USAID COVID-19 Oxygen Programs Interim Review

May 2024

Sustaining Technical and Analytical Resources (STAR) is a project of the Public Health Institute (PHI) implemented in partnership with the University of California, San Francisco (UCSF) and Aspen Management Partnership for Health (AMP Health).

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Acronyms

AMP Health	Aspen Management Partnership for Health
ASU	air separation unit
BME	biomedical engineer
BMET	biomedical equipment technician
CHAI	Clinton Health Access Initiative
COVID-19	coronavirus disease 2019; caused by the SARS-CoV-2 virus
DIS	Development Information System
EpiC	Meeting Targets and Maintaining Epidemic Control
FBLA	facility-based learning needs assessment
GHS	Ghana Health Service
GHSC-PSM	Global Health Supply Chain-Procurement and Supply Management
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HCW	healthcare worker
HRH	human resources for health
ICU	intensive care unit
IP	implementing partner
IPC	infection prevention and control
KII	key informant interview
KPI	key performance indicator
LMIC	low- and middle-income country
LOX	liquid oxygen
M&E	monitoring and evaluation
MNCH	maternal, newborn, and child health
MOH	Ministry of Health
O2	oxygen
ODK	Open Data Kit
PSA	pressure swing adsorption
RE-AIM	Reach, Effectiveness, Adoption, Implementation, Maintenance
RISE	Reaching Impact Saturation and Epidemic Control
SOW	scope of work
STAR	Sustaining Technical and Analytic Resources
TA	technical assistance
TWG	technical working group
UCSF	University of California, San Francisco
VIE	vacuum insulated evaporator
VSA	vacuum swing adsorption
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

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- Staff at Meeting Targets and Maintaining Epidemic Control (EpiC)/FHI360 headquarters and in-country offices, as well as their respective subcontractor partners, in Côte d'Ivoire, the Democratic Republic of the Congo, Malawi, Mozambique and Vietnam
- Staff at Reaching Impact Saturation and Epidemic Control (RISE)/Jhpiego headquarters and in-country offices, as well as their respective subcontractor partners, in Ghana and Mozambique
- Staff at Global Health Supply Chain-Procurement and Supply Management (GHSC-PSM) headquarters and in-country offices, as well as their respective subcontractor partners, in Ghana and Mozambique
- Key officials from the Ministries of Health (MOHs) in Côte d'Ivoire, the Democratic Republic of the Congo, Ghana, Malawi, Mozambique, and Vietnam
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Executive Summary

Overview

Background

The COVID-19 pandemic revealed and exacerbated global shortcomings in oxygen supply and delivery systems, highlighting gaps in health systems' abilities to provide respiratory care. In response, the United States Agency for International Development (USAID) engaged implementing partners (IPs) to address these issues in select low- and middle-income countries (LMICs). Implementing partners, including EpiC (Meeting Targets and Maintaining Epidemic Control, led by FHI 360), RISE (Reaching Impact Saturation and Epidemic Control, led by Jhpiego), GHSC-PSM (Global Health Supply Chain-Procurement and Supply Management, led by Chemonics) and other key partners undertook programs to enhance oxygen access in more than 25 countries.

USAID oxygen programs included various combinations of the following components: infrastructure support such as installation of oxygen supply systems (e.g. liquid oxygen (LOX), medical gas piping, pressure swing adsorption (PSA) plants, vacuum swing adsorption (VSA) plants, cylinder filling stations, cylinder manifold systems, etc.), clinical and non-clinical technical assistance (TA), provider and key personnel trainings, commodity and oxygen procurement, facility modifications, and market-shaping activities.

Program design was informed by engagement with local stakeholders as well as rapid assessments conducted across potential countries to identify environments likely to benefit from investment in various oxygen modalities. Each country had different challenges, priorities and opportunities. Some countries already had high utilization of LOX and were looking to expand access to more rural settings. Other countries had limited or no access to LOX and were focused on other oxygen strategies including expanding PSA/VSA plants, improving oxygen markets, and utilizing oxygen in central hubs to supply other parts of the country. USAID supported PSA plants in six countries and technical assistance, LOX infrastructure and market shaping in 15 countries via American Rescue Plan Act (ARPA) Congressional Notification (CN) 164, ARPA CN165, ARPA Disaster Funding, Global Fund Technical Assistance, LOX Infrastructure, LOX market shaping, and other funding streams. This Interim Review focused on programs in six of the countries where USAID supported oxygen activities.

Oxygen Programs Interim Review

In August 2022, USAID engaged the Sustaining Technical and Analytic Resources (STAR) project and its sub-partner, the University of California, San Francisco (UCSF) to lead an Interim Review of USAID oxygen programs in Côte d'Ivoire, the Democratic Republic of the Congo, Ghana, Malawi, Mozambique, and Vietnam, focusing primarily on the three USAID programs dedicated to oxygen support: the oxygen ecosystems/PSA activity, the LOX infrastructure activity and the market shaping activity. The Interim Review aimed to assess impact on oxygen use and availability, based on data and interviews from the multi-stakeholder teams engaged in implementing these programs.

Objectives:

- Identify key successes and challenges as well as enablers and barriers to oxygen investment in selected countries
- Demonstrate how USAID's investment in oxygen support over the course of the pandemic, in the context of other simultaneous stakeholder investments and activities, influenced the availability of oxygen in the identified countries
- Identify priorities to ensure the sustainability of USAID's investment in oxygen support since September 2020

Methods

To achieve these objectives, STAR-UCSF conducted the following activities:

Activity 1: Desk review of implementation materials

- A desk review of oxygen ecosystems-related documents was conducted to map the implementation process from obligation of funds to availability and implementation of oxygen ecosystems solutions in selected health facilities in each country.

Activity 2: Assessment of implementation outcomes based on national- and facility-level indicators

- National- and facility-level indicators were created by STAR-UCSF based on the IPs' SOWs, USAID COVID-19 Saving Lives Now - Oxygen Indicators, and the World Health Organization (WHO) Key Performance Indicators (KPIs) for Medical Oxygen Ecosystems. These indicators were collected in-country and assessed focusing on the oxygen ecosystem investment's public health outcomes. Results were mapped to the Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework where possible.

Activity 3: Key informant interviews and Delphi survey

- Enablers, best practices, barriers, challenges, and successes were assessed via virtual and in-person key informant interviews (KIIs), conducted at the headquarter (HQ), national, and facility levels. Key themes were identified through a rapid thematic analysis.
- The appropriateness and feasibility of WHO KPIs for medical oxygen ecosystems were assessed using a consensus building methodology (Delphi survey). Participants were medical oxygen experts and stakeholders purposively sampled from USAID HQ and country missions, IP HQ and country offices, Ministries of Health (MOH), and in-country health facilities.

Findings

Activity 1: Desk Review

- 127 documents were reviewed as a part of the desk review, including workplans, job aids, training materials, guidance documents, implementation frameworks and data collection tools. Most were country-specific, instead of being applicable cross-nationally.

- Of the workplans reviewed, most included investment in LOX equipment and infrastructure. TA was universally planned, but varied in subject matter and audience.
- Market-shaping activities, facility needs assessments, investment in oxygen piping, and PSA plant and LOX tank installations were planned.
- Sustainability plans, market-shaping reports, and standard operating procedures were under development by IPs but were not available at the time of desk review.

Activity 2: Program Implementation Assessment using National- and Facility-Level Indicators

In total, the STAR-UCSF team conducted five national surveys (excluding the Democratic Republic of the Congo) and eight facility surveys, (two in Côte d'Ivoire, zero in the Democratic Republic of the Congo, one in Ghana, two in Malawi, one in Mozambique, and two in Vietnam). See Appendix 3 and 4 for the survey tools developed by STAR-UCSF for the Interim Program Review. Reporting timeframes varied depending on the timing of STAR-UCSF in-country data collection visits, beginning in March-Oct of 2022 and spanning June 2023 to January 2024. Data was also obtained from the USAID Development Information System (DIS) up to February 2024, which superseded STAR-UCSF surveys if newer information was available.

To the extent possible, program implementation was assessed using the RE-AIM framework. The specific program components evaluated included: infrastructure support (LOX infrastructure expansion and/or PSA plant support); TA; provider and key personnel trainings; commodity and oxygen procurement; and market-shaping activities.

No RE-AIM domains could be fully assessed, as oxygen programs were at different stages across countries, and most were not yet completed at the time of this Interim Review.

Implementation indicators assessed the consistency of delivery of the program and resources in terms of fidelity to intended program deployment. Information such as the planned and actual timelines for implementation of activities as well as common factors impacting implementation decisions are included in this aspect of the assessment.

- Implementation timelines for each country's workplan were mapped, ranging from March 2021 (Ghana and Mozambique), and slated to end up until March 2026 (the Democratic Republic of the Congo). All workplans were extended due to delays related to supply chain and procurement challenges, evolving government approval processes and health priorities, and in-country logistical constraints.
- Commodities donated included PSA plants, oxygen concentrators, LOX tanks, oxygen cylinders, pulse oximeters, ventilators, high-flow nasal devices, and more, with Malawi and Vietnam reporting the highest number of commodities delivered.
- More oxygen concentrators were donated in Ghana, Malawi, and Mozambique than elsewhere. Vietnam's donations focused more on LOX tanks and PSA or VSA plants. Ghana, Malawi, and Mozambique also reported substantial donations of pulse oximeters and other devices, such as air filters, patient monitors, and regulators.
- Oxygen investment types and progress varied; for LOX infrastructure, some countries had not completed any LOX tank installations or trainings, in others, construction was in

progress, facility modifications made, or only trainings held. For market-shaping activity, most countries were underway but in the earlier stages and had not yet completed these activities.

Reach indicators assessed penetration of program activities in relation to the intended coverage, such as the number of facilities that received technical assistance (TA), facility-level modifications to support oxygen delivery, or donations of oxygen-related supply sources.

- TA varied considerably based on the progress of activities in each country, with a considerable reach of TA programs to 34 facilities in Ghana and 48 instances of TA reported in Vietnam. Other countries had limited or no reporting data for the number of facilities receiving TA or instances of TA.
- Five or more facilities in most of the six Review countries reported 1) installation of LOX tanks, 2) installation of PSA/VSA plants, and/or 3) improving existing pipe systems for oxygen to copper piping or an upgraded manifold system.
- In addition to the donation of thousands of monitors (e.g. pulse oximeters) and hundreds of thousands of oxygen delivery devices, USAID Oxygen Programs reported donations of oxygen supply sources underway in all countries including Mozambique (2 PSA, >300 portable concentrators, 2,100 oxygen cylinders and 5 LOX systems), Vietnam (2 PSA Plants and 13 LOX systems in Phase I with a plan for 10 more in Phase II), Democratic Republic of the Congo (2 LOX systems planned and 1,452 oxygen cylinders), Malawi (5 LOX systems and 259 oxygen cylinders), Côte d'Ivoire (7 LOX systems and 350 cylinders), and Ghana.
- Across the six Review countries, oxygen access is being directly expanded in >140 facilities, which collectively have a catchment of nearly 1000 additional facilities.

Adoption indicators assessed the characteristics of whether programs were implemented by relevant participants, organizations or stakeholders, and if and how these programs were modified (e.g. adoption of national strategic plans, existence of regulatory entities).

- National engagement varied. The Democratic Republic of the Congo, Ghana, Vietnam and Malawi reported either the availability of national strategic plans for oxygen or that creation of such plans was in progress.
- Malawi and Vietnam reported existing regulatory entities for oxygen at the national level to ensure security for medical oxygen. Ghana reported a national-level oxygen management team. Côte d'Ivoire has established a monitoring committee. All Interim Program Review countries had identified a key point person for oxygen within the MOH. Technical working groups (TWGs) on oxygen ecosystem strengthening have been established in Mozambique and the Democratic Republic of the Congo. A National Medical Gas Strategy is in development in Mozambique.
- Facility-level Program adoption is ongoing as IP workplan activities remain in progress.

Activity 3A: Key Informant Interviews

In total, the STAR-UCSF team conducted 33 oxygen program KIIs, including five HQ-level interviews with program managers, directors, medical officers, advisors; 20 country-level interviews with project officers, country directors, ministry officers, etc.; and eight facility-level interviews with health facility staff such as HCWs, BMEs, and BMETs. From these KIIs, overall oxygen enablers, best practices, barriers, and challenges were identified.

Five enablers were identified in some or all of the Interim Review countries:

1. The presence of *strong MOH commitment, coordinated local leadership and passionate donor, implementer, and MOH champions* played an important role in program successes, as reported by multiple stakeholders.
2. *Formal recognition of oxygen as an essential medicine* with benefits beyond COVID-19 (e.g. childhood pneumonia and tuberculosis) strengthened commitment to oxygen infrastructure.
3. The presence of *near real-time, high-quality data on oxygen needs* were critical to inform decision making processes (e.g. on facility infrastructure and country oxygen needs, transport and allocation).
4. *Technical Working Groups (TWGs) facilitated consensus and efficient resource allocation*, allowing local partners and MOHs to rapidly develop guidelines, identify priorities, and resolve technical challenges.
5. Countries that included *relationship-building as a key to market shaping* noted improvement in relationships that positively impacted local supply, such as during supply chain interruptions.
6. *Existing LOX infrastructure* was identified in KIIs as an enabler for LOX-related program success.

Best practices emerged as approaches that were leveraged in oxygen ecosystems investment and can be used and adapted to situations and contexts.

1. Planning for *sustainable, cost-effective approaches* from day one, taking into account future oxygen supply issues and needs, both empowered local leadership and increased chances of continued program success.
2. The inclusion of a *comprehensive training and workforce development package* had cross-cutting impacts: developing champions, increasing technical expertise, identifying knowledge gaps, increasing engagement, and augmenting biomedical engineering/technician capacity, among others.

Five barriers were identified in some or all of the Interim Review countries:

1. The most frequent barrier was *procurement and supply chain limitations*, which significantly impacted oxygen programs throughout the delivery chain and likely will impact future maintenance capacity.
2. Implementation was difficult in settings with *insufficient infrastructure (e.g. power and roads) and faulty or under-utilized equipment,* which hampered and slowed program activities.
3. Transportation of oxygen via *long, restricted, and often unsafe commutes* was identified in all countries as a hindrance to the efficient delivery of oxygen, especially LOX.
4. A significant long-term barrier to the availability of accessible and affordable oxygen was *insufficient financing and market imbalances*, especially in areas with limited suppliers.
5. *Limited harmonization across stakeholders*, despite attempts to harmonize knowledge sharing efforts, led to duplicative efforts or competing priorities.

Four key challenges were identified in some or all of the Interim Review countries:

1. For settings with limited LOX experience, there was a *steep learning curve related to LOX*, increasing time and complexity of implementation.
2. Given the complexity of medical oxygen maintenance and delivery, the *limited BME[T] workforce and human resources for health (HRH)* were common concerns.
3. The presence of *gaps in oxygen policies and guidelines* for procurement, transportation, accountability and consumption monitoring contributed to delays.
4. The complexity of oxygen scale up activities, particularly in the midst of a pandemic, resulted in *time-consuming implementation,* delays to timelines, and the extension and revision of workplans.

Activity 3B: Delphi Survey

In February 2023, WHO released the Medical Oxygen System KPIs, intended to provide guidance on the monitoring of global investments in oxygen. We sought to establish consensus on the appropriateness and feasibility of these KPIs using a modified Delphi approach with a purposively sampled group of oxygen programs implementers and key stakeholders. At the time of this report the consensus process is completing its first round, with 28 stakeholders having responded, representing viewpoints from USAID and IP HQs, five country programs, and three facility perspectives.

The six KPIs that were considered to be the most appropriate and feasible include:

(1) Inclusion of oxygen on the Essential Medicines List in countries with oxygen investments (WHO KPI #7)
(2) Number of beds at the facility equipped with a functional oxygen supply out of the total number of beds at the facility (WHO KPI #8)
(3) Number of countries that have oxygen included as part of national health strategy documents and/or plans (WHO KPI #10)
(4) Number of health facilities with functional oxygen systems out of the total number of health facilities (WHO KPI #12)
(5) Number of clinical staff trained on oxygen therapy at the facility level out of the total number of clinical staff at the facility level (WHO KPI #9)
(6) Number of technical staff trained on oxygen systems operation and maintenance at the facility level out of the total number of technical staff at the facility level (WHO KPI #13)

Availability and quality of relevant data were frequently cited as barriers to appropriateness and feasibility of KPIs.

Conclusion and Recommendations

Successes of USAID's Oxygen Investment

The pandemic provided not only unprecedented investment in oxygen ecosystems, but an opportunity to learn from these initiatives to design sustainable, future efforts. There are notable early successes; further achievements will become clear as implementation progresses.

Expanded oxygen access

- Across the six Interim Program Review countries, oxygen access is being expanded in approximately 146 facilities and more than 13,000 patient beds. In some facilities visited during the Interim Review, staff celebrated how new oxygen supplies increased self-reliance in managing patients and how many lives had been positively impacted.
- Progress toward expanding access to LOX occurred both in areas with existing LOX infrastructure as well as areas with limited LOX infrastructure (e.g. no local LOX producer, variable electricity, no medical gas piping, limited roads, etc.).

Highlighted the need for additional, specialized trainings for oxygen

- Countries included in the Interim Review learned how to improve their oxygen systems and increase local capacity to use and maintain those systems. The spectrum of teaching has included clinicians, BME[T]s, administrators and managers.
- Training assessments have been done, and teaching tools have been created for use in different countries. Additional training resources are desired, especially human resources trained in oxygen conservation and stewardship.
- Oxygen ecosystem education is seen as a huge step forward for improved access to oxygen. Individuals, IPs, and MOHs are more knowledgeable about oxygen systems and the need to improve them. Oxygen knowledge and training is useful and still needed.

Collaboration maximized impact

- A collaborative approach between technical partners, funders, and governments created synergy and enabled multiple stakeholders to augment their impact.
- USAID-supported IPs engaged with each other to collaborate on TWGs, regional meetings/workshops, and participation in global initiatives (e.g. the Oxygen Alliance, Every Breath Counts Coalition, and the Lancet Global Health Commission on Oxygen Security). They also engaged with other actors in the oxygen space not part of USAID's investment, by forming partnerships, or hosting meetings to share lessons and strategy.
- Strong oxygen ecosystems were recognized for their far-reaching impact across healthcare systems and are necessary to achieve universal healthcare coverage.

Recommendations for Future Programming

While USAID's investment has been a driving force to cultivating healthy, resilient oxygen ecosystems, there are still barriers to ensuring these systems meet their goals.

Promote sustainability post-USAID investment

- National and facility level sustainability plans for the future are clearly articulated recommendations by partners.
- Plans should involve the details about sources of ongoing funding and resources, including both local funding from governments as well as donor organizations.
- Progress was best when actors were coordinated; sustainability plans should be similarly coordinated to increase their effectiveness and reduce overlapping activities. Ensuring harmonization with MOH through endorsement and active participation will increase their chance of success.

- Nearly all Interim Program Review countries shared concerns about the maintenance of the newly-improved oxygen ecosystems without ongoing, outside support.

Create locally-adaptable blueprints for future oxygen investments

- Guidance for investing in oxygen systems based on local factors will be helpful for streamlining future initiatives, including barriers, enablers and lessons learned from specific, local contextual factors. TA, infrastructure improvement and procurement strategies, and stakeholder engagement priorities should be covered.

Improve oxygen data and timing of site selection

- Account for the complexity of oxygen infrastructure development with sufficient time for assessment of country- and facility-level oxygen capacity. Assessment was complex and more time-consuming than anticipated, yet necessary for programmatic success. Avoid resource-intensive and often duplicative assessments by multiple stakeholders and invest in longitudinal national data systems that integrate oxygen indicators.
- Design and support purposeful, sustainable oxygen programs by investing in these activities prior to the next pandemic. This will better ensure appropriate time for site selection and planning, and minimize tendency toward stop-gap solutions.

Financing, market shaping, and procurement strategies

- Identifying and sustaining a competitive, local solution for procurement of oxygen and supplies is critical. Many key informants noted that current national budgets and donor contributions still do not go far enough to set up sustainable oxygen systems in LMICs.
- Few market shaping activities had taken place at the time of the Interim Review, especially as relates to systems or service level interventions. Investment and market shaping will take time, but likely will lead to more competitive negotiations and benefit country programs, and therefore should be supported.

Leverage opportunities for future learning

This Interim Review identified specific areas for potential learning that are not feasible at present, but can be done in the near future and would be invaluable to inform future initiatives.

- Complete assessment of feasibility and utility of oxygen-related KPIs and share knowledge with other ongoing efforts.
- Conduct cost-analysis and create business cases for implementation of different oxygen supply strategies at the facility level (e.g. LOX, PSA/VSA, cylinder etc) and national level (e.g. local ASU plant, import model etc.).
- Conduct detailed case studies and long term follow-up on market shaping activities to fully characterize impact and extrapolate lessons learned for other settings.
- Assess long-term functionality of oxygen investments (e.g. MGPS, LOX, PSA systems, hub-and-spoke distribution models) at five years. Learning opportunities such as better characterizing oxygen-related health system vulnerabilities and oxygen-supply solutions, must be seized.

Limitations

The most significant limitation of this Interim Program Review was the lack of available data primarily as a result of incomplete Program implementation at the time of Review. Countries were at different stages of completion for oxygen programs when the STAR-UCSF team conducted site visits, KIIs, and data abstraction. No implementers or countries had completed all workplans covered by this Interim Review and in some cases, final workplans were not yet approved or begun. Numerous indicators had not yet been fully reported.

Background

On March 11, 2020, the World Health Organization (WHO) declared the novel coronavirus (COVID-19) a global pandemic. In response to this, in April 2020 with funding from the United States Agency for International Development (USAID), the Meeting Targets and Maintaining Epidemic Control (EpiC) central mechanism, led by the implementing partner (IP) FHI 360, the Reaching Impact Saturation and Epidemic Control (RISE) central mechanism, led by Jhpiego, and the Global Health Supply Chain-Procurement and Supply Chain Management (GHSC-PSM) central mechanism, led by Chemonics, among other mechanisms, were engaged to respond to COVID-19, including testing, surveillance, case management, and, later, oxygen supply and delivery in low- and middle-income countries (LMICs).

Reliable access to medical oxygen is essential for treating patients across all clinical settings and is an integral part of a robust health system. The COVID-19 pandemic revealed and exacerbated global shortcomings in oxygen supply and delivery systems. During the pandemic, ministries of health (MOHs), aid organizations, and many other global stakeholders launched numerous initiatives to close gaps in the availability and accessibility of medical oxygen. Like many aspects of the pandemic response, there was no roadmap for rapidly expanding access to this essential medical resource. Despite oxygen being a fundamental and longstanding treatment, there were surprisingly few tools available to guide core aspects of oxygen scale-up, including procurement decision-making, maintenance, delivery, and regulatory considerations. Furthermore, because oxygen impacts nearly all aspects of medicine and patients from neonates to adults, primary care to speciality surgery, and inpatient to outpatient care, integrating oxygen systems into the broader healthcare system is complex. To this end, the COVID-19 pandemic made the complexity of providing secure, reliable, and sustainable medical oxygen as part of larger medical oxygen ecosystems on a global scale more apparent.

To ensure health care facilities and frontline staff could safely procure, store, maintain, and deliver oxygen to patients, a strategic response to addressing the shortcomings was required. USAID's investment in oxygen ecosystems during the COVID-19 pandemic was an unprecedented initiative to support LMICs. Throughout the course of USAID support for oxygen programming, USAID and IPs worked closely with numerous local and global initiatives also aiming to improve access to oxygen.

Early in the pandemic (2020-2022), USAID oxygen activities were focused on urgent issues such as surges in oxygen demand and lack of frontline provider support. This included modalities that could be relatively rapidly deployed, such as frontline provider training, personal protective equipment, oxygen cylinders, bedside oxygen concentrators and PSA plants. As part of this support from USAID, the Sustaining Technical and Analytic Resources (STAR) project received COVID-19 funding and engaged with its sub-partner, the University of California, San Francisco (UCSF) to work alongside EpiC, RISE, and GHSC-PSM and others to assemble technical experts who could provide advice, create tools for assessment, knowledge sharing, and education, and to implement technical assistance (TA) in these important aspects of countries' responses to the COVID-19 pandemic. In October 2021, USAID obligated funds to EpiC, RISE, and STAR-UCSF to jointly produce global goods – tools and resources that could be accessed by anyone globally and used to respond to COVID-19 in the areas of case management, oxygen delivery, emergency care, and vaccines. Much of this effort went to support the curation of essential, up-to-date “oxygen global goods” for partners, stakeholders, and implementers.

As the pandemic progressed (2022-2024), USAID expanded the breadth of oxygen programs beyond emergency response to also include investments in long-term solutions to deficiencies in oxygen infrastructure. As part of this, USAID incorporated liquid oxygen (LOX) as a potential solution to the long-standing oxygen gap for select countries.

In August 2022, STAR-UCSF was engaged to carry out an interim Program Review to assess progress and impact of USAID’s investment into oxygen in six of more than 25 countries that received USAID funding for oxygen activities, including several focused on the expansion of LOX. Elements of this Interim Review are intended to be released publicly pending USAID concurrence and predicated on agreement from Ministries of Health (MOHs), which was sought at the earliest stage of the Program Review.

Previous LOX Feasibility Assessments

Multiple global stakeholders conducted assessments to inform the planning of multiple oxygen-related initiatives. For USAID, this included assessments of baseline oxygen needs prior to the pandemic (Appendix 1) as well as rapid (~four-week) assessments by EpiC across 530 hospitals in 26 countries to determine the feasibility, local interest and potential for investment in LOX. The LOX assessments included all six Review countries and provided an overview of the context of LOX landscapes in those countries at that time. All available data were utilized by USAID and IPs to select implementation countries for the LOX infrastructure program. Below are brief summaries of the key findings from some of these assessments of the oxygen landscapes in the selected countries.

In Côte d'Ivoire, concentrators and pressure swing adsorption (PSA) plants were common sources of oxygen. Assessments found some existing LOX infrastructure, including a local supplier, two hospitals that use LOX, eight cryogenic tanks, 14 facilities with some infrastructure in place to use LOX if available, and 32 biomedical engineers (BMEs) available for LOX maintenance. There had been a ~four-fold increase in medical oxygen consumption since the start of the COVID-19 pandemic, but, at the time, very little donor investment in LOX and significant challenges in meeting demand. Two donors supporting oxygen in-country were The Global Fund (14 PSAs) and World Bank (9 PSAs). LOX is only funded by USAID. The government had demonstrated commitment to LOX by budgeting for LOX at public health facilities and expanding piping to 1,416 beds. Potential investment opportunities identified by initial assessments included providing TA to PSA sites, upgrading health facilities to use LOX, training for BMEs, support for oxygen transportation, and support to develop the policy and regulatory environment for oxygen.

In the Democratic Republic of the Congo, multiple oxygen-related capacity assessments were conducted near the beginning of the project period by multiple stakeholders. USAID IP planning assessments found that there were limited options for local LOX supply and no public hospitals using LOX, but several health facilities had basic infrastructure to support LOX if available.

Many facilities had medical gas piping systems (MGPSs), though due to leakages and wear, many needed to be replaced. The assessments also found that there were 80 BMEs available across the country. During the pandemic, oxygen consumption in some facilities had nearly doubled. According to a 2020-21 survey conducted by PATH (as part of the COVID-19 Respiratory Care Response Coordination project, a partnership between PATH, Clinton Health Access Initiative (CHAI), and the Every Breath Counts Coalition) of 692 facilities surveyed, only two had continuous reliable oxygen supplies (PSA plants), 68% had never provided oxygen (<50% for tertiary care facilities), and only 20% of tertiary facilities had MGPSs. The production capacity of oxygen was estimated to be less than 6% of total need across the country.[1] A Unitaid supported assessment by CHAI found 28 PSA plants in the Democratic Republic of the Congo, 18 of which were medical oxygen, 10 of which were industrial, and all were located in only six of the 26 national provinces. Across capacity assessments, there were financial and technical gaps identified, including LOX manufacturing, expanding local markets, health facility infrastructure, supply chain infrastructure, and an existing but unvalidated regulatory system for production and use of medical oxygen.

In Ghana, needs assessments conducted in 2020 by WHO and Ghana Health Service (GHS) highlighted the need for expanded oxygen infrastructure. In 2021, USAID supported the addition of four PSA plants and additional capacity assessments in 2022. These assessments identified seven domestic industrial gas producers (all medical LOX was imported), one facility using LOX, 14 facilities with some infrastructure to use LOX if available, and 150 trained BMEs. The 2022 assessment also identified 11 facilities as potential LOX expansion sites based on significant unmet oxygen demand, stable power supply, and adequate water supply, among other factors. Investment opportunities included support for local manufacturing, lowering purchasing costs to facilities, and reducing facilities' reliance on cylinders. Several global partners were supporting medical oxygen access in Ghana, including USAID, United Nations Children's Fund (UNICEF), CHAI, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and WHO.

In Malawi, assessments found that the available medical oxygen supply (~89 tonnes per month) was ~50% of the estimated demand, and in some tertiary care facilities, as many as 70% of hypoxic patients did not receive oxygen due to supply or equipment challenges. LOX is not widely utilized in the country with only one dominant LOX vendor (AFROX), and most oxygen is imported as LOX from South Africa and converted to gas cylinders in the country. Seven PSA plants were present early in the pandemic, and a total of ten as of April 2023, with 5-9 planned to be installed. All were impacted during COVID-19 surges and could not meet national demand. LOX infrastructure was sparse as no facilities used LOX and 90% of facilities lacked a MGPS, but eight facilities were identified with potential capacity to use LOX if available. Investment opportunities included LOX tanks, training of biomedical and clinical staff, and long-term contracts to supply LOX locally. USAID and other global partners were supporting efforts to strengthen LOX systems and medical oxygen access. The Malawi MOH created a technical

[1] PATH. (2022). *Assessment Report on the Availability of Oxygen and Biomedical Equipment in Health Facilities: DRC Facility Survey Report.* Seattle: PATH.; Ecole de Santé Publique de l'Université de Kinshasa/ESPK République Démocratique du Congo and ICF. (2019). *République Démocratique du Congo: Evaluation des Prestations des Services de soins de Santé EPSS RDC 2017- 2018.* Kinshasa, RDC and Rockville, Maryland, USA: ESPK and ICF.

working group (TWG) (Emergency Task Force on Oxygen) to collaborate with oxygen suppliers and donor partners to improve the medical oxygen system. A Medical Oxygen Roadmap was also launched in December 2021 and the Pharmacy Medicines Regulatory Authority was working on standards to regulate oxygen production and delivery for the country (still in draft as December 2023).

In Mozambique, multiple assessments were conducted between October 2021 to January 2022, including a national oxygen assessment by the USAID GHSC-PSM project, CHAI and the Mozambique MOH. These assessments found that oxygen cylinders and concentrators were the most common oxygen sources. There were few PSA systems found, and only 30% of installed units were functioning properly. USAID IP planning assessments identified a strong commitment to expanding the LOX market. The assessment found that the MOH receives LOX support from different donors and partners, including Global Fund, World Bank, WHO, USAID and CHAI (with support from Unitaid, and USAID via EpiC). Like Malawi, Mozambique relies on importation of LOX from a single producer in South Africa. There are only two local distributors, MEDIQUIP, which uses cylinders filled from a PSA plant to supply only the northern provinces, and MOGÁS. Local LOX production has been limited by reliable power among other factors. Limited competition, costs of importation and public sector procurement challenges result in high costs for medical oxygen. There were ~13 facilities identified that used LOX,[2] 12 facilities with the capacity to use LOX if available, two filling stations to convert LOX to gas, four cryogenic tanks, and a small number of trained BMEs in the private sector. While total LOX and PSA-produced oxygen supplies have been estimated by some as theoretically sufficient to meet national demand, the geographic concentration of LOX in the south and frequent PSA breakdowns result in limited access to oxygen. Estimates based on facility invoices for oxygen (consumption) and clinical needs (by CHAI assessment) suggest that consumption is less than ~60% of clinical need. Identified investment opportunities included transportation upgrades, improved reliability of storage and distribution systems, piping improvements, more trainings for engineers and technicians, and expansion of oxygen supply particularly to the central and northern regions. Multiple partners have been supporting oxygen expansion in Mozambique.

Finally, in Vietnam, data from multiple sources, including reports by PATH, CHAI, Vietnam MOH and EpiC, were available to inform work planning. The government had prioritized expanding oxygen infrastructure during the pandemic, including LOX availability. There were 54 local LOX suppliers and significant infrastructure and systems in place to utilize LOX, including national funding and favorable regulatory and policy frameworks. LOX was covered by the national social health insurance, making it affordable for facilities as costs could be reimbursed for many patients via social security. According to a 2021 study of 993 facilities, 100% of central hospitals (avg 1,349 beds/hospital), 63% of provincial hospitals (avg 570 beds/hospital), and 6% of district hospitals (avg 171 beds/hospital) used LOX.[3] Gaps were primarily identified at the provincial and district levels, and investment opportunities included specific interventions such as procurement of cryogenic tanks for facilities with piping but no

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[2] Estimates varied by report from eight to 13 facilities, mostly located in the south.
[3] Nguyen, C., Hoong, V. N., Nguyen, S., Nowak, S., Nguyen, C., Nguyen, N., & Ha, A. D. (2021). *Medical Oxygen Suppliers in Vietnam*, Vietnam Ministry of Health and PATH Presentation; and Ministry of Health Decision No. 4308/QD-BYT. September 7, 2021.

tanks. There has been notable commitment to expanding LOX access in Vietnam, which is supported by USAID and other global partners like CHAI, PATH, UNICEF, Unitaid, BMGF and the Global Fund.

