cylinders per day (40L of oxygen per cylinder), and production capacity has been noted to be limited by availability of workers, lack of stable electricity, and shortage of cylinders. There has been one source of liquid oxygen via an air separation unit (ASU) production plant in Liberia noted which was functional in the past; however, the exact capacity and current state of functionality is unclear.

Current National Oxygen Demand

To understand the total oxygen needs of the country, a total oxygen demand quantification was conducted for Liberia in June 2020. The quantification exercise was intended to allow for the planning of ideal mixture of oxygen delivery approaches and to enable gap analyses for future procurement of oxygen technologies and supplies. The quantification outputs are intended for a gap analysis and issue recommendations in this Roadmap to close the oxygen gap and scale up oxygen access in Liberia.

Methodology

The quantification exercise used the Excel-based UNICEF Oxygen System Planning Tool (UNICEF Office of Innovation, 2020), which has the following functions:

- ❑ Estimate oxygen demand at health facilities and aggregate demand across counties and regions,
- ❑ Provide facility-level recommendations for appropriate oxygen source options based on infrastructure, proximity to oxygen plants, and other inputs,
- ❑ Automate calculation of distances between facilities and existing oxygen plants,
- ❑ Estimate capital and operating costs for oxygen supply system recommendations, for facilities and aggregated,
- ❑ Generate a list of oxygen equipment and consumables for each facility based on oxygen supply system recommendations to inform procurement and donations, and
- ❑ Support planning around the placement of new oxygen plants.

The quantification exercise considered a total of 53 facilities in Liberia (see above section on oxygen assessment), across all 15 counties and inclusive of private and public facilities. The approach to oxygen demand quantification was based on the number of beds (of different types of facility wards) and their associated hypoxemia prevalence,

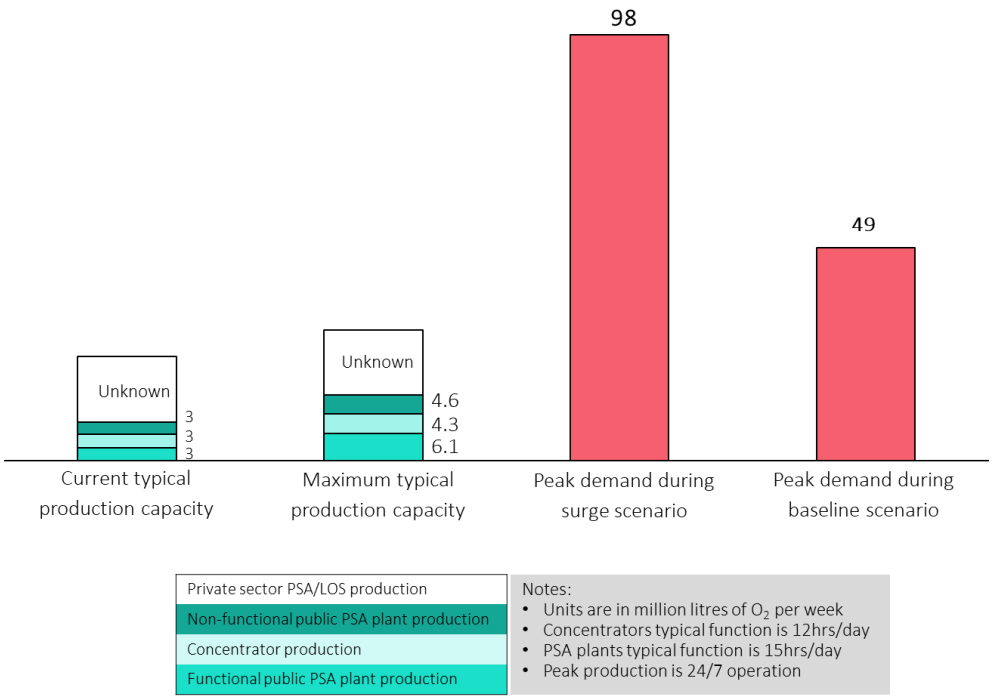
typical flowrate in liters per minute (LPM), oxygen therapy duration for each bed type, and bed turnover of the health facility (Liberia Ministry of Health and CHAI, 2021a). Assumption details can be found in Appendix 5.

Key Outputs

Annual need for oxygen was calculated by facility type. For the 19 health centers in Liberia included in the quantification exercise, annual oxygen need was estimated at 313,380,120 liters, and for the 34 hospitals demand was estimated at over 1.77 billion (1,777,382,400) liters.

To calculate current and maximum oxygen production capacity in Liberia, the quantification used inputs based on private sector PSA production, non-functional and functional public PSA plant production, and concentrator production. Peak oxygen demand during baseline and surge scenarios were also calculated. In the surge scenario case, which is meant to reflect oxygen needs at the peak of a surge in oxygen demand due to a sudden rise in cases of respiratory illness (such as COVID-19), which assumes full occupancy in the country's ICU and isolation wards. Peak demand during baseline and surge scenarios were found to be much higher than current and maximum typical production capacity, indicating the need for increased oxygen production to fill this gap (Figure 5).

Figure 5. Liberia oxygen production capacity vs. demand, in million liters of O_2 per week



Gap Analysis

Gap analysis was conducted by subtracting number of currently available & functional in-country devices (data from the 2020 oxygen assessment) from the forecasted needs (generated using the UNICEF quantification tool). These values are shown as the 'quantity for procurement' in the tables below.

Since the scope of the initial assessment was focused on 53 health centers and hospitals (health system levels where there is any oxygen delivery capacity), the forecasted demand and quantity for procurement are also limited to these secondary and tertiary facilities at this moment.

Since completion of the 2020 oxygen assessment, additional devices have also been procured, thus filling some of the identified gaps. Routine review of the quantification outputs and gap analysis will be conducted to ensure up-to-date data on oxygen availability are available for decision-making.

PSA Plants

Based on outputs from the national oxygen demand quantification and additional assessments of public sector PSA plants conducted in September 2020 by MOH with support from the World Health Organization, a plan for upgrading of existing PSA plants and installation of new PSA plants was developed. This plan will support MOH plans for increasing the availability of oxygen in Liberia to meet the need in a baseline scenario. The high-level recommendations are summarized below in Table 2.

Table 2. PSA plant upgrade and installation recommendations

County	Facility	Existing PSA Plant?	Recommendation
Bong	Phebe Hospital	Yes	Upgrade existing PSA plant to capacity of 15 Nm^3/ hr or 272,000 L/day (40 cylinders per day)
Bong	TBD	No	Install new PSA plant with capacity of 20 Nm^3/ hr or 442,000 L/day (65 cylinders per day)
Grand Bassa	TBD	No	Install new PSA plant with capacity of 8 Nm^3/ hr or 136,000 L/day (20 cylinders per day)
Maryland	TBD	No	Install new PSA plant with capacity of 20 Nm^3/ hr or 442,000 L/day (65 cylinders per day)
Maryland	JJ Dossen Hospital	Yes	Upgrade existing PSA plant to capacity of 15 Nm^3/ hr or 272,000 L/day (40 cylinders per day)
Montserrado	JFK Hospital	Yes	Install new PSA plant with capacity of 15 Nm^3/ hr or 272,000 L/day (40 cylinders per day)
Montserrado	Redemption Hospital	Yes	Upgrade existing PSA plant to capacity of 8 Nm^3/ hr or 136,000L /day (20 cylinders per day), then relocate to Chief Jallahone Medical Center in Gbarpolu county
Montserrado	Star Base Treatment Unit	No	Install new PSA plant with capacity of 50 Nm^3/hr or 680,000 L/day (100 cylinders per day)
Nimba	Jackson F. Doe Hospital (Tappita)	Yes	Upgrade existing PSA plant to capacity of 15 Nm^3/ hr or 272,000 L/day (40 cylinders per day)

Note that TBD=facility location to be determined; 1 J-size cylinder is 6,800 L.