Overview of Oxygen Programs Interim Review

In August 2022, STAR-UCSF was engaged to carry out two Program Reviews, one focused on USAID's investment into oxygen and the other on the COVID-19 Test-to-Treat program implementation. As outlined below, this Oxygen Programs Interim Review was undertaken in collaboration with USAID and with support of the three USAID central mechanisms, EpiC, RISE, and GHSC-PSM.

This Interim Program Review focused on six of more than 25 countries that received USAID funding for oxygen activities and relied on stakeholder engagement at every stage, beginning with the design of the Interim Review. USAID and IPs provided feedback on the overall scope of work (SOW) as well as national- and facility-level indicators; received updates on the Program Review in routine meetings; and facilitated initial introductions to stakeholders in the Interim Review countries. STAR-UCSF relied on USAID leadership for engagement with IPs, as well as facilitation of access to existing aggregate, non-clinical data.

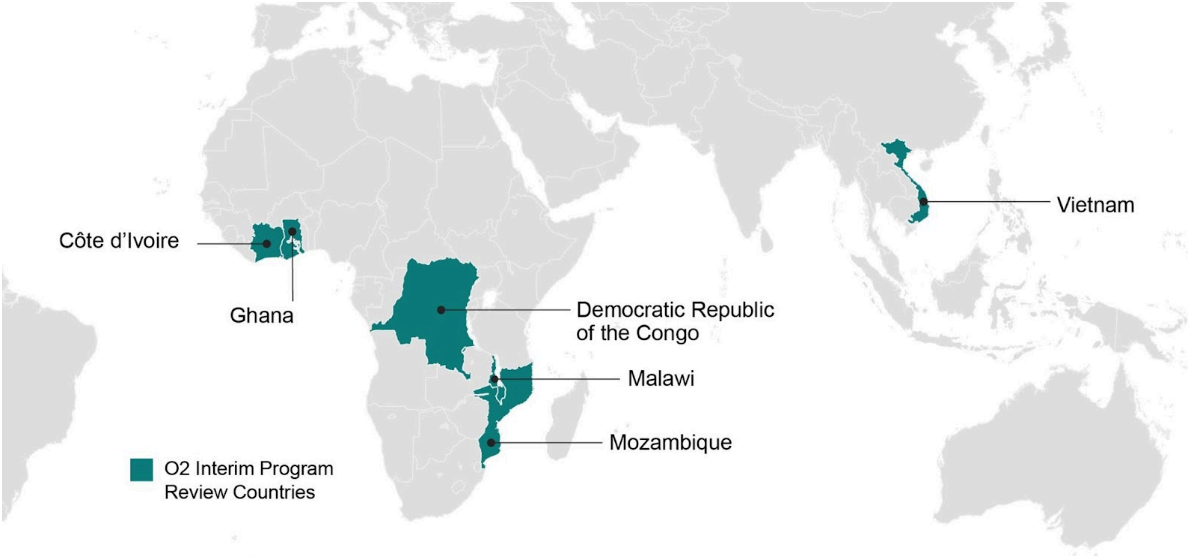
Objectives: The STAR-UCSF team conducted the Oxygen Programs Interim Review, leveraging the experience of public health experts, frontline care clinicians, engineers, technicians, and others engaged in building scalable oxygen ecosystems in LMICs, in order to:

- Identify key successes and challenges as well as enablers and barriers to oxygen ecosystems investments in selected countries
- Demonstrate how USAID's investment in oxygen support over the course of the COVID-19 pandemic, in the context of other simultaneous stakeholder investments and activities, influenced the availability of oxygen in the identified countries
- Identify priorities to ensure the sustainability of USAID's investment in oxygen support since September 2020

Activities: The Interim Program Review was designed around three activities across selected countries:

- Desk review of implementation materials
- Application of the RE-AIM implementation science framework to assess the public health outcomes of USAID's investment in oxygen systems at both facility and national levels
- Stakeholder engagement using key informant interviews and a Delphi survey

Figure 1. Countries included in the Oxygen Programs Interim Review.



Methods

Ethical Approval

In November and December 2022, STAR-UCSF developed and submitted the Interim Review protocol and associated documents to the UCSF Institutional Review Board (IRB). In December 2022, the UCSF IRB determined that the review was "Not Human Subjects Research" as the review was "a project that includes program evaluations, quality improvement activities, or other activities that do not require further IRB oversight according to the federal regulations summarized in 45 CFR 46.102(l)" (Appendix 2).

Country-specific IRB approvals were not required, except in Ghana where STAR-UCSF submitted an expedited review and exemption request in October 2023. In November 2023, the GHS granted approval to complete the Interim Review (GHS-ERC: 004/11/23) (Appendix 3).

Country Selection

Between October and December 2022, STAR-UCSF engaged USAID headquarters (HQ) and IPs to select countries for the Oxygen Programs Interim Review. Côte d'Ivoire, the Democratic Republic of the Congo, Ghana, Malawi, Mozambique, and Vietnam were recommended by USAID and chosen for the Interim Review, as they were already implementing a broad range of oxygen activities, and also were countries that were pursuing LOX-related activities.[4] STAR-UCSF and USAID worked collaboratively to determine whether all Review objectives would be assessed in all countries.

Activity 1: Desk Review

Between December 2022 and March 2023, STAR-UCSF gathered USAID oxygen support desk review materials from USAID and the IPs. In February 2024, prior to finalization of this report, STAR-UCSF conducted a final round of material solicitation from IPs to account for content created during the Interim Program Review period.

The desk review entailed a thorough review of materials related to USAID's oxygen investments, including protocols, fact sheets, guidance documents, training curricula, implementation plans or frameworks, IP workplans/SOWs, job aids and algorithms for healthcare workers (HCWs), presentation slides or recordings, minutes from partnership or TWG meetings, commodities tracking documents (e.g., availability of LOX, cannulae, etc.), funding allocations, national strategic plans, operations/maintenance logs, and IP progress reports. In May and June 2023, STAR-UCSF reviewed these materials and categorized them according to type of material, creator, audience, topic, language(s), country, and other key details, and developed a summary table to provide a brief overview of USAID-supported oxygen interventions (e.g., LOX systems, TA and training, market shaping, etc.) across the Interim Review countries. During the initial desk review, the STAR-UCSF team mapped the implementation process from obligation of funds to availability and implementation of oxygen solutions in selected health facilities in each country.

[4] USAID HQ initially chose Zambia for the Review, but it was withdrawn due to local circumstances. The Democratic Republic of the Congo was subsequently included for review.

Activity 2: National and Facility-Level Indicators

Following the collection and review of all available program-related materials, in February and April 2023, STAR-UCSF developed national- and facility-level indicators based on the IPs' SOWs and USAID COVID-19 Saving Lives Now - Oxygen Indicators. Additionally, the STAR-UCSF team included select indicators from the WHO key performance indicators (KPIs) for medical oxygen ecosystems[5] which were released in February 2023.

These Review indicators were structured using the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) implementation science framework[6] to assess USAID's oxygen investment's impact on public health outcomes.[7] The UCSF-STAR team also used relevant aggregate, non-clinical quantitative and qualitative data collected by USAID, IPs, and MOHs during the program period at both facility and country levels. The former involved a facility assessment in a subset of facilities in selected countries, using a quantitative assessment tool that sought to assess how USAID's investment has impacted oxygen ecosystems in these facilities and built on previous facility-level assessments performed by the IPs. The data abstracted were mapped to the RE-AIM framework. Most domains were not fully evaluated in this interim review given incomplete and limited duration of program implementation. However, these may be explored at a later date.

In March 2023, the proposed Interim Program Review indicators were shared with USAID and IP HQ teams, followed by multiple rounds of revision and incorporation of their feedback in April. In May and June 2023, the finalized indicators were programmed onto electronic tablets using Open Data Kit (ODK) (Appendix 4; Appendix 5) with slight revisions as needed for form functionality.

Data were gathered during country visits, KIIs and USAID COVID-19 Saving Lives Now - Oxygen Indicators data reports. During country visits, the STAR-UCSF team worked with country-level USAID, IP, MOH, and health facility staff to fill in the respective country- and facility-level forms, to the extent that data were available at that time. Of note, country visits were not conducted in the DRC (due to the late addition of this country to the Interim Review) or in Ghana (due to Program timing). In these instances, data were solicited via KIIs and via email communications, though limited data were available. The USAID Oxygen Ecosystems data were compiled by USAID HQ from voluntary reporting by IPs and were shared with STAR-UCSF in September and December 2023. In instances of data discrepancies between sources, the most current data were included and attempts to reconcile with IPs were undertaken.

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[5] World Health Organization. (2023, February 17). *Developing key performance indicators for the medical oxygen ecosystem through Delphi consensus*. Retrieved from https://iris.who.int/bitstream/handle/10665/366085/WHO-2019-nCoV-Clinical-Oxygen-KPIs-2023.1-eng.pdf?sequence=1

[6] https://re-aim.org/

[7] Adapted from: Klesges, L. M., Estabrooks, P. A., Dzewaltowski, D. A., Bull, S. S., & Glasgow, R. E. (2005). Beginning with the application in mind: Designing and planning health behavior change interventions to enhance dissemination. *Annals of Behavioral Medicine*, 29(2), 66-75.

Table 1. RE-AIM framework

Reach (individual level): Number and characteristics of individuals who participated
● What percentage of the target population came into contact with the program? ● Did the program reach those with the most need? ● Did the participants reflect the targeted population?
Effectiveness
● Did the intervention affect key targeted outcomes? ● What unintended adverse consequences occurred?
Adoption (Setting or organizational level): Number and characteristics of settings or organizations that participated
● What percentage of target settings and organizations implemented the program? ● Did the organizations include high-risk or underserved populations? ● Did the program fit within organizational goals and capacities?
Implementation (Setting or organizational level): Consistent delivery of intervention and resources with quality
● Can different levels of staff successfully implement the program? ● What proportion of staff within a setting implemented the program? ● Were various components delivered as intended?
Maintenance (Individual, setting or organizational level): Long-term implementation and program effectiveness
● Did the program produce long-term individual behavior change? ● Will organizations sustain the program over time? ● What are the characteristics of persons and settings showing maintenance?

Activity 3A: Key Informant Interviews

To better understand the implementation of USAID oxygen activities, STAR-UCSF conducted key informant interviews (KIIs) with global and country-specific experts involved in USAID's oxygen programs in each country. The interviews aimed to solicit information on all dimensions of USAID's oxygen investment, identifying examples of successes and challenges, as well as enablers and barriers. In addition, the KIIs collected information on stakeholder engagement, such as the existence of a TWG, its membership, and function, to assess the collaborations between USAID, IPs, the MOHs, local organizations, and other key stakeholders and determine the potential impact of these partnerships on strengthening oxygen ecosystems.

In February and March 2023, STAR-UCSF developed KII guides for HQ, country, and facility levels with questions relating to keys domains of USAID's oxygen investments: 1) Procurement and Supply Chain Logistics, 2) Oxygen-Related Activities, 3) Facility-Level Equipment and Maintenance, 4) Training and Workforce, 5) Oxygen Policies, Guidelines, and Tools, 6) Financing and Market Shaping Activities, and 7) Future Translatability. To prevent bias, feedback for these questions was not elicited from USAID or IPs as they were part of the groups being interviewed. In April 2023, STAR-UCSF had the KII guides professionally translated into French, Portuguese, and Vietnamese for the Democratic Republic of the Congo, Mozambique, and Vietnam, respectively.

For HQ-level interviews, STAR-UCSF invited key stakeholders who were the leads for the oxygen technical work at their respective organizations. STAR-UCSF asked these stakeholders to invite others who had also been involved in the design, implementation, monitoring, and/or decision-making related to USAID's oxygen investments in the Interim Review countries. For country- and facility-level interviews, HQ staff provided a list of proposed key informants from USAID local mission and IP offices; these country-level informants provided recommendations on who should be included from the MOH and health facilities. There was no formal inclusion or exclusion criteria. Key informants were invited to participate by STAR-UCSF or country-level USAID or IP teams if they had been involved in USAID-funded oxygen programming.

In May and July 2023, STAR-UCSF conducted HQ-level KIIs with USAID and EpiC, RISE, and GHSC-PSM IP staff virtually via Zoom. Between July and January 2024, STAR-UCSF conducted virtual and in-person KIIs at the country and health facility levels with USAID local missions, IP country offices, and MOHs as well as HCWs, BMEs, and biomedical equipment technicians (BMETs), and management staff at the site level.

Staff from organizations at each level were interviewed as a group unless they were the sole key stakeholder at that organization's level or it was not possible to schedule a group interview. After explaining the background, purpose, risks, and benefits of the KIIs, verbal consent was obtained by each participant. One to two members of the STAR-UCSF team conducted the interview using a semi-structured interview guide, while another member took notes (Appendix 6). Interviews ranged from 30 to 75 minutes and were conducted in English, French, Portuguese, or Vietnamese. Names and other personally-identifying information were not recorded. During interviews, key informants were asked to share their perceptions, experiences, and opinions about USAID's oxygen investments. When possible, interviews were initially audio-recorded to ensure the accuracy of the conversation in the interview notes. Once KII notes were finalized within five days of the interview, audio recordings were permanently deleted. Immediately following each interview, STAR-UCSF team members who conducted the interview and took notes debriefed to identify preliminary themes.

After each country-level visit, the STAR-UCSF team conducted a more in-depth analysis of KIIs by reviewing interview notes and identifying main themes. The team used a rapid thematic analysis method to systematically interpret the meaning of the qualitative data collected during the KIIs. During a six-step process, each HQ- and country-facility KII was analyzed, assigned codes, and further reduced into themes and sub-themes, each with associated codes. The six-step process involved: familiarizing with the data, generating initial codes, searching for themes, reviewing themes, refining themes, and adding sub-themes. Codes were then used to

identify enablers, barriers, facilitators, and best practices in oxygen ecosystem program implementation.
Definitions:

- An enabler is a facilitating factor which creates an environment where progress can be made by the team or something that helps program progress or achievement. Enablers can be physical, environmental, structural, or systemic and facilitate key stakeholders in reaching a program's goals. Enablers can be internal or external and can arise from various factors such as availability of resources, existing systems or structures, social or cultural norms, or political environment and will.
- A best practice is an intervention or approach that has shown evidence of effectiveness and is likely to be replicable to other situations or programs. A best practice is a lesson learned or knowledge about what works in specific contexts without using extraordinary resources to achieve the desired results.
- A barrier is an obstacle or impediment that prevents progress or achievement and cannot be easily overcome. Barriers can be physical, environmental, structural, or systemic and hinder key stakeholders from reaching a program's goals. Barriers can be internal or external and can arise from various factors such as lack of resources, social or cultural norms, or personal beliefs.
- A challenge is a difficult task or situation that requires effort, skill, and determination to overcome. A challenge can be an opportunity for growth and development, requiring key stakeholders to overcome it in order to reach the program's full potential.

Activity 3B: Delphi Survey

Despite long-standing barriers to equitable access to medical oxygen in LMICs, until recently, no standardized metrics existed to assess gaps, guide investments, or track improvements in medical oxygen. Consequently, many investments addressing technical and clinical barriers to oxygen delivery in LMICs during the COVID-19 pandemic were made with limited or no standardized metrics to characterize these barriers or to assess impact.

In February 2023, the WHO developed the first-ever list of KPIs to guide and monitor investments in medical oxygen ecosystems. However, little data exists about the operationalization of these KPIs in LMICs. Throughout the KIIs, the wide variability in readiness to collect data necessary to assess WHO Medical Oxygen Ecosystem KPIs was apparent across all the Program Review countries. Consequently, STAR-UCSF planned to use the Delphi methodology to conduct an anonymous, online survey methodology to seek consensus among USAID oxygen program implementers and stakeholders on the appropriateness and feasibility of the WHO KPIs at select sites which received USAID oxygen investments.

In January 2024, STAR-UCSF used REDCap to begin a prospective, online, cross-sectional Delphi survey of key stakeholders working in medical oxygen ecosystems at the facility-, national-, and HQ-level to establish consensus on the perceived appropriateness and feasibility of the WHO Medical Oxygen Ecosystem KPIs and to assess uptake of these KPIs in various settings. One-hundred twelve participants were selected using a purposive sampling approach of medical oxygen experts at USAID HQ, USAID country missions, IP HQ and in-country offices, MOHs, and health facilities where oxygen investments had been made, including all those who had been invited to and/or successfully participated in the KIIs.

The Delphi survey was professionally translated into English, French, Portuguese and Vietnamese and emailed to participants, including a message introducing the survey and providing information on how it would be conducted (Appendix 7). Participants were asked a set of questions designed to assess the appropriateness and feasibility of each of the 24 WHO Medical Oxygen Ecosystem KPIs. The following questions were posed to each survey participant:

1) **Appropriateness:** Is this KPI suitable and likely to be useful for monitoring and evaluating the oxygen delivery ecosystem in your setting?
2) **Feasibility:** Can the data/information necessary to report this KPI be systematically and routinely collected in your setting?

The survey also asked participants the following: 1) if they are currently using the KPIs in assessments of existing medical oxygen ecosystems and/or new investments; and 2) whether they know of, recommend, or are using other metrics for assessing and monitoring medical oxygen ecosystems. To assess consensus on appropriateness and feasibility of each KPI, participants were asked to rate appropriateness and feasibility on a Likert scale, with scores 1-2 representing relatively inappropriate or infeasible KPIs, 3 representing uncertain appropriateness or feasibility, and 4-5 representing relatively appropriate or feasible KPIs. Iterative rounds of the survey were planned to continue through the full program implementation period and until ≥70% of survey responses for each KPI fall between 1-3 or 7-9. At the time of this report, only the first round has been completed.

Responses were expected from 30-50 participants from the Interim Review countries and were intended to include individuals at all levels of the health system involved in implementation of program activities, across all Review countries. Respondents classified the appropriateness and feasibility of each WHO Oxygen Ecosystem KPI, characterized the adoption of each KPI, and described the usage of alternative metrics for assessing and monitoring medical oxygen ecosystems.

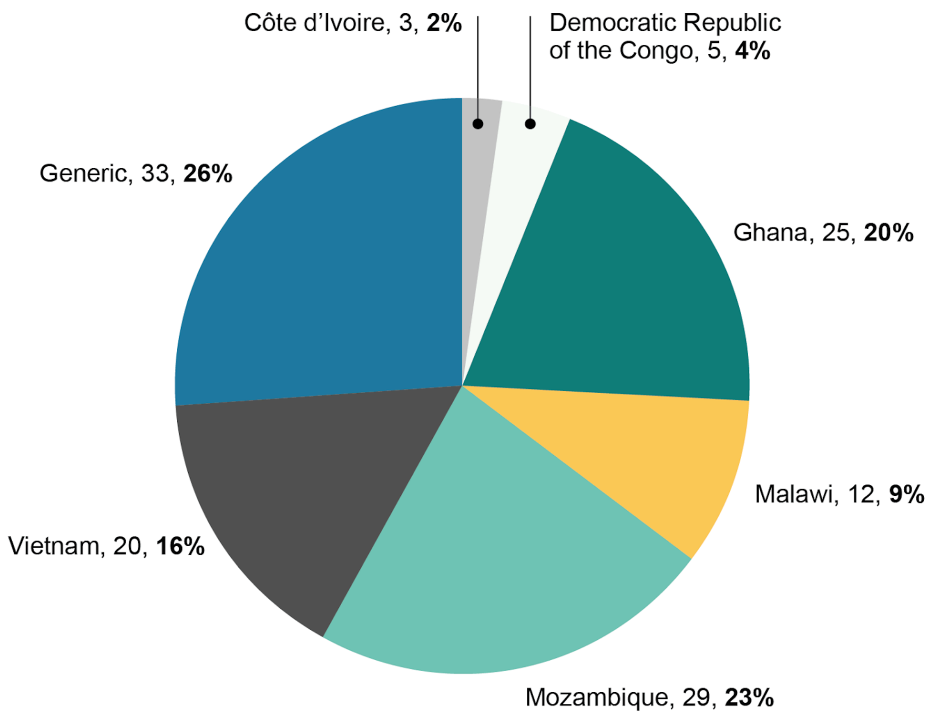
See Appendix 8 for a timeline of Oxygen Programs Interim Review activities.

Findings

Activity 1: Desk Review

The desk review encompassed a total of 127 documents in various languages, including English, French, Portuguese, and Vietnamese, from EpiC, RISE, GHSC-PSM, and USAID teams. Some materials were linked to publicly-accessible websites (e.g., opencriticalcare.org, fhi360.org), while others were internal documents only accessible to the IPs and/or USAID teams. These materials were reviewed and classified based on different criteria, including public availability, content creator, language, category or type of document, subject matter, intended audience, date, and country-specific or general, cross-country materials (Appendix 9).

Figure 3. Summary of materials reviewed, by geography.



As shown in Figure 3, the majority of documents shared were created or adapted for specific country use. Several country programs were able to provide only a limited number of documents due to delayed implementation timelines (i.e. many relevant documents were not yet finalized or able to be shared). Country-specific documents included country workplans, training materials for oxygen equipment, national roadmaps for oxygen, and country assessments. Others were generic and included training and educational materials on oxygen technologies provided by IPs.

Figure 4 shows the breakdown of these materials by type of document, including fact sheets, guidance documents, implementation plans/frameworks, IP workplans/SOWs, job aids, presentations, reports, and training materials. The workplans reviewed largely had implementation start dates ranging from March 2021 to April 2023, though most underwent revisions and extensions of their end dates, including some into 2026.

Overall, the number of oxygen documents shared with the STAR-UCSF team was smaller than anticipated, based on estimates of materials known to be under development via KIIs and workplans. Many IPs reported materials under development but not yet ready for sharing. This included sustainability plans, market-shaping reports, and standard operating procedures, to name a few. Although monitoring and evaluation (M&E) plans were incorporated in various forms within each workplan, the documentation to support this process was not available during the desk review.

A separate table comparing countries' oxygen ecosystem approaches was created using relevant country SOWs and workplans that were shared with STAR-UCSF by USAID (Table 2). This comparison highlighted oxygen investments by country, lead IP, sites selected, and key oxygen-related activities. In the Program Review countries, projects focused on multiple areas of the oxygen ecosystem with some similarities in all six countries including investment in LOX infrastructure and TA (training). Other areas of focus in some countries but not all include market shaping activities, formal facility needs assessments, oxygen quantification and investment in oxygen piping, civil works, oxygen delivery equipment and PSA plants. This table was updated for accuracy as country-level KIIs and data collection occurred.

Figure 4. Summary of materials, by type of document.

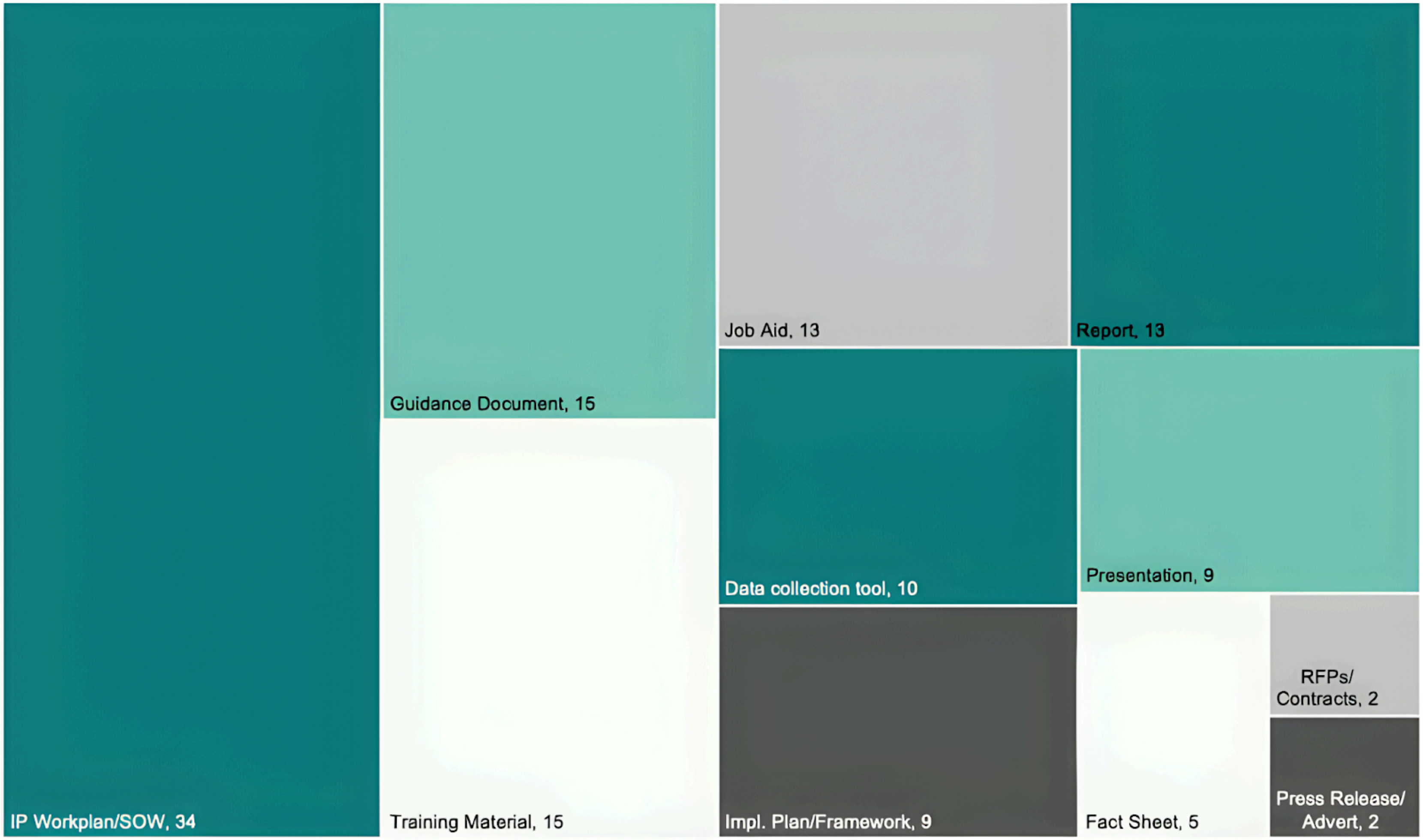


Table 2. Desk review summary of IP workplans as of March 2024 across Interim Program Review countries

Country	IP(s)	Activities	Workplan Dates
Côte d'Ivoire	EpiC (FHI 360)	<u>LOX Infrastructure:</u> 1. Conduct in-depth assessment of seven facilities 2. Procurement and installation of LOX equipment (piping, tank, evaporator, oxygen (O2) pump, manifold, cylinders) at seven facilities 3. Build capacity of MOH staff in maintenance and use of LOX 4. Develop sustainability plans with seven facilities and higher government authority	June 2022 – December 2024 (Original end date June 2023)
		<u>LOX TA:</u> 1. Establish a Task Force to coordinate infrastructure and equipment mapping and maintenance 2. Build capacity, develop, and validate guidelines and SOPs related to infrastructure, equipment, and maintenance 3. Strategic information and M&E, including field support and quality assurance	November 2022 – December 2024 (Original end date November 2023)
Democratic Republic of the Congo	EpiC (FHI 360 and CHAI)	<u>LOX Infrastructure:</u> 1. Upgrade/install LOX system (piping system, vaporizers, and pressure regulation) and build central O2 storage and cylinder filling at one depot storage facility 2. Outfit three catchment facilities with cylinder storage and 85 facilities with oxygen use equipment 3. Build capacity of MOH staff in maintenance and use of LOX, including develop/adapt training materials, conduct clinical and non-clinical training, and follow-up mentorship 4. Develop operational plans with LOX facilities and higher government authority, including integration and oversight by committees 5. Develop sustainability plan for LOX system with facilities and higher government authority	June 2022 – December 2024 (Original end date June 2023)

Country	IP(s)	Activities	Workplan Dates
	EpiC (FHI 360 and CHAI)	Market Shaping: 1. Facility assessments to identify filling station location and sites to be supplied to optimize transport costs and resource allocation 2. Landscaping of foreign and local air separation units (ASUs) and LOX companies to identify potential medical suppliers 3. Capital financing menu creation and selection 4. Quantification of O2 need in target provinces 5. LOX pricing agreements and supply (negotiate sustainable bulk medical liquid oxygen contracts) 6. LOX hub operations to aggregate demand, maintenance service-level agreements, and transportation in Kinshasa 7. Support design and implementation of a national oxygen supply chain, and pilot model cylinder distribution model 8. Provide support to selected ASUs or LOX supplier(s) to facilitate entry into medical oxygen market 9. Integrate LOX operations and costs into the government system	July 2022 – June 2026
Ghana	GHSC-PSM (Chemonics)	Non-Clinical TA: 1. Ensure four facilities meet National Medicines Regulatory Authority standards and maintenance of essential supplies/products/equipment 2. Create a sustainability plan for four facilities' O2 systems and identify opportunities for market shaping 3. Improve human resource capacity to optimize O2 systems	March 2021 - July 2024 (Original end date September 2021)
	RISE (Jhpiego) and GHSC-PSM (Chemonics)	Clinical TA: 1. Facility-based learning needs assessment (FBLA) at four facilities 2. TA at four facilities on medical oxygen therapies for acute and severe hypoxia	March 2021 – March 2022 (Original end date September 2021)

Country	IP(s)	Activities	Workplan Dates
	RISE (Jhpiego)	PSA Plant: 1. PSA facility site preparation including facility modifications (PSA site, cylinder shed, MGPS) and TA at one facility (with cylinder refill capabilities) 2. TA for clinical support personnel including total quality improvement in clinical engineering 3. TA for the establishment of medical equipment assets management 4. Support gaps in Global Fund maintenance for oxygen assets	August 2022 – August 2024 (Original end date September 2021)
		LOX Infrastructure: 1. Preparation and installation of LOX equipment (tanks, ancillary infrastructure) in 10 facilities 2. Procure LOX for the 10 facilities	July 2022 – May 2025
		Oxygen Assessment and TA in Maternal Newborn and Child Health (MNCH): 1. Assess the oxygen ecosystem in MNCH areas of health facilities in northern and western Ghana 2. Provide TA to HCWs staffing facilities	April 2023 – September 2024
		Oxygen TA: 1. Site-level and institution-based oxygen planning 2. Installation of oxygen equipment at newly relocated PSA plant site, pre-installation work and piping, toolkits for BMEs 3. Support capacity building of GHS to do planned preventive maintenance	December 2023 - November 2024
Malawi	EpiC (FHI 360 and CHAI)	LOX Infrastructure: 1. Improve hospital infrastructure to support the introduction of LOX in eight health facilities (two facilities with LOX and liquid-to-gas (L2G) filling stations, three facilities with LOX without filling stations, and three facilities	June 2022 – December 2024 (Original end date June 2023)

Country	IP(s)	Activities	Workplan Dates
		with MGPS and manifold system for cylinders to be filling from LOX filling stations) a. Site readiness assessments b. Construction of eight manifold houses, five concrete foundations and fences, access roads and driveways c. Installation of five LOX tanks, reticulation/eight MGPS (medical gas pipeline systems), eleven automated manifolds, two L2G stations 2. TA to MOH to expand LOX a. Training of trainers for biomedical engineers in LOX systems b. Development of training package c. Capacity building for biomedical engineers and orientations for healthcare workers d. Development of SOPs and guidelines on LOX safety, monitoring and inventory management. 3. Develop sustainability plans a. Workshops and stakeholder consultative engagements to develop sustainability plan b. Strengthening of technical and support human resource capacity	

Country	IP(s)	Activities	Workplan Dates
		Market-Shaping: 1. Analysis of oxygen demand, supply networks, and distribution catchment areas to identify the most cost-effective LOX approach 2. Engage regional LOX suppliers to assess opportunities for lower-cost LOX imports 3. Integrate LOX volumes in business case discussions with regional suppliers for opportunities to expand LOX production in Tanzania, Zambia, and Mozambique and secure low-cost supply 4. Identify at least one supplier able to achieve delivered LOX price of <$1,000 per tonne 5. Support MOH to negotiate LOX supply agreement with identified supplier 6. Support MOH and other stakeholders to integrate potential bulk LOX solutions into the national oxygen scale-up exercises 7. LOX procurement under negotiated agreement between MOH and supplier 8. Ongoing monitoring of LOX supplier performance & procurement contract management	June 2022 – November 2025
Mozambique	GHSC-PSM (Chemonics)	Non-Clinical TA: 1. Ensure one facility meets National Medicines Regulatory Authority standards and maintenance of essential supplies/products/equipment 2. Create a sustainability plan for facilitiy's O2 systems and identify opportunities for market shaping 3. Improve human resource capacity to optimize O2 systems 4. Procure and install PSA plant	March 2021 – September 2021
	RISE (Jhpiego) and GHSC-PSM (Chemonics)	Clinical TA 1: 1. FBLAs at nine facilities 2. TA at nine facilities on medical oxygen therapies for acute and severe hypoxia	March 2021 – September 2021

Country	IP(s)	Activities	Workplan Dates
	RISE (Jhpiego)	Clinical TA 2: 1. Install piping and wall oxygen outlets at three COVID-19 treatment centers 2. Acquire and distribute, 65 high-flow nasal oxygen devices and required consumables	October 2021 – September 2022
		Clinical TA 3: 1. Extension of piping at one facility to additional wards to optimize clinical care and use of the oxygen generated by the PSA plant procured and installed by GHSC-PSM 2. Expand clinical capacity building for non-physician medical professionals 3. Provide continued human resources support and support for strengthening front-line patient triage and stabilization capacity at two facilities	March 2022 – May 2022
		PSA Plants: 1. Provide TA for PSA plant installation at one facility 2. Capacity building of staff at one facility on use, maintenance, and troubleshooting of PSA plant system	October 2022 – March 2023
	EpiC (FHI 360 and CHAI)	Market Shaping: 1. Secure lower-cost bulk medical LOX imports from one or more suppliers via long-term, negotiated supply agreements with volume-based pricing 2. Re-establish domestic bulk medical LOX production in central Mozambique by facilitating investment in a dedicated power supply for the Beira air separation unit	September 2022 – June 2026 (Original end date April 2024)
	EpiC	LOX Infrastructure: 1. Install LOX tanks at five facilities as primary source to reduce supply challenges 2. Upgrade/refurbish the manifold (for cylinder bank), pipeline and outlets	June 2022 - December 2024 (Original end date June 2023)

Country	IP(s)	Activities	Workplan Dates
		3. Supply and install a full pressure-controlled switching manifold system (in hospitals with multiple source types) 4. Commission the installed system, pressure test the line, and test outlets 5. Sustainability planning 6. Training clinical and technical staff on the oxygen ecosystem	
Vietnam	EpiC (FHI 360)	Strengthen COVID-19 Response (scope split with Hot Spot funding): 1. Procurement of equipment and supplies for oxygen ecosystems, patient monitoring, and infection prevention and control (IPC) 2. TA and infrastructure to improve COVID-19 clinical care (scope shared with funding below)	August 2021 – October 2023 (original end date March 2022)
		COVID-19 Hot Spot Emergency Response (scope split with Strengthen COVID-19 Response funding): 1. Develop/adapt and conduct IPC trainings and assessments in five focal provinces 2. Develop/adapt and conduct clinical webinars on case management for COVID-19 patients in five focal provinces, including job aids and other tools 3. Adapt and train on oxygen forecasting tool for Vietnam 4. Develop/adapt and conduct trainings on mental health for human resources for health (HRH) in five focal provinces 5. Procure and install LOX at 13 facilities 6. Provide training and ongoing TA for LOX use at 13 facilities 7. Procure two mobile PSA systems and train mobile oxygen team 8. Procure and deliver other oxygen-related commodities (e.g., electronic syringe pumps, high-flow nasal cannula, N95 masks, etc.) in five focal provinces	October 2021 – June 2023 (original end date October 2022)

Country	IP(s)	Activities	Workplan Dates
		LOX Infrastructure: 1. Develop or improve provincial oxygen sustainability plans in six poorest provinces that have interest and track record collaborating with international partners 2. Procure, deliver, and install LOX systems at 9-10 facilities (4,066 beds) 3. Develop and deliver comprehensive, site-based TA packages on LOX use at 10 facilities	July 2022 – July 2024 (Original end date July 2023)

Activity 2: National- and Facility-Level Indicators

In total, we conducted five national surveys (excluding the Democratic Republic of the Congo) (Appendix 4) and eight facility surveys (two in Côte d'Ivoire, zero in the Democratic Republic of the Congo, one in Ghana, two in Malawi, one in Mozambique, and two in Vietnam) (Appendix 5, Appendix 11).[8] We also obtained IP-reported data for USG oxygen indicators from USAID in December 2023 and February 2024. All indicator data were collected prior to complete program implementation in all sites, and prior to initiation of implementation of select programs. As a result, it is not yet possible to fully report on most aspects of the RE-AIM framework. Limited available data are summarized below.

Implementation

Within the standard RE-AIM framework, implementation aims to assess, at the setting or organizational level, the consistency of delivery of the program and resources with quality.

During the STAR-UCSF data collection, it was noted that implementation of facilities modifications led to increased oxygen access at numerous selected sites. Côte d'Ivoire reported 1,416 beds across 7 facilities with new or upgraded access to oxygen as a result of these modifications. Ghana reported 931 beds with new or upgraded access across 37 facilities (including USAID support for high-flow concentrators, PSA plants and LOX installations). Mozambique reported 707 beds in 7 facilities, and Vietnam reported 450 beds in 13 facilities.

Beyond understanding the number of facilities which benefited from oxygen-related TA and/or oxygen supply sources, there are numerous types of commodities which were provided to countries and facilities to improve access to medical oxygen. Specifically, this included PSA/VSA plants, oxygen concentrators, LOX tanks, oxygen cylinders, pulse oximeters, high-flow nasal devices, and more. Oxygen-related supply sources or commodities were defined as having been donated if they were procured by a USAID IP and considered delivered when the product reached its final destination according to the Incoterms of the procurement. Generally, this was defined by the Central Medical Stores of the receiving country.

Figures 8a and 8b show limited available data on the number of commodities donated by type and country. By far, Malawi and Vietnam had the highest number of commodities delivered, when taking into account pulse oximeters and other types of commodities (which were not defined at the time of reporting). In terms of oxygen delivery supplies, the most oxygen concentrators were donated in Ghana, Malawi, and Mozambique. Vietnam's donations focused more on oxygen delivery systems like LOX tanks and PSA or VSA plants. Ghana, Malawi, and Mozambique also reported substantial donations of pulse oximeters and other devices, such as air filters, patient monitors, and regulators.

At the time of STAR-UCSF data collection visits to each Review country, market-shaping activities were in relatively early stages of implementation. Furthermore, workplan timelines for

[8] For Ghana, all data was collected virtually via Zoom with in-country teams due to delays in receiving local IRB approval and scheduling challenges close to the 2023-24 holiday season.

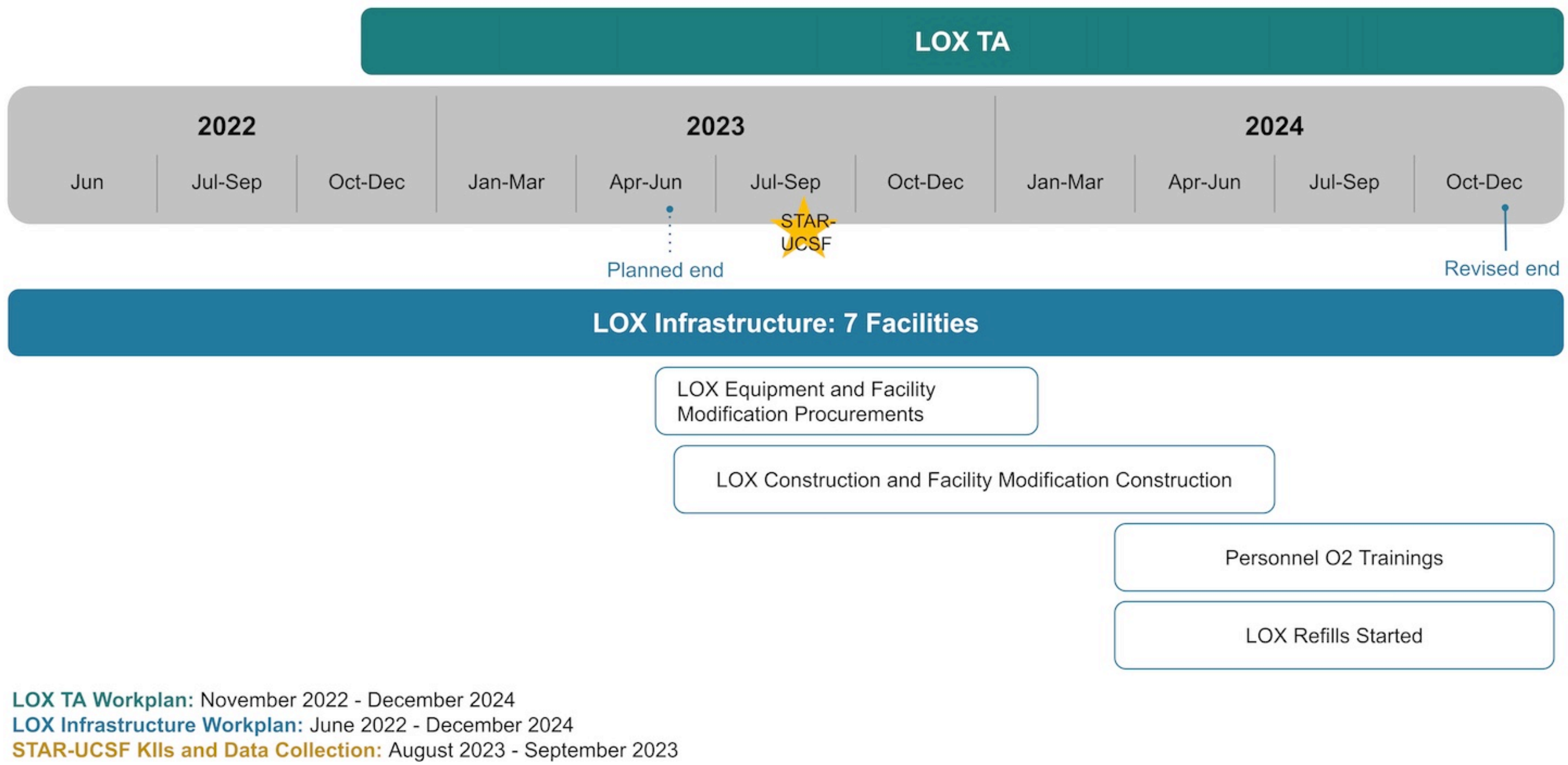
these specific activities were long and in some cases not to be completed until 2026. Thus, limited data were available.

As part the desk review, by utilizing IP workplans/SOWs and meeting minutes from routine calls on oxygen activity progress, STAR-UCSF mapped out the implementation timelines for each review country, comparing the intended or originally planned timelines to the actual timelines of implementation (Figures 5-10 below). Key variations and reasons for delays in the implementation timelines are noted below:

Côte d’Ivoire

Following the execution of LOX tank procurement contracts in May 2023, construction began at six facilities in June and was largely completed in August 2023. LOX vendor contracts were signed between August to October 2023, and all equipment and facility modification procurements completed in January 2024, with equipment cleared by customs and dispatched to all sites. As of April 2024, initial LOX tank fills and trainings have begun. Construction at the seventh facility began in March 2024 and is expected to be completed in June.

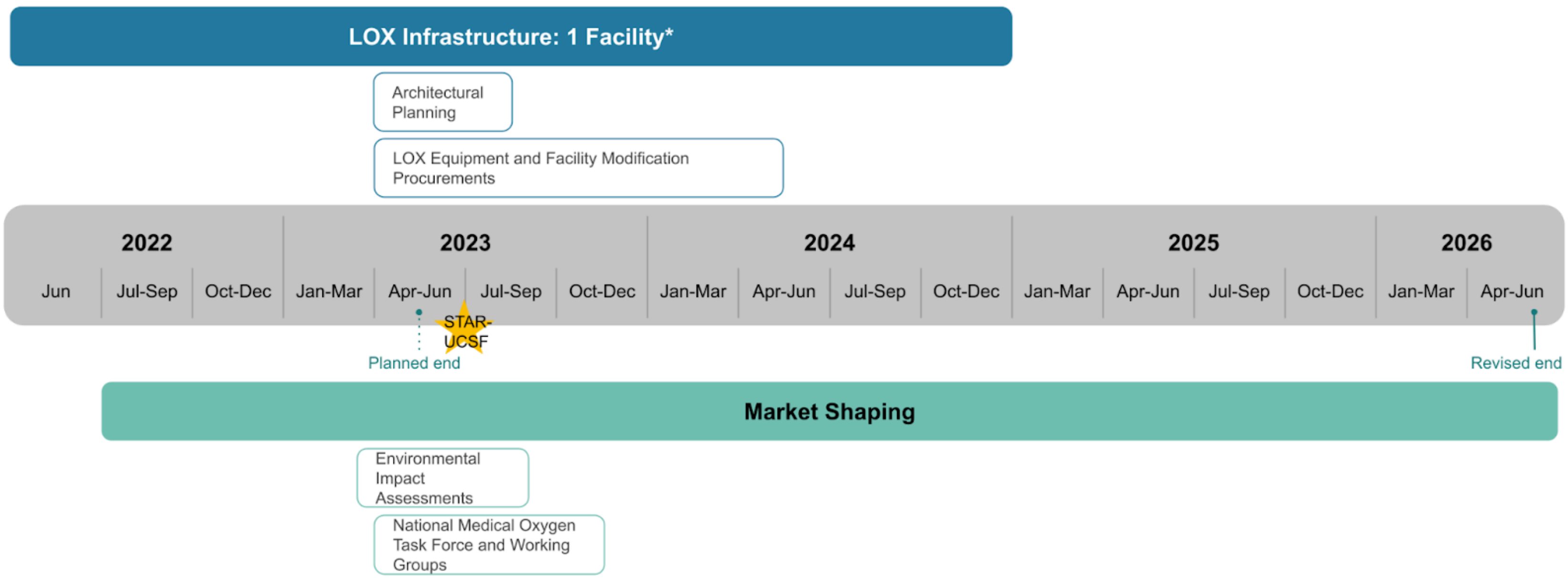
Figure 5. Oxygen ecosystem activities timeline in Côte d’Ivoire, 2022-2024.



Democratic Republic of the Congo

Due to global supply chain barriers and in-country infrastructure challenges, oxygen-related activities have been delayed. From April 2023 through April 2024, multiple RFPs for LOX related activities have been posted, revised and undergoing technical and financial evaluations and approvals. As of March 2024, trainings and LOX infrastructure activities have not yet occurred.

Figure 6. Oxygen ecosystem activities timeline in the Democratic Republic of the Congo, 2022-2026.



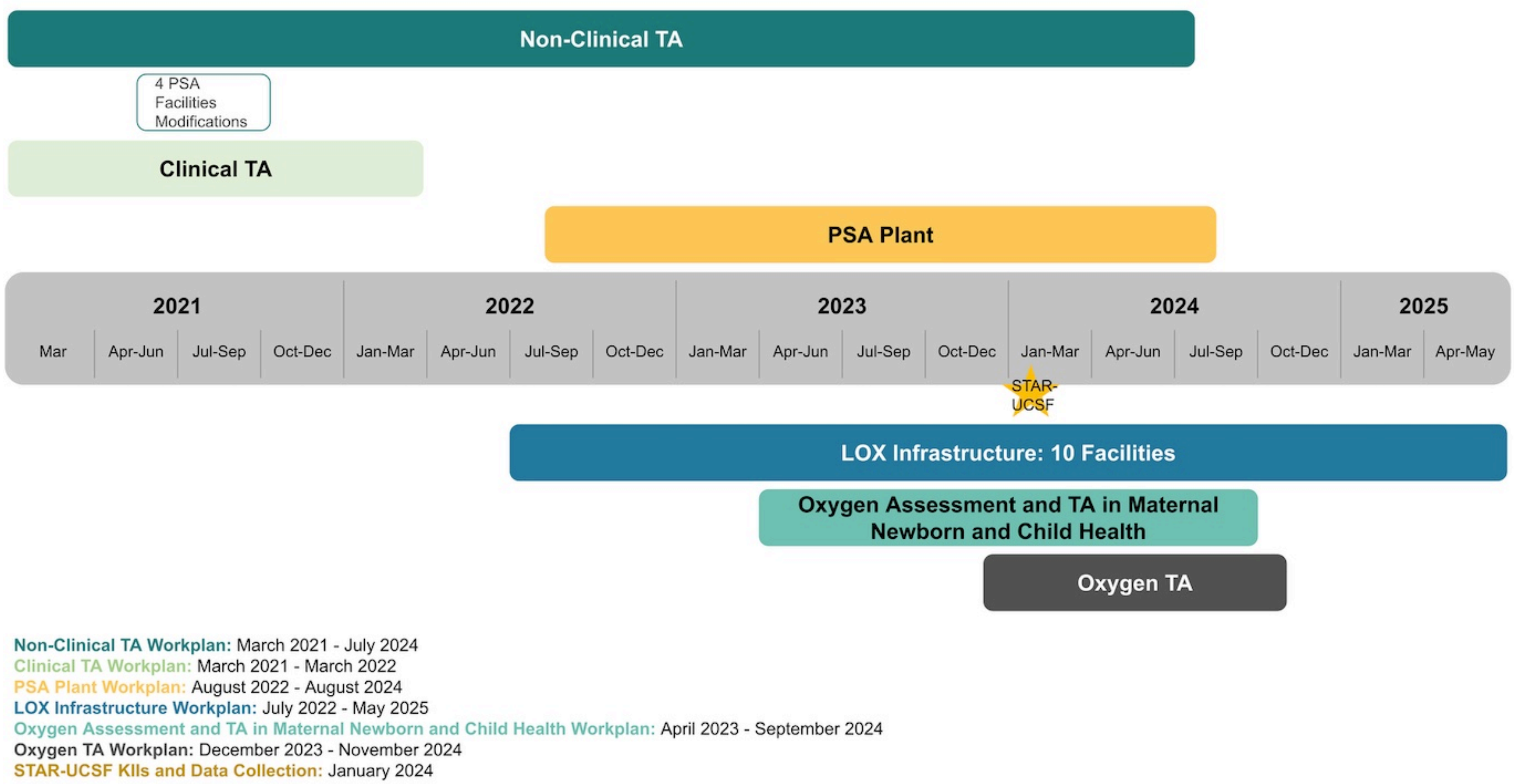
LOX Infrastructure Workplan: June 2022 - December 2024
Market Shaping Workplan: July 2022 - June 2026
STAR-UCSF KIIs and Data Collection: June 2023 - July 2023

* The specific activities to support LOX in Democratic Republic of the Congo were developed based on priorities expressed by the MOH and a landscape analysis. The program is providing LOX Infrastructure to one facility (Cliniques Universitaires de Kinshasa) to serve as a hub/filling station. The hub facility will supply oxygen to a network of 85 hospitals/7,486 beds within the city of Kinshasa. Within this network, four health facilities will benefit from additional investment to serve as oxygen cylinder storage sites.

Ghana

Since the onset of funding, five PSA plants have been installed and trainings for engineers and health service administrators on PSA plant operation, management, and maintenance have been conducted. As of January 2024, facilities have yet to receive LOX infrastructure support as 10 LOX installations remain underway.

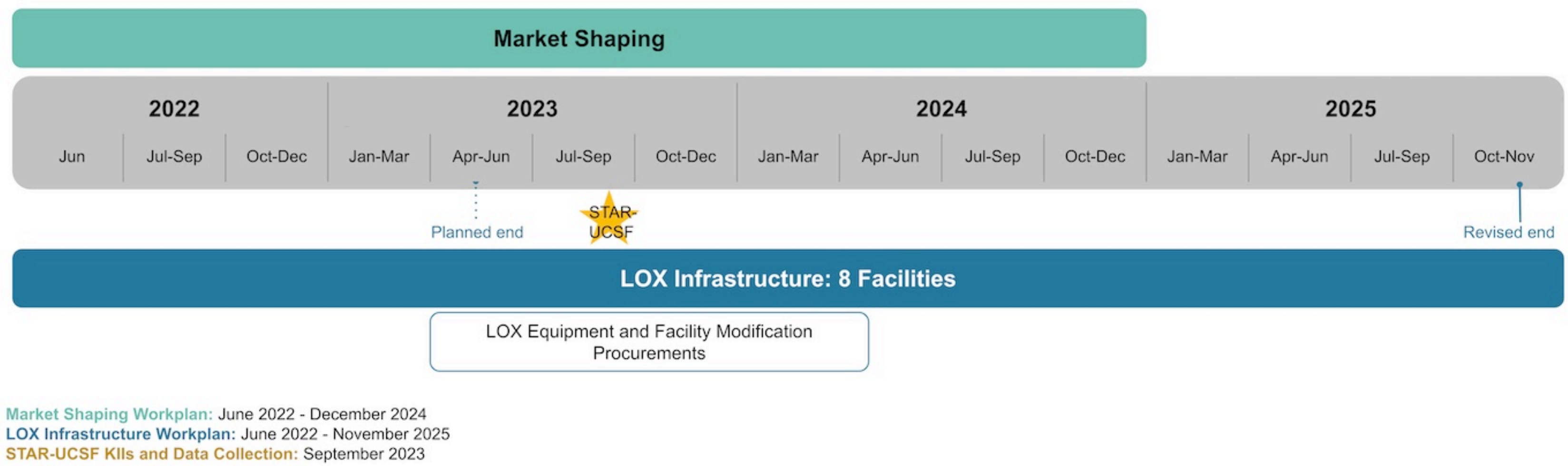
Figure 7. Oxygen ecosystems activities timeline in Ghana, 2021-2024.



Malawi

Due to global supply chain challenges, delayed responses by vendors, and competing health priorities, including a large cholera outbreak from December 2022 to August 2023 and a damaging cyclone in March 2023, oxygen-related activities in Malawi have been delayed. The RFP process for LOX tanks and LOX procurement have been ongoing since April 2023. As of April 2024, trainings have not been conducted, and LOX tank installations have yet to occur, pending final technical clearance.

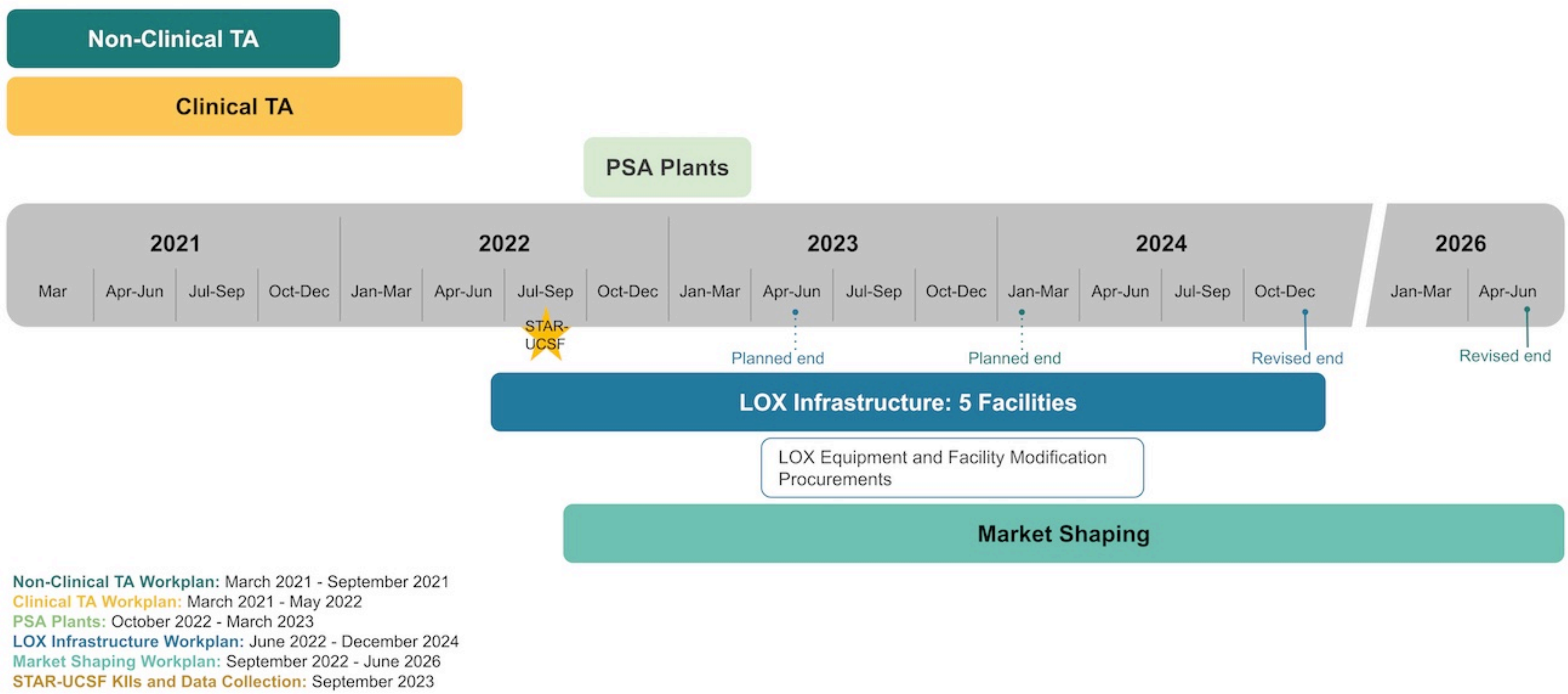
Figure 8. Oxygen ecosystem activities timeline in Malawi, 2022-2025.



Mozambique

Global supply chain barriers, lengthy governmental approval processes, and additional risk assessments after a March 2023 cyclone have delayed oxygen activities in Mozambique. As of March 2024, USAID-supported trainings and LOX tank installations have yet to occur.

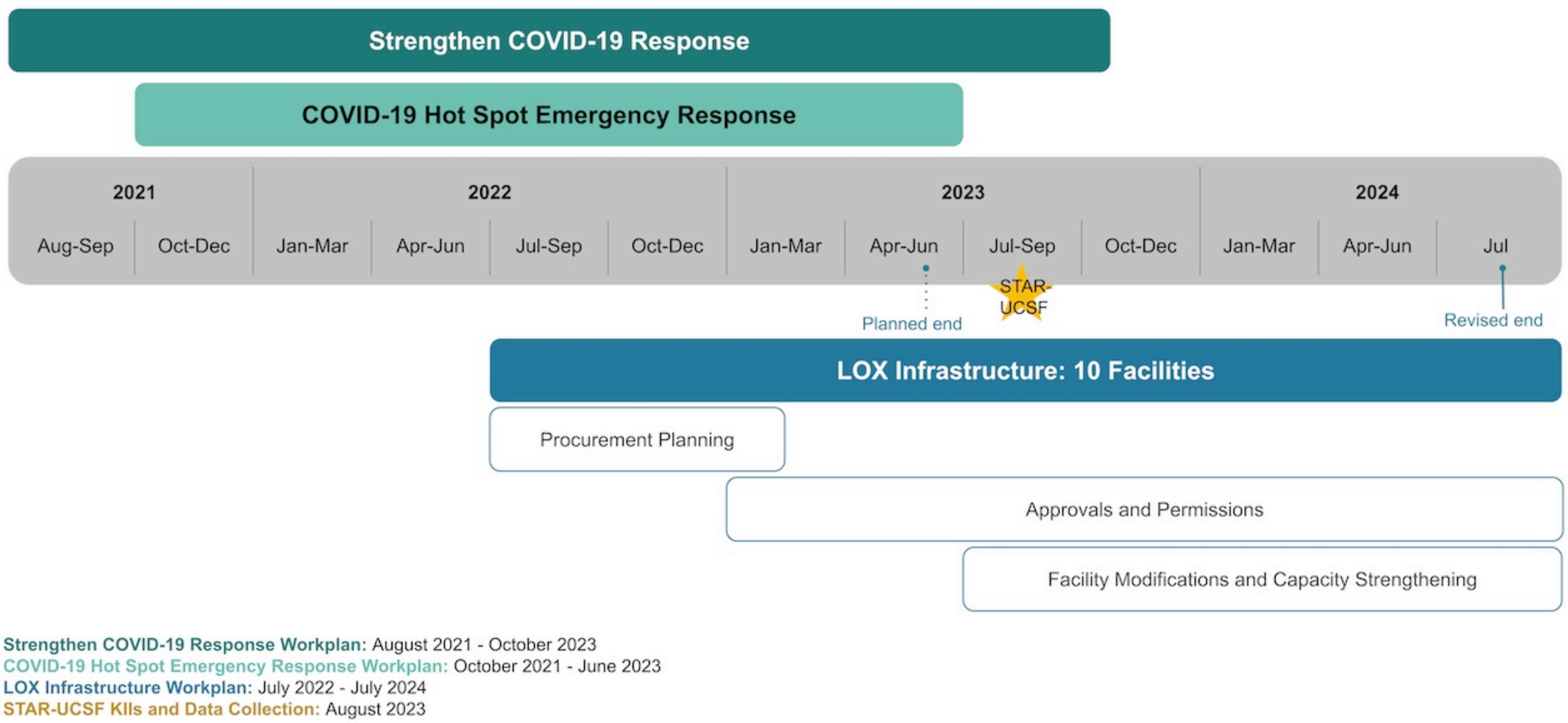
Figure 9. Oxygen ecosystem activities timeline in Mozambique, 2021-2026.



Vietnam

Despite procurement delays due to long global manufacturing lead times, LOX tank installations were completed in 13 facilities from May to October 2023 with ARPA CN164, CN165 and COVID-19 Hot Spot funding. Separate LOX infrastructure activities at 10 facilities have been in progress since July 2022 due to delays in local approvals. During the funding period, existing personnel were trained via an online introductory course on medical oxygen systems.

Figure 10. Oxygen ecosystem activities timeline in Vietnam, 2021-2024.



Reach

The current programs in the Democratic Republic of the Congo, Côte d'Ivoire, Ghana, Malawi, Mozambique, and Vietnam are expanding access to oxygen in approximately 146 facilities and more than 8,000 patient beds, based on estimates from the initial workplans.

Due to the lack of data and Program delays (e.g. LOX and trainings had not yet been delivered to many facilities) at the time of this Interim Review, it is not possible to accurately comment on aspects of 'reach' such as the number of facilities, beds or patients receiving oxygen, or the number of clinicians and other staff who received trainings and TA as part of the Programs. Where available, facility level data on aspects of program implementation are reported.

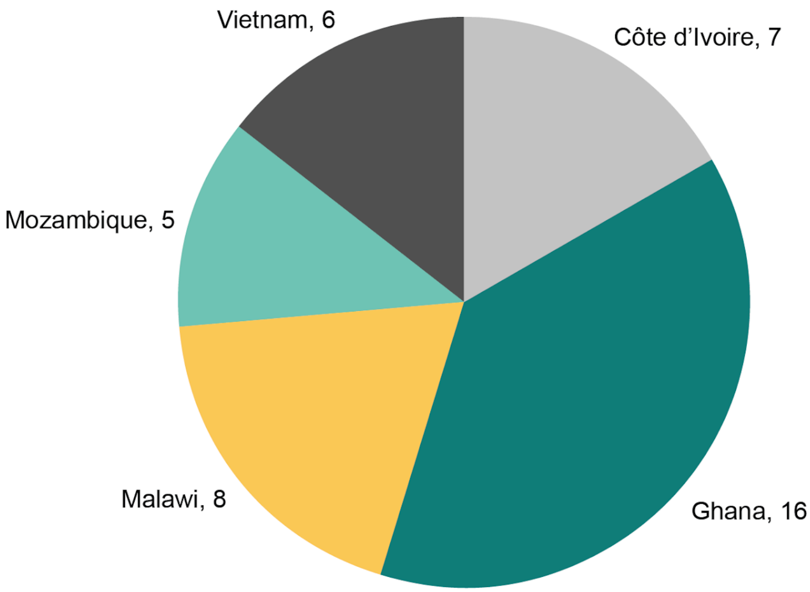
The RISE team in Ghana reported program activities in a total of 10 facilities (with a total of 2,234 beds). These facilities have an additional 237 facilities in their catchment areas, which serve an estimated 7,500,000 people. The RISE oxygen program in Mozambique is expected to reach 13 districts across four provinces (five districts directly and eight districts indirectly). The EpiC team in the Democratic Republic of the Congo is supporting a central LOX hub (with 138 beds with MGPS), and this hub will serve an additional 85 facilities with 7,486 beds. In Malawi, EpiC is supporting 8 facilities with 1,149 beds (with a catchment of 242 facilities). In Mozambique, EpiC is supporting 5 facilities (possibly to be expanded to 14 facilities) with 427 beds with MGPS (with a catchment of 427 facilities). In Côte d'Ivoire, EpiC is supporting 7 facilities with 1,416 beds (with a catchment of 42 facilities), and in Vietnam, EpiC is supporting oxygen programming at 23 facilities with 962 beds and a catchment of approximately 16,400,000 people.

Across all Interim Program Review countries, IPs provided TA to health facilities. This TA, funded by the United States government, included various forms of support such as training, mentorship, or other technical support. This included clinical TA to clinicians or other staff at health facilities for oxygen delivery and other aspects of case management of COVID-19 patients; engineering TA to facilities to optimize or maintain oxygen resources and effectively ensure oxygen supply is available to COVID-19 patients requiring it; and/or above-site TA to MOHs or relevant oversight organizations on the development and dissemination of key policies and SOPs, sustainability plans, coordination efforts across stakeholders, national oxygen strategies, M&E of oxygen activities, logistics and distribution support, and/or market-shaping.

In addition to providing oxygen-focused TA, many facilities in the selected Review countries had included facility-level modifications in their workplans (Table 2). This required that facilities meet certain structural requirements in order to support oxygen delivery beyond portable cylinders or other short-term measures. As such, IPs worked to modify these facilities through the construction and upgrading and/or installation of the identified equipment/oxygen delivery system to allow for more permanent oxygen delivery. This included: 1) installation of LOX systems, 2) installation of PSA/VSA plants, and/or 3) upgrading or improving existing MGPS (e.g. to copper piping or to include an upgraded valve or manifold system). Each facility that received any of those types of modifications was counted once if this activity was completed and reported, as shown in Figure 11. While no facilities were reported as being modified in the

Democratic Republic of the Congo, all other countries included in the Interim Program Review reported at least one facility. Among those with modifications completed, the number ranged from five facilities modified in Mozambique to 16 facilities modified to support oxygen delivery in Ghana. However, as part of the EpiC's oxygen activities in the Democratic Republic of the Congo, four health facilities are planned to benefit from additional investment to serve as oxygen cylinder storage sites.