If additional resources are available, the quantification results recommend that additional, larger size plants should be procured and installed – a total of eight medium size (30 Nm^3/hr) PSA plants and one large size (50 Nm^3/hr) PSA plant would be needed to satisfy all oxygen demand based on the baseline scenario forecast (49,000,000 L/week). An additional 49,000,000 L/week, or twice the amount of oxygen, is required in a peak scenario.

Cylinders

To meet weekly forecasted oxygen demand with cylinders (estimated to be 20,918,755 L/week) for the next 3 years, the quantification tool was used to calculate the number of small (680 L), medium (6800 L), large (7080 L) cylinders (and corresponding number of regulators, flowmeters, and humidifiers) that would be needed. The following quantities of cylinders and accessories were recommended for procurement:

Table 3. Forecasted cylinder needs in Liberia, 3-year period

Item	Forecasted Qty[4]	Qty for procurement
Weekly oxygen demand to be met using cylinders (in L)	20,918,755	
Number of Small (680 L) cylinders needed	639	634
Number of Medium (6800 L) cylinders needed	5,390	5,363
Number of Large (7080 L) cylinders needed	639	639
Regulators	480	394
Flowmeters	1,022	804
Humidifiers	1,022	1,022**

**Data not gathered in the 2020 oxygen assessment

Concentrators

The UNICEF Oxygen System Planning Tool uses a tiered approach to recommending oxygen sources, meaning that forecasted concentrator needs assume that all forecasted cylinder needs are met (i.e. cylinders available and filled), and then the remaining demand can be met by the forecasted concentrator quantities. Based on this, quantities of concentrators and concentrator accessories were recommended for procurement to meet remaining oxygen demand for the next 3 years as detailed in Table 4.

Table 4. Forecasted concentrator needs in Liberia, 3-year period

Item	Forecasted Qty[5]	Qty for procurement	Qty of replacement and spare parts for 1 year
Concentrators, 10 LPM	93	93	0
Concentrators, 5 LPM	12	5	0
Flow-splitters	24	20	0
Tubing (in cm)	39,960	39,960**	13,320
Surge suppressors	102	102**	0

**Data not gathered in the 2020 oxygen assessment

Pulse Oximeters and Patient Monitors

Diagnostic devices are a critical part of any oxygen system to reliably diagnose hypoxemia and should be allocated wherever oxygen therapy is to be delivered. Recommended quantities for procurement to meet oxygen demand are detailed in Table 5 below.

Table 5. Forecasted diagnostic device needs in Liberia, 3-year period

[4] Limitation on cylinder numbers:
- Quantified based on needs, regardless if there is sufficient source (e.g. PSA plant) to fill them
- Does not account for back-up cylinders needed during refills and transportation

[5] UNICEF tool uses a tiered approach to recommend oxygen sources, so numbers here assumes that all forecasted cylinder needs are met (i.e. cylinders are filled), and remaining demand can be met by concentrators.

Item	Forecasted Qty[6]	Qty for procurement	Qty of replacement and spare parts for 1 year
Patient Monitor	497	473	-
Probes, adult	946	946**	630
Pulse oximeter, hand-held	319	277	-
Probes, adult	213	213**	355
Probes, pediatric	52	52**	86
Probes, neonatal	53	53**	88
Batteries	included in product	included in product	106

**Data not gathered in the 2020 oxygen assessment

Oxygen Delivery Interfaces

The quantification tool was also used to forecast quantities of consumables needed for procurement. After accounting for consumables that are already available and functioning in Liberia, the following quantities were recommended for further procurement:

Table 6. Forecasted oxygen delivery interface needs in Liberia, 3-year period

Item	Forecasted Qty[7]	Qty for procurement
Nasal prongs/cannula, adult	81,940	78,877
Nasal prongs/cannula, pediatric	8,220	7,270
Nasal prongs/cannula, neonatal	9,800	8,996

[6]Finger-tip pulse oximeters not included since use is only in OPD for screening and initial vital signs (not continuous monitoring); can do additional quantification.

[7] UNICEF tool does not consider other consumables such as simple face masks, Venturi masks, non-rebreather masks; additional quantification forthcoming.

Roadmap to Scale-Up Oxygen Access

Vision

MOH recognizes that oxygen is an **essential medicine** that is key to improving health outcomes of a wide range of patient conditions, including those of life-threatening newborn and maternal emergencies. **It is the vision of the MOH that no patient in Liberia dies from hypoxemia.**

Guiding Principles

The following principles should guide the scale up of oxygen access in Liberia:

- ❑ Recognition of oxygen as an essential medicine
- ❑ Provision of high-quality oxygen therapy and respiratory care guided by evidence-based best practices
- ❑ Availability of high-quality oxygen supplies and technologies
- ❑ Integration of oxygen therapy and respiratory care across all levels of the health system, and across all essential health services
- ❑ Equal access to high-quality services for hard-to-reach, vulnerable, and disadvantaged populations, such as populations in rural and remote areas

Purpose of Roadmap

Given the current baseline situation in Liberia, scaling up oxygen access in the country must tackle both technical and financial gaps that exist. The purpose of this national roadmap is to guide implementation and coordination of oxygen activities in Liberia, to provide cost estimates for implementation, and to support resource mobilization efforts. Interventions to be implemented as part of this roadmap is organized by and aimed to achieve four main objectives:

1) Create enabling environment for oxygen access scale-up
2) Increase availability and quality of oxygen technologies and supplies
3) Improve clinical oxygen delivery and maintenance of oxygen technologies
4) Integrate oxygen data into routine health information systems

Appendix 6 provides details on the timeline and estimated cost for implementing each of the proposed interventions.

Roles & Responsibilities

The Ministry of Health through the Health Services Division shall have the overall responsibility for coordination and implementation oversight with regards to oxygen-related interventions in the health sector. In particular, the following units will serve as the technical leads for the implementation of oxygen-related activities:

- Emergency Medical Response (EMR) Division, which includes the sub-units for Emergency Medical Services (EMS) and for Respiratory Care
- Healthcare Technology Management Unit (HTMU)

These units will work closely and collaboratively with health facilities and with other relevant Ministry programs, regulatory agencies, professional boards and training institutions, health facilities, as well as donors and non-government partners to improve oxygen access in Liberia.

Objective 1: Create enabling environment for oxygen access scale-up

Strategy 1.1: Integrate oxygen delivery into existing national policies and strategies

Where opportunities exist to update and revise national health strategies and investment cases, oxygen delivery considerations should be incorporated into these documents to further solidify government commitment to oxygen access, and to serve as advocacy and resource mobilization tools. Potential national documents to incorporate oxygen interventions and considerations include the Standard Therapeutic Guidelines/Essential Medicines List (STG/EML), Essential Package of Health Services (EPHS), RMNCAH Investment Case, etc.

Activities

1.1.1 Disseminate National Roadmap plan and activities (including a 2-page advocacy brief) to increase involvement of stakeholders and resource commitments

1.1.2 Revise existing national documents (STG/EML, EPHS, RMNCAH Investment Case, etc.) to incorporate oxygen interventions and financing considerations

Strategy 1.2: Establish and utilize central coordination and technical advisory platform for implementation and coordination of oxygen activities

A functional technical working group for oxygen led by the MOH is essential to provide a platform for relevant Ministry units, health facilities, implementing partners and donors to effectively coordinate implementation of oxygen-related activities. Regular TWG meetings should be utilized for accountability, monitoring the implementation of the roadmap, information and knowledge-sharing, avoid duplication of efforts, and harmonize use of available resources. This platform should be linked to subnational (county) and private sector mechanisms to ensure alignment on strategies and priorities – for example, central updates provided at the Oxygen TWG should be shared with each county, and county-level implementation updates should be aggregated and shared centrally on a regular basis through county presentations.

Activities

1.2.1 Validate and approve the Terms of Reference for Oxygen TWG

1.2.2 Hold regular Oxygen TWG meetings as a coordinating mechanism for implementation of the Roadmap

1.2.3 Link national coordinating mechanism to subnational mechanisms (e.g. county health team meetings), private sector mechanisms, and service providers, for implementation of roadmap activities

Strategy 1.3: Ensure a sustainable financing mechanism or secured external funding for oxygen

A plan for financing oxygen activities is critical to ensure that the activities detailed in this roadmap can be successfully implemented. To build long-term commitment to oxygen access scale-up, the MOH and partners can explore a variety of financing options and employ a combination of solutions. Within the national health budget, there should be a dedicated allocation for oxygen-related activities under all relevant MOH units or departments. External donor funding sources should also be identified and confirmed for all activities costed under the oxygen roadmap. Beyond securing the initial funds for activities, sustainable funding mechanisms including results-based financing (RBF), cost recovery mechanisms such as revolving drug funds (RDF), and public-private partnerships should be explored for feasibility to ensure costs of oxygen delivery (including ongoing procurement and maintenance of oxygen technologies) can be covered in the long-term. Furthermore, reductions in procurement costs for oxygen devices may be possible through coordinated and pooled procurement, price negotiations, or other market-shaping interventions.

Activities

1.3.1 Develop resource mobilization strategy and advocacy documents to increase investment in the national oxygen system, or incorporate oxygen into existing national resource mobilization strategies
1.3.2 Incorporate resource mapping for oxygen-related activities and ongoing costs into annual resource mapping exercise for the Liberian health sector to understand funding sources, availability, and allocations. engage domestic and international funding resources
1.3.3 Incorporate oxygen into existing mechanisms used to allocate government budgets, to ensure support is available for implementation coordination and for procurement of oxygen technologies and supplies
1.3.4 Perform feasibility study on sustainable funding mechanisms including results-based financing, revolving drug funds, and public-private partnerships
1.3.5 Use national coordinating mechanism (TWG) to coordinate procurement of oxygen technologies and supplies for increased negotiating power and cost-savings

Strategy 1.4: Develop plan for future surges in oxygen use that considers availability of oxygen technologies and supplies and health workforce capacity

In a situation where demand for medical oxygen surges, such as a sudden rise in cases of respiratory illness, prior planning for increasing the oxygen supply, accessing additional oxygen equipment, emergency stockpiling, and mobilizing trained health workers allows for a more rapid response. Events including the rise of COVID-19 in Liberia has demonstrated the need for comprehensive surge preparedness planning. This plan should build upon lessons learned from Liberia's experiences with Ebola and COVID-19 to rapidly scale up health worker capacity and oxygen availability. Activities that fall under this plan could include emergency oxygen trainings for clinicians, rapid demand quantification tools, and strategies for rapidly increasing medical oxygen and oxygen technology availability. This plan should be reviewed and updated at least every three years to capture changes in the country's oxygen system.

Activities

1.4.1 Create a national preparedness plan for oxygen demand surges, building upon lessons learned from past surges, to detail the steps that the MOH and partners should take in event of a surge (or incorporate oxygen planning into existing national epidemic preparedness plans)
1.4.2 Conduct an assessment of frontline healthcare workers' (particularly physicians') competence in oxygen therapy to inform capacity building interventions (also refer to Strategy 3.3)
1.4.3 Create emergency oxygen trainings for clinicians to allow for surge capacity training
1.4.4 Develop rapid assessment & quantification tools to determine oxygen needs during demand surges
1.4.5 Proactively create partnerships with private sector oxygen suppliers in preparation for future surges (e.g. rapid increase in production capacity, diverting from industrial to medical oxygen)
1.4.6 Update plan every three years to reflect current country capacity and needs

Objective 2: Increase availability and quality of oxygen technologies and supplies

Strategy 2.1: Conduct routine quantification exercise to forecast national oxygen demand and undertake routine quantification review

Accurate understanding of total oxygen demand for the country based on population data will inform the quantity and types of oxygen technologies and supplies needed in health facilities. Key oxygen technologies and supplies to be considered include but are not limited to oxygen concentrators, oxygen cylinders, oxygen plants, ventilators, pulse oximeters, delivery interface (e.g. nasal cannula/prongs, simple face masks, non-reservoir masks). To determine the optimal route of oxygen delivery and procure the ideal mix of equipment for oxygen production and delivery, the exercise must consider data such as patient volume, patient oxygen needs and disease burdens, facility electricity and power availability, geography/proximity to oxygen plant, oxygen transport options, and provider training. The National Quantification Technical Committee (NQTC) should lead the quantification and review exercises with support and technical inputs from MOH vertical programs. A quantification exercise should be conducted every three years, with quantification reviews conducted each year to update the requisite procurement budgets and supply plans.

Activities

2.1.1 Conduct robust quantification exercise every 3 years to forecast oxygen demand
2.1.2 Conduct quantification review annually and update procurement budgets accordingly
2.1.3 Review and update supply plans on a quarterly basis, in line with other supply plan review exercises

Strategy 2.2: Develop technical specifications for the donation and procurement of oxygen technologies and supplies

Technical specifications and standards are necessary to regulate the quality and fit of oxygen technologies and supplies in the country, whether donated by partners or procured by the government. Specifications should be adapted based on international regulatory guidelines such as the ISO 13485 (Medical devices - Quality management systems - Requirements for regulatory purposes), with considerations of local context and needs, such as correct voltage for compatibility of technologies. National regulatory agencies such as the Liberia Medical & Health Products Regulatory Authority (LMHRA), working alongside the MOH, should be responsible for monitoring the quality of incoming oxygen technologies and supplies based on validated technical specification and standards, and conduct post-market surveillance to ensure the safe use of oxygen technologies and supplies. Non-government partners who donate oxygen technologies and supplies should also abide by these technical specifications and standards in their selection of oxygen technologies and supplies. Donations of new equipment should also be completed in coordination with training of health workers and biomedical engineering technicians to ensure proper use and maintenance of donated technologies and supplies.

Activities

2.2.1 Develop technical specifications for oxygen equipment to meet international standards (e.g. European Conformity (CE), U.S. Food and Drug Administration (FDA) approval)
2.2.2 Disseminate technical specifications for oxygen technologies and supplies to partners and health facilities, to guide procurements and donations
2.2.3 Establish systems for ongoing monitoring of the quality of oxygen technologies and supplies, or incorporate into existing systems

2.2.4 Consolidate and maintain list of pre-qualified suppliers of oxygen equipment for streamlined public procurement

Strategy 2.3: Update and revise national donation guidelines to incorporate oxygen technologies a\nd supplies

The current *Guidelines for the Donation of Medicines and Medical Supplies* for Liberia has not been updated since 2014 and its scope is limited to medicines and medical supplies. Technologies and supplies such as those needed for oxygen therapy are not considered. Based on the national technical specifications for oxygen technologies and supplies, the national donation guidelines should establish safety and quality assurance requirements for the donation of oxygen technologies and supplies. The donation guidelines should then be implemented under the oversight of relevant MOH units such as the Department of Pharmaceutical Services (DPS).

Activities

2.3.1 Update national donation guidelines to incorporate considerations for oxygen technologies and supplies, such as integration of national technical specifications

2.3.2 Implement donation guidelines through dissemination among donors and partners involved in funding or coordinating donations

2.3.3 Establish systems to ensure that donations adhere to technical specifications, such as linking technical specification checklists or reviews to duty-free status

Strategy 2.4: Establish a procurement and supply management process for procurement and distribution of oxygen, oxygen technologies and supplies

The lack of national guidance regarding procurement and distribution of oxygen technologies and supplies can result in disjointed procurement and distribution activities which lead to delays and shortages in the supply of oxygen technologies and supplies throughout facilities in the country. The establishment of a process for procurement and supply management (PSM) ensures coordination between the government and partners to procure and distribute oxygen technologies and supplies in a manner that is organized and informed by national oxygen demand. The PSM processes for oxygen technologies and supplies should be embedded and aligned with the processes used for other health commodities and equipment as much as possible. For example, an inventory system that is routine updated at the county and national levels should be put in place to ensure procurement of oxygen technologies and supplies meet the gaps in inventory. Processes and standardized tools for bids and tendering, supply selection, and supply planning should be developed by relevant MOH units and partners and implemented by MOH.