*Figure 11. Facilities modified to support oxygen delivery**

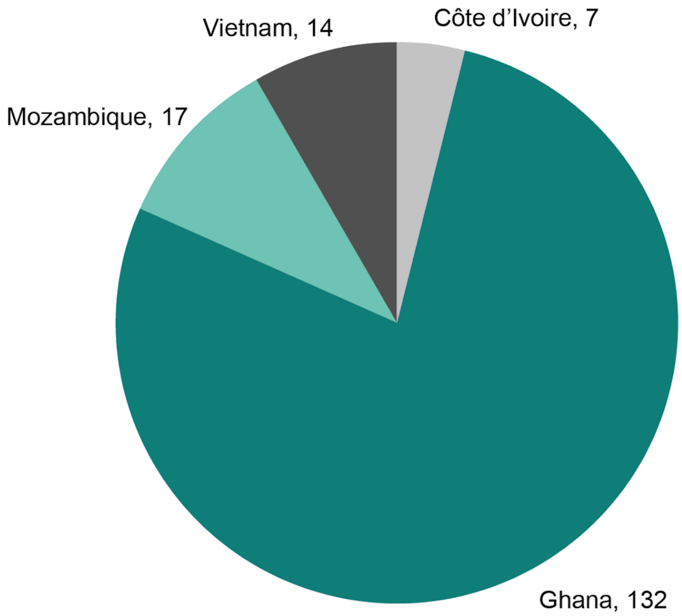


* Figure is based on data reported to USAID by countries in February 2024, supplemented by facility survey data collected by STAR-UCSF

Beyond modifying facility infrastructure for oxygen delivery systems, IPs in some countries assisted with the donation of other oxygen-related supplies and sources. These included: PSA/VSA oxygen-generating plants, portable oxygen concentrators (for COVID-19 patients, at least 10L/min), and oxygen cylinders (liquid or gaseous - as defined by USG Indicators). Figure 12 highlights the number of facilities, by country included in the Interim Program Review, which received these types of donations, as reported by USAID IPs. Malawi reported no facilities receiving donated supply sources; however, it is suspected to be a data completeness issue as Figure 13 below highlights oxygen concentrators being delivered to the country. Ghana reported the most facilities receiving oxygen-related supply sources at 132, with Mozambique, Vietnam, and Côte d'Ivoire providing sources to 17, 14, and 7 facilities, respectively. Côte d'Ivoire reported the fewest number of facilities receiving donated supply sources with seven facilities benefiting.

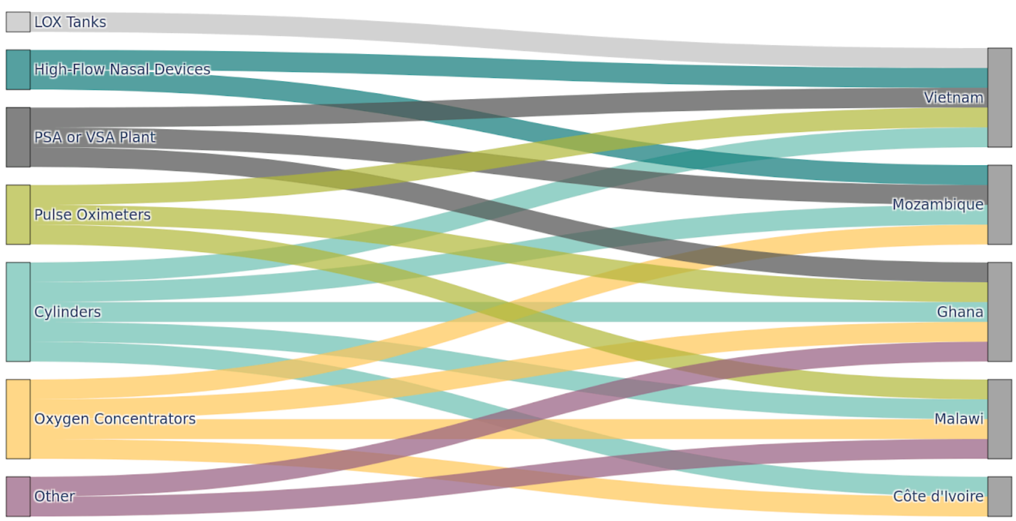
USAID funds were used to procure a range of oxygen supplies and equipment, such as LOX tanks, high-flow nasal devices, PSA/VSA plants, pulse oximeters, oxygen cylinders, oxygen concentrators, and other supplies. Ghana and Vietnam reported receiving five types of supplies, while Côte d'Ivoire reported receiving just two types (Figure 13).

*Figure 12. Facilities that received United States Government-donated oxygen-related supply sources by country**



* Figure is based on data reported to USAID by countries in February 2024, supplemented by facility survey data collected by STAR-UCSF.

*Figure 13. Types of USG-donated oxygen-related commodities and recipient countries**



* Figure is based on data reported to USAID by countries in February 2024, supplemented by facility survey data collected by STAR-UCSF.

Effectiveness

Within the standard RE-AIM framework, effectiveness aims to assess, at the individual level, the number and characteristics of individuals who benefitted.

At the time of this Interim Review, there was insufficient time for Program implementation and thus inadequate data to assess effectiveness of oxygen programming on clinical outcomes at either the individual or population health level. These would include outcomes of hospitalizations for acute hypoxemic respiratory failure and associated conditions. Future iterations of this Review will be needed to adequately explore Program effectiveness.

Adoption

Within the standard RE-AIM framework, adoption aims to assess, at the setting or organizational level, the number and characteristics of settings or organizations that participated in the program, including how programs were implemented and if and how programs were modified.

Because many of the oxygen activities will continue to be implemented well into 2024 and beyond, the STAR-UCSF team had a limited ability to assess the adoption of these activities, especially at the facility level. As part of the desk review, country-level workplans were shared outlining the types of facilities which have received or are intended to receive these interventions. A list of facilities planned to receive LOX infrastructure improvements and/or installations is outlined in Appendix 12.

Based on country-level workplans, KIIs and progress to date, it is clear that program implementation both shared some similarities and at the same time varied across countries and even within countries. As outlined later in this report (see Barriers and Enablers), several barriers and enablers shaped adoption and adaptation of oxygen programs across these countries. The Democratic Republic of the Congo, Ghana, Vietnam and Malawi reported either the availability of national strategic plans for oxygen or that creation of such plans was in progress. Stakeholders in Mozambique were also developing a sustainability plan for their oxygen ecosystems activities, with support from the local EpiC team. Prior to USAID funding for oxygen, Mozambique had no policies in place, and oxygen was treated as an “emergency” resource. Once completed, national plans could be compared across Interim Program Review countries to better understand adoption of oxygen programming across these settings.

Both Malawi and Vietnam reported regulatory entities for oxygen at the national level to ensure security for medical oxygen and support program adoption. Key informants in Ghana reported a national-level oxygen management team, which included technical staff from the health sector to monitor oxygen activities across the country, as well as the Ghanaian Food and Drugs Authority which ensures equipment meet quality standards, including those related to medical oxygen under regulations set by the MOH in 2023. Similarly, Côte d’Ivoire has established a monitoring committee, including key stakeholders from both the national level within the MOH and the decentralized level, at the level of health facilities. The aim of this committee will be to coordinate between the technical and medical teams, so that all activities linked to oxygen are implemented appropriately. In the Democratic Republic of the Congo, the National Oxygen Taskforce (GTOM) coordinates all activities aimed at improving the availability and accessibility of medical oxygen in health facilities. The GTOM is composed of experts from the MOH and partner organizations involved in the oxygen ecosystem. The GTOM is responsible for ensuring periodic planning, implementation, monitoring and evaluation of medical oxygen activities and to strengthen joint coordination and partnership on medical oxygen issues. The GTOM consists of a technical secretariat which meets once a month for the routine management of the GTOM, and a plenary whose role is to examine and adopt GTOM resolutions and recommendations. Lastly, all six Review countries had identified a key point person for oxygen within the MOH, including civil engineers and BMEs.

Only as IPs complete implementation of more activities, and additional implementation outcomes are documented, can Program adoption be fully assessed.

Observations of Adoption from Selected Facilities

Côte d'Ivoire

As EpiC works to provide support for the expansion of seven new LOX sites outside of Abidjan (for a total of 14 in Côte d'Ivoire), activities remained slow-moving in the country. LOX activities were in the early stages, as of the STAR-UCSF visit in August 2023, with physical construction still underway at all seven facilities. At Centre Hospitalier Regional De Yamoussoukro, one training had occurred on site focused on safe filling, storage, and transport of cylinders, safe and proper delivery of oxygen to patients, as well as contingency plans for failure of oxygen systems.

Malawi

At the two health facilities visited in Malawi, a high volume of patients and overburdened clinical staff were reported by site-level staff. They indicated high staff turnover and onboarding as significant challenges to their workforce, highlighting the HRH challenges faced more widely in Malawi. Moreover, there was limited existing oxygen infrastructure observed at both Kamuzu Central Hospital and Salima District Hospital, and neither had received an oxygen-related training as part of the USAID oxygen investment.

Mozambique

At Hospital Distrital de Monapo, there was a widely-celebrated increase in oxygen supply to the facility and nearby sites, as a result of PSA plant preparation and installation by RISE and GHSC-PSM. While there were oxygen-related logbooks and SOPs available at the site including many translated into Portuguese, some were only in English, posing a challenge for the local Portuguese-speaking staff. As part of the USAID activities, 29 HCWs were trained during four on-site trainings on use of supplies to deliver oxygen to patients, all of whom were retained at least six months after the trainings. Additional trainings focused on PSA plant safety and maintenance and safe filling, storage, and transport of cylinders.

Vietnam

While the COVID-19 protocols in Vietnam were extremely strict and limited the ability to procure and transport supplies and conduct in-person trainings, USAID's investment into LOX at Can Duoc Health Center and Dinh Quan General Hospital were viewed positively. Sites reported that the newly installed LOX tanks liberated health facilities from the oxygen vendors, no longer requiring them to install/uninstall vendors' tanks with each change in LOX vendor. Now, as both facilities have their own LOX tank, they can change vendors when needed, offering freedom to choose more cost effective LOX vendors. As part of the EpiC project, one training was conducted on site at Can Duoc Health Center, which focused on vacuum insulated evaporator (VIE) safety and maintenance as well as proper delivery of oxygen to patients. On-site training has been conducted at all additional sites that received an oxygen system.

Quantitative data relevant to Program adoption were collected via facility-level ODK forms during site visits. Table 3 represents a summary of available data:

Table 3. Oxygen supply system and BME[T]s available and trained at select facilities during Interim Program Review.[9]

	Côte d'Ivoire		Malawi		Mozambique	Vietnam	
Facility Name	Centre Hospitalier Regional De Daloa	Centre Hospitalier Regional De Yamoussoukro	Kamuzu Central Hospital	Salima District Hospital	Hospital Distrital de Monapo	Can Duoc Health Center	Dinh Quan General Hospital
Type of Oxygen Supply Source	Unknown	Concentrators and Cylinders	PSA/VSA, Concentrators, and Cylinders	Concentrators and Cylinders	PSA/VSA and Concentrators	VIE/LOX and Cylinders	VIE/LOX and Cylinders
Newly Installed with USAID Funding?	N/A	Unknown	No	No	Yes, PSA/VSA	Yes, LOX system	Yes, LOX system
BME[T]s On-Site, #	Yes, 4	Yes, 6	Yes, 8	No	No	Yes, Unknown	Unknown
BME[T]s Trained on Oxygen Systems Operation and Maintenance by USAID IP	2	2	0	Unknown	0 (1 maintenance technician)	Yes	Yes

[9] Site-level data were not collected from Oxygen Ecosystem sites in the Democratic Republic of the Congo nor received from Kumasi Government Hospital in Ghana, and therefore neither was included in the RE-AIM facility-level analysis.

Maintenance

Within the standard RE-AIM framework, maintenance aims to assess, at the individual and setting or organizational levels, the long-term implementation and program effectiveness.

As a result of delays in program implementation across the Interim Review countries, maintenance indicators that focused on sustainability were not available at the time of this Interim Review though should be evaluated after sufficient time has passed since program implementation.

Activity 3A: Key Informant Interviews

In total, the STAR-UCSF team conducted 33 KIIs, including five HQ-level interviews with program managers, directors, medical officers, advisors; 20 country-level interviews with project officers, country directors, ministry officers, etc.; and eight facility-level interviews with health facility staff such as HCWs, BMEs, and BMETs (Table 4).

Table 4. Number of Oxygen Ecosystems KIIs by level and country.

Headquarter-Level			**5**
		USAID	2
		IP (EpiC)	1
		IP (RISE)	1
		IP (GHSC-PSM)	1
Côte d'Ivoire			**5**
Country-Level	**3**	**Facility-Level**	**2**
USAID	1	Centre Hospitalier Regional De Daloa	1
IP (EpiC)	1	Centre Hospitalier Regional De Yamoussoukro	1
MOH	1		
Democratic Republic of the Congo			**3**
Country-Level	**3**	**Facility-Level**	**0**
USAID	1		
IP (EpiC)	1		
MOH	1		
Ghana			**4**
Country-Level	**3**	**Facility-Level**	**1**
USAID	1	Kumasi South Hospital	1
IP (RISE)	1		
IP (GHSC-PSM)	1		
Malawi			**5**
Country-Level	**3**	**Facility-Level**	**2**
USAID	1	Kamuzu Central Hospital	1
IP (EpiC)	1	Salima District Hospital	1
MOH	1		
Mozambique			**5**
Country-Level	**4**	**Facility-Level**	**1**
USAID	1	Hospital Distrital de Monapo	1
IP (EpiC)	1		
IP (RISE)	1		
MOH	1		
Vietnam			**6**
Country-Level	**4**	**Facility-Level**	**2**
USAID	1	Can Duoc Health Center	1
IP (EpiC)	2	Dinh Quan General Hospital	1
MOH	1		

Enablers and Best Practices for Oxygen Investment

The main purpose of the KIIs was to better understand oxygen investment activities in selected countries, including procurement of medical oxygen, availability of BME[T]s and other critical facility-based staff, implementation of oxygen-related activities, market shaping activities, data use, and more. Key informants were asked to share their perceptions, experiences, and opinions about the Oxygen activities funded by USAID. Common enablers and best practices were identified from the KII notes and described below. Some themes were cross-country and commonly experienced in many of the Interim Review countries, while others were unique to specific local contexts (Table 5). Of note, KIIs were conducted prior to the complete implementation of IP workplans.

Table 5. Common enablers and key successes for oxygen investment across countries.

	Côte d'Ivoire	DRC	Ghana	Malawi	Mozambique	Vietnam
Enablers						
Strong MOH commitment and coordinated local leadership	X	X	X	X	X	X
Recognition of oxygen as an essential medicine		X	X	X	X	X
Data on oxygen needs and use drives decision-making			X	X	X	X
TWGs facilitate consensus and efficient resource allocation	X	X	X	X	X	X
Relationship-building as a key to market shaping	*	*	X	X	X	NA
Pre-existing LOX infrastructure						
- Facility infrastructure	X	O	O	O	X	X
- Medical LOX in use	X		X		X	X
- In-country LOX production	X			O		X

	Côte d'Ivoire	DRC	Ghana	Malawi	Mozambique	Vietnam
Best practices						
Sustainable, cost-effective approaches	X	X		X	X	X
Comprehensive training and workforce development packages	X		X		X	

* Limited data available or no market shaping activities planned
o Present in some facilities but with significant investment needed

Enablers

For the purposes of this Interim Program Review, STAR-UCSF has defined an enabler as a facilitating factor which creates an environment where progress can be made by the team or something that helps program progress or achievement. Enablers can be physical, environmental, structural, or systemic and facilitate key stakeholders in reaching a program's goals. Enablers can be internal or external and can arise from various factors such as availability of resources, existing systems or structures, social or cultural norms, or political environment and will. The enablers found through this Interim Program Review included: 1) strong MOH commitment and coordinated local leadership, 2) recognition of oxygen as an essential medicine, 3) data on oxygen needs and use drives decision-making, 4) TWGs facilitate consensus and efficient resource allocation, 5) relationship-building as a key to market-shaping, and 6) pre-existing LOX infrastructure facilitates scaleup.

Strong MOH commitment and coordinated local leadership

> *"The talk of oxygen ecosystems [at the MOH] is very exciting."*
> -Malawi

Overall, buy-in and support from key stakeholders at the national level played an important role for oxygen programming in the six Review countries. Furthermore, the existence of passionate champions from donors to implementers to MOH officials as well as availability of oxygen-related governance structures and evidence-based national policies were also identified as key enablers. Four of six Review countries (Democratic Republic of the Congo, Ghana, Malawi, and Vietnam) had created a national oxygen roadmap to support a coordinated response to scaling oxygen during COVID-19. IPs in these countries reported strong collaboration between the USAID mission and IP teams. Similarly, there was shared understanding from most MOHs of the current gaps and the benefits of strengthening oxygen ecosystems beyond COVID-19, including benefits to tuberculosis patients noted by the Mozambique MOH as well as newborns as noted in Ghana by the local USAID team. In nearly all KIIs, there was broad recognition that oxygen investments were important, including but not limited to COVID-19 needs.

> *"It is about how do we really talk together with [the MOH] and how do we really make sure that what we are supporting is what they need and what they want and how they want it."*
> -Vietnam

USAID's investment in oxygen in Malawi has been centered around a collaborative approach under the leadership of the MOH. In December 2021, the Malawi Medical Oxygen Roadmap was launched and, together with the "Emergency Task Force on Oxygen" TWG, all oxygen-related activities in the country were streamlined under a single plan. In preparation for the roadmap, a national oxygen needs assessment identified priorities for investment, including diversifying oxygen sources and the expansion of LOX systems in a hub-and-spoke model. Further collaboration between multiple organizations, including the MOH and USAID's IPs EpiC and CHAI enabled the development of a robust workplan to support LOX expansion in the country. In Ghana, a partnership between RISE and GHSC-PSM on training materials allowed both partners to hone in on their areas of expertise, with RISE focusing on clinical TA and GHSC-PSM on non-clinical elements. Coordination was equally important at the sub-national and facility levels in countries like Côte d'Ivoire and Vietnam where support from provincial departments of health was key for working with health facilities. Furthermore, EpiC in Vietnam supported local on-site supervisory support to improve communication and daily updates across sites. These examples of multi-stakeholder collaboration have avoided wasteful duplication of resources and demonstrate the importance of collaboration and stakeholder engagement.

Recognition of oxygen as an essential medicine

In five of the six countries included in the Interim Review - the Democratic Republic of the Congo, Ghana, Malawi, Mozambique, and Vietnam - MOHs have already classified oxygen as an essential medicine, which was seen as demonstrating government buy-in and as a facilitator for the development of specific guidelines and standards at a national level. While some countries are just beginning the development of national strategic plans or roadmaps, others like the Democratic Republic of the Congo, Vietnam, Ghana, and Malawi already have them (or have them in progress), which has strengthened the shared commitment to oxygen's importance in national procurement systems and budgets. For example, in Malawi, the prioritization of oxygen by the national oxygen roadmap was identified as an important facilitator that allowed the MOH to work with IPs for strategic oxygen ecosystem development. In addition to national level recognition of oxygen as a priority, it was highlighted by multiple teams that advocacy with facility administrators and managers was essential to ensure adequate prioritization in facility level decision-making.

> *"Previously, oxygen was not considered essential in the health sector. It's through COVID [that] we've realized that oxygen is now needed and part of the medicine outline."*
> -Ghana

Data on oxygen needs and use drives decision-making

It was evident in all Review countries that access to near real-time, high-quality data on oxygen needs and consumption were critical to inform and facilitate decision-making processes. As outlined earlier in this report, IPs utilized data from multiple sources to inform program design and implementation. In Ghana, Malawi, Mozambique, and Vietnam, multiple tools and strategies for oxygen quantification were developed and deployed. In Malawi, EpiC's approach involved building on past assessments and conducting additional assessments for site selection and programmatic planning. EpiC was able to work with sites to develop detailed floor plans/site layouts to ensure that piping modifications and locations for LOX tanks/filling stations would meet site specifications. In Vietnam, EpiC built on and incorporated findings from previous PATH, CHAI, and MOH surveys alongside their own assessments for their first phase of implementation. They worked closely with STAR-UCSF to develop and implement the OxygenCalculator.com tool (in Vietnamese) to help inform oxygen supply and demand decisions at public facilities around the country. Similarly, in Mozambique, RISE created oxygen dashboards accessible at both the above-site and site- level to monitor patient consumption of medical oxygen versus supply expenditure (see Case Study above). USAID provided prompt support to procure oxygen equipment and worked in collaboration with the MOH, Jhpiego and GHSC-PSM to choose sites for PSA installation that would have the largest impact. Moving forward, EpiC is also incorporating lessons from Phase One of implementation between October 2022 and September 2023 into Phase Two which began October 2023. In addition, EpiC in Mozambique is working to develop an oxygen ecosystem strategy for the country, linking all local partners and leveraging all available data to create a harmonized strategy. Similar collaborative efforts were seen in the Democratic Republic of the Congo and Ghana where geographic and population data were used for strategic placement of PSA plant locations to serve the largest and most populous facilities and regions.

Mozambique Case Study:
Data-Driven Solutions

In Mozambique, USAID's IP, RISE, was asked to create a tool to track oxygen supply and demand during the country's first COVID-19 wave. This tool used real-time data entered daily by designated staff and provided comparison of the oxygen supplied to a health facility versus patient use. Estimates for oxygen flow rate by therapy type per patient and ward were co-developed with STAR-UCSF and used to create a publicly available oxygen dashboard tool that was used in multiple countries - OxygenCalculator.com. Internal audits compared estimates to actual flow rates and the model was adjusted accordingly to ensure international assumptions were locally applicable. Dashboards at both facility- and national-levels provided feedback on the volumes of oxygen consumed by patients over 24-hours periods, tracking changes in demand.

The real power of data-driven solutions is illustrated by facilities where oxygen consumption from the LOX tank seemed to be far greater than patient use. Without data, this was difficult for health facilities to demonstrate. Following implementation of the dashboard, the RISE team realized that the daily volume of LOX depletion was far greater than the estimated oxygen consumption by patients. These unaccounted losses amounted to a significant cost and were likely to reflect poor value for money from the supplier. Working closely with sites, assessments were conducted to identify sources of the leaks. Health facilities were then able to implement a maintenance program to fix the leaks and reduce wastage of oxygen. Following this, supplies of LOX were noticed to last much longer than previously, reducing the burden on the supply chain.

TWGs facilitate consensus and efficient resource allocation

TWGs exist and met at the national level in Côte d'Ivoire, the Democratic Republic of the Congo, Ghana, Malawi, and Mozambique. In the Democratic Republic of the Congo, the TWG facilitated by the MOH worked closely with IPs to reach consensus to require national production of medical oxygen in 17 locations across the country. In Malawi, the MOH-facilitated TWG engaged local partners and focused on developing guidelines and standards for oxygen as an essential medicine. To augment local expertise in LOX, which is a relatively new technology in Malawi, EpiC subcontracted CHAI to utilize their global expertise for local implementation and to provide input as part of the TWG. In Vietnam, cross-cutting TWGs met at national and facility levels and oxygen work involved technical teams at the MOH, including the Infrastructure and Medical Device Administration and National Institute of Medical Device and Construction. In Côte d'Ivoire, TWGs have also been utilized at the facility level. For example, local hospitals had technical committees involved in oxygen-related activities.

Relationship-building as a key to market shaping

While the limited number of LOX suppliers and local oxygen-related manufacturers was a barrier in almost every Review country, countries which included market shaping activities in their SOWs, namely the Democratic Republic of the Congo, Malawi, and Mozambique, did note improvements in building relationships they hoped one day would improve local supply. Malawi and Mozambique completed pre-market assessments which allowed for strategic relationship-building. For example, during periods of global supply chain interruptions and funding delays, the GHSC-PSM HQ team was able to focus on establishing relationships with vendors and then turning those relationships into contracts once funding and supplies became available. GHSC-PSM's strong relationship with a main manufacturer allowed them to better gauge needs on the ground in countries like Ghana and Mozambique.

Additionally, market shaping activities led by EpiC in Malawi, which lacks a domestic LOX supplier, were able to identify a potential vendor to construct an air separation unit (ASU) in Malawi to supply LOX locally in the future - reducing reliance on international suppliers such as AFROX in South Africa. In the Democratic Republic of the Congo, though gaps remain, there was strong support from the local USAID office to further involve the private sector to meet those gaps and utilize this project as an opportunity to start building those relationships as a foundation for future private support in the health space. Vietnam was an outlier with robust access to dozens of high-quality, domestic LOX vendors and tank manufacturers.

Pre-existing LOX infrastructure facilitates implementation

In the assessment period, careful attention was given to existing LOX infrastructure as this was correctly identified as a key enabler, something corroborated by KIIs in multiple countries. This included availability and number of medical LOX vendors in-country, ASUs to generate medical LOX locally, pre-existing use of LOX locally, and availability of MGPS. For example, in Vietnam, the presence of multiple LOX vendors and pre-existing use of LOX in many facilities in the country were significant enablers for implementation. In contrast, several countries like Malawi and the Democratic Republic of the Congo had little to no prior experience with LOX and no local ASUs (Table 5). Furthermore, even in facilities identified as having potential capacity for LOX (i.e. those with MGPS), it was frequently determined that existing infrastructure would need significant refurbishment to facilitate efficient and safe LOX implementation.

Best Practices

For the purposes of this Interim Program Review, STAR-UCSF has defined a best practice as an intervention or approach that has shown evidence of effectiveness and is likely to be replicable to other situations or programs. A best practice is a lesson learned or knowledge about what works in specific contexts without using extraordinary resources to achieve the desired results. Best practices here ideally focus on those which were leveraged in USAID's oxygen investment in the selected countries, though not unique to those contexts, and can be used to develop and implement solutions adapted to similar health problems in other situations and contexts. The best practices found through this Interim Program Review included: 1) sustainable, cost-effective approaches, and 2) comprehensive training and workforce development package.

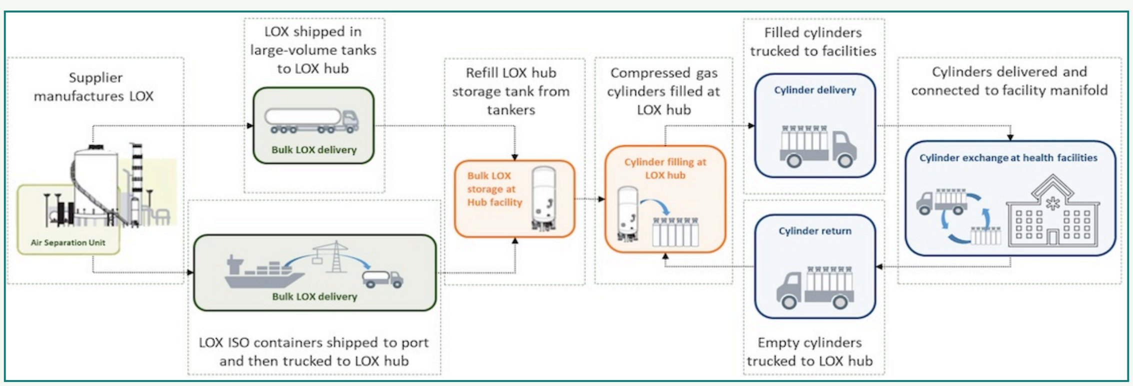
The Democratic Republic of the Congo Case Study: Designing a Hub-and-Spoke Model to Expand Access to Oxygen

In the Democratic Republic of Congo, 27% of tertiary facilities and only 12% of secondary facilities have access to oxygen cylinders, and no public hospitals use LOX. With no local LOX supplier, the country has to rely on importing oxygen or establishing agreements with industrial suppliers. Prior to the pandemic, the country's production capacity of oxygen was less than 5% of estimated total need. During the pandemic, supply limitations rendered medical oxygen unaffordable with cylinder costs increasing four-fold from $25 to $100 per cylinder.

The vast geographic size of the country, challenging road and power infrastructure, and absence of a local LOX supplier necessitated a strategic, cost-effective solution to improve oxygen access and distribution, particularly to remote and rural areas. Following the MOH's request to support LOX infrastructure in the country, EpiC has been working to bring together key oxygen supply chain stakeholders to augment existing delivery systems, expand LOX infrastructure, and develop market shaping activities to improve access to reliable, affordable medical oxygen.

Notably, EpiC and CHAI are piloting a hub-and-spoke, liquid-to-gas distribution model (see diagram). The partners are preparing one site as a LOX filling station (hub) that convert supplied LOX into gas which then can be used to directly supply patients at those facilities, and also can be used to fill cylinders that are stored at three additional storage facilities, which can serve a network of 85 healthcare facilities in Kinshasa (spokes). These gas cylinder recipient sites are receiving TA to prepare for augmented oxygen delivery capacity. The teams are exploring multiple potential import routes to overcome challenges of internal transport networks. These include routes from Kenya via Uganda, from Zambia, and by sea over in the west of the country.

The implementation of infrastructure for the hub-and-spoke model is ongoing. If the pilot is successful, this could serve as a blueprint for other countries confronting similar oxygen supply and distribution challenges especially in remote and underserved areas.



EpiC Democratic Republic of Congo LOX Market Shaping Work Plan: Modification 2. Submitted to USAID November 2023.

Sustainable, cost-effective approaches

Across countries, sustainable practices were incorporated into the design and/or implementation of oxygen ecosystems activities, ranging from high-level efforts for market-shaping and sustainability planning across partners, to facility-level strategies to reduce oxygen waste. The EpiC team in Malawi supported the vision of the nation's oxygen roadmap through ongoing market shaping work and the development of a sustainability plan with the MOH. Though not yet finalized, such efforts exemplified IP approaches across countries of utilizing iterative practices to promote sustainability from initial design, which included working within national and subnational political or regulatory structures, involving local players in design and decision-making, and utilizing risk assessments and needs-based approaches.

In many settings it was noted that vendor-supplied tanks often come with exclusivity requirements that limit options for future oxygen provision. In Côte d'Ivoire, the Democratic Republic of the Congo (see Case Study above), and Vietnam, it was noted that the installation of USAID LOX tanks at facilities was empowering, providing greater flexibility in sourcing LOX from different vendors without having to install/uninstall vendor tanks and reducing reliance on poorer quality oxygen delivered via cylinders. Similarly, in Ghana, it was noted that the newly installed PSA plant at one facility allowed that facility and other local facilities to access a more affordable source of oxygen compared to the private sector monopoly, which had instituted COVID-19 related price hikes. In Mozambique, focus shifted away from oxygen concentrators and cylinders toward long-term planning for country-level LOX infrastructure. A new USAID-funded PSA plant was also installed as a sustainable, local solution (see Case Study below) to alleviate the need for reliance on international distributors. Alongside new oxygen supply solutions like PSA plants, RISE's clinical oxygen training and identification of facility-level champions promoted institutional knowledge and longevity of the newly-installed solutions at sites. In the future, there are plans to assess the current situation, map oxygen distribution across the country, and make market shaping recommendations for bringing in the private sector to promote long-term sustainability.

> *"You need to assess, working very closely with those hospitals, the suppliers, and other things, to see how [programs] can be cost-effective and sustainable."*
> -Vietnam

Most Review countries were in the process of creating Sustainability Plans at the time of this Interim Review. Because IP workplans were not yet completed at the time of this Review, further data are needed to fully characterize the sustainability and cost-effectiveness of these programs. Given the heterogeneity of facility and national level needs, and the diversity of oxygen supply solutions deployed, further review of these programs will be invaluable and widely applicable for other programs seeking to implement cost-effective solutions.

Comprehensive training and workforce development packages

In several countries, cross-cutting trainings and workforce development packages were designed to bridge existing knowledge gaps identified through facility needs assessments among both clinical and non-clinical staff. These trainings ranged from medical oxygen systems' safety, operation and maintenance with BME[T]s, to oxygen therapy, IPC and the use of supplies to deliver oxygen for clinicians. Other training included administrators, oxygen equipment handlers, and storekeepers.

Implementing partners and local partners created content and taught courses, but also supported site-level champions who helped train colleagues at nearby facilities to expand impact, as was the case in Mozambique. An electronic training platform hosted by the MOH, *TeleSaúde*, was used to provide training videos and courses on multiple topics including the use of oxygen concentrators. Trainings were conducted in parallel to or soon after delivery or installation of equipment. Similarly, key informants in Côte d'Ivoire reported the successful delivery of strong, practical-based clinical oxygen trainings by EpiC.

> *"The big impact of this is technical training. I didn't know how to handle high flow hypoxia management, COVID management. With the support of USAID, we have the opportunity to strengthen this capacity. Today, even if it is a Provincial Hospital or a Health Center, they already know."*
>
> -Mozambique

In Ghana, RISE leveraged local communities of practices to create ownership plans and tailor trainings to the local context with hands-on experiences. As a result, they were able to quadruple the number of BME[T]s trained in basic competency and in return, reported knowledge gains and improved outcomes. Their use of the local champion model allowed BMEs to train staff at local facilities and even facilities in other countries. In the Democratic Republic of the Congo, a mentorship model for training engineers is being used, and numerous oxygen training resources were created. The MOH is working to integrate these trainings into university courses to ensure wider reach and sustainability. In Mozambique, an online course was created for PSA plant maintenance and is hosted on the MOH's telehealth website. Centralized or integrated trainings were highlighted as a potential mechanism to overcome challenges of conducting facility-level trainings at facilities facing high staff turnover.