Activities

2.4.1 Map existing supply chain processes including existing commercial PSA/ASU plants, cylinder delivery, and equipment distribution for oxygen delivery systems

2.4.2 Ensure tracking of oxygen consumables, supplies and spare parts in LMIS, for reporting on use of consumables and informing replenishment of consumables and supplies

2.4.3 Develop and maintain a national database of oxygen equipment inventory for tracking of oxygen devices and equipment

2.4.4 Review and update distribution process for oxygen technologies and supplies (including process for clearance, inspection, inventory, storage, and delivery), utilizing LMIS to ensure distribution is timely and based on demand

2.4.5 Develop standard tools and guidelines for the operation, repair and maintenance of existing and planned oxygen plants to assist with resource mobilization and planning immediately and at the outset of procurement

2.4.6 Develop plans for cylinder distribution and wheel/spoke model for installation of new oxygen plants or upgrade of existing public plants

2.4.7 Establish process for procurement of oxygen technologies and supplies including equipment for oxygen production, equipment of oxygen delivery, and spare parts based on aggregated demand, during baseline and peak demand scenarios

2.4.8 Engage private sector oxygen plants to gap-fill where needed to ensure consistent oxygen supply at health facilities, during baseline and peak demand scenarios

Strategy 2.5: Procure oxygen technologies and supplies to meet forecasted demand

After the quantification has been completed and supply plans updated, procurement of key oxygen technologies and supplies must occur to ensure adequate supply in health facilities and centers. Procurement should be informed by the quantification review and supply plans and follow the procurement and supply management processes as detailed in Strategy 2.4.

Activity

2.5.1 Procure oxygen technologies and supplies (including plants, devices, equipment, parts, and consumables) based on national quantification outputs and up-to-date supply plans

Strategy 2.6: Improve the process for equipment maintenance, repair, and replenishment

To ensure that inventory is distributed in accordance with health system needs, an inventory management and logistics information system should also be developed. Several global tools help inform national understanding of the supply of oxygen and pulse oximetry, and how oxygen delivery is incorporated into the health system. Monitoring will be coupled with capacity building in preventative maintenance management and corrective maintenance among central and county HTMU and facility focal persons.

Activities

2.6.1 Incorporate key indicators into LMIS to monitor oxygen equipment availability and distribution

2.6.2 Conduct routine supervision and mentoring in health facilities to ascertain availability and functionality of oxygen technologies and supplies

2.6.3 Build local capacity for the monitoring and maintenance of oxygen production plants in Liberia (also refer to Activity 3.5.3)

Objective 3: Improve clinical oxygen delivery and maintenance of oxygen technologies

Strategy 3.1 Develop national clinical management guidelines for hypoxemia and oxygen therapy

Clinical management guidelines for the detection and management of hypoxemia using oxygen therapy developed based on current, evidence-based clinical best practices are needed to standardize service delivery and ensure a high quality of care. Clinical management guidelines should provide guidance on hypoxemia diagnosis and management, basic oxygen delivery, and advance/invasive respiratory care for a wide range of patients (neonates, children, adults), and underlying causes and disease conditions where oxygen therapy may be warranted (infectious diseases, non-communicable diseases and injuries).

Activities

3.1.1 Develop and validate national clinical management guidelines for hypoxemia and oxygen therapy based on international best practices and adapted to country context, including guidance for health facility staff (primary, secondary, and tertiary) and emergency response/ambulance staff

3.1.2 Review national clinical management guidelines every 3 years to ensure contents reflect current best practices

3.1.3 Disseminate national clinical management guidelines at county and facility levels

3.1.4 Monitor the use of national clinical management guidelines through routine mentoring and joint integrated supportive supervision (JISS) (also see Activity 3.4.2)

Strategy 3.2 Review, update, and implement pre-service training packages to include comprehensive contents on hypoxemia management and oxygen therapy

Pre-service training materials for skilled birth attendants (SBAs) (nurses, midwives, physician assistants, doctors) should be updated to ensure they include the most up-to-date contents on hypoxemia management and oxygen therapy, including the use of oxygen technologies such as pulse oximeters, concentrators, cylinders, and ventilators. Training topics should include not only clinical delivery but also basic repair and maintenance of oxygen technologies.

Activities

3.2.1 In the short-term, develop an oxygen training module that can be used as an extension to existing pre-service training curricula

3.2.2 In the medium and long-term, review, update, and validate pre-service training materials for SBAs with up-to-date contents on hypoxemia management and oxygen therapy, based on international best practices and adapted to country context

3.2.3 Integrate validated oxygen training materials into existing pre-service training curricula for each cadre of SBAs

3.2.4 Procure simulation equipment and training supplies for pre-service training

Strategy 3.3 Review, update, and implement in-service training packages to include comprehensive contents on hypoxemia management and oxygen therapy to increase quantity of providers able to deliver oxygen therapy

In-service training materials for SBAs should be updated to ensure they include the most up-to-date contents on hypoxemia management and oxygen therapy, including the use of oxygen technologies such as pulse oximeters, concentrators, cylinders, and ventilators. Training topics should include not only clinical delivery but also basic

repair and maintenance of oxygen technologies. In-service training should be conducted routinely to nurses, midwives, physician assistants, and doctors, using the national in-service training package on hypoxemia management and oxygen therapy. At least 2 providers per clinic, 3 providers per health center, and 5 providers per hospital should receive new or refresher training on oxygen therapy each year, using the national in-service training package.

Activities

3.3.1 Develop and validate in-service training materials for SBAs with up-to-date contents on hypoxemia management and oxygen therapy, and integrate into any existing platforms for continuing professional development (CPD)
3.3.2 Procure training supplies for in-service training
3.3.3 Plan and hold new or refresher trainings for at least 2 providers per clinic, 3 providers per health center, and 5 providers per hospital
3.3.4 Update and maintain a database of trained providers
3.3.5 Increase quantity of respiratory therapists in country with priority focus on county hospitals

Strategy 3.4 Conduct routine facility-based mentoring focused on oxygen delivery

While a cluster training approach can be used, in-service capacity-building should also include a continuous mentoring component that emphasizes on-the-job support for clinicians within a health facility setting, which will ensure sustained skills-building and knowledge retention. Mentoring should be provided by subnational supervisors/mentors, with support and oversight from central-level mentors from the Ministry of Health EMR Division) who will serve as mentors (e.g. county and district clinical supervisors), with a minimal frequency of making at least one mentoring visit to each health facility every quarter. These mentoring visits should be separate from supervision visits such as those under the Joint Integrated Supportive Supervision, so that sufficient time can be spent on providing clinical support, as opposed to administrative oversight and data collection. If resources are limited, mentoring visits can focus on oxygen delivery as well as other clinical services (for example, integrated into RMNCAH mentoring); however, if resources allow, at least one mentoring visit each quarter should be focused exclusively on hypoxemia management and oxygen therapy.

Activities

3.4.1 Develop plan and mentoring tools for routine facility-based mentoring for oxygen delivery in collaboration with county and district health officials and health facility administrators
3.4.2 Build the capacity of national and sub-national mentors to conduct routine mentoring
3.4.3 Conduct routine mentoring visits to facilities to ensure each facility is visited at least quarterly, focusing on hypoxemia management and oxygen therapy
3.4.4 Update and maintain a record of mentoring visits

Strategy 3.5 Develop and utilize standard operating procedures for planned preventive maintenance and corrective maintenance of oxygen equipment and devices

The MOH HTMU currently has generic PPM and CM templates used across all biomedical equipment and devices. However, to best maintain and repair oxygen technologies at the facility level, standard operating procedures (SOPs) for planned preventive maintenance (PPM) and corrective maintenance (CM) should be developed and rolled out to biomedical engineering technicians. These SOPs will build capacity for regular repairs and will increase the number of functional machines in the country.