> *"As an engineer, I am able to build my capacity. Before the PSA came in, I had no knowledge of that. Now other countries like Tanzania and eSwatini have benefited from this as I went there [to provide trainings]."*
>
> -Ghana

Mozambique Case Study:
PSA Plants as a Local Solution

Pressure swing adsorption (PSA) oxygen plants take in atmospheric air, remove unwanted nitrogen gas, and produce medical grade oxygen. While dependent on stable power and regular maintenance, they can otherwise operate independently from national supply chains and can be designed with specifications and production capacity determined by baseline facility and regional assessments. At Monapo District Hospital in Mozambique, with a $1 million investment from USAID, a new PSA oxygen plant was installed alongside infrastructure improvements, materials and TA to optimize function and utilization.

Monapo District Hospital previously received oxygen cylinders from a distributor based in the nearby port city of Nacala. During the COVID-19 pandemic, distributors were unprepared to meet the surge in demand, resulting in severe supply chain disruptions and few alternatives for facilities dependent on regular oxygen deliveries. A local solution was needed for oxygen production that had the capacity to meet the needs of the busy hospital, to supply other nearby health facilities, and to overcome the current logistical challenges.

The benefits of this oxygen plant were felt as soon as it became operational. Challenges with oxygen supply at the district level were minimized with Monapo District Hospital acting as a central supply hub. Coordinated management guaranteed that oxygen was always available and led to improved patient safety with a noticeable reduction in the number of patients being transferred to the next level hospital in Nampula province because of oxygen-related gaps. This increased oxygen supply has enhanced local capacity to treat life-threatening medical conditions and improve patient care.

> *"We no longer have to transfer patients to Nampula because Monapo does not have oxygen. So, the fact of not having to transfer patients has improved a lot, which would be our health service offering. This is for the patient."*

Barriers and Key Challenges to Oxygen Investment

Similar to enablers and best practices, common barriers and key challenges were also identified from the KII notes and described below. Some themes were cross-country and commonly experienced in many of the Interim Review countries, while others were unique to specific local contexts (Table 6). Once again, it is important to note that KIIs were conducted prior to the complete implementation of IP workplans.

Table 6. Common barriers and challenges for oxygen ecosystems across countries.

	Côte d'Ivoire	DRC	Ghana	Malawi	Mozambique	Vietnam
Barriers						
Procurement and supply chain limitations	*	*	*	X	X	X
Insufficient infrastructure and faulty or under-utilized equipment	X	X		X	X	X
Long, restricted, or unsafe commutes transporting oxygen	X	X	X	X	X	X
Insufficient financing and market imbalance	*	X	*	X	X	X
Limited harmonization across stakeholders	X	X		X		
Key Challenges						
Steep learning curve related to LOX	*	X	*	*	*	X
Limited BME[T] workforce and HRH	X	*	*	X	*	X
Gaps in oxygen policies and guidelines		X		X	X	X
Time-consuming implementation	X	X	X	X	X	X

* Limited data available

Barriers

For the purposes of this Interim Program Review, STAR-UCSF has defined a barrier as an obstacle or impediment that prevents progress or achievement and cannot be easily overcome. Barriers can be physical, environmental, structural, or systemic and hinder key stakeholders from reaching a program's goals. Barriers can be internal or external and can arise from various factors such as lack of resources, social or cultural norms, or personal beliefs. The barriers found through this Interim Program Review included: 1) procurement and supply chain limitations, 2) insufficient infrastructure and faulty or under-utilized equipment, 3) long and often unsafe commutes transporting oxygen, 4) insufficient financing and market imbalance, and 5) limited harmonization across stakeholders.

Procurement and supply chain limitations

Increased demand for medical oxygen and supply limitations severely strained health facilities across all Review countries during the COVID-19 pandemic. This impacted multiple components of oxygen ecosystems including LOX and compressed oxygen, oxygen supply equipment, oxygen delivery devices, and maintenance equipment, among others. These items were challenging to source, and even if found, they were difficult to procure in an affordable and timely manner. The supply-demand imbalance resulted in price surges, especially in settings with limited vendor options. Rapidly changing prices not only made it costly to procure oxygen, but also created significant procurement delays as quoted prices may have changed significantly by the time a contract could be approved and executed, necessitating restarting the bid and approval processes. This was compounded by rapid changes in currency value (see Case Study below)

> *"This [slowness] was not just in Mozambique, but we saw it all over the world. But, on the other hand, there are also other internal factors that ended up tripling delays."*
> -Mozambique

Oxygen cylinders at Kamuzu Central Hospita's PSA plant, Lilongwe, Malawi, September 2023.

Additional sources of procurement delays included the lack of existing processes, contract templates, vendor requirements, regulatory and safety frameworks (e.g. fire safety and environmental impact compliance), import barriers, delays in device registration, and lack of precedent for many facilities and teams who were procuring technologies that were relatively new to some settings. In many countries, like Malawi, time allotted in the initial workplans to set up supplier contracts was inadequate. During one COVID-19 surge, a site in Malawi reported that the shortage of oxygen forced them to turn to non-medical grade industrial oxygen to save patient lives, a practice commonly seen during the pandemic in many other countries. The facility visited by the STAR-UCSF team in Mozambique reported difficulties acquiring supplies such as nasal cannulae and face masks due to insufficient supply chains and global competition. In several countries, the contract negotiation process took more time than anticipated, in part because vendors were not always familiar with the technologies being chosen or the newest technical specifications and thus had lengthy back and forth communications to clarify and address questions. In Mozambique, IPs met with potential vendors prior to RFP bidding to ensure vendors understood all technical requirements to avoid future delays. In Vietnam, as in other countries, manufacturing and importation delays during COVID-19 surges led to long delays in bringing needed oxygen supplies to facilities. Additionally in Vietnam, certain country-specific factors caused delays such as the need for oxygen vendors to be approved by the national insurance plan, and lengthy provincial-level approval requirements for aid programs (government required Aid Approval Plans).

> *"At the peak of COVID, we were left with no other options. We had to make a decision whether people die or at least we give them [industrial oxygen]...But immediately after the peak subsided, we stopped that."*
>
> -Malawi

Several additional procurement-related challenges pre-dated program implementation and posed challenges during the implementation period in several countries. One was pre-existing vendor agreements that had high prices but limited services, and thus required renegotiations. Another challenge was the emphasis on procuring products and equipment, with relatively less emphasis on long-term contracts to ensure oxygen supply. And finally, policies at both the donor and country-level frequently did not distinguish between major construction (e.g., building a hospital) and minor construction (e.g., preparing a health facility for oxygen delivery systems) thereby adding barriers to vendor contracting and what IPs could undertake. For example, some vendors or IPs could procure, deliver and install equipment, but were not allowed to engage in building the foundation needed to hold the equipment.

Malawi Case Study:
Currency Volatilities and Fluctuating Oxygen Prices

Due to global economic conditions during COVID-19 as well as local factors, Malawi has seen a surge in demand for foreign currency, in particular the United States Dollar. This increased demand has prompted the Central Bank to recalibrate the exchange rate of Malawian kwacha to maintain equilibrium in the foreign exchange market. In May 2022, there was a 25% devaluation, and a year and a half later, in November 2023, the currency was devalued again and significantly by 44%.[10] These devaluations highlight the ongoing economic challenges facing the country. In part due to the currency fluctuations seen with the Kwacha, local key informants in Malawi reported additional challenges related to the dynamic cost of medical oxygen and supplies. This often resulted when budgets in Kwacha changed considerably once stakeholders were ready to procure oxygen and implement oxygen activities.

Insufficient infrastructure and faulty or under-utilized equipment

In five countries in the Interim Review, namely Côte d'Ivoire, the Democratic Republic of the Congo, Malawi, Mozambique, and Vietnam, infrastructural barriers and defective mechanical equipment disrupted operations and/or reduced the supply of oxygen available to patients. These challenges varied by country but included infrastructure such as power supply (and backup power), roads, storage space, and MGPSs as well as equipment like PSA plants, wall oxygen outlets and oxygen delivery devices. At the two health facilities visited by the STAR-UCSF team in Malawi, there was inadequate storage for oxygen cylinders. Additionally, one facility had a faulty generator, which meant that routine load-shedding and unexpected power outages rendered the hospital PSA plant and elevators as non-functional and prevented the site from supplying and transporting oxygen throughout the hospital and to neighboring sites that relied on that hospitals' PSA plant. Similarly, in the Democratic Republic of the Congo, lack of reliable electricity was also noted as a barrier, particularly in isolated areas, in addition to limited availability of cylinders and local products.

In Côte d'Ivoire, aside from limited oxygen-related equipment (e.g. face masks), one site reported that their PSA plant had been non-functional and in need of maintenance for over a month, which required the facility to purchase oxygen cylinders from local markets to keep treating patients. In Mozambique, one facility reported non-functional oxygen concentrators and was also able to detect a high wastage of oxygen due to leaks in medical gas piping after analyzing data in the oxygen dashboard built by RISE (see Case Study above). Additionally, at this district hospital, HCWs triaged patients within the hospital ward according to oxygen need, which was provided via a limited number of wall access points. In Vietnam, there were safety concerns regarding using ramps to decant oxygen, and no ramps were in place to fill cylinders. As a result, there were limited solutions for oxygen supply when needed for patient transport. In addition, one hospital reported that due to lack of adequate valves in the MGPS, the whole hospital system has to shut down during maintenance.

[10] Okemwa, E. (2023, November 22). Navigating Economic Turbulence: Factors Behind Malawi's Kwacha Devaluation. Retrieved from https://erokemwa.medium.com/navigating-economic-turbulence-factors-behind-malawis-kwacha-devaluation-6246fa57afe0

In multiple Review countries, the heterogeneity and incompatibility of oxygen supply connectors created additional barriers for delivery of oxygen from supply to the patient. For example, in Vietnam, one site installed a German connection, as that was all that was available from suppliers at the time, but this was recognized to likely limit future maintenance and compatibility options with other more commonly available connection types.

Long, restricted, and often unsafe commutes transporting oxygen

In all six Review countries, transportation was noted as a significant barrier to oxygen delivery. This ranged from lack of safe roads (or lack of any roads in the case of some regions), to lack of safe transport vehicles, as well as challenges importing long distances across national borders. These transport challenges are relevant to LOX and gaseous oxygen (e.g. in cylinders), but especially important for LOX which often requires larger vehicles and higher-risk transports. Such challenges were noted as factors for selecting oxygen supply strategies. In Malawi, rural health facilities often relied on more central health facilities to supply oxygen, but faced risks transporting oxygen on dangerous roads without specialized vehicles. In fact, due to limited access to vehicles designed to transport oxygen, ambulances would sometimes be used, which in turn diverted them from their regular function. Similarly, in Mozambique, in-country distribution required driving over long distances by land. Moreover, the lack of established regional distribution points in Malawi and Mozambique meant longer and more frequent in-country distribution trips were required, thus exhausting valuable resources. Over time, these long commutes can become a costly burden in an already fuel-scarce country, as well as increasing risks of road traffic accidents and further deteriorating an already overburdened transportation infrastructure. Similar logistical barriers in transporting oxygen were also noted in Côte d'Ivoire and in more remote regions in the Democratic Republic of the Congo. In Vietnam, travel restrictions during COVID-19 lockdowns were also noted as a barrier to timely oxygen delivery to patients.

> *"There is still need for more investment to minimize the travel time from one location to another, knowing how life-saving oxygen as a medical product can be, especially in critical care conditions."*
>
> -Ghana

Insufficient financing and market imbalance

Across four of the countries in the Interim Review, the limited availability of accessible and affordable LOX supply posed a significant, long-term barrier. In the Democratic Republic of the Congo, key informants noted there were many suppliers for oxygen; however, they were all internationally-based. In Malawi and Mozambique, there was widespread sentiment, from hospital clinicians to MOH officials, that the current supply of oxygen in country did not

> *"[There are] many needs and few resources. If we want to see an impact in the context of the DRC, it is more resources, financing, and time."*
>
> -DRC

meet the overall need. This is a significant hurdle to overcome, as Malawi lacks a local ASU and depends on an international supply monopoly from South Africa for LOX. Similarly, in Mozambique, only two suppliers for LOX were available, a local vendor, MOGÁS, and an international supplier, AFROX. It was also reported that even if facilities have LOX tanks or oxygen cylinders installed and available to fill, they cannot be filled if they are not branded with those companies' names or logos. While this is a common challenge in many countries worldwide, and is in part intended to ensure equipment quality and safety, it likely represents an opportunity to improve access through market shaping activities.

This was also reported to be a challenge in Vietnam, despite its robust market with many LOX suppliers. Some sites in Vietnam experienced challenges in local procurement of LOX as they often were only initially provided with the tank and one fill of LOX by the local IP, EpiC. At times, sites subsequently struggled to develop plans for refills because they had to establish their own contract with a LOX vendor, and in many places the contracting can be a lengthy process. In many cases, sites lacked historical consumption justification for the procurement, and government procurement and bidding approvals are subject to approval by the national insurance plans - often leading to additional delays.

> *"What worries me is the plan and budget."*
>
> -Malawi

Limited harmonization across stakeholders

Harmonization of donors and stakeholders is a perpetual global health challenge that predated the COVID-19 pandemic. The urgency and scale of the COVID-19 response coupled with a lack of consensus on optimal strategies for expanding access to medical oxygen, created a challenging situation for nearly all countries worldwide. Multiple global, regional, national and subnational mechanisms were working to coordinate oxygen scaleup response with varying levels of success. Numerous countries had TWGs that brought together stakeholders, though multiple Review countries, including Côte d'Ivoire, Democratic Republic of the Congo, and Malawi, highlighted opportunities for improved coordination among donors and other stakeholders. For example, in Malawi, IPs had to repeat the facility site selection process after finding out that another donor began working in one of their sites without communicating plans.

> *"Safety, and in this case, the guarantee that there is oxygen at all times, necessarily requires very coordinated management."*
>
> -Mozambique

In several countries, the lack of consensus on optimal oxygen supply and delivery strategies (including mixed approaches) was accompanied by strong and conflicting donor/stakeholder preferences that posed additional challenges. For example, one donor might be focusing only on one oxygen supply type (e.g. PSA/VSA plants, LOX, portable oxygen concentrators, or cylinders) based on institutional knowledge or emphasis on short- versus long-term goals, whereas another donor might be choosing another investment for their own similar reasons. Such competing priorities can contribute to program delays and increase the burden on local teams.

While conducting the desk review and KIIs, it was also apparent that oxygen stakeholders across numerous donors, IPs and MOHs had invested immense resources to create a large number of tools (e.g. trainings, policy documents, SOPs, frameworks, information sheets, capacity assessments, etc.) yet it appeared that stakeholders were at times unaware of the availability of these resources or not all resources were shared publicly. While there were attempts by several IPs to publicly curate and share materials, no existing mechanisms appeared to be completely sufficient. This was true for USAID and non-USAID funded IPs. Of note, USAID-funded IPs met regularly throughout the project period, and broader stakeholder meetings did take place with the explicit intention of sharing available resources and lessons learned.

Further analysis of why certain knowledge management efforts failed or succeeded, and identifying strategies to effectively share the lessons learned and tools created by oxygen-related initiatives since the beginning of the pandemic, would likely have great global value.

Key Challenges

For the purposes of this Interim Program Review, STAR-UCSF has defined a challenge as a difficult task or situation that requires effort, skill, and determination to overcome. A challenge can be an opportunity for growth and development, requiring key stakeholders to overcome it in order to reach the program's full potential. Challenges can be both internal and external factors and can be mitigated or controlled for with modifications to program development and implementation. The key challenges found through this Interim Program Review included: 1) steep learning curve related to LOX, 2) limited BME[T] workforce and HRH, 3) gaps in oxygen policies and guidelines, and 4) time-consuming implementation.

Steep learning curve related to LOX

Liquid oxygen is a new technology in many settings, and while the gaseous product that enters the patient is the same as from other technologies (i.e. cylinder, PSA plants and portable concentrators), nearly everything up until that point is different when using LOX. This can include how it gets to the bedside (e.g. MGPS), equipment to store and release it onsite (e.g., VIE system, storage tanks and slabs for installation), how to maintain it, setting up a delivery schedule, preventing waste, financing, safety protocols and operating in hot, humid environments, to name a few. This requires BME[T] support, monitoring (e.g. de-icing and supply tracking), and regular maintenance of backup systems.

> *"We didn't know much about the technical [aspects]...it is like learning by doing. [Now] things are much easier because we know how it works, so we know the players in the field."*
>
> -Vietnam

For settings that have relatively limited experience with LOX, the learning curve was reported to be steep. In the Democratic Republic of the Congo, implementers reported gaps at the procurement and supply chain level, as implementation of LOX delivery had not yet begun. Even in countries with significant experience and infrastructure for LOX, new opportunities for learning arose during the COVID-19 pandemic. In Vietnam, there was a need to rapidly develop and learn systems to facilitate procurement of large quantities of LOX, a new challenge. Additionally, teams in Vietnam noted that there was limited availability of in-country technical LOX guidance and inadequate training opportunities to expand local capacity. Specifically, technical training was often done by the oxygen vendors, and in retrospect, were deemed inadequate. In response to this feedback, in later trainings, EpiC in Vietnam liaised with a government technical credentialing body to provide appropriate training. In Malawi, multiple key informants noted that LOX was a new technology for the region, for which there was limited experience and pre-existing infrastructure, and significant training needs.

Limited BME[T] workforce and HRH

Three countries in the Interim Review expressed the need for more HRH for medical oxygen maintenance and delivery to patients. In Côte d'Ivoire, the MOH expressed concerns about not having a sufficient number BME[T]s to support oxygen investments and other key informants emphasized the need for further LOX training. This was a common concern across most countries. Key informants in Vietnam noted a shortage of site-level engineering capacity and workforce gaps to utilize LOX, particularly among BME[T]s. In Malawi, in addition to increasing the number of central MOH-hired BME[T]s from two BME[T]s, sites indicated a need for more site-wide, oxygen-related safety trainings specifically focused on equipment and safe medical oxygen storage.

Gaps in oxygen policies and guidelines

In implementing oxygen activities, four countries, the Democratic Republic of the Congo, Malawi, Mozambique, and Vietnam, reported gaps in governance and reporting structures. For example, despite Vietnam's existing oxygen policies, there were still limitations surrounding budget and a lack of national or provincial guidelines specifically for oxygen security, maintenance of LOX systems, and delivery of medical oxygen to patients. In Mozambique, although efforts to develop an oxygen ecosystem strategy were underway, there was still a lack of regulations for medical oxygen across all levels. Though some countries have multiple regulatory authorities for receiving and distributing oxygen, the absence of national guidelines for procurement, transportation, accountability, and monitoring consumption contributed to the delays across the various suppliers in some countries.

> *"Because of COVID demand, we have already seen the need for the country to have a strategic oxygen plan."*
> -Mozambique

Ghana Case Study:
Strict Policies and Standards to Prevent Waste

Multiple countries were developing strategies to minimize oxygen waste as an integral part of increasing access to oxygen. In 2023, following close collaboration within the TWG in Ghana, the Government of Ghana launched its first-ever oxygen policy and guidelines with standards for oxygen. This provided specific guidance and signage to restrict movement and ensure safety at facilities with PSA plants. At five of these health facilities, engineers have been trained and provided with oxygen analyzers and other tools to monitor the flow and quality of oxygen throughout the medical gas system, including at the point of delivery to the patient. Additionally, the PSA plant includes systems to check the quality of cylinders being filled for distribution. The PSA is able to check for and extract any excess air in the cylinders before it goes through the filling system to align with national guidelines and ensure quality of oxygen delivery.

Time-consuming implementation

Based on the reported experience of the IPs (and other ongoing oxygen initiatives), it is clear that oxygen infrastructure simply cannot be scaled up in an effective or sustainable way without significant investment of time and money. Furthermore, attempting to rapidly expand long-term infrastructure in the midst of a pandemic is not only unprecedented, but arguably the most difficult time to conduct such work. Because the pandemic was truly global, in contrast to other more geographically isolated public health crises, global supply chain disruptions caused massive and underestimated delays for activities that under other circumstances would have been thought of as relatively rapid. For example, PSA plants were initially thought by many initiatives to be a 'quick fix.' By the time procurement delays were realized and added to infrastructure and training timelines, these projects took much longer than anticipated. Furthermore, the reality of longer timelines also created an opportunity to consider investments like LOX, which early in the pandemic were assumed to require too much time to be practical.

Taken altogether, the barriers and key challenges discussed above led to significantly more time required for implementation than was originally planned. For example, initial needs assessments in some countries were planned to take place over two weeks but took more than two months. The amount of time that would be needed for contract negotiations, equipment delivery, local aid approvals, site planning, environmental and safety approvals, infrastructure improvements, workforce preparation, and USAID construction approvals was often underestimated and contributed to delays. Based on EpiC's experience with work that qualified as construction, the USAID construction approval process could be lengthy given the specific requirements, and private sector companies did not always understand or appreciate the need for the required approval processes. As a result of these delays, most workplans underwent multiple revisions and extensions, with some being extended for double or triple the originally planned timelines. At the time of this Interim Program Review, most were only partially executed.

Activity 3B: Delphi Survey

At the time of this Interim Program Review, the Delphi Survey was only partially complete. Currently, 28 individuals out of 125 (22.4%) invited have responded to the Delphi survey assessing the appropriateness and feasibility of 24 WHO Medical Oxygen Ecosystem KPIs. The respondents represent five of six program evaluation countries and all IPs. Notably, only five respondents (17.9%) represented health facility level perspective (Table 7). The majority of KPIs (21, 84%) were ranked high in terms of appropriateness and feasibility (i.e., Likert scores >3), as shown in Figure 14. Not all respondents rated the appropriateness or feasibility of each KPI highly, in such cases they were prompted to provide reasons for their low rating (Table 8). A common theme among most low ratings was concerns over data availability and quality.

The seven KPIs that would be the most appropriate and feasible are:

- *Inclusion of oxygen on the Essential Medicines List (EML) in countries with oxygen investments. (WHO KPI #7)*
- *Number of beds at the facility equipped with a functional oxygen supply out of the total number of beds at the facility. (WHO KPI #8)*
- *Number of countries that have oxygen included as part of national health strategy documents and/or plans. (WHO KPI #10)*
- *Number of clinical staff trained on oxygen therapy at the facility level out of the total number of clinical staff at the facility level. (WHO KPI #9)*
- *Number of health facilities that received technical support (e.g. biomedical or mechanical engineering) for maintaining oxygen systems out of the total number of health facilities with oxygen systems. (WHO KPI #2)*
- *Number of health facilities with functional oxygen systems out of the total number of health facilities. (WHO KPI #12)*
- *Number of technical staff trained on oxygen systems operation and maintenance at the facility level out of the total number of technical staff at the facility level. (WHO KPI #13)*

The three KPIs that would be the least appropriate and feasible are:

- *Time it takes for the items to arrive at the facility from the destination agreed to in the purchase order (for orders where destination agreed in purchase order is not facility). (WHO KPI #21)*
- *Number of hospitalized patients receiving oxygen therapy and having their oxygen saturation monitored at least twice per 24 hours out of the number of hospitalized patients receiving oxygen therapy. (WHO KPI #15)*
- *Number of hospitalized patients receiving oxygen with $SpO_2 < 93\%$ at 24 hours post-admission out of the total number of hospitalized patients receiving oxygen therapy. (WHO KPI #20)*

Table 7. Delphi survey respondent demographics

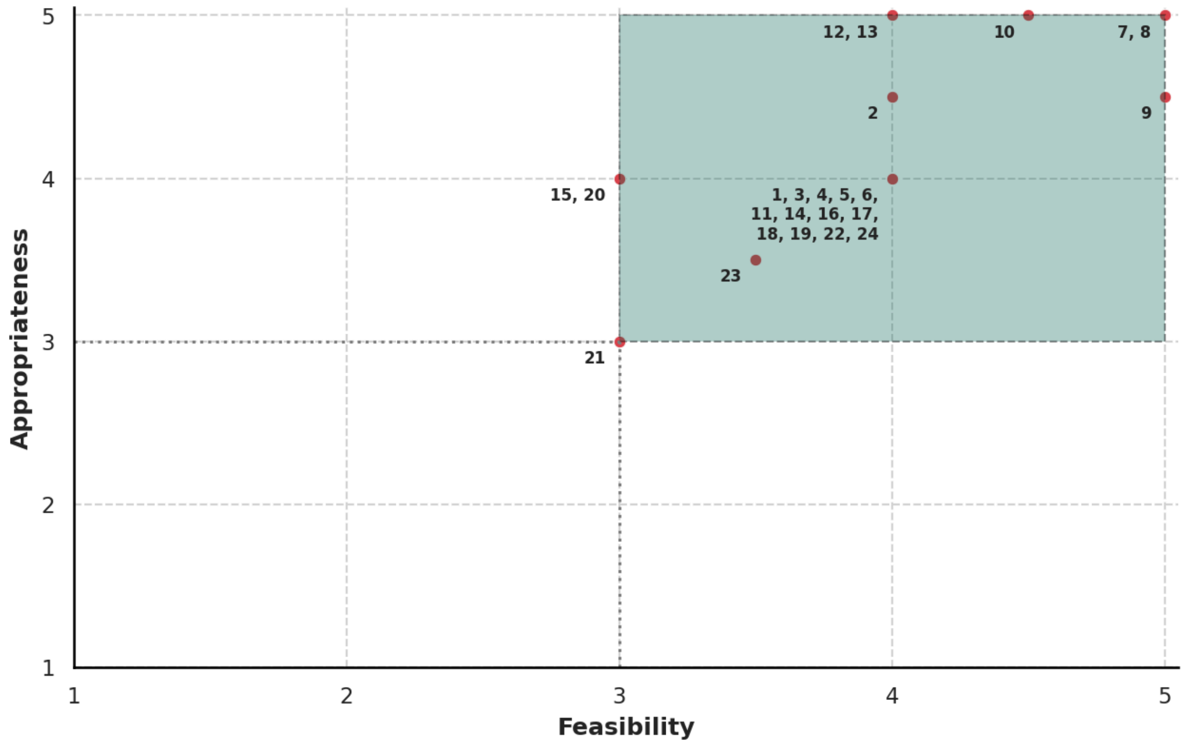
	Count (%) (n=28)
Place of Work	
Implementing Partner Country Office	9 (32.1%)
USAID Country Mission	5 (17.9%)
Healthcare Facility	5 (17.9%)
Ministry of Health	3 (10.7%)
Other (please write)	3 (10.7%)
USAID Headquarters	2 (7.1%)
Implementing Partner Headquarters	1 (3.6%)
Country of work*	
Côte d'Ivoire	6 (22.2%)
Ghana	5 (18.5%)
Mozambique	5 (18.5%)
Vietnam	4 (14.8%)
Democratic Republic of Congo	3 (11.1%)
Malawi	2 (7.4%)
United States/Headquarters	2 (7.4%)
Role/Professional Background*	
Project Management/Project Specialist	13 (37.1%)
Physician	7 (20.0%)
Public Health	6 (17.1%)
Biomedical Engineer	5 (14.3%)
Data Analyst/Monitoring & Evaluation	2 (5.7%)
Nurse	1 (2.9%)
Biomedical Equipment Technician	1 (2.9%)
Procurement/Finance/Operations	0 (0.0%)
Respiratory Therapist	0 (0.0%)
Academic/Researcher	0 (0.0%)

*Respondents were instructed to select all responses that apply.

Table 8. Most frequently cited reasons for low appropriateness and feasibility ratings

Reason for Low Rating (Likert Score <3)	Number of KPIs with Reason for Low Rating Invoked by ≥1 Respondent	
	N = 24 KPIs	%
The data necessary to assess this KPI cannot be verified or quality assured (appropriateness)	15	54
This KPI has little or no significance to oxygen delivery in my setting. (appropriateness)	14	50
Other - or please suggest an alternative wording for this KPI. (appropriateness)	10	36
The data necessary to inform this KPI is considered too sensitive for public reporting. (appropriateness)	6	21
The data necessary to assess this KPI is not available. (feasibility)	18	64
The data necessary to assess this KPI has been/would be difficult to collect due to limitations of current data systems, tools, personnel, capacity, etc. (feasibility)	17	61
The data necessary to assess this KPI has been/would require too much time and/or other resources to collect. (feasibility)	14	50
The data necessary to assess this KPI could be collected once, but routine data collection would not be sustainable. (feasibility)	7	25
Other, or please suggest an alternative wording for this KPI. (feasibility)	7	25

Figure 14. Median Appropriateness and Feasibility Ratings of WHO Key Performance Indicators for Medical Oxygen Ecosystems



Note: Ratings shown are median Likert scores, where 1 represents the least appropropriate/feasible and 5 represents the most appropriate/feasible. WHO KPI numbers for rating combination indicated below red markers. Green shaded area indicates favorable appropriateness and feasibility. See Appendix 10 for a full list of the WHO Medical Oxygen KPIs and their appropriateness and feasibility ratings.

The majority of KPIs in this first round of surveys were considered both feasible and appropriate for use in monitoring and evaluation of oxygen ecosystems. Other than seven KPIs, none received scores <3 for either feasibility or appropriateness. While overall ratings were high, concern existed that the majority of KPIs could be impractical due to challenges with data quality, access, and availability to routinely construct these metrics. Additional evaluation is required to validate these results.

Conclusion and Recommendations

As the COVID-19 pandemic evolved, so too did the investment strategies of many global stakeholders, including USAID. The earliest investments focused on interventions that were thought to be relatively easier and more rapidly implemented (e.g. portable oxygen concentrators, PSA/VSA plants, oxygen delivery devices, PPE, and clinical TA). In some cases, such as PSA/VSA plants, the actual time for implementations was markedly longer than anticipated due to myriad factors including global supply chain disruptions. As the historical neglect and true size of the global oxygen gap became clearer, investments began to incorporate more workforce strengthening, market shaping, relationship building, and infrastructure building. This included LOX for select settings, as a reliable and rapidly scalable oxygen supply. Collectively, these activities which comprise the core of the USAID oxygen programs, require considerable time to implement, especially when initiated during a pandemic. It is unsurprising that these Programs are behind their original timelines, and these delays should be taken in the context of challenges and barriers as outlined above, as well as in the context of other COVID-19 and oxygen-related activities undertaken by IPs.

The pandemic evoked not only unprecedented investment in oxygen ecosystems by USAID and numerous stakeholders, but also created an unprecedented opportunity to learn from these initiatives to design sustainable, future efforts. Much of this learning will take place in the years that follow program completion (2025-2026 for several aspects of the Program, including market shaping activities).

Despite delays in project implementation and limited data available at the time of this Interim Review, we outline several successes and recommendations for future programming based on findings of our review of USAID-supported oxygen programs in the Democratic Republic of the Congo, Côte d'Ivoire, Ghana, Malawi, Mozambique, and Vietnam.

Successes of USAID's Oxygen Investment

Expanded oxygen access

The current oxygen programs in the Democratic Republic of the Congo, Côte d'Ivoire, Ghana, Malawi, Mozambique, and Vietnam are expanding access to oxygen in approximately 146 facilities and more than 13,000 patient beds. Prior to the pandemic, there was no blueprint and limited information to guide rapid scaleup of medical oxygen infrastructure, including selection of optimal oxygen supply sources tailored to local resources and needs. The approaches implemented as part of USAID-supported oxygen programs varied by country and most often required a combination of supply modalities (e.g. LOX, PSA, cylinders, etc.) and strategies (e.g. hub-and-spoke distribution, import, local production, etc.). In all Review countries, LOX was recognized as playing an important role for scaling the local oxygen ecosystem and improving capacity to

> *"How many lives have we saved? We have already saved many lives."*
> -Mozambique

respond to future surges. This was true in countries like Vietnam where LOX was already commonly used in many sites around the country, as well as the Democratic Republic of the Congo where no local LOX producer existed and variable electricity and limited road infrastructure were common - necessitating a different (hub-and-spoke) approach.

Old and new oxygen cylinders at Hospital Distrital de Monapo, Nampula Province, Mozambique, September 2023.

Facility-level staff at multiple health facilities showed pride and appreciation of the important investment made by USAID in oxygen ecosystems. At one facility in Mozambique, health facility staff proudly displayed photos of the day the PSA plant was installed and members from their team who had been trained on its maintenance and use. They noted that not only did the PSA plant increase their self-reliance in managing patients at their hospital and its referral sites, but they also celebrated how many lives had been positively impacted. Similarly in Côte d'Ivoire and Mozambique, LOX tanks were installed and new oxygen equipment provided, respectively, which will expand oxygen access for facilities' catchment areas and allow for the refurbishment of existing piping and manifold systems.

"This support, as far as PSA plants are concerned, changed the landscape greatly. This infrastructure made a difference not just for the facility, but we had as many as four regions coming to refill oxygen for their facilities and hospitals."

-Ghana

In all countries, the Program investments were felt to have benefits beyond COVID-19 oxygen needs. Facilities in Ghana reported not only improvement in their facilities' abilities to respond to COVID-19, but also improvements in broad-reaching infrastructure requirements such as electricity in order to improve the oxygen supply sources. In the Democratic Republic of the Congo, Ghana, and Mozambique, key informants noted that USAID's oxygen investment not only benefits patients with COVID-19, but other clinical programs as well such as tuberculosis, pneumonia, labor and delivery, and more.

Highlighted the need for additional specialized trainings for oxygen

Prerequisites to establishing a healthy and robust oxygen ecosystem are skills and knowledge. This includes not only technical training for clinicians and BME[T]s, but also non-technical trainings for administrators and managers who are vital to a functional oxygen ecosystem. The IPs spent considerable efforts assessing local training needs and designing tailored interventions to address these needs. At the time of this Interim Review, many had not yet been finalized or implemented, though several approaches and resources were emerging.

> *"The investment by USAID has also brought with it training and capacity building for both engineers and healthcare workers across the landscape."*
> -Ghana

Countries like Mozambique reported the need for more HRH - in particular as it relates to recruitment and training, especially for LOX and oxygen conservation to reduce wastage and improve stewardship. In Mozambique, it was noted that additional clinical trainings in case management were needed due to high staff turnover at sites exacerbated training gaps. One key informant noted that in the future, developing local TWGs that include donors and MOHs could mitigate knowledge gaps about oxygen products and expedite product selection and negotiation.

Short courses, job aids, presentations, workshops and conferences were common modalities for training. These short-term interventions came with anticipated challenges like sustainability and reach. Several countries noted training challenges due to high staff turnover in the targeted facilities. Expanding oxygen training as an integral part of pre-service training is a promising alternative that is being explored in multiple countries, including the Democratic Republic of the Congo. It is promising to see that some of the materials created by the Programs have been packaged for adaptation or adoption by other initiatives, and in some cases were being integrated into pre-service training programs. More real-time sharing of training materials, especially those which can augment national, certified training pathways, will be needed for sustained response.

> *"[We had] an opportunity to increase the technical capacity of doctors, mainly, where they [oxygen] devices are placed. This brought a great benefit to the Mozambican population."*
> -Mozambique

Like many aspects of USAID's oxygen investment, the impact of expanded oxygen education efforts may not be fully realized until years after the programs have ended, as more locally-generated initiatives stem from these initial investments.

An additional and noteworthy benefit of USAID's oxygen investments is the expanded subject matter expertise and capacity of the IPs. Prior to the pandemic there were relatively few implementers with experience in oxygen ecosystem strengthening. Beyond USAID's oxygen programs, the IPs can serve as a valuable resource for local partners and global oxygen ecosystem activities in the future.

Expanded impact through collaboration

The COVID-19 pandemic highlighted wide-reaching gaps in oxygen systems and focused global attention on the urgent need to work together to strengthen access to oxygen, especially in LMICs. Prior to the pandemic, relatively few donors, MOHs or stakeholders focused on oxygen initiatives. As the pandemic evolved and impacted nearly every aspect of the health system, lack of oxygen impacted a wide range of stakeholders including those previously focused on HIV/AIDS, TB, MNCH, and surgery/anesthesia, among others.

With stakeholders rapidly entering the oxygen space, and each bringing a wide range of resources, interests, prior experiences and focus countries, IPs recognized early on the need for participation in national, regional and global coordination bodies. This came in the form of TWGs, regional meetings/workshops, and participation in global initiatives such as the Oxygen Alliance, the Every Breath Counts Coalition, and the Lancet Global Health Commission on Oxygen Security, among others. USAID-supported IPs also quickly engaged with other initiatives that had been going on in the oxygen space for longer periods of time. They did this by forming direct partnerships and subawards with new partners, as well as hosting national and regional meetings to share lessons learned and iterate on strategy.

The finances required to build and maintain oxygen ecosystems that meet countries' demands are far greater than the MOH allocated budgets in most LMICs, and there is no single donor, IP, or international organization that can provide solutions for all of these gaps. A collaborative approach between technical partners, funders, and governments prevents duplication, unburdens local partners and can create synergies that not only make these projects possible, but also maximize their impact.

Recommendations for Future Programming

Promote sustainability post-USAID investment

At the time of this Interim Review, most of the six Program Review countries were in the process of drafting sustainability plans for LOX, and many countries had or were developing national oxygen roadmaps to ensure durable system change. While none of these reports was available for review, prioritization of this activity clearly highlighted the recognized importance of this aspect of the Program.

> *"How do we keep this running for years to come?"*
>
> -Malawi

Just as planning and implementation of LOX infrastructure and market-shaping activities required considerably more time and support than initially anticipated, it is likely that the same will be true for planning and implementation of sustainability activities. These activities will likely require continued support and investment beyond the end of this current round of USAID funding, and will require funding from local governments, public-private partnerships, as well as donor organizations. Furthermore, sustainability will require deliberate, ongoing collaboration among stakeholders, as complex systems will be left in place, almost certainly with less external funding and TA than they currently have available.

Sustainability plans should be shared in real time during the development process, harmonized across stakeholders, and revisited regularly after the project period. Ideally these plans should be developed with and endorsed by the MOHs to ensure plans have central coordination and buy-in. With multiple initiatives simultaneously transitioning complex and relatively unfamiliar programs to local support, a central coordination mechanism can also help avoid a scenario where multiple programs assume availability of the same resources needed for sustainability (i.e. two different health programs assuming the same national resources or budget will go to them). At a minimum, central coordination mechanisms and/or MOHs will likely require ongoing support to not be overburdened by the implementation and coordination of sustainability plans, even if they are primarily funded at the national level.

Nearly all Program Review countries (Côte d'Ivoire, the Democratic Republic of the Congo, Malawi, Mozambique, and Vietnam) shared concerns about the maintenance and sustainability of the newly-improved oxygen ecosystems without ongoing, external support. The MOH in Côte d'Ivoire recommended USAID's support for three additional years through their local IP EpiC to ensure sustained success. In the Democratic Republic of the Congo, USAID's investment to date was celebrated as a catalyst for improving oxygen access around the country, but there were concerns here and in other countries that momentum could easily be lost after the project ends. In Mozambique, there was a desire to sustain investment in MGPSs at more health facilities to prevent wastage of oxygen from leaking pipes. Key informants in Malawi expressed concerns that the local government is not yet able to manage their own financial support at this stage and noted that the progress to date will need future investments to sustain the program. It was noted there may be opportunity in Malawi to utilize the local pharmaceuticals budget to purchase medical oxygen, for example, to finance these gains going forward. Key informants also highlighted the need for ongoing investment to scale up current projects (including investments in filling stations) as well as to augment monitoring and evaluation. Concerns were also raised in Vietnam regarding sustainability of the gains made through USAID's investment, especially if future external donor support were to halt entirely. Key informants there urged that emphasis be placed on creating a pathway toward long-term sustainability beyond external assistance (e.g. integration into facility and national budgets). In Mozambique, there was a request to continue

> *"This investment is really important. How do you sustain it? And even if the liquid oxygen is not filled and how do you make sure that tanks will not be clogged out, tanks will not get rusty, and that all the systems will be maintained? And what's the cost of maintenance?"*
>
> -Vietnam

supporting the USAID oxygen investments, especially through capacity building and training focused on oxygen TA.

While stakeholder harmonization activities were taking place in and across several Program countries in the form of workshops, TWGs, and international alliances, there likely are opportunities to invest further in these types of activities. This includes not only live forums, but also mechanisms for asynchronous knowledge sharing. Despite attempts by USAID IPs and other global stakeholders, no central knowledge management system emerged to help serve as a comprehensive, up-to-date repository for oxygen-relevant resources. Better mechanisms for knowledge sharing across IPs, donors and MOHs could accelerate learning and implementation for oxygen ecosystems and similar endeavors.

> *"Sustainability will not happen without local buy-in…where we learn together, we move together. Then lessons learned from there can be brought back to other places. That's the only way we can do this sustainably. Sustainability is not money - it goes beyond that."*
>
> -Vietnam

Sustainability planning, and the implementation of these plans, will be essential for determining the true impact of USAID's oxygen investment. Sustained investment in oxygen systems for the near future is likely the most cost-effective way to prepare for future pandemics, while also scaling up care for the massive, neglected global burden of hypoxic illness that is present today. Enlisting and harmonizing broad oxygen stakeholder support (e.g. organizations focused on MNCH, TB, COPD, and emergency, critical, and operative care, etc.) can help sustain progress.

Create locally-adaptable blueprints for oxygen investments and strategies

Universal access to oxygen for all patients requires infrastructure solutions that are designed for the complexity and diversity of health facilities across LMICs. As discussed earlier in this Interim Review, prior to the pandemic there was limited consensus and no one-size-fits-all oxygen solution. A complete picture of the factors and considerations for designing optimal, locally-tailored oxygen solutions is only now beginning to emerge and be tested at scale. When available, the data and lessons learned from this Program will provide invaluable contributions to future initiatives as well as ongoing efforts to create oxygen infrastructure guidance. For example, at the time of this Interim Review, USAID and IPs were actively engaged with multiple ongoing global efforts to consolidate knowledge, including the development of the "WHO Technical

> *"This is for future emergencies…but to tell you the truth…you go to a maternity ward and there is nothing of that kind, so even for the newborn, but also for the mothers and everything. I think its use will go beyond itself. I even wonder if the country would have enough for the next pandemic."*
>
> -DRC

Specifications for health facility based medical oxygen system products," and the WHO National Oxygen Scale-Up Frameworks initiative. Comprehensive capacity building strategies for medical oxygen must incorporate elements of production, distribution, administrative and regulatory management, as well as clinical provision.

Sustained engagement in these efforts is essential, as consolidated guidance will be foundational for future initiatives and pandemic preparedness. If done successfully, contributions to the creation of turn-key packages for oxygen scaleup could be one of the most valuable outputs of this Program.

Improve oxygen data and timing of site selection

In general, oxygen ecosystem strengthening activities are time-consuming, especially when conducted at a time of unprecedented global supply chain disruptions and exceptional strain on health systems (i.e. during a pandemic). Thus, there is no better time to invest in oxygen ecosystems than on the heels of a pandemic and before the next one.

This Interim Review identified multiple enablers and barriers that significantly impacted Program timelines and could be better accounted for in future oxygen activities. In hindsight, some of the reasons for prolonged implementation timelines (e.g. stockouts) appeared easier to anticipate than others (e.g. currency and oxygen price fluctuations). Early decisions and estimates were being made based on limited available information and urgent requests from stakeholders.

The complexity and time-consuming nature of oxygen capacity assessments and program implementation were certainly compounded by the concurrent emergency response to the pandemic and multiple parallel efforts. In some cases this was beneficial, as stakeholders rapidly shared knowledge to inform a coordinated approach. Though in other cases it caused delays, as some donors worked in parallel, even choosing the same sites for intervention without realizing prior to implementation. Assessments were time- and cost-intensive, and yielded data that in some cases was quickly out of date. While it is uncertain the extent to which these possibilities could have been better accounted for in workplan timelines for the oxygen Programs, the experience of these Programs provides clear guidance that future initiatives must incorporate more time for oxygen ecosystems activities. Furthermore, to avoid resource-intensive and often duplicative assessments by multiple stakeholders in the future, there is clear need and value in investing in local partner capacity and longitudinal national data systems that integrate oxygen indicators and can be utilized for future assessments and planning. Further work to identify optimal oxygen indicators based on feasibility and utility are

> *"There is that advocacy piece that is critical to this work. Education and shifting mindsets between various [oxygen supply] options available in these countries is key."*
> -EpiC HQ

underway by initiatives such as the Lancet Global Health Commission on Oxygen Security and others.

Country and site selection processes could expedite timelines by convening parallel assessment and data sharing efforts. While many of these reports were eventually published, neither these efforts nor their data appeared to always be evident to other stakeholders.

To ensure efficient selection and implementation of optimal supply modalities (e.g. LOX, PSA, cylinders, etc.) and strategies (e.g. hub-and-spoke distribution, import, local production, etc.), it is necessary to work with and build capacity with local, country-level leadership. In particular, early advocacy and empowerment of senior leadership within MOHs for example were viewed as crucial for the success of country programs.

A significant factor impacting program timelines was the novelty of LOX. Many key informants emphasized that pre-existing LOX production, oxygen affordability and the presence or absence of relevant oxygen policies and regulations should be better accounted for on a country-specific basis.

Only once the oxygen Programs are completed will it be possible to fully characterize all barriers and enablers that impacted timelines, and to translate this knowledge into future recommendations.

Develop oxygen financing, market shaping, and procurement strategies

Medical oxygen investment is a unique and necessary opportunity to achieve ambitious global health outcomes. However, the barriers to solve market and procurement issues are multifaceted and difficult to address, especially in the short run (see Barriers and Key Challenges). Despite concerted efforts to supply oxygen access, many key informants noted that current national budgets and donor contributions still do not go far enough to set up sustainable oxygen systems in LMICs. In short, providing funding alone without a cohesive, integrated strategy will not improve sustained access to affordable medical oxygen.

> *"Market shaping is the key to the sustainability of oxygen."*
>
> -USAID HQ

Since there were relatively few oxygen vendors and suppliers in most Review countries, the distribution of control over supply and pricing was a frequently cited concern. With countries like Malawi and Mozambique relying heavily on regional distributors from nearby South Africa, identifying and sustaining a competitive, local solution will require significant investment. In the Interim Review process, stakeholders identified multiple potential areas for future investment that could help improve market efficiencies, including better importation policies, systems for national supply chain management, improved vendor warranties, and strategies for volume guarantee incentives contracts, most of which are already part of planned market shaping activities.

At the time of this Interim Review, many Program countries were planning market-shaping activities to address these challenges, however, all were incomplete, and limited conclusions or recommendations can be made at this time. However, it was clear that these activities will likely play a central role in determining the long-term viability of oxygen ecosystems investments, and that sustained market shaping efforts will be needed for years to come.

Leverage opportunities for future learning

The COVID-19 pandemic and the global response were unprecedented. As Programs like USAID's oxygen investment are being implemented and evaluated in the coming years, there is an important opportunity to learn. A goal of these Programs is not only the timely scaleup of access to affordable medical oxygen, but also contributions to global frameworks for how best to achieve this goal.

Based on the findings of this Interim Review, we have identified several opportunities for potential future learning. These include questions that we set out to answer for this Review but were unable to complete due to current availability of data. These also include ideas generated from desk review, KIIs and broader stakeholder input. Each of these recommendations for review is listed below along with a proposed timeline for data collection:

- Complete Key Performance Indicators consensus process (December 2024)
- Review oxygen quantification and forecasting methods that were developed (December 2024)
- Estimate total cost of LOX, PSA and MGPS implementation by facility, including essential clinical and non-clinical TA (February 2025)
- Estimate time for RFP process, delivery and installation of LOX (and other oxygen-related) equipment (December 2025)
- Collect data on KPIs generated from the Delphi consensus process (December 2025)
- Compare completed national strategic plans for oxygen to better understand adoption of oxygen programming across these settings (December 2025)
- Identify barriers to more effective knowledge sharing/management across USAID IPs and across donors (December 2025)
- Compare national regulatory guidance pre and post Program implementation (December 2026)
- Estimate annual operating cost of LOX, PSA and MGPS by facility (December 2026)
- Fully characterize barriers and enablers for the Oxygen Ecosystems Review countries, building off the foundation of this Interim Review (December 2026)
- Repeat Desk Review with an emphasis on compiling and analyzing SOPs and market shaping outputs (including sustainability plans and negotiated vendor contracts from before and after the Program)(December 2026)
- Conduct detailed case study(s) of market shaping activities and impact (December 2026)

- Examine if potential risks identified in initial IP workplans were encountered and if so, then how they were mitigated (December 2026)
- Review asset management platforms that were developed (December 2026)
- Examine successes and challenges in providing complementary TA for other donors (e.g. supporting gaps in Global Fund maintenance of donated oxygen assets) (December 2026)
- Conduct detailed case study(s) of TWG activities and impact (December 2026)
- Evaluate utilization and functional status of LOX, PSA and MGPS investments by facility, including system integrity (leaks) (December 2027)

Limitations

The most significant limitation of this Interim Program Review was the lack of available data primarily as a result of incomplete Program implementation at the time of review. Countries were at different stages of completion for oxygen activities when the STAR-UCSF team conducted site visits, KIIs, and data abstraction. No implementers or countries had completed all workplans covered by this Interim Review and in some cases, final workplans were not yet approved or begun. As a result, some countries were able to provide relatively more complete reflections and experiences during the desk review and KIIs stages, while others had only recently started implementation with multiple years ahead in their workplans (e.g., the Democratic Republic of the Congo).

Another limitation of this Interim Review was the biases inherent during KIIs, as participants often exhibited a preference for sharing successes rather than openly acknowledging challenges. The presence of USAID, IP, and/or MOH representatives during some facility-level KIIs added another potential bias as health facility staff may have been less willing to openly express negative feedback about this program or its stakeholders. Despite concerted efforts to include the most informed individuals in the KIIs, as identified by IPs, logistical challenges arose as some key stakeholders were either busy, unavailable, or had already left the project at the time of the STAR-UCSF visits. These constraints, in some instances, led to incomplete responses to certain questions or the acquisition of less reliable information. Furthermore, specific to the Democratic Republic of the Congo, no national- or site-level data collection occurred as the country was added to the Interim Review after it had begun (following Zambia's withdrawal). Moreover, some KIIs were conducted virtually, which may have led to less openness to share feedback without the STAR-UCSF team first building rapport in-person. This limitation significantly curtailed the depth and comprehensiveness of the limited Interim Program Review in the Democratic Republic of the Congo. Similarly, virtual KIIs were conducted in Ghana due to limitations around stakeholders' availability and the timeline of the Interim Program Review.

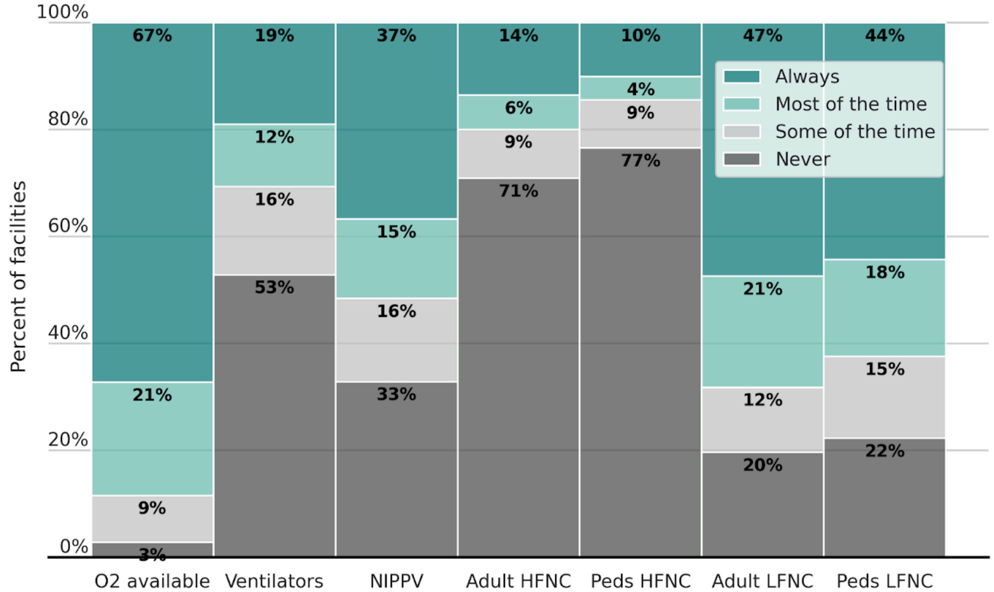
Finally, the assessment of indicators had several limitations, primarily marked by a vast amount of missing data as many country programs and facilities did not collect or have access to the data requested to fully characterize oxygen ecosystems implementation. In part, this is because the Interim Program Review was developed after the USAID IPs had designed their programs. Moreover, in some instances, data reported to USAID and/or documented in IP HQ workplans differed from what was made available to the STAR-UCSF team while in-country or virtually.

Finally, due to variability in the scope of workplans across countries (and variability in stage of implementation), it was difficult to provide country-level comparisons. The team was also unable to generalize facility-level findings based on the limited subset of sites.

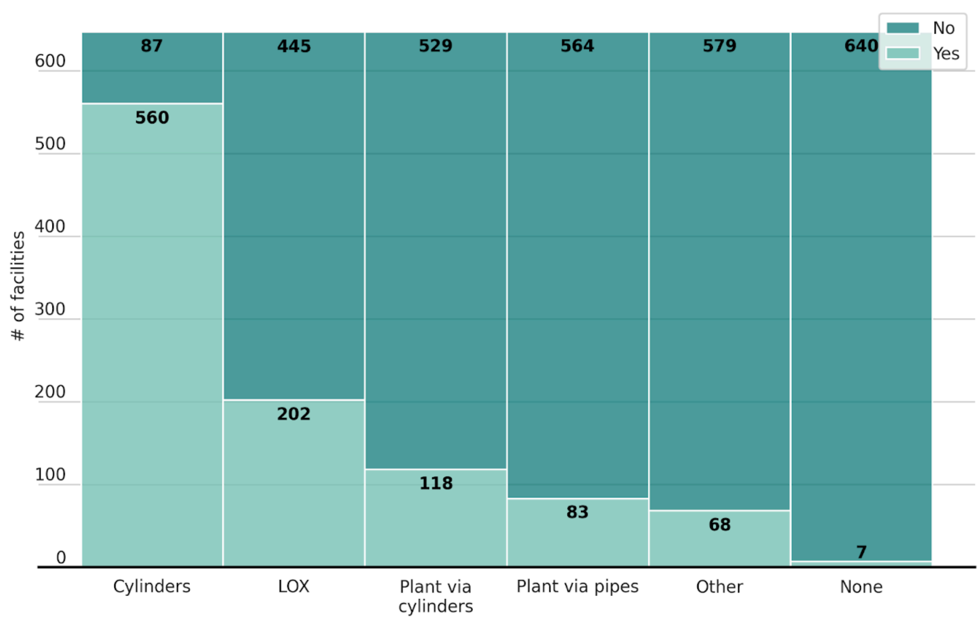
Appendices

1. USAID IP Facility Assessments for O2 and Critical Care Capacity

Oxygen delivery devices: Proportion of facilities, across >30 USAID aid recipient countries, reporting availability of oxygen delivery devices in 2020-21



Oxygen sources: Number of facilities, across >30 USAID aid recipient countries, reporting oxygen source availability in 2020-21



These data originate from USAID's Facility-Level Assessment, administered to 688 facilities across >30 countries by implementing partners RISE and EpiC FHI 360, and developed by RISE, FHI 360, and STAR-UCSF. Undertaken June 2020-December 2021, these results illustrate the availability of oxygen sources and delivery devices in countries receiving USAID COVID-19 assistance. Of note, countries and facilities surveyed with the FLA are not necessarily the same as those included in the Interim Program Review.

2. UCSF IRB Outcome Letter

UCSF
University of California
San Francisco

irb.ucsf.edu

Human Research Protection Program
Institutional Review Board (IRB)

IRB Determination

Conducting Research During the COVID-19 Public Health Outbreak: Please visit the Interim UCSF Policy on Human Subjects-Related Research Visits at San Francisco Campuses during COVID-19 Outbreak, which can be found at https://research.ucsf.edu/interim-ucsf-policy-human-subjects-related-research-visits-san-francisco-campuses-during-covid-19 to determine whether and how this Policy may affect this IRB approved or exempt study.

Date: December 09, 2022

Principal Investigator
Dr. Michael Lipnick, MD

Study Title: COVID-19 Program Reviews of Test to Treat (T2T) and Oxygen Ecosystem Activities Funded by USAID
Study Status: Not Human Subjects Research
Study #: 22-38124
Reference #: 363646

We have reviewed your project and have made the following determination:

Based on the information you have provided to us, this is a project that includes program evaluations, quality improvement activities, or other activities that do not require further IRB oversight according to the federal regulations summarized in 45 CFR 46.102(l).

You are not required to submit anything further to the IRB. Should you have any questions, or should key project activities change, you may contact me directly, or you can contact the IRB office at 476-1814.

Given the nature of your project, a Material Transfer Agreement may be required if you are transferring specimens and/or data into or out of UCSF. For additional information, please see http://ita.ucsf.edu/researchers/mta.

3. GHS IRB Outcome Letter

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted

Research & Development Division
Ghana Health Service
P. O. Box MB 190
Accra
Digital Address: GA-050-3303
Mob: +233-50-3539896
Tel: +233-302-681109
Email: ethics.research@ghs.gov.gh
3rd November 2023

My Ref. GHS/RDD/ERC/Admin/App/23/648
Your Ref. No.

Dr. Michael Lipnick
University of California, San Francisco
Institute for Global Health Sciences
Mission Hall, Global Health and Clinical Sciences Building
San Francisco, CA, United States of America 94158

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	**GHS-ERC: 004/11/23**
Study Title	STAR-UCSF COVID-19 Oxygen Ecosystems and Test to Treat Program Review
Approval Date	3rd November 2023
Expiry Date	2nd November 2024
GHS-ERC Decision	**Approved**

This approval requires the following from the Principal Investigator

- Submission of a yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report after completion of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why.
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

You are kindly advised to adhere to the national guidelines or protocols on the prevention of COVII -19

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementatio

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED...
Mr. Kofi Wellington
(GHS ERC Chairperson)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

4. National-Level Indicators ODK Survey

O2 Program Review National Survey USAID O2 Program Review 2023

National-Level Indicators

Name of Data Collector

Name of Country

- Côte d'Ivoire
- Ghana
- Malawi
- Mozambique
- Vietnam

Implementing Partner(s) working on O2 in country

- EPIC
- RISE
- GHSC-PSM
- Other, please specify

Data Review Period Start Date
yyyy-mm-dd

Data Review Period End Date
yyyy-mm-dd

PART 1: REACH

» Question 1. Planned Oxygen-related TA

Question 1a. Number of facilities that planned to receive oxygen-related technical assistance

This should be the sum of facilities that planned to receive clinical, engineering, and/or other oxygen-related technical assistance
or
No data available

Question 1b. Number of facilities that planned to receive clinical oxygen-related technical assistance

Question 1c. Number of facilities that planned to receive engineering oxygen-related technical assistance

Question 1d. Number of facilities that planned to receive other oxygen-related technical assistance

» Question 2. Oxygen-related TA

Question 2a. Number of facilities that received oxygen-related technical assistance within the reporting period

USAID O2 Indicator: CV2.5-24. This should be the sum of facilities that received clinical, engineering, and/or other oxygen-related technical assistance
or
No data available

Question 2b. Number of facilities that received clinical oxygen-related technical assistance within the reporting period

Question 2c. Number of facilities that received engineering oxygen-related technical assistance within the reporting period

Question 2d. Number of facilities that received other oxygen-related technical assistance within the reporting period

» Question 3. # Times TA Received

Question 3a. Number of times oxygen-related technical assistance was provided within the reporting period

USAID O2 Indicator: CV2.5-25

This should be the sum of facilities that received clinical, engineering, above site, and/or other oxygen-related technical assistance

or

No data available

Question 3b. Number of times clinical oxygen-related technical assistance was provided within the reporting period

Question 3c. Number of times engineering oxygen-related technical assistance was provided within the reporting period

Question 3d. Number of times above site oxygen-related technical assistance was provided within the reporting period?

Question 3e. Number of times other oxygen-related technical assistance was provided within the reporting period

» Question 4. Planned Supplies

Question 4a. Number of facilities that planned to receive USG-donated oxygen-related supply sources

(PSA/VSA, oxygen concentrators, liquid oxygen tanks, oxygen cylinders, other oxygen related supply sources)

or

No data available

Question 4b. Number of facilities that planned to receive USG-donated PSA/VSA

Question 4c. Number of facilities that planned to receive USG-donated oxygen concentrators

Question 4d. Number of facilities that planned to receive USG-donated liquid oxygen (LOX) tanks

Question 4e. Number of facilities that planned to receive USG-donated oxygen cylinders

Question 4f. Number of facilities that planned to receive other USG-donated oxygen-related supply sources

» Question 5. Received Supplies

Question 5a. Number of facilities that received USG-donated oxygen-related supply sources

(PSA/VSA, oxygen concentrator, LOX tank, oxygen cylinders) during the reporting period

USAID O2 Indicator: CV2.5-22
or
No data available

Question 5b. Number of facilities that received USG-donated PSA/VSA during the reporting period

Question 5c. Number of facilities that received USG-donated oxygen concentrators during the reporting period

Question 5d. Number of facilities that received USG-donated liquid oxygen tanks during the reporting period

Question 5e.Number of facilities that received USG-donated oxygen cylinders during the reporting period

Question 5f. Number of facilities that received other USG-donated oxygen-related supply sources during the reporting period

» Question 6. Modified Facilities

Question 6a. Number of facilities that planned to be modified to support oxygen delivery

Question 6b. Number of facilities that were modified to support oxygen delivery during the reporting period
USAID O2 Indicator: CV2.5-23

» Question 7. Number of beds with new or upgraded access to oxygen during the reporting period

PART 2: IMPLEMENTATION

» Question 8. Number of market shaping interventions that are being implemented to increase demand for oxygen at national level during the reporting period

» Question 9. Number of facilities that are benefitting from negotiated supply agreements for oxygen during the reporting period

» Question 10. Check which of the following are available

- Nation strategic O2 plan
- National PSA/LOX maintenance plan
- National-level oxygen planning document
- Other, Please specify
- Unknown

» Question 11. Is there a regulatory entity for O2 at the national level?

- Yes
- No

» Question 12. Delivered Donations

Question 12a. Number of USG-donated oxygen-related commodities delivered during the reporting period

(PSA/VSA plants, oxygen concentrators, pulse oximeters, LOX tanks, oxygen cylinders, other oxygen-related commodities)
USAID O2 Indicator: CV2.5-21
or
No data available

Question 12b. Number of PSA/VSA plants constructed during the reporting period

Question 12c. Number of oxygen concentrators delivered during the reporting period

Question 12d. Number of pulse oximeters delivered during the reporting period

Question 12e. Number of LOX tanks delivered during the reporting period

Question 12f. Number of oxygen cylinders delivered during the reporting period

Question 12g. Number of other oxygen-related commodities delivered during the reporting period
Please specify

» Question 13-14. LOX

Question 13. Total volume of LOX procured during reporting period

Question 13a. Unit of volume

Question 14. Total USD spent on LOX during reporting period?

PART 3: MAINTENANCE

» WORKFORCE

Question 15a. Is there an identified point person for O2 at the MOH?
- Yes
- No

Question 15b. What type of staff is the identified point person?
- Clinician
- Biomedical engineer
- Biomedical technician
- Other, please specify

» STAFFING

» Question 16. Total BME/T

Question 16. Total number of (full-time and part-time) biomedical engineers (BME) and biomedical equipment technicians (BMET) that are currently employed or in recruitment at the national level
or
No data available

» Question 17. BME/T Staff Disagg

Question 17a. Number of part-time BME staff

Question 17b. Number of part-time BMET staff

Question 17c. Number of full-time BME staff

Question 17d. Number of full-time BMET staff

Question 17e. Number of in recruitment BME staff

Question 17f. Number of in recruitment BMET staff

» Question 18. Pre-USAID Funding Total BME/T

Question 18. Before USAID investment, total number (full-time and part-time) BME and BMET employed or in recruitment at the national level

or

No data available

» Question 19. BME/T Staffing Pre-USAID Funding

Question 19a. Before USAID investment, number of part-time BME staff

Question 19b. Before USAID investment, number of part-time BMET staff

Question 19c. Before USAID investment, number of full-time BME staff

Question 19d. Before USAID investment, number of full-time BMET staff

Question 19e. Before USAID investment, number of BME staff in recruitment

Question 19f. Before USAID investment, number of BMET staff in recruitment

» Question 20. LOX price

Question 20. What is the percent change in LOX price due to new negotiated LOX supply and delivery agreements?

Please use whole numbers (e.g., 20 for 20%)

or

No data available

» Question 21. Financing

Question 21a. Total estimated budget for financing oxygen ecosystems in USD

or

No data available

Question 21b. Estimated local government/MOH budget for oxygen ecosystems in USD

Question 21c. Estimated donor(s) budget for oxygen ecosystems in USD

Question 21d. Estimated private sector budget for oxygen ecosystems in USD

» Question 22-26. Leadership & Governance

Question 22. Review the national list(s) of essential medicines and medical devices for adults and children for this country. Are medical oxygen and associated medical devices included?

- Yes, oxygen included

- Yes, oxygen and associated medical devices included
- No, neither oxygen nor associated medical devices include   Unknown/no data

Question 23. Costed national plan to increase access to quality assured, affordable medical oxygen systems available in country

- Yes
- No

Question 24. Review national LOX procurement plans. Check if any of the following were present in the national plan.

- National policies for use
- Incorporation into national MOH/budget
- Quantifications completed
- Supply chain/logistics plans confirmed
- Other, Please specify
- Unknown/no data

Question 25. Oxygen forecasting capabilities and capacity to estimate and supply and demand available in country

- Yes
- No

Question 26. Review country's supply chain for oxygen and associated supplies. Check if any of the following are identified.

- Procurement mechanism in place
- Stockout(s) in the last 12 months of oxygen
- Stockout(s) in the last 12 months of associated supplies
- Other, Please specify
- Unknown/no data

» Question 27-29. Sustainability

Question 27. Number of weekly COVID-19 diagnoses national over last 6 months

or

No data available

» » Sustainability Plan

Question 28. Number of average weekly respiratory hospitalizations nationally over last 6 months

or

No data available

» SUSTAINABILITY PLAN

Question 29. Number of national-level sustainability plans developed

or

No data available

5. Facility-Level Indicators ODK Survey

O2 Program Review Facility Survey

USAID O2 Program Review 2023

Name of Data Collector

Name of Country

- Côte d'Ivoire
- Ghana
- Malawi
- Mozambique
- Vietnam

Facility Name

Region Name

Province Name

District Name

Start Date of O2 Data Collection
yyyy-mm-dd

End Date of O2 Data Collection
yyyy-mm-dd

PART 1: REACH

» Question 1

Question 1. What oxygen supply source does this facility have?
In general, not just supplied/modified by USAID

- Vacuum-insulated evaporator (VIE) and/or Liquid oxygen tanks (LOX)
- Pressure swing absorption (PSA) / vacuum swing absorption (VSA) plant
- Oxygen cylinders
- Oxygen concentrators
- Other, please describe

or
No data available

PART 1A: WORKFORCE

» Question 2. BME/T Onsite

Question 2. Are there biomedical engineers (BME) or biomedical equipment technician (BMET) staff available onsite?