Activities

3.5.1 Develop SOPs for planned preventive maintenance (PPM) and corrective maintenance (CM) of oxygen technologies

3.5.2 Disseminate SOPs to biomedical engineering technicians

3.5.3 Conduct new and refresher trainings training for biomedical engineering technicians on PPM and CM of oxygen technologies, including maintenance of oxygen production plants

3.5.4 Increase quantity of biomedical engineering technicians in country with the aim of having at least one technician per public hospital

3.5.5 Update and maintain a database of trained biomedical engineering technicians

3.5.6 Conduct routine supervision and mentoring visits focused on oxygen to ensure proper use and adherence to SOPs, on a quarterly basis

3.5.7 Train and deploy maintenance staff to health facilities according to need, reviewing equipment availability and functionality annually

3.5.8 Facilitate trainings, to be held by biomedical engineering technicians, for health workers on basic maintenance of oxygen technologies

Objective 4: Integrate oxygen data into routine health information systems

Strategy 4.1: Establish national indicators and data collection tools for oxygen

National indicators for hypoxemia diagnosis and management, patient oxygen consumption (disaggregated by age and disease condition or service), oxygen technologies and supplies availability and functionality, oxygen production capacity and quality, provider training, should be developed and added into the routine HMIS/DHIS-2 (or LMIS if more appropriate; see Strategy 2.6) to allow for facilities and counties to report oxygen data in a standardized manner. Facility ledgers should be reviewed and updated to incorporate data fields for oxygen therapy based on national indicators.

Activities

4.1.1 Develop definitions for national indicators on oxygen, such as for hypoxemia management, use of oxygen equipment, oxygen quality, and oxygen administration

4.1.2 Develop and roll out oxygen production and consumption trackers, facility ledgers, and other data tools as needed to collect information on oxygen quality, use and demand (data should be disaggregated by patient age and service and used alongside/integrated with relevant data in LMIS)

4.1.3 Integrate oxygen-data aggregation into HMIS Monthly Reporting Form or a supplementary form as needed to inform quantification, forecasting, procurement, and distribution.

4.1.4 Train facility, county, and central focal persons on collecting oxygen-related data

Strategy 4.2: Encourage use of oxygen-related data for decision-making

Once indicators are selected and implemented, routine data quality assurance (DQA) visits can be conducted to ensure quality data is being collected. After incorporation of oxygen data collection into HMIS, LMIS, or training databases, data should be analyzed and used for decision-making and continuous improvement efforts at the facility, county, and national levels.

Activities

4.2.1 Disseminate and orient county and central MOH staff on use of oxygen data, leveraging existing structures at county and district levels such as county coordination meeting, county data review meetings, etc.

4.2.2 Develop user-friendly data outputs from standardized tools, templates and ledgers to ensure comparability across health facilities and counties, and disseminate data regularly through existing platforms (including but not limited to the Oxygen TWG) to inform decision-making at facility, county, and national levels

4.2.3 Conduct facility-level data quality assurance (DQA) visits to verify and improve timeliness, accuracy and completeness of oxygen service data, developing and utilizing training-specific indicators for visits

4.2.4 Cross-reference data on equipment functionality to support evidence-based decision-making on oxygen administration and use

Monitoring roadmap implementation

It is important to assess the progress of implementing the Roadmap to ensure scale-up of oxygen access in Liberia. To track progress of the Roadmap, annual reporting using key high-level indicators is recommended. The Ministry of Health will submit a yearly report to the Health Sector Coordination Committee (HSCC) on the implementation status of the oxygen strategy, using the suggested key high-level indicators in Table 7 to track progress.

Table 7. High-level indicators for roadmap objectives

Objective	Indicator	Means of Verification
Objective 1: Create enabling environment for oxygen access scale-up	Existing national documents revised to incorporate oxygen	Updated documents
	# of Oxygen TWGs held per year	Meeting minutes
	Resource mapping exercise completed	Completed documents
	National preparedness plan created	Completed documents
Objective 2: Increase availability and quality of oxygen technologies and supplies	Supply plans updated	Completed plans
	# of oxygen products procured	TWG tracker with specifications on items procured
	Technical specifications developed	Completed documents
	# of oxygen equipment available and functional	LMIS
	# of routine supervision and mentoring conducted	Field visit reports
Objective 3: Improve clinical oxygen delivery and maintenance of oxygen technologies	National clinical management guidelines developed	Completed documents
	Pre-service training materials updated and validated	Completed documents
	In-service training materials updated and validated	Completed documents
	# of trained providers	Database
	# of routine mentoring visits conducted for providers	Field visit reports
	SOPs for PPM and CM developed	Completed documents
	# of trained BMETs	Database
	# of routine supervision and mentoring visits conducted for BMETs	Field visit reports
Objective 4: Integrate oxygen data into routine health information systems	Facility-based ledgers developed and in use	Ledgers
	Data collection process established	HMIS Monthly Reporting Form or supplementary form
	Oxygen use and demand	Oxygen consumption tracker
	# of DQA visits conducted	DQA visit forms

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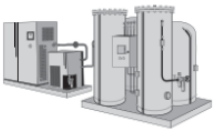
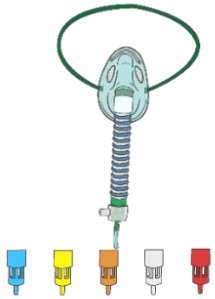
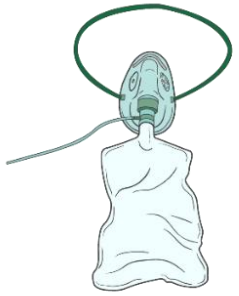
Appendix 1. Common Oxygen Sources

	Cylinder	Concentrator	Oxygen Plant (PSA)
			
Description	▪ Refillable, portable vessel used to store and transport oxygen in compressed gas form ▪ Refilled at oxygen plant then transported to health facility (or put on manifold to be supplied on-site)	▪ Self-contained, electrically powered device that supplies oxygen by extracting air from the environment and separating the nitrogen via pressure swing absorption (PSA)	▪ Onsite oxygen-generating system using PSA technology
Use cases and clinical applications	▪ Facilities without reliable power source or in close proximity of a plant ▪ Provides medium-high flow rates	▪ Facilities with reliable power source ▪ Provides low to medium flow rates (generally between 5–10 LPM depending on device)	Large facilities with reliable power source and other infrastructure, and skilled technicians
Distribution mechanism	▪ Direct to patient with delivery interface and flowmeter, OR ▪ Connected to manifold of central piping system	▪ Direct to single patient with delivery interface or to multiple patients with delivery interface and flowmeter stand/flow splitter	▪ Central piping system, OR ▪ By refilling cylinders that are connected to manifold system at facility or transported to another facility
Maintenance	Limited maintenance required by trained technicians	Moderate maintenance required by trained technicians	Significant maintenance required by highly trained technicians and engineers
Advantages	No need for electricity	▪ Continuous supply at low running cost (when electricity available) ▪ Output can be split among multiple beds via flowmeter stand/flow splitter	▪ Continuous supply at high pressure ▪ Most cost-effective for larger facilities
Disadvantages	▪ Transportation logistics and costs may be a barrier ▪ Exhaustible supply; highly dependent on supplier ▪ Sensitive to leakage ▪ Explosion risk ▪ Only one bed served per cylinder	▪ Requires stable and uninterrupted power supply ▪ Low output ▪ Requires more servicing and supply of spare parts	▪ High CAPEX ▪ Requires stable and uninterrupted power supply ▪ Requires highly-skilled technicians and adequate infrastructure ▪ System potentially hazardous

Appendix 2. Common Oxygen Delivery Interfaces in Liberia





Nasal Cannula	Simple Facemask	Venturi Mask	Non-rebreather mask (NRM)
• Delivers low to moderate levels of oxygen (1-6 LPM) • Generally the most suitable delivery interface to be used with infants and under-five children	• Delivers moderate flowrate for a short time • Minimum 6 LPM flowrate must be used to prevent re-breathing CO2	• Non-invasive face mask, used with different types of diluters (color-coded) with set flow rates (LPM) to give a specific FiO2 (%	• Simple facemask with a reservoir bag attached, with one-way valves • Delivers higher flowrates (10–15LPM)

Appendix 3. Terms of Reference for Technical Working Group on Oxygen & Respiratory Care

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. Therefore, oxygen therapy is considered an essential medicine by the World Health Organization and is identified as one of 20 priority lifesaving treatments for newborns, children and pregnant women.