- Yes
- No

or

No data available

» Question 2. Current BME/T staffing

Question 2a. Number of total BME/T staff (full-time and part-time) assigned to the facility

Question 2b. Number of part-time BME staff assigned to the facility

Question 2c. Number of part-time BMET staff assigned to the facility

Question 2d. Number of full-time BME staff assigned to the facility

Question 2e. Number of full-time BMET staff assigned to the facility

» Question 3. Facility Staffing

Question 3a. Number of total of clinical staff
Clinical staff includes clinical supervisor/logistics, clinical HCWs, community/lay HCWs, and other HCWs

Question 3b. Number of total full-time clinical staff
Clinical staff includes clinical supervisor/logistics, clinical HCWs, community/lay HCWs, and other HCWs

Question 3c. Number of total part-time clinical staff
Clinical staff includes clinical supervisor/logistics, clinical HCWs, community/lay HCWs, and other HCWs

Question 3d. Number of total non-BME/T and non-clinical staff
Non-clinical staff includes pharmacy, lab, data entry, and other

Question 3e. Number of full-time non-BME/T and non-clinical staff
Non-clinical staff includes pharmacy, lab, data entry, and other

Question 3f. Number of part-time non-BME/T and non-clinical staff
Non-clinical staff includes pharmacy, lab, data entry, and other

» Question 4. BME/TStaffing Pre-USAID Funding

Question 4a. Before USAID investment, number of full-time BME staff assigned to the facility

Question 4b. Before USAID investment, number of full-time BMET staff assigned to the facility

Question 4c. Before USAID investment, number of part-time BME staff assigned to the facility

Question 4d. Before USAID investment, number of part-time BMET staff assigned to the facility

PART 1B: STAFF TRAINED

» Question 5. BME/T Training

Question 5. Number of BME/BMET staff trained on medical oxygen systems operation and maintenance by USAID Implementing Partners (IPs) (EpiC, RISE, GHSC-PSM) assigned to the facility

or

No data available

Question 5a. Number of full-time BME/BMET staff trained on medical oxygen systems operation and maintenance by USAID IPs assigned to the facility
Question 5b. Number of part-time BME/BMET staff trained on medical oxygen systems operation and maintenance by USAID IPs assigned to the facility

» Question 6. Clinical Staff Trained

Question 6. Number of clinical staff trained on oxygen therapy by USAID IPs
or
No data available

Question 6a. Number of full-time clinical staff trained on oxygen therapy by USAID IPs

Question 6b. Number of part-time clinical staff trained on oxygen therapy by USAID IPs

» Question 7. # Others Trained

Question 7. Number of non-BME/T and non-clinical staff trained on medical oxygen systems management by USAID IPs
or
No data available

Question 7a. Number of full-time non-BME/T and non-clinical staff trained on medical oxygen systems management by USAID IPs

Question 7b. Number of part-time non-BME/T and non-clinical staff trained on medical oxygen systems management by USAID IPs

» Question 8. HCW Trained

Question 8. Number of HCWs at facility trained on use of supplies to deliver oxygen to patients

Question 9. Retention: Number of trained HCWs that remain assigned to the facility after 6 months (or 3 months)?
This number should be less than or equal to the number of HCWs trained (Question 8)

Question 10. Retention: Number of BME(s) onsite 6 months after implementation (or 3 months if not yet reached 6 months)
This should be less than or equal to the number of current BME staff on site

PART 1C: TRAININGS

» Question 11. Trainings
Question 11. Number of oxygen ecosystem (O2)-related trainings conducted (onsite, virtual, etc.) for facility-based staff (includes both clinical and non-clinical trainings)

Question 11a. Number of O2-related trainings for BME/T STAFF conducted (onsite, virtual, etc.) for facility-based staff

Question 11b. Number of O2-related trainings for CLINICAL STAFF conducted (onsite, virtual, etc.) for facility-based staff

Question 12. Did trainings address VIE or PSA/VSA plant safety?
- Yes

- No

Question 12a. Number of sessions that focused on VIE or PSA/VSA plant safety

Question 12b. Did trainings for BME/T STAFF address VIE or PSA/VSA plant safety?
- Yes
- No

Question 12c. Number of sessions for BME/T STAFF that focused on VIE or PSA/VSA plant safety

Question 12d. Did trainings for CLINICAL STAFF address VIE or PSA/VSA plant safety?
- Yes
- No

Question 12e. Number of sessions for CLINICAL STAFF that focused on VIE or PSA/VSA plant safety

Question 13. Did trainings address VIE or PSA/VSA plant maintenance?
- Yes
- No

Question 13a. Number of sessions that focused on VIE or PSA/VSA plant maintenance

Question 13b. Did trainings for BME/T STAFF address VIE or PSA/VSA plant maintenance?
- Yes
- No

Question 13c. Number of sessions for BME/T STAFF that focused on VIE or PSA/VSA plant maintenance

Question 13d. Did trainings for CLINICAL STAFF address VIE or PSA/VSA plant maintenance?
- Yes
- No

Question 13e. Number of sessions for CLINICAL STAFF that focused on VIE or PSA/VSA plant maintenance

Question 14. Did trainings address safe filling, storage, and transport of cylinders?
- Yes
- No

Question 14a. Number of sessions that focused on safe filling, storage, and transport of cylinders

Question 14b. Did trainings for BME/T STAFF address safe filling, storage, and transport of cylinders?
- Yes
- No

Question 14c. Number of sessions for BME/T STAFF that focused on safe filling, storage, and transport of cylinders

Question 14d. Did trainings for CLINICAL STAFF address safe filling, storage, and transport of cylinders?
- Yes
- No

Question 14e. Number of sessions for CLINICAL STAFF that focused on safe filling, storage, and transport of cylinders

Question 15. Did trainings address contingency plans for failure of O2 system?

- Yes
- No

Question 15a. Number of sessions that focused on contingency plans for failure of O2 system

Question 15b. Did trainings for BME/T STAFF address contingency plans for failure of O2 system?

- Yes
- No

Question 15c. Number of sessions for BME/T STAFF that focused on contingency plans for failure of O2 system

Question 15d. Did trainings for CLINICAL STAFF address contingency plans for failure of O2 system?

- Yes
- No

Question 15e. Number of sessions for CLINICAL STAFF that focused on contingency plans for failure of O2 system

Question 16. Did trainings result in identifying clinical and technical point persons for the event of O2 system failure?

- Yes
- No

Question 17. Did trainings address safe and proper delivery of O2 to patients?

- Yes
- No

Question 17a. Number of sessions that focused on proper delivery of O2 to patients, including pulse oximeters, flowmeters, and masks/nasal cannula

Question 17b. Did trainings for BME/T STAFF address safe and proper delivery of O2 to patients?

- Yes
- No

Question 17c. Number of sessions for BME/T STAFF that focused on proper delivery of O2 to patients, including pulse oximeters, flowmeters, and masks/nasal cannula

Question 17d. Did trainings for CLINICAL STAFF address safe and proper delivery of O2 to patients?

- Yes
- No

Question 17e. Number of sessions for CLINICAL STAFF that focused on proper delivery of O2 to patients, including pulse oximeters, flowmeters, and masks/nasal cannula

Question 17f. Did trainings address safe and proper measurement of O2 to patients by pulse oximeter?

- Yes
- No

Question 17g. Number of sessions that focused on proper measurement of O2 to patients by pulse oximeter

Question 17h. Did trainings address safe and proper delivery of O2 to patients by flowmeter?
- Yes
- No

Question 17i. Number of sessions that focused on proper delivery of O2 to patients by flowmeter

Question 17j. Did trainings address safe and proper delivery of O2 to patients by masks/nasal cannula?
- Yes
- No

Question 17k. Number of sessions that focused on proper delivery of O2 to patients by masks/nasal cannula

Question 18. Did trainings address O2 conservation?
- Yes
- No

Question 18a. Number of sessions that addressed O2 conservation

Question 18b. Did trainings for BME/T STAFF address O2 conservation?
- Yes
- No

Question 18c. Number of sessions for BME/T STAFF that addressed O2 conservation

Question 18d. Did trainings for CLINICAL STAFF address O2 conservation?
- Yes
- No

Question 18e. Number of sessions for CLINICAL STAFF that addressed O2 conservation

PART 2D: INFRASTRUCTURE

» BEDS

» Question 19. Total number of beds at selected facility

or
No data available

Question 19a. Total number of beds in intensive care unit (ICU)

Question 19b. Total number of beds in high dependency unit (HDU)
Also called step-down, progressive and intermediate care units

Question 19c. Total number of bed in emergency department (ED)

» Question 20. Number of beds with O2

Question 20. Number of beds equipped with functional oxygen supply

or
No data available

Question 20a. Number of beds equipped with functional oxygen supply from wall outlets
Question 20b. Number of beds in intensive care unit (ICU) equipped with functional oxygen supply from wall outlets

Question 20c. Number of beds in high dependency unit (HDU) equipped with functional oxygen supply from wall outlets
Also called step-down, progressive and intermediate care units

Question 20d. Number of beds equipped with functional mobile cylinder (manifold) oxygen supply from wall outlets

Question 20e. Number of beds equipped with functional PSA/VSA supply from wall outlets

Question 20f. Number of beds equipped with functional LOX supply from wall outlets

Question 20g. Number of beds equipped with functional oxygen supply from wall outlets from other sources

Question 20h. Number of beds equipped with functional oxygen supply not through wall outlets

Question 20i. Number of beds equipped with functional oxygen supply via mobile cylinder (not through wall outlets)

Question 20j. Number of beds equipped with functional oxygen supply via portable oxygen concentrators (not through wall outlets)

» Question 21-22. Gas Piping

Question 21. Has there been an increase in medical gas piping from the O2 source to the patient bedside at this site after USAID investment?
- Yes
- No

Question 22a. Number of wards with access to central medical gas piping/wall outlets

Question 22b. Number of wards with access to central medical gas piping/wall outlets before USAID investment

Question 22c. Number of beds with access to central medical gas piping/wall outlets

Question 22d. Number of beds IN ICU with access to central medical gas piping/wall outlets
ICU = intensive care unit

Question 22e. Number of beds IN HDU with access to central medical gas piping/wall outlets
Also called step-down, progressive and intermediate care units

Question 22f. Number of beds IN ED with access to central medical gas piping/wall outlets

Question 22g. Number of beds with access to central medical gas piping/wall outlets before USAID investment

Question 22h. Number of beds IN ICU with access to central medical gas piping/wall outlets before USAID investment
ICU = intensive care unit

Question 22i. Number of beds IN HDU with access to central medical gas piping/wall outlets before USAID investment
Also called step-down, progressive and intermediate care units

Question 22j. Number of beds IN ED with access to central medical gas piping/wall outlets before USAID investment

PART 2: EFFECTIVENESS

» Question 23. New Installations

Question 23. Were any of the following newly installed or procured with USAID funding?

LOX system
- Yes
- No

PSA/VSA plant
- Yes
- No

Cylinder-filling station
- Yes
- No

Concentrators
- Yes
- No

Medical gas pipeline system
- Yes
- No

» Question 24. Increased O2 cylinder amount

Question 24. Was an increased amount of oxygen cylinders received from offsite as a result of USAID funding?
- Yes
- No

or
No data available

» Question 25. Repair

Question 25. Was an existing medical gas system repaired?
- Yes
- No

or
No data available

» Question 26. Log Books

Question 26. Is a log book(s) available with total number and volume of O2 cylinders (filled or unfilled) and liquid oxygen (LOX) tank gaseous O2 volume?

- Yes
- No

Question 26a. Total estimated average of O2 storage capacity (in liters of gas) in pressurized cylinders and LOX onsite at any given time
(Number of cylinders x cylinder volume liters gas) + LOX tank gaseous O2 volume

Question 26b. As a result of USAID investment, estimate of newly added O2 storage capacity in pressurized cylinders and LOX
(Number of NEW cylinders x cylinder volume liters gas) + LOX tank gaseous O2 volume

» Question 27. Max Flow

Question 27. What is the maximum flow capacity at 93% purity of the installed O2 system?
No. of gaseous liters per minute (LPM) OR Nm3/min

or
No data available

Question 27b. Units for maximum flow capacity
LPM or Nm3/mm

» Question 28. Hours of Operation

Question 28a. Number of hours per day that the PSA/VSA plant is operational

or
No data available

Question 28b. Number of hours per day that the PSA/VSA plant was operational before the USAID investment

or
No data available

» Question 29. Max Capacity

Question 29a. What is the maximum O2 supply capacity of LOX cylinder?

or
No data available

Question 29b. Units for maximum capacity
Gallons or Liters

Question 29c. Is the average monthly supply of oxygen less than the maximum capacity?
Meaning, does the health facility NOT refill fully every month due to budgetary concerns, for example

- Yes
- No

Question 29d. What is the average supply capacity?

» Question 30. Total max O2 supply

Question 30a. What is the total maximum O2 supply capacity of the new PSA/VSA plant?

or

No data available

Question 30b. What is the total max O2 supply capacity?

*(Total volume of cylinders received from offsite each month) + (cumulative max flow of all existing PSA/VSA plants) + (max flow of portable oxygen concentrators (POCs) * number of POCs)*

» Question 31. Cylinders

Question 31. Is a manifold system for backup delivery of oxygen via cylinders available if the primary O2 system fails?

- Yes
- No

Question 31a. Was the manifold system installed from USAID funding?

- Yes
- No

Question 31b. Number of filled cylinders available at facility for backup delivery of oxygen

PART 3: IMPLEMENTATION

» Question 32. Facility Plans

Question 32. Is a facility-level plan for O2 available?

- Yes
- No

Question 32a. Does it include plans for increasing and/or training staff?

- Yes
- No
- Unknown

Question 32b. Does it include estimates of commodity/supply requirements?

- Yes
- No
- Unknown

Question 32c. Does it include infrastructure plans?

- Yes
- No
- Unknown

Question 32d. Does it include financing?

- Yes
- No
- Unknown

» Question 33. Adaptations

Question 33. What is the number of adaptations to the facility-level O2 plan after adoption?

or

No data available

Question 34. Is a budget for annual maintenance costs for VIE, concentrators, and/or PSA/VSA plant available?

- Yes
- No

» Question 35. SOP/Job Aids

Question 35a. Is a standard operating procedure (SOP) for safe filling, storage, and transport of O2 cylinders available?

- Yes
- No

Question 35b. How many job aids for safe filling, storage, and transport of O2 cylinders were available?

Question 35c. Is a SOP for operation of LOX tank or PSA/VSA plant available?

- Yes
- No

Question 35d. How many job aids for operation of LOX tank or PSA/VSA plant were available?

Question 35e. Is a SOP for operation of oxygen concentrators available?

- Yes
- No

Question 35f. How many job aids for operation of oxygen concentrators were available?

Question 35g. Is a SOP for O2 logistics and procurement available?

- Yes
- No

Question 35h. How many job aids for O2 logistics and procurement were available?

Question 35i. Is a repair & maintenance SOP for LOX tank, concentrators, or PSA/VSA plant available?

- Yes
- No

Question 35j. How many repair & maintenance job aids for LOX tank, concentrators, or PSA/VSA plant were available?

Question 35k. Is an emergency SOP for addressing failure of O2 system (LOX/PSA) available?

- Yes
- No

Question 35l. How many job aids for addressing failure of O2 system were available?

Question 35m. Is a SOP for responding to alarms and troubleshooting errors in the O2 system available?
- Yes
- No

Question 35n. How many job aids or working tools for troubleshooting O2 system were available?

Question 35o. Is a SOP for de-icing and prevention of ice accumulation available?
- Yes
- No
- N/A

Question 35p. How many job aids or working tools for de-icing and prevention of ice accumulation were available?

<u>» Question 36-39. Logs</u>

Question 36a. Are logs of oxygen cylinders filled by relevant LOX tanks or PSA/VSA plants available?
- Yes
- No

Question 36b. Is there sufficient detail to determine total volume of O2 cylinders delivered or received (to the facility; not patient-level)?
- Yes
- No

Question 37a. Are delivery logs/purchase orders for cylinders received from or sent offsite available?
- Yes
- No

Question 37b. Is there sufficient detail to determine total volume of O2 delivered or received?
- Yes
- No

Question 37c. Is there sufficient detail to capture time to delivery of oxygen cylinders?
- Yes
- No

Question 37d. What is the average number of days to receive/send O2 cylinders?

Question 37e. Total gaseous volume of cylinders received from offsite each month

Question 37f. Total gaseous volume of cylinders received from offsite each month before USAID investment

Question 38a. Are delivery logs/purchase orders for LOX tank refills available?
- Yes
- No

Question 38b. What is the average time to delivery of LOX tank refills? (# of days to send/receive LOX tanks)

Question 38c. What is the average number of monthly LOX tank refills per month (average over last 12 months)?

Question 39. What is the capacity (liquid liter) of the tank?

» Question 40. PSA Plant specifications

Question 40a. What is the make/model of the PSA plant?

Question 40b. Is the PSA plant single/duplex/multiplex?
- Single
- Duplex
- Multiplex
- Unknown

Question 40c. Is the PSA plant containerized/skid mounted/onsite built?
- Containerized
- Skid mounted
- Onsite Built
- Other
- Unknown
- Other, specify

» Question 41. VIE sites

Question 41a. Number of VIE sites

Question 41b. Number of VIE sites with supportive infrastructure (co-located access to water and electricity)

Question 42a. Is a backup generator present onsite?
- Yes
- No

Question 42b. Is it connected to the oxygen supply system (i.e., PSA/VSA or VIE system)?
- Yes
- No

PART 4: MAINTENANCE

» Question 43. Total costs over 6 months

Question 43a. Estimate total costs (USD) related to O2 access over the last six months

Question 43b. Estimated power costs (USD) (electricity and fuel) over last six months

Question 43c. Estimated maintenance parts costs (USD) over last six months

» Question 44. Costs, Part2

Question 44. Is there a service level agreement (SLA) for plant maintenance?
- Yes
- No

Question 44a. What is the annual cost of SLA? (USD)

Question 44b. What is the estimated purchase cost (USD) of the equipment?

Question 44c. What is the estimated installation cost (USD)?

Question 44d. What are the estimated other significant costs (USD)?

Question 44e. What is the most significant type of cost in oxygen strategy?
Select 1 response
- Personnel
- Logistics/Transport
- Infrastructure (e.g., water, electricity, etc.)
- Commodities
- Maintenance
- Other, please describe

» Question 45. Supply availability

Question 45. Are the following supplies related to delivering oxygen to patients available?

Pulse oximeter
- Yes
- No

Mask/nasal cannulae
- Yes
- No

Flowmeter
- Yes
- No

» Question 46. Repair logs

Question 46. Are repair/maintenance logs available for the following:

a. PSA/VSA Plants
   - Yes
   - No

   Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

b. LOX tanks
   - Yes
   - No

   Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

c. Filling stations
   - Yes
   - No

   Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

d. Oxygen cylinders
   - Yes
   - No

   Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

e. Ramps
   - Yes
   - No

   Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

f. Manifolds
   - Yes
   - No

Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

g. Piping
   - Yes
   - No

Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

h. Wall outlets
   - Yes
   - No

Are frequency of occurrences where equipment failure impacts oxygen delivery to patients recorded?
   - Yes
   - No

» Question 47-48. Monitoring

Question 47. Is there a functional oxygen analyzer onsite?
- Yes
- No

Question 47a. Is there daily monitoring of oxygen purity and pressure?
- Yes
- No

Question 47b. What is the average number of days per week with monitoring of oxygen purity and pressure?

Question 48. Is there daily monitoring of pressure at manifolds? (all sites with wall piping)
- Yes
- No
- N/A

Question 48a. What is the average number of days per week with monitoring of pressure at manifolds

» Question 49-51. Operation

Question 49. How many hours on average per 24-period was O2 system in operation in the past month?

Question 50. How many power outages in the past month negatively impacted O2 system functioning?

Question 50. Number of functioning O2 supply systems (pre-existing and new)

6. Key Informant Interview Guide

Oxygen Ecosystems Key Informant Interview (KII) Guide

Instructions for Interviewer:

1. *Before the Interview:*
    a. *Introduce yourself (and your team, if applicable) and confirm the title/position(s) and organization(s) of the key informant(s).*
    b. *Read the background information below about the program review and scope of the KII. Give the KI(s) a copy of the "Project Information and Contact Information" document and answer any questions they may have.*
    c. *Once the KI(s) have received the information and had their questions answered, proceed to obtain informed consent to record and conduct the interview.*
2. *Conducting the interview:*
    a. *Once informed consent has been provided, start recording the interview on your device (e.g., phone or computer). At the start of the recording, verbally state, "Informed consent to conduct this key informant interview has been given by the key informants from [Organization Name] today, on [X Date]."*
    b. *If possible, take notes as you conduct the interview. If you miss anything during the interview, you may use the recording afterwards to fill in any gaps in your notes.*
    c. *Allow the interview to flow naturally - questions do not have to be answered in order and some KIIs may naturally focus on certain domains/topics and skip others depending on the informant's area(s) of expertise. Allow other topics to be discussed but be sure to guide the interview back to the questions listed.*
3. *After the interview:*
    a. *Thank the KI(s) for their time and remind them of the contact information provided should they have further questions.*
    b. *Complete your notes within 5 business days of the interview. If more than one member of the team took notes, be sure to work together to complete one set of accurate and comprehensive notes.*
        i. *Note: if interview is conducted in a non-English language, then notetaker should not only complete notes within 5 business days, but also the translation into English.*
    c. *DocuSign where designated to indicate that informed consent was given by the KI(s).*

Background Information (to be read prior to the interview):

Hello, thank you for joining us today. My name is __________, and I am working as part of a review team at University of California, San Francisco (UCSF) in support of the USAID Sustaining Technical and Analytic Resources (STAR) project. At the request of USAID, part of this project is dedicated to conduct a program review of COVID-19 oxygen programs aimed at providing technical assistance and improving infrastructure for oxygen delivery to patients in select countries. The purpose of this program review is to better understand the implementation of those oxygen-related activities in selected countries, including procurement and supply chain logistics, trainings of engineers and other facility-based staff, infrastructure support and development, oxygen-related policies and guidelines technical assistance, market-shaping activities, and more.

This interview shouldn't take longer than 90 mins at most, and your participation is 100% voluntary. Your name or other personally-identifying information won't be recorded. The interview will be audio-recorded to ensure the accuracy of our conversation today in the interview notes. You may skip questions or stop at any time.

If you agree to take part in the interview, we want you to share your perceptions, experiences, and opinions about the oxygen programs funded by USAID. There are no risks or benefits to you for participating, and what you share will be summarized in a report on the lessons learned and challenges identified in implementing oxygen-related work.

Everything you share today will be secure and anonymous. As mentioned earlier your name or any other personal information about you will not be recorded. Overall findings will be summarized and provided to USAID, implementing partners, and Ministries of Health.

If you have any questions about taking part in this interview or about the reviews, please ask them now.

Pause to allow the KI(s) to read the "Project Information and Contact Information" document and to answer any questions.

This program review has been given a non-human subjects research determination by the IRB at UCSF as its primary focus is programmatic quality improvement. Your taking part in the interviews indicates that you've had the opportunity to ask any questions and that they have been answered to your satisfaction. If you have any further questions, please refer to the contact information provided in the "Project Information and Contact Information" document. I will record your informed consent on your behalf. Thank you!

Key Informant Interview Consent Form *(complete via DocuSign)***:**

Interviewer: I have read this informed consent form aloud to the interviewee and confirm that the individual(s) has agreed to participate.

Name of the interviewer: ______________________

Signature of the interviewer: ________________________

Date: ________________________

Oxygen Ecosystems Key Informant Interview Guide per Domain by Type of Interviewee[11]

Title/position: ___________________

Organization: ____________________

<table>
<tr><th>Domain</th><th>USAID and EpiC/RISE HQ Teams</th><th>MOH/USAID Mission Offices and EpiC/RISE Local Offices</th><th>Oxygen-Related Site/Facility Staff</th></tr>
<tr><td rowspan="3">(1) Procurement and Supply Chain Logistics</td><td>Describe the process and timeline for the procurement, importation, and/or production of oxygen.
What about oxygen cylinders?
What about liquid oxygen (LOX) or pressure swing adsorption (PSA) plant equipment?
Any other oxygen-related equipment such as pulse oximeters, flowmeters, and masks/nasal cannula?
Who are the key stakeholders?</td><td>Describe the process and timeline for the procurement, importation, and/or production of oxygen [Country X].
What about oxygen cylinders?
What about liquid oxygen (LOX)/\ or pressure swing adsorption (PSA) plant equipment?
Any other oxygen-related equipment such as pulse oximeters, flowmeters, and masks/nasal cannula?
Who are the key stakeholders?
How were prices of products/services negotiated?</td><td></td></tr>
<tr><td>Describe the process and timeline for building, improving, and/or scaling-up a LOX vacuum insulated evaporator (VIE) to store LOX or pressure swing adsorption (PSA) or vacuum swing adsorption (VSA) plants.
Who are the key stakeholders?</td><td>Describe the process and timeline for building, improving, and/or scaling-up a LOX vacuum insulated evaporator (VIE) to store LOX or pressure swing adsorption (PSA) or vacuum swing adsorption (VSA) plants in [Country X].
Who are the key stakeholders?</td><td></td></tr>
<tr><td></td><td>What was the logistical process in distributing oxygen and oxygen-related products to facilities?
How did you track the oxygen and related products (from importation to facility, from facility to patient)?
How long does it take on average between successful importation distribution or production to delivery to facilities?</td><td></td></tr>
</table>

[11] Note underlined questions came from the Lancet Global Health Commission on Medical Oxygen Security assessment, and they have not been edited in any way.

<table>
<tr><th>Domain</th><th>USAID and EpiC/RISE HQ Teams</th><th>MOH/USAID Mission Offices and EpiC/RISE Local Offices</th><th>Oxygen-Related Site/Facility Staff</th></tr>
<tr><td></td><td>Have you experienced any major procurement and/or supply chain challenges in procuring, importing, producing, filling, storing, and/or distributing any oxygen-related products mentioned in selected countries?
If so, describe major barriers.</td><td>Have you experienced any major procurement and/or supply chain challenges in procuring, importing, producing, filling, storing, and/or distributing any oxygen-related products mentioned in [Country X]?
If so, describe major barriers.</td><td>Have you experienced any supply chain issues or stock-outs of oxygen or oxygen-related products at your facility, and if so, describe major barriers.
If the facility didn't experience stock outs, were there significant periods of low supply for oxygen or oxygen-related products?
If so, were the root causes identified for the stock-outs or low supply (e.g., lack of power/generators/fuel, natural disasters, etc.)?</td></tr>
<tr><td></td><td>What actions have been taken and/or resources have been used to mitigate procurement and/or supply chain issues?</td><td>What actions have been taken and/or resources have been used to mitigate procurement and/or supply chain issues?</td><td>What actions have been taken and/or resources have been used to mitigate supply chain issues?</td></tr>
<tr><td></td><td><u>We'd like to ask a few questions about regulation, accountability, and monitoring, thinking about the oversight mechanisms for medical oxygen services:</u>
<u>What accountability mechanisms are in place for medical oxygen security at an international or global level?</u>
<u>Who are the key actors responsible for implementing this?</u>
<u>Who is responsible for regulating medical oxygen?</u>
<u>Probe: including clinical delivery, production, diagnostic devices.</u>
<u>Can you describe your mechanisms for monitoring implementation?</u>
<u>Do you face any challenges in regulation?</u></td><td><u>We'd like to ask a few questions about regulation, accountability, and monitoring, thinking about the oversight mechanisms for medical oxygen services:</u>
<u>What accountability mechanisms are in place for medical oxygen security in [Country X]?</u>
<u>Who are the key actors responsible for implementing this?</u>
<u>Who is responsible for regulating medical oxygen [Country X]?</u>
<u>Probe: including clinical delivery, production, diagnostic devices.</u>
<u>Probe: are these different from regional-level actors?</u>
<u>Can you describe your mechanisms for monitoring implementation?</u>
<u>Do you face any challenges in regulation?</u></td><td><u>We'd like to ask a few questions about regulation, accountability, and monitoring, thinking about the oversight mechanisms for medical oxygen services at your facility:</u>
<u>What accountability mechanisms are in place for medical oxygen security at this facility?</u>
<u>Who are the key actors responsible for implementing this?</u>
<u>Who is responsible for regulating medical oxygen at this facility?</u>
<u>Probe: including clinical delivery, production, diagnostic devices.</u>
<u>Probe: are these different from regional-level actors?</u>
<u>Can you describe your mechanisms for monitoring implementation?</u>
<u>Do you face any challenges in regulation?</u></td></tr>
</table>

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
	Across countries, what have been best practices in procurement and supply chain for oxygen and oxygen-related products? What have been common challenges?	In [*Country X*], what have been best practices in procurement and supply chain for oxygen and oxygen-related products? What have been common challenges?	At your site/facility, what has worked well regarding procurement and supply chain for oxygen and oxygen-related products? And what has been challenging?
(2) Oxygen-Related Activities	Who were the key stakeholders involved in the design and implementation of oxygen-related activities supported by USAID? ● *E.g., USAID, EpiC/RISE/GHSC-PSM, etc.*	Who were the key stakeholders involved in the implementation of oxygen-related activities in [*Country X*]? ● *E.g., USAID, MOH, Global Fund, EpiC/RISE/GHSC-PSM, etc.*	Who were the key stakeholders involved in the implementation of oxygen-related activities at this facility? ● *What are their departments within the facility?* ● *Are there other local institutions involved, for example transportation companies?*

	Which countries were chosen for oxygen-related activities and, as far as you understand, why and how were they selected?
	● *What are key characteristics of each country? (i.e., geographic region, healthcare worker cadre, population served, etc.)*
	● *What methods did you use to focus on health inequities?*
	● *Was there an effort to harmonize multiple stakeholders working on oxygen-related activities?*
	● *Was there an effort to include input from oxygen-related facility-based staff to tailor the activities?*
		Provide a brief overview of oxygen-related activities and how these activities were selected.
		● *What activities are being implemented and where? Installation of LOX/PSA/VSA? Installation of oxygen pipeline systems? Market shaping interventions? Oxygen policies or guidelines developed or adapted?*
		● *Which facilities/sites were chosen [Country X] for oxygen-related activities and how were they selected?*
		● *If so, what are key characteristics of each health facility? (i.e., geographic region, healthcare worker cadre, population served, etc.)*
		  ● *Was there an effort to include input from oxygen-related facility-based staff to tailor the activities?*
		  ● *If so, what additional service delivery details played a role in selecting facilities (e.g., number of inpatient beds, incidence of acute respiratory infections, etc.)*
			Were any site-level staff at this facility involved in the decision-making process of oxygen-related work here?
			● *Was there an effort to include your input to tailor the activities?*
			
			What role does each type of health facility staff member play in oxygen-related activities?
			● *From delivery and receipt of oxygen, to maintaining adequate supply of oxygen, to patient intake, screening, and triaging, to delivering oxygen to patient*

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
		● *What methods did you use to focus on health inequities?* ● *Was there an assessment of ongoing efforts to harmonize multiple stakeholders working on oxygen-related activities?*	
	Was a central oxygen ecosystems technical working group established? ● *Who is part of the technical working group and how were they selected?* ● *How often does the technical working group meet?* ● *What are the main functions of the technical working group?* ● *Describe MOHs' involvement in the technical working group*	What are the national coordinating or regulatory bodies or technical working group for oxygen ecosystems in [*Country X*]? What is the function, composition, and oversight of each coordinating body? ● *Who is part of the coordinating body or technical working group and how were they selected?* ● *Is there an identified point person for oxygen-related activities at the MOH?* ● *How often do the bodies or groups meet?* ● *What are the main functions of the bodies or groups?* ● *Describe MOH's involvement in the bodies or groups*	At this facility, who is the responsible individual or authority for oxygen-related activities? ● *What type is this staff person (e.g., biomedical engineer, biomedical equipment technician, pharmacist, manager, clinician, etc.)?*
(3) Facility-Level Equipment & Maintenance			**For Healthcare Workers:** What has worked well in delivering oxygen to patients since these oxygen-related activities began? And what has been challenging? **For Biomedical Engineers:** What has worked well with maintaining and operating a vacuum insulated evaporator (VIE), pressure swing adsorption (PSA), and/or vacuum swing adsorption (VSA) plant? And what has been challenging? **For Biomedical Equipment Technicians:** What has worked well with maintaining and repairing a vacuum insulated evaporator (VIE), pressure swing adsorption (PSA),

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
			and/or vacuum swing adsorption (VSA) plant? And what has been challenging?
			During the last month, on average how many hours per day was the PSA/VSA plant operational? If 24 hours, what were enablers to this coverage? If less than 24 hours, what were barriers? In a given month, how many power cuts have occurred that resulted in interruption of oxygen delivery to patients?
(4) Training & Workforce	Were any oxygen-related trainings conducted under this USAID support? ● *If so, which topics did they cover?* ● *For which audiences?*	Were any oxygen-related trainings conducted under this USAID support in [*Country X*]? ● *If so, which topics did they cover?* ● *For which audiences?* ● *In your opinion, which were most useful?* ● *Were additional trainings needed or wanted in [Country X]?* ● *Were there other trainings not supported by USAID that also covered oxygen-related topics?*	Were any health care workers, biomedical engineers, biomedical equipment technicians, clinicians, or other staff at this facility trained on oxygen-related topics by EpiC/RISE/GHSC-PSM? ● *If so, which topics did they cover?* ● *What was the format of the trainings (i.e., on-site, virtual, hybrid)?*
	How were oxygen-related training materials developed? ● *Were they adapted for specific audiences (i.e., staff type, country, etc.)?* ● *What were the goals of the trainings from your perspective?*	How were oxygen-related training materials developed or adapted? ● *Were they adapted for [Country X]'s audiences (i.e., staff type, country, etc.)?* ● *What were the goals of the trainings from your perspective?*	Were any facility or site staff included in the development or adaptations of training materials? *Who and how?* ● *What were the goals of the trainings from your perspective?* ● *What was the most impactful or helpful aspect of the trainings?*
		Describe how trainings were conducted: ● *How many trainings? Were there any follow-up trainings?* ● *How many participants per training?* ● *Types of staff members trained?*	If you attended the training(s), can you describe how they were conducted?