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. As a first step, a strong central coordination mechanism must be established with clear linkages to county, district, facility and community platforms, in order to provide oversight for oxygen activities.

Aim

This TWG will be a regular platform for knowledge-sharing, technical advisory, coordination and implementation oversight related to all oxygen and respiratory care activities in Liberia.

Specific objectives

- Lead the coordination, support implementation, and ensure sustainability of all oxygen and respiratory activities in Liberia
- Conduct and update partner mapping and resource mapping (across both public and private sector) for current and future oxygen activities
- Develop and update national documents for oxygen, including country strategy/roadmap for long-term scale-up, financing strategies, clinical guidelines, PSM guidelines, BME standards, training materials, etc.
- Provide technical advice and oversight for oxygen activities
- Mobilize resources for oxygen activities
- Ensure integration of services such as oxygen and respiratory care across all MOH vertical programs

Structure & Roles

Chairs

The TWG shall be chaired by MOH Health Services Division.

Responsibilities

- Oversee TWG meetings
- Ensure alignment of planned activities with broader policies, strategies and plans endorsed by relevant Ministries
- Present TWG discussions, recommendations, and activity updates to higher level coordination and decision-making bodies, such as the Health Sector Coordination Committee (HSCC)

- Present TWG discussions, recommendations, and activity updates to other MOH coordination bodies where oxygen access is relevant, including but not limited to Supply Chain TWG, MNDSR Committee, Reproductive Health Technical Committee (RHTC)
- Approve new membership requests

Secretariat

The Clinton Health Access Initiative (CHAI) shall serve as the secretariat, with close support from the MOH Department of Planning.

Responsibilities

- In consultation with the Chair, prepare meeting agenda
- Send invitation, agenda, and other relevant documents ahead of scheduled meeting
- Take meeting minutes and share with members in advance of the subsequent meeting
- Support the Chair to make follow up on action points from the TWG meetings
- Maintain, update, and regularly share TWG key documents (e.g. partner/resource mapping)
- Maintain and update membership listing
- Serve as point-of-contact for any inquiries related to the TWG scope of work, and direct said inquiries to the appropriate TWG member(s)
- Support planning and logistics related to TWG meetings

Members

The TWG shall be represented by focal persons across the MOH and other government agencies, non-government organizations (NGOs), donors, training institutions and other private sector partners.

Responsibilities

- Attend all TWG meetings, and any other consultative meetings, workshops, conferences, etc.
- Share regular updates on ongoing or planned activities related to oxygen (via verbal updates, presentations, briefing notes, emails, etc.), as well as any relevant updates from other coordination/decision-making bodies
- Provide technical inputs and advice on the formulation and implementation of oxygen activities
- Present TWG discussions, recommendations, and activity updates to other relevant coordination and decision-making bodies where oxygen activities are discussed

Subcommittees

Subcommittees will be formed to work on specific activities and deliverables in the following areas:

- ❑ Policy and Strategy
- ❑ Clinical Care
- ❑ PSM and BME Management
- ❑ Infrastructure

County-level TWGs should also be established as needed, or embedded into existing county meetings, to ensure coordination of oxygen activities are all levels of the health system. In particular, county hospitals should be represented either at the county-level of central-level TWG.

Meeting frequency & venue

The TWG will meet on Thursdays, once every 2 weeks for an initial 6-month period, after which it will meet on a monthly basis. Depending on the level of control of the COVID-19 situation in Liberia and public health measures in place, meetings may be conducted virtually by Zoom (link will be shared) or in-person.

Appendix 4. Facilities included in oxygen availability assessment

County	Facility name	Facility type	Ownership
Bomi	Liberia Government Hospital (Bomi)	Hospital	Public
Bong	Bong Mines Hospital	Hospital	Public
Bong	C.B. Dunbar Maternity Hospital	Hospital	Public
Bong	Phebe Hospital	Hospital	Public
Gbarpolu	Chief Jallahlon Medical Center	Hospital	Public
Grand Bassa	Liberia Government Hospital (Buchanan)	Hospital	Public
Grand Bassa	Arcelol Mittal Hospital	Hospital	Private
Grand Cape Mount	St. Timothy Hospital	Hospital	Public
Grand Cape Mount	Sinje Health Center	Health Center	Public
Grand Gedeh	Gbarzon Health Center	Health Center	Public
Grand Gedeh	Konobo Health Center	Health Center	Public
Grand Gedeh	Martha Tubman Memorial Hospital	Hospital	Public
Grand Kru	Rally Time Hospital	Hospital	Public
Grand Kru	Buah Health Center	Health Center	Public
Grand Kru	Sass Town Health Center (Domo Nimene Maternity Hospital)	Health Center	Public
Lofa	Foya Boma Hospital	Hospital	Public
Lofa	Bolahun Health Center	Health Center	Public
Lofa	Kolahun Hospital	Hospital	Public
Lofa	Vahun Health Center	Health Center	Public
Lofa	Curran Lutheran Hospital	Hospital	Public
Lofa	Tellewoyan Memorial Hospital	Hospital	Public
Margibi	Salala Rubber Corporation (SRC) Health Center	Health Center	Public
Margibi	C.H. Rennie Hospital	Hospital	Public
Margibi	Unification Town Health Center	Health Center	Public
Maryland	J.J. Dossen Hospital	Health Center	Public
Maryland	Pleebo Health Center	Health Center	Public
Montserrado	14 Military Hospital	Hospital	Public
Montserrado	Redemption Hospital	Hospital	Public
Montserrado	Bensonville Hospital	Hospital	Public
Montserrado	JFK Medical Center	Hospital	Public
Montserrado	SDA Cooper Memorial Hospital	Hospital	Private
Montserrado	St. Joseph Catholic Hospital	Hospital	Public
Montserrado	Benson Hospital	Hospital	Private
Montserrado	Duport Road Health Center	Health Center	Public
Montserrado	ELWA Hospital	Hospital	Public
Montserrado	Pipeline Health Center	Health Center	Public
Montserrado	Barnersville Health Center	Health Center	Public
Montserrado	James N. David Memorial Hospital	Hospital	Public
Montserrado	Bardnesville Junction Hospital	Hospital	Private
Montserrado	TB Annex Hospital	Hospital	Public

County	Facility name	Facility type	Ownership
Montserrado	Nyehn Health Center	Health Center	Public
Nimba	Karnplay Health Center	Health Center	Public
Nimba	Saclepea Comprehensive Health Center	Health Center	Public
Nimba	Arcelol Mittal Hospital	Hospital	Private
Nimba	G.W. Harley Hospital	Hospital	Public
Nimba	Ganta Methodist Hospital	Hospital	Public
Nimba	Jackson F. Doe Memorial Hospital	Hospital	Public
Nimba	Zoe Geh Medical Center	Health Center	Public
River Gee	Gbeapo Health Center	Health Center	Public
River Gee	Fish Town Hospital	Hospital	Public
Rivercess	St. Francis Hospital	Hospital	Public
Sinoe	F.J. Grante Hospital	Hospital	Public
Sinoe	Karquekpo Clinic	Health Center	Public

Appendix 5. Key Assumptions for Oxygen Demand Quantification

Facility assessment data used (N=53 facilities)
County
Longitude & latitude
Total number of beds
Power availability
Availability of central oxygen piping
Availability of on-site PSA plant & capacity
DHIS-2 data used (N=53 facilities)
Annual admissions/patient volume

Oxygen consumption assumptions			
Ward/Unit	**Hypoxemia prevalence (%)**	**Typical oxygen flowrate (LPM)**	**Duration of oxygen therapy for typical hypoxemia case (hours)**
OPD	1%	5	1
General adult (male + female)	6%	6	72
Adult	1%	6	144
Pediatric	10%	2	72
Neonatal	20%	1	72
ICU	100%	30	96
OT	100%	8	6
ER	30%	6	16
Isolation ward	100%	10	72
OB ward	6%	5	72

Device allocation assumptions for health facilities	
10 LPM concentrator needs	1 per high flow bed (ICU, COVID ward, operating theatre)
5 LPM concentrator needs	1 concentrator can serve multiple pediatric and neonatal patients with a flow splitter
Tabletop pulse oximeter needs	1 per ICU and operating theatre bed
Handheld pulse oximeter needs	1 per 10 beds in adult, pediatric, neonatal, ER, pediatric ER, and maternity wards 1 per COVID severe bed (in treatment centers)
Fingertip pulse oximeter needs	Used for OPD patient screening; 1 per 50 OPD visits per day.

Additional assumptions (details available upon request)
Energy costs
Transportation costs for cylinders
Bed capacity and distance considerations for PSA plant recommendations
Cost of products from global suppliers

Appendix 6. Implementation Costing

Note: Full costing assumptions, details and other summaries can be found in the Excel budget file that can be obtained from the MOH.

Strategy	#	Activity	2021	2022	2023	2024	Total cost ($USD)
1.1 Integrate oxygen delivery into existing national policies and strategies	1.1.1	Disseminate National Roadmap plan and activities (including a 2-page advocacy brief) to increase involvement of stakeholders and resource commitments	$5,550	-	-	-	$5,550
	1.1.2	Revise existing national documents (STG/EML, EPHS, RMNCAH Investment Case, etc.) to incorporate oxygen interventions and considerations	-	$16,200	-	-	$16,200
1.2 Establish and utilize central coordination and technical advisory platform for implementation and coordination of oxygen activities	1.2.1	Validate Terms of Reference for Oxygen TWG	$0	-	-	-	$0
	1.2.2	Hold regular Oxygen TWG meetings as a coordinating mechanism for implementation of the Roadmap	$0	$900	$900	$900	$2,700
	1.2.3	Link national coordinating mechanism to subnational mechanisms (e.g. county health team meetings), private sector mechanisms, and service providers, for implementation of roadmap activities	-	$1,200	$1,200	$1,200	$3,600
1.3 Ensure a sustainable financing mechanism or secured external funding for oxygen	1.3.1	Develop resource mobilization strategy and advocacy documents to increase investment in the national oxygen system, or incorporate oxygen into existing national resource mobilization strategies	$1,725	$1,725	$1,725	$1,725	$6,900
	1.3.2	Incorporate oxygen into existing mechanisms used to allocate government budgets, to ensure support is available for implementation coordination and for procurement of oxygen technologies and supplies	-	$825	$825	$2,475	$4,125
	1.3.3	Perform feasibility study on sustainable funding mechanisms including results-based financing, revolving drug funds, and public-private partnerships	-	$4,800	-	-	$4,800
	1.3.4	Use national coordinating mechanism (TWG) to coordinate procurement of oxygen technologies and supplies for increased negotiating power and cost-savings	$0	$0	$0	$0	$0
1.4 Develop plan for future surges in oxygen use that considers availability of oxygen technologies and supplies and health workforce capacity	1.4.1	Create a national preparedness plan for oxygen demand surges, building upon lessons learned from past surges, to detail the steps that the MOH and partners should take in event of a surge (or incorporate oxygen planning into existing national epidemic preparedness plans)	-	$7,625	-	-	$7,625
	1.4.2	Conduct an assessment of frontline healthcare workers' (particularly physicians') competence in oxygen therapy to inform capacity building interventions (also refer to Strategy 3.3.3)	$0	-	-	-	$0
	1.4.3	Create emergency oxygen trainings for clinicians to allow for surge capacity training	$115,625	--		-	$115,625

Strategy	#	Activity	2021	2022	2023	2024	Total cost ($USD)
	1.4.4	Develop rapid assessment & quantification tools to determine oxygen needs during demand surges	-	$7,350	-	-	$7,350
	1.4.5	Proactively create partnerships with private sector oxygen suppliers in preparation for future surges (e.g. rapid increase in production capacity, diverting from industrial to medical oxygen)	$1,550	-	-	-	$1,550
	1.4.6	Update plan every three years to reflect current country capacity and needs	-	-	-	$3,675	$3,675
2.1 Conduct routine quantification exercise to forecast national oxygen demand and undertake routine quantification review	2.1.1	Conduct robust quantification exercise every 3 years to forecast oxygen demand	$2,040	-	-	-	$2,040
	2.1.2	Conduct quantification review annually and update procurement budgets accordingly	-	$1,350	$1,350	$1,350	$4,050
	2.1.3	Review and update supply plans on a quarterly basis, in line with other supply plan review exercises	-	$1,000	$1,000	$1,000	$3,000
2.2 Develop technical specifications for the donation and procurement of oxygen technologies and supplies	2.2.1	Develop technical specifications for oxygen equipment to meet international standards (e.g. European Conformity (CE), U.S. Food and Drug Administration (FDA) approval)	$3,100	-	-	-	$3,100
	2.2.2	Disseminate technical specifications for oxygen technologies and supplies to partners and health facilities, to guide procurements and donations	-	$1,700	-	-	$1,700
	2.2.3	Establish systems for ongoing monitoring of the quality of oxygen technologies and supplies, or incorporate into existing systems	$101,800	$101,800	$101,800	$101,800	$407,200
	2.2.4	Consolidate and maintain list of pre-qualified suppliers of oxygen equipment for streamlined donation and procurement	-	$0	-	-	$0
2.3 Update and revise national donation guidelines to incorporate oxygen technologies	2.3.1	Update national donation guidelines to incorporate considerations for oxygen technologies and supplies, such as integration of national technical specifications	-	$4,950	-	-	$4,950
	2.3.2	Implement donation guidelines through dissemination among donors and partners involved in funding or coordinating donations	-	$1,475	-	-	$1,475
	2.3.3	Establish systems to ensure that donations adhere to technical specifications, such as linking technical specification checklists or reviews to duty-free status	$2,800	-	-	-	$2,800
2.4 Establish a procurement and supply management (PSM) process for procurement and distribution of oxygen technologies and supplies	2.4.1	Map existing supply chain processes including existing commercial PSA/ASU plants, cylinder delivery, and equipment distribution for oxygen delivery systems	-	$7,100	-	-	$7,100
	2.4.2	Ensure tracking of oxygen consumables, supplies and spare parts in LMIS, for reporting on use of consumables and informing replenishment of consumables and supplies	-	$10,050	-	-	$10,050
	2.4.3	Develop and maintain a national database of oxygen equipment inventory for tracking of oxygen devices and equipment	-	$14,650	-	-	$14,650

Strategy	#	Activity	2021	2022	2023	2024	Total cost ($USD)
	2.4.4	Review and update distribution process for oxygen technologies and supplies (including process for clearance, inspection, inventory, storage, and delivery), utilizing LMIS to ensure distribution is timely and based on demand	-	$2,600	-	-	$2,600
	2.4.5	Develop standard tools and guidelines for the operation, repair and maintenance of existing and planned oxygen plants to assist with resource mobilization and planning immediately and at the outset of procurement	-	$0	-	-	$0
	2.4.6	Develop plans for cylinder distribution and wheel/spoke model for installation of new oxygen plants or upgrade of existing plants	-	$0	-	-	$0
	2.4.7	Establish process for scheduled procurement of oxygen technologies and supplies based on aggregated demand	-	$0	$0	$0	$0
	2.4.8	Engage private sector oxygen plants to gap-fill where needed to ensure consistent oxygen supply at health facilities	-	$1,500	-	-	$1,500
2.5 Procure oxygen equipment to meet forecasted demand	2.5.1	Procure oxygen technologies and supplies based on national quantification outputs and up-to-date supply plans	$8,121,808	$820,633	$853,459	-	$9,795,900
2.6 Improve the process for equipment maintenance, repair, and replenishment	2.6.1	Incorporate key indicators into LMIS to monitor oxygen equipment availability and distribution	-	$0	-	-	$0
	2.6.2	Conduct routine supervision and mentoring in health facilities to ascertain availability and functionality of oxygen technologies and supplies	$350	$350	$350	$350	$1,400
	2.6.3	Build local capacity for the monitoring and maintenance of oxygen production plants in Liberia (also refer to Activity 3.5.3)		$0	$0	$0	$0
3.1 Develop national clinical management guidelines for hypoxemia and oxygen therapy	3.1.1	Develop and validate national clinical management guidelines for hypoxemia and oxygen therapy based on international best practices and adapted to country context, including guidance for health facility staff (primary, secondary, and tertiary) and emergency response/ambulance staff	$6,000	-	-	-	$6,000
	3.1.2	Review national clinical management guidelines every 3 years to ensure contents reflect current best practices	-	-	-	$3,075	$3,075
	3.1.3	Disseminate national clinical management guidelines at county and facility levels	$5,550	-	-	-	$5,550
	3.1.4	Monitor the use of national clinical management guidelines through routine mentoring and joint integrated supportive supervision (JISS) (also see Activity 3.4.2)	$0	$0	$0	$0	$0
3.2 Review, update, and implement pre-service	3.2.1	In the short-term, develop an oxygen training module that can be used as an extension to existing pre-service training curricula	-	$18,825	-	-	$18,825

Strategy	#	Activity	2021	2022	2023	2024	Total cost ($USD)
training packages to include comprehensive contents on hypoxemia management and oxygen therapy	3.2.2	In the medium and long-term, review, update, and validate pre-service training materials for SBAs with up-to-date contents on hypoxemia management and oxygen therapy, based on international best practices and adapted to country context	-	-	$3,825	-	$3,825
	3.2.3	Integrate validated oxygen training materials into existing pre-service training curricula for each cadre of SBAs	-	-	$13,600	-	$13,600
	3.2.4	Procure simulation equipment and training supplies for pre-service training	-	$152,650	-	-	$152,650
3.3 Review, update, and implement in-service training packages to include comprehensive contents on hypoxemia management and oxygen therapy to increase quantity of providers able to deliver oxygen therapy	3.3.1	Develop and validate in-service training materials for SBAs with up-to-date contents on hypoxemia management and oxygen therapy, and integrate into any existing platforms for continuing professional development (CPD)	$4,650	-	-	-	$4,650
	3.3.2	Procure training supplies for in-service training	$30,000	-	-	-	$30,000
	3.3.3	Plan and hold new or refresher trainings for at least 2 providers per clinic, 3 providers per health center, and 5 providers per hospital	$121,600	$575,850	$191,800	$200,400	$1,089,650
	3.3.4	Update and maintain a database of trained providers	$0	$0	$0	$0	$0
	3.3.5	Increase quantity of respiratory therapists in country with priority focus on county hospitals	-	$300,000	$300,000	$300,000	$900,000
3.4 Conduct routine facility-based mentoring focused on oxygen delivery	3.4.1	Develop plan and mentoring tools for routine facility-based mentoring for oxygen delivery in collaboration with county and district health officials and health facility administrators	-	$6,225	-	-	$6,225
	3.4.2	Build the capacity of national and sub-national mentors to conduct routine mentoring	-	$173,700	-	-	$173,700
	3.4.3	Conduct routine mentoring visits to facilities to ensure each facility is visited at least quarterly, focusing on hypoxemia management and oxygen therapy	$64,200	$113,200	$64,200	$98,200	$339,800
	3.4.4	Update and maintain a record of mentoring visits	$0	$0	$0	$0	$0
3.5 Develop and utilize standard operating procedures (SOPs) for planned preventive maintenance (PPM) and corrective maintenance (CM) of oxygen equipment and devices	3.5.1	Develop SOPs for planned preventive maintenance (PPM) and corrective maintenance (CM) of oxygen technologies	-	$3,000	-	-	$3,000
	3.5.2	Disseminate SOPs to biomedical engineering technicians	$1,050	-	-	-	$1,050
	3.5.3	Conduct new and refresher trainings for biomedical engineering technicians on PPM and CM of oxygen technologies, including maintenance of oxygen production plants	-	$9,200	$1,700	$10,500	$21,400
	3.5.4	Increase quantity of biomedical engineering technicians in country with the aim of having at least one technician per public hospital	-	-	$250,000	$250,000	$500,000

Strategy	#	Activity	2021	2022	2023	2024	Total cost ($USD)
	3.5.5	Update and maintain a database of trained biomedical engineering technicians	$0	-	-	-	$0
	3.5.6	Conduct routine supervision and mentoring visits to ensure proper use and adherence to SOPs, on a quarterly basis	$0	$0	$0	$0	$0
	3.5.7	Train and deploy maintenance staff to health facilities according to need, reviewing equipment availability and functionality annually	$850	$8,950	$14,100	$18,400	$42,300
	3.5.8	Facilitate trainings, to be held by biomedical engineering technicians, for health workers on basic maintenance of oxygen technologies	$0	$0	$0	$0	$0
4.1 Establish national indicators and data collection tools for oxygen	4.1.1	Develop definitions for national indicators on oxygen, such as for hypoxemia management, use of oxygen equipment, oxygen quality, and oxygen administration	-	$5,125	-	-	$5,125
	4.1.2	Develop and roll out oxygen production and consumption trackers, facility ledgers, and other data tools as needed to collect information on oxygen quality, use and demand (data should be disaggregated by patient age and service and used alongside/integrated with relevant data in LMIS)	-	$33,525	$27,200	-	$60,725
	4.1.3	Integrate oxygen-data aggregation into HMIS Monthly Reporting Form or a supplementary form as needed	-	$0	-	-	$0
	4.1.4	Train facility, county, and central focal persons on collecting oxygen-related data	-	$17,750	-	-	$17,750
4.2 Encourage use of oxygen-related service data for decision-making	4.2.1	Disseminate and orient county and central MOH staff on use of oxygen data, leveraging existing structures at county and district levels such as county coordination meeting, county data review meetings, etc.	-	$9,500	-	-	$9,500
	4.2.2	Develop user-friendly data outputs from standardized tools, templates and ledgers to ensure comparability across health facilities and counties, and disseminate data regularly through existing platforms (including but not limited to the Oxygen TWG) to inform decision-making at facility, county, and national levels	-	$0	$0	$0	$0
	4.2.3	Conduct facility-level data quality assurance (DQA) visits to verify and improve timeliness, accuracy and completeness of oxygen service data, developing and utilizing training-specific indicators for visits	-	$23,250	$23,250	$23,250	$69,750
	4.2.4	Cross-reference data on equipment functionality to support evidence-based decision-making on oxygen administration and use	-	$0	$0	$0	$0
Grand Total ($USD)			**$8,590,248**	**$2,460,533**	**$1,852,284**	**$1,018,300**	**$13,921,365**