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
		• *Training model (i.e., ToT, National, etc.)?*	
	Across country-level oxygen-related trainings, what best practices and common challenges have you identified?	Were participants given pre- and post-tests to measure competency or understanding? Did healthcare workers, biomedical engineers, and biomedical equipment technicians demonstrate increased competency?	**For Healthcare Workers:** After the training, did you feel adequately prepared to deliver oxygen safely to patients? Was the training enough time to learn the material or did you need more/less time? **For Biomedical Engineers:** After the training, did you feel adequately trained to operate a vacuum insulated evaporator for LOX and/or pressure swing adsorption or vacuum swing adsorption plant? **For Biomedical Equipment Technicians:** Did you feel trained to repair or maintain a vacuum insulated evaporator for LOX and/or pressure swing adsorption or vacuum swing adsorption plant?
	What are your recommendations for future oxygen-related trainings?	In [*Country X*], what has worked well in training healthcare workers, biomedical engineers, and biomedical equipment technicians on oxygen-related topics? And what has been challenging?	Have you received training on any SOPs or SOWs? Do you think these materials provide adequate instruction on storing, maintaining, and delivering oxygen safely to patients? If not, how would you have changed these materials?
	Were there goals for human resources in oxygen production, maintenance, and delivery to patients in [Country X]? • *How were these benchmarks established?*	In your opinion, are there sufficient human resources for oxygen production, maintenance, and delivery to patients in [*Country X*]? • *Do you have enough trained biomedical engineers and biomedical equipment technicians to support the needs nationally and in all regions/provinces?*	In your opinion, are there sufficient human resources for oxygen production, maintenance, and delivery to patients at this facility? • *Do you have enough trained clinicians, biomedical engineers, and biomedical equipment technicians to support the needs of patients at this facility?*

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
(5) O2 Policies, Guidelines, and Tools	Were and, if so, how the global clinical guidelines for delivering oxygen to patients used to tailor USAID's oxygen-related program? How and by whom were they developed or adapted? ● *How were the guidelines developed? Did you use any technical guidance (i.e., WHO, FDA, etc.)?* ● *Which stakeholders were involved in the decision-making process?*	What are [*Country* X]'s clinical guidelines for delivering oxygen to patients? How and by whom were they developed or adapted? ● *Are certain populations or age groups prioritized and if so, what were these groups and how were they chosen?* ● *Are there any contraindications for delivering oxygen to patients? If so, how did availability of resources (e.g., evaluation of LOX supply, oxygen cylinders) affect application of those guidelines?* ● *How were the guidelines developed and adapted for [Country X]? Did you use any technical guidance (i.e., WHO, FDA, etc.)?* ● *Are the oxygen clinical guidelines finalized and adopted nationally? Are they incorporated into other national- or sub-national level guidelines?* ● *Which stakeholders were involved in the decision-making process?* ● *Were these guidelines revised at a later date? If so, describe the revisions and how they were made.*	**For Healthcare Workers:** What clinical criteria or guidelines do you as providers use to deliver oxygen to patients? ● *What tools do you use to inform oxygen delivery to patients (i.e., clinical standards/algorithms, and other system support tools)?* ● *Do you receive assistance from above-site technical staff to deliver oxygen to patients (e.g., MOH, EpiC/RISE)?*
	How were the oxygen-related guidelines disseminated to implementing partners and countries?	How were the oxygen-related guidelines disseminated to facilities? Were health facility-based staff trained on these guidelines?	

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
	We'd like to ask a few questions about oxygen policies: ● *Can you tell me about the relevant policies that you work with around medical oxygen services?* ○ *Probe: Who published this policy? Is it an institutional, national, regional or global standard? Was there a political/scientific/economic/logistical reason for this?* ○ *Probe: If none is provided… is this because they do not exist, or they are not relevant to your work?* ● *Are these guidelines/policies reviewed or evaluated?* ○ *Probe: How often? How? By who?* ● *Thinking of your work, are the policies for medical oxygen sufficient?* ○ *Probe: Why/why not?*	Do national plans (e.g., national strategic oxygen plans, PSA/VSA/LOX maintenance plans, other national-level oxygen planning documents, etc.) exist? How and by whom were they developed or adapted? ● *When were they developed?* ● *How were they developed?* ● *How are they used?*	Does this site have a facility-level plan for oxygen? How and by whom was it developed or adapted?
	We'd like to ask a few questions about policy commitment: ● *What are the key areas that you think need to be the focus of any new oxygen policy? E.g. technological approaches, health system strengthening* ● *Which areas do you think current policy is suitable for i.e. which areas do not need changing?* ● *Which areas require further development? why? and how could this be done?*	**We'd like to ask a few questions about policy commitment:** ● *What are the key areas that you think need to be the focus of any new oxygen policy? E.g. technological approaches, health system strengthening* ● *Which areas do you think current policy is suitable for i.e. which areas do not need changing?* ● *Which areas require further development? why? and how could this be done?*	

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
	What oxygen-related tools and resources were developed with support from USAID investment to produce or procure, distribute, and manage stocks of oxygen and deliver it safely to patients and how: ● *Any SOPs? Job aids?* ● *How did you determine which support tools would be needed?* ● *Who led development?* ● *How were existing tools deemed suitable and, if needed, adapted for oxygen-related activities implementation?* ● *Were tools tailored to each country?*	What oxygen-related tools and resources were developed and adapted to produce or procure, distribute, and manage stocks of oxygen and deliver it safely to facilities in [*Country X*] and how: ● *Any SOPs? Job aids?* ● *How did you determine which support tools would be needed?* ● *Who led development?* ● *How were existing tools deemed suitable and, if needed, adapted for oxygen-related activities?* ● *Was there a review process or input from end-users such as BME/Ts or clinicians? Were tools tailored to the specific populations being served by facilities?*	What oxygen-related tools and resources were developed and/or used by this facility to transport and manage stocks of oxygen and deliver it safely to patients? ● *Any SOPs? Job aids? Repair or maintenance logbooks? Purchase order tracking sheets?* ● *Do you use any oxygen demand tracking or forecasting tools?* ● *How are repair and maintenance logs used? Are they useful?* ● *How are purchase order logs for LOX tanks, cylinders, and other upstream sources used? Are they useful?* ● *Who is the audience for each tool?* ● *What is the purpose or intended use of each tool?*
	Overall, did these tools improve oxygen-related activities? Are certain tools more useful or widely used than others?	Overall, did these tools improve oxygen-related activities? Are certain tools more useful or widely used than others?	Which oxygen-related tools do you use most frequently? Which do you find most useful?
(6) Financing &	Describe how market-shaping activities were developed across oxygen ecosystem support countries. ● *What demand generation tools were developed? (e.g., TV ad, radio spots, posters, etc.)* ● *Any activities aimed to weaken oxygen delivery monopolies?* ● *What was the audience for each activity? Were activities tailored to each country?*	What market shaping interventions have been implemented to increase demand for oxygen at a national level in [*Country X*]? ● *What market-shaping activities have been implemented?* ● *Are these activities focused nationally or in specific subregions of the country?*	

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
		<u>**We'd like to ask a few questions about financing, thinking about how medical oxygen services are currently financed:**</u> ● <u>*Where does the funding for medical oxygen come from?*</u> ● <u>*Who are the key actors responsible for oxygen program resourcing?*</u> ○ <u>*Probe: are these different from regional-level actors?*</u> ○ <u>*Probe: How is funding for healthcare provision prioritized?*</u> ● <u>*What are the challenges involved in securing national or local government commitment to oxygen programs?*</u> ● <u>*What are the challenges involved in securing private (including for-profit and not-for profit) funds for oxygen programs locally?*</u> ● <u>*What is the main shortfall in resourcing for oxygen programs?*</u> ○ <u>*Probe: infrastructure, consumables, people*</u>	
	What were best practices across country-level market-shaping activities and what were common challenges?	What has worked well in shaping the oxygen market in [*Country X*]? And what have been challenges?	
(7) Future Translatability & Closing	In your opinion, what have been the major benefits of USAID's oxygen program?	In your opinion, what have been the major benefits of USAID's oxygen program in [*Country X*]?	In your opinion, what have been the major benefits of USAID's oxygen program at this facility?
	What are the ongoing barriers to optimizing robust oxygen ecosystems in the focus countries?	What are the ongoing barriers to optimizing robust oxygen ecosystems in [*Country X*]?	What are the ongoing barriers to optimizing robust oxygen ecosystems at this facility?
	Of all the oxygen related activities we discussed today, which do you think are most essential for developing a sustainable model for oxygen supply and delivery	Of all the oxygen related activities we discussed today, which do you think are most essential for developing a sustainable model for oxygen supply and delivery in	Of all the oxygen related activities we discussed today, which do you think are most essential for developing a sustainable model for oxygen supply and delivery at

Domain	USAID and EpiC/RISE HQ Teams	MOH/USAID Mission Offices and EpiC/RISE Local Offices	Oxygen-Related Site/Facility Staff
	globally? Why? Why were others not as important?	[*Country X*]? Why? Why were others not as important?	your facility? Why? Why were others not as important?
	Going forward, what would be your recommendations for the biggest priorities in oxygen system investments in the focus countries?	Going forward, what would be your recommendations for the biggest priorities in oxygen system investments in [*Country X*]?	Going forward, what would be your recommendations for the biggest priorities in oxygen system investments at this facility?
	We'd like to ask a few questions focusing in on [*Case Study*] in [*Country X*]: ● *In your view, what were the key contextual factors that led to success?* ● *In your view, were there any obstacles to this success? How were they overcome?* ● *Do you think this approach could be adapted in other contexts?* ● *Which contexts, why? What key lessons could you share?* ● *How do you plan to sustain this success?*	**MOH Only:** Does the MOH in [*Country X*] plan to continue oxygen ecosystem activities after end of USAID's-funded program? ● *If YES, how will the MOH ensure the sustainability, including national and facility leadership, presence of sustainability plans and ongoing funding mechanism(s)?* ● *If YES, will the oxygen-related activities be adapted or remain as it is currently implemented? How will adaptation occur and what elements of the program would be retained after the USAID-funding ends?* ● *If NO, why not? What are the reasons that make it unlikely for this program to be continued?*	
	Is there anything else you would like to discuss/share that we did not cover in this interview?	Is there anything else you would like to discuss/share that we did not cover in this interview?	Is there anything else you would like to discuss/share that we did not cover in this interview?

Project Background and Contact Information (to be printed and provided to key informants)

Project Background

You are being interviewed by a member of the review team at UCSF in support of the USAID Sustaining Technical and Analytic Resources (STAR) project. Part of this project is dedicated to conduct a program review of programs aimed at improving the oxygen ecosystems in select countries. The purpose of this program review is to assess the implementation of those oxygen-related activities, including procurement and supply chain logistics, trainings of engineers and other facility-based staff, infrastructure support and development, oxygen-related policies and guidelines technical assistance, market-shaping activities, and more.

Information about your interview:

The interview should take between thirty to ninety minutes of your time and your participation is 100% voluntary. We will not be recording your name or other personally-identifying information about you. The interview will be audio-recorded to ensure the accuracy of our conversation today in the interview notes. At the end of the project period, the recording will be deleted in all forms. You may skip questions or stop at any time. You will not be given any money to participate.

If you agree to take part in the interview, we want you to share your perceptions, experiences, and opinions about the oxygen ecosystem program. The information that you provide should not harm you in any way. Similarly, there is no direct benefit to you in taking part, other than helping the review team assess the implementation of oxygen ecosystem strengthening activities funded by USAID.

All information generated will be secure, and anonymity of those taking part will be protected. Only the assessment team will have access to the interview data. Feedback on our overall findings will be provided to USAID, oxygen ecosystem implementing partners, Ministries of Health, and other key stakeholders. As stated above, your name or any other personal information about you will not be recorded. Results will be aggregated to the national-level and above before reporting to others. De-identified findings may be shared and/or published publicly, pending agreement from key stakeholders.

Your taking part in the interviews will indicate that you have had the opportunity to ask any questions and that they have been answered to your satisfaction. If you have any further questions, please refer to the contact information provided. Informed consent will be recorded on your behalf.

Contact Information:

Principal Investigator:	Interviewer 1:	Interviewer 2:
Email:	Email:	Email:

7. Emails Sent to Delphi Participants

First Round

Dear Colleague:

We are working as part of a review team at University of California, San Francisco (UCSF) in support of the USAID Sustaining Technical and Analytic Resources (STAR) project. At the request of USAID, part of this project is dedicated to conducting a survey of key stakeholders involved in implementation and support of medical oxygen delivery in select participating countries. Specifically, this survey focuses on eliciting perspectives on the appropriateness and feasibility of specific metrics (i.e., key performance indicators) for monitoring and evaluation of medical oxygen delivery ecosystems.

The survey consists of two rounds. During the first round you will be asked to rate the appropriateness and feasibility of key performance indicators (KPIs) for monitoring and evaluation of medical oxygen delivery ecosystems. You will also be given the opportunity to suggest additional key performance indicators which will then be rated for appropriateness and feasibility during the second round. We estimate each round will take less than 20 minutes of your time.

Your participation is 100% voluntary. Everything you share will be secure and anonymous. Overall findings will be de-identified, summarized, and included in our overall program review report to USAID, who may then choose to disseminate aggregate findings to implementing partners or ministries of health. This survey has been given a non-human subjects research determination by the Internal Review Board at UCSF as its primary focus is programmatic quality improvement. If you have any questions, please contact Priya Shete at [insert email here] or Sky Vanderburg at [insert email here].

Click on this link to begin the survey: [insert link here]. To ensure your responses are included in the first round, please complete the survey by January 28th, 2024.

Thank you in advance for taking the time to complete this survey! We look forward to hearing from you!

Sincerely,
The UCSF-STAR Oxygen Review Team

Second Round (not yet conducted, postponed until further into program implementation)

Dear Colleague:

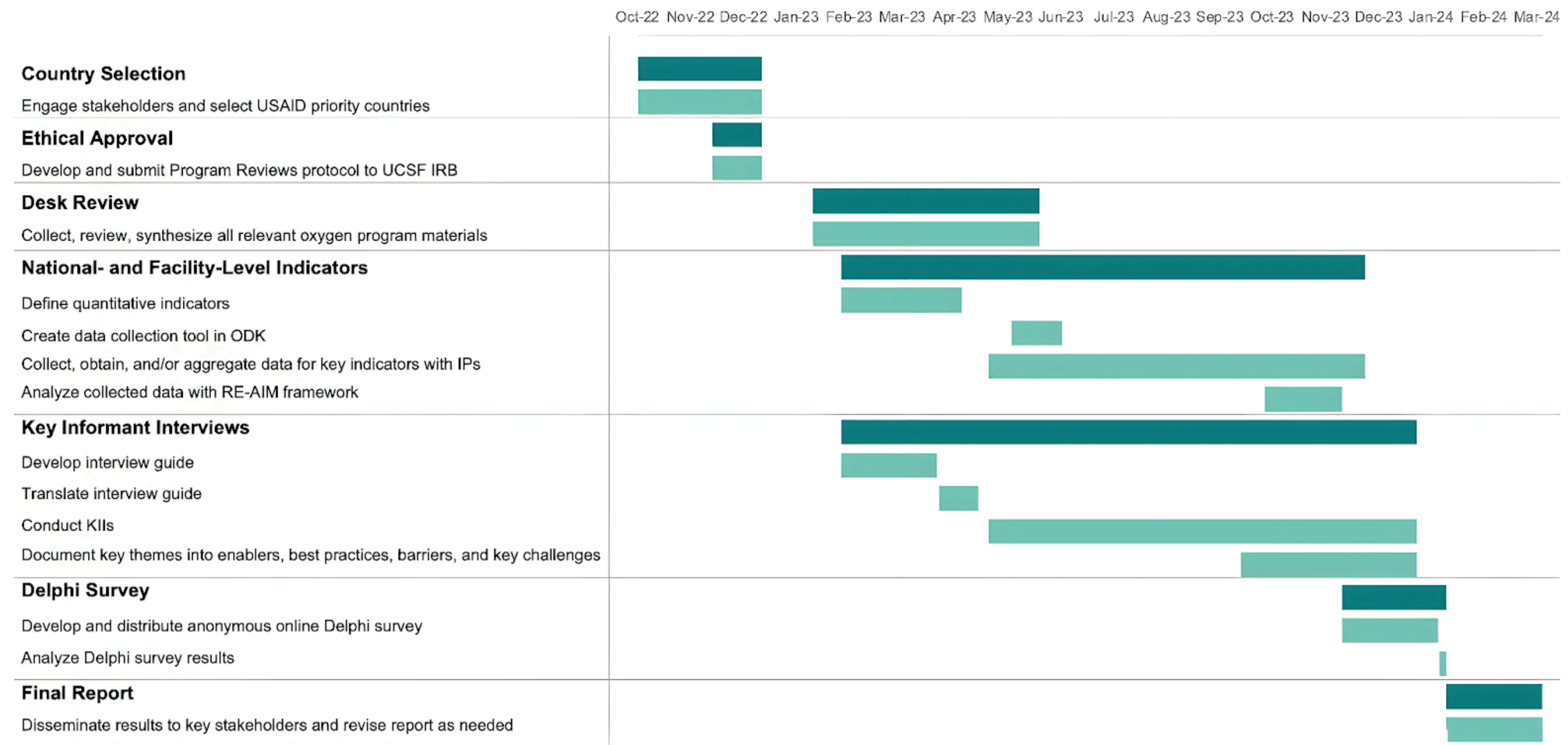
Thank you for completing round one of this survey. Many of you suggested additional key performance indicators (KPIs) for monitoring and evaluation of medical oxygen delivery ecosystems. For the final survey round, we ask that you also rate the appropriateness and feasibility of these suggested KPIs.

Click on this link to begin the survey: [insert link here]. To ensure your responses are included in the first round, please complete the survey by TBD.

Thank you in advance for taking the time to complete this survey! We look forward to hearing from you!

Sincerely,
The UCSF-STAR Oxygen Review Team

8. Timeline of Oxygen Programs Interim Review Activities



9. Desk Review Table

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
1	Vietnam LOX Infrastructure Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	7/21/2022	Country-Specific	Vietnam
2	Mozambique O2 Clinical High-Level Workplan.pdf	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	7/16/2021	Country-Specific	Mozambique
3	Mozambique_Final_Oxygen Ecosystem Non-Clinical TA Workplan.xlsx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	4/2/2021	Country-Specific	Mozambique
4	Mozambique LOX Assessment Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	10/5/2022	Country-Specific	Mozambique
5	MOZAMBIQUE EpiC COVID Market Shaping Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	8/8/2022	Country-Specific	Mozambique
6	Mozambique Oxygen Dashboard Goals, Impact, and Findings RISE.pptx	Yes	EN	Presentation	Oxygen Dashboard	USAID, Country-Level Stakeholders, MOHs	6/1/2022	Country-Specific	Mozambique
7	RISE COVID_Mozambique_Emergency Response_Workplan_Revised_1 Mar 2022.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	3/1/2022	Country-Specific	Mozambique
8	RISE Mozambique_COVID ARPA_Workplan_RVSD_12 Oct 2021.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	9/26/2021	Country-Specific	Mozambique

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
9	Ghana O2 Clinical High-Level Workplan v.3.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	7/12/2021	Country-Specific	Ghana
10	Ghana_ Final_Oxygen Ecosystem Non-Clinical TA Workplan.xlsx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	7/5/2021	Country-Specific	Ghana
11	Oxygen RISE assessment work.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	NA	Country-Specific	Ghana
12	Ghana LOX Workplan_27 Oct 2022.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (Epic/RISE/ GHSC-PSM)	10/27/2022	Country-Specific	Ghana
13	Final V4 RISE Ghana PSA Installation Workplan1.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	2/21/2023	Country-Specific	Ghana
14	RISE Ghana Oxygen Infrastructure.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	9/3/2021	Country-Specific	Ghana
15	Medical Gas System Training RISE Rikair	No	EN	Training Material	Medical Oxygen Systems	HCWs, MOHs	NA	Country-Specific	Ghana
16	Oxygen Concentrators Primer RISE Rikair	No	EN	Training Material	Medical Oxygen Systems: Oxygen Concentrators	HCWs, MOHs, Maintenance Teams	4/1/2022	Country-Specific	Ghana
17	Oxygen therapy and role of technology in management of severe COVID19 RISE	No	EN	Training Material	Clinical Management	HCWs	NA	Country-Specific	Ghana
18	Oxygen Therapy - Techiman, RISE	No	EN	Training Material	Clinical Management	HCWs	9/1/2018	Country-Specific	Ghana

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
19	Airway, breathing and oxygen therapy - RISE	No	EN	Training Material	Clinical Management	HCWs	3/18/2022	Country-Specific	Ghana
20	Join clinical and non-clinical training on medical gas management RISE	No	EN	Training Material	Medical Oxygen Systems	HCWs, MOHs, Maintenance Teams	NA	Country-Specific	Ghana
21	Ghana LOX health facility assessment - Baseline.pdf	No	EN	Report	LOX Facility Assessment	USAID, IPs (EpiC/RISE/ GHSC-PSM), MOHs	12/1/2022	Country-Specific	Ghana
22	New O2 Needs New Skills - Nov22- Ghana - approved final.pdf	Yes	EN	Report	Investment Impact	General Public	11/1/2022	Country-Specific	Ghana
23	Côte d_Ivoire LOX Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	7/20/2022	Country-Specific	CDI
24	Malawi LOX Assessment Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	5/13/2022	Country-Specific	Malawi
25	MALAWI EpiC COVID Market Shaping Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	8/9/2022	Country-Specific	Malawi
27	DRC EpiC COVID Market Shaping Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	8/8/2022	Country-Specific	DRC
28	DRC LOX Infrastructure Workplan.docx	No	EN	IP Workplan/SOW	Workplan: Objectives & Activities	USAID, IPs (EpiC/RISE/ GHSC-PSM)	9/20/2022	Country-Specific	DRC
29	LOX Rapid Assessment Summary Slides- 26 countries.pptx	No	EN	Presentation	LOX Facility Assessment	USAID, IPs (EpiC/RISE/ GHSC-PSM)	2/1/2022	Country-Specific	CDI, Ghana, Malawi, Mozambique,

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
									Vietnam, DRC
30	Acute Hypoxia Course RISE	No	EN	Training Material	Clinical Management	HCWs	NA	Generic	
31	RISE Oxygen Ecosystem Briefer_Dec 2022.pdf	No	EN	Report	Oxygen Ecosystem	General Public	12/1/2022	Generic	
32	USAID guidance on oxygen ecosystem (NT, GS, BH).mp4	Yes	EN	Presentation	Oxygen Ecosystem	IPs (EpiC/RISE/ GHSC-PSM), USAID, Country-Level Stakeholders	10/4/2021	Generic	
33	Consumption comparison.pdf	Yes	EN	Fact Sheet	Medical Oxygen Systems	HCWs, MOHs, Country-Level Stakeholders	NA	Generic	
34	Johns Hopkins RISE COVID 19 Oxygen Resources.docx.pdf	Yes	EN	Guidance Document	Oxygen Ecosystem	HCWs, MOHs, Country-Level Stakeholders	4/1/2021	Generic	
35	RISE Liquid Oxygen Brochure	Yes	EN	Fact Sheet	Medical Oxygen Systems: LOX	HCWs, MOHs, Country-Level Stakeholders	NA	Generic	
36	AirSep PSA Responsibility Matrix_General_Jhpiego and PSM.xlsx	Yes	EN	Implementa-tion Plan/ Framework	Medical Oxygen Systems: PSA	IPs (EpiC/RISE/ GHSC-PSM)	NA	Generic	
37	RISE PSA Plant Brochure	Yes	EN	Fact Sheet	Medical Oxygen Systems: PSA	HCWs, MOHs, Country-Level Stakeholders	NA	Generic	
38	Oxygen delivery modalities_RISE 4 Oct 2021.pptx	Yes	EN	Training Material	Medical Oxygen Systems	HCWs, MOHs, Country-Level Stakeholders	10/4/2021	Generic	

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
39	RISE NEST360 Job Aid Flow Splitter Illustrator.pdf	Yes	EN	Job Aid	Medical Oxygen Systems: Flow Splitter	HCWs, MOHs, Country-Level Stakeholders	NA	Generic	
40	PATH O2 generation and storage report 2021.pdf	Yes	EN	Guidance Document	Medical Oxygen Systems	MOHs, Country-Level Stakeholders	7/1/2021	Generic	
41	LHSS C19 Learning Activity_Workshop Book_GHANA_05NOV23	No	EN	Report	Oxygen Ecosystem	USAID	11/1/2023	Country-Specific	Ghana
42	REPORT_ASSESSMENT of NEWBORN MEDICAL EQUIPMENT in GHANA_2023_FINAL	Yes	EN	Report	Oxygen Ecosystem	Country-Level Stakeholders	6/1/2023	Country-Specific	Ghana
43	EpiC Vietnam_ARPA_COVID_CN 164_Narrative Workplan_Mod 1_5.15.2023.pdf	No	EN	IP Workplan/SOW	COVID-19 Emergency Response	USAID	5/15/2023	Country-Specific	Vietnam
44	EpiC-Vietnam-COVID-19 CN 165 ARPA Workplan_Mod 1_5.15.2023.pdf	No	EN	IP Workplan/SOW	COVID-19 Emergency Response	USAID	5/15/2023	Country-Specific	Vietnam
45	Vietnam LOX Assessment Workplan_Mod 1_8.1.2023.pdf	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID	8/1/2023	Country-Specific	Vietnam
46	Mozambique meeting new demands for PPE, vaccines, oxygen and emergency supply chain response technical brief December 2022	Yes	EN	Report	Oxygen Ecosystem investment impact	General Public	12/1/2022	Country-Specific	Mozambique

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
47	EpiC Mozambique LOX Infrastructure Workplan_Approved_4.7.2023.pdf	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (Epic/RISE/ GHSC-PSM)	4/7/2023	Country-Specific	Mozambique
48	FINAL RISE COVID Mozambique Emergency Response Workplan.docx	No	EN	IP Workplan/SOW	COVID-19 Emergency Response	USAID, IPs (EpiC/RISE/ GHSC-PSM)	3/1/2022	Country-Specific	Mozambique
49	FINAL RISE Mozambique_COVID ARPA_Workplan_RVSD_USAID feedback.docx	No	EN	IP Workplan/SOW	COVID-19 Emergency Response	USAID, IPs (EpiC/RISE/ GHSC-PSM)	11/23/2021	Country-Specific	Mozambique
50	RISE Mozambique GF TA Mocuba O2 (8 November 2022).docx	No	EN	IP Workplan/SOW	Non-clinical TA	USAID, IPs (EpiC/RISE/ GHSC-PSM)	11/8/2022	Country-Specific	Mozambique
51	EpiC LOX Sites in Malawi.HEIC	No	EN	Implementation Plan/Framework	LOX Sites Details	USAID, IPs (EpiC/RISE/ GHSC-PSM)	NA	Country-Specific	Malawi
52	Map of Malawi showing oxygen investments.HEIC	No	EN	Implementation Plan/Framework	Oxygen investments	USAID, IPs (EpiC/RISE/ GHSC-PSM)	NA	Country-Specific	Malawi
53	EpiC Malawi Market Shaping Workplan_Mod 1_11.2.2023.docx	No	EN	IP Workplan/SOW	Market Shaping	USAID, IPs (EpiC/RISE/ GHSC-PSM)	11/2/2023	Country-Specific	Malawi
54	Malawi LOX Infrastructure Workplan_Mod 1_10.10.2023.docx	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (EpiC/RISE/ GHSC-PSM)	10/10/2023	Country-Specific	Malawi
55	RISE Ghana Ad Hoc GF TA Workplan Bole PSA Plant (24 April 2023).docx	No	EN	IP Workplan/SOW	PSA Plants	USAID, IPs (EpiC/RISE/ GHSC-PSM)	4/24/2023	Country-Specific	Ghana

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
56	RISE Ghana Revised LOX Workplan (27 January 2023).docx	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (EpiC/RISE/ GHSC-PSM)	1/27/2023	Country-Specific	Ghana
57	RISE Ghana Revised O2 Assessment Workplan (24 March 2023).docx	No	EN	IP Workplan/SOW	Oxygen Ecosystem Assessment	USAID, IPs (EpiC/RISE/ GHSC-PSM)	3/24/2023	Country-Specific	Ghana
58	EpiC DRC LOX Market Shaping Workplan DRC_Mod 2_11.9.2023.docx	No	EN	IP Workplan/SOW	Market Shaping	USAID, IPs (EpiC/RISE/ GHSC-PSM)	11/9/2023	Country-Specific	DRC
59	EpiC DRC_LOX Infrastructure Workplan_Mod 1_10.4.2023.docx	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (EpiC/RISE/ GHPSM)	10/4/2023	Country-Specific	DRC
60	EpiC Côte d'Ivoire LOX TA Workplan_Final_1.11.2023.pdf	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (EpiC/RISE/ GHSC-PSM)	1/11/2023	Country-Specific	CDI
61	EpiC Côte d'Ivoire LOX Workplan_Mod 1_6.27.2023_FINAL.pdf	No	EN	IP Workplan/SOW	LOX Infrastructure	USAID, IPs (EpiC/RISE/ GHSC-PSM)	6/27/2023	Country-Specific	CDI
62	OxygenCalculator.org	Yes	EN, FR, PT, VN	Job Aid	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, General Public, Country-level stakeholders	NA	Generic	
63	Oxygen delivery show and tell video	Yes	EN, FR	Presentation	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, General Public, Country-level stakeholders	NA	Generic	

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
64	Oxygen graphics toolkit	Yes	EN	Job Aid	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, General Public, Country-level stakeholders	NA	Generic	
65	Oxygen FAQ	Yes	EN, FR, PT, VN	Job Aid	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, General Public, Country-level stakeholders	NA	Generic	
66	Considerations when buying an oxygen concentrator	Yes	EN, FR, PT, VN	Fact Sheet	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, Country-level stakeholders	NA	Generic	
67	Top ways for conserving oxygen	Yes	EN, FR, PT VN	Fact Sheet	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, Country-level stakeholders	NA	Generic	
68	Oxygen Encyclopedia		EN, FR, PT, VN	Job Aid	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, General Public, Country-level stakeholders	NA	Generic	
69	Facility level respiratory care commodity quantification tool	Yes	EN	Job Aid	Medical Oxygen Systems	IPs, HCWs, Maintenance Teams, Country-level stakeholders	NA	Generic	

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
70	Ghana National Oxygen Roadmap	Yes	EN	Implementation Plan/Framework	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	1/1/23	Country-Specific	Ghana
71	Ghana Medical Oxygen Operational Development Plan Framework 2022	Yes	EN	Implementation Plan/Framework	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	6/3/2023	Country-Specific	Ghana
72	Ghana Oxygen Operational Plan	Yes	EN	Implementation Plan/Framework	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	NA	Country-Specific	Ghana
73	Vietnam National Oxygen Roadmap	Yes	VN	Implementation Plan/Framework	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	5/9/2021	Country-Specific	Vietnam
74	Medical oxygen equipment management strategy and roadmap Mozambique GHSC-PSM	Yes	EN	Implementation Plan/Framework	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	12/5/2023	Country-Specific	Mozambique
75	Strengthening medical oxygen ecosystems EpiC	Yes	EN	Report	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	NA	Generic	
76	Emergency supply chain playbook GHSC-PSM	Yes	EN, FR	Implementation Plan/Framework	COVID-19 Emergency Response	IPs, Country-level stakeholders, MOHs	1/18/2024	Generic	
77	MTaPS Quality Assurance Practices for Medical Oxygen Systems	Yes	EN	Report	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	7/20/2023	Generic	
78	EpiC LOX Rapid Assessment Tool	No	EN, FR, ES, PT	Data Collection Tool	LOX Facility Assessment	IPs, USAID	NA	Generic	
79	Malawi National Oxygen Usage Guidelines 2022	No	EN	Guidance Document	Clinical Management	IPs, Country-level stakeholders, MOHs	1/1/2023	Country-Specific	Malawi

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
80	Malawi COVID-19 Case Management Manual	No	EN	Guidance Document	Clinical Management	IPs, Country-level stakeholders, HCWs	9/1/2020	Country-Specific	Malawi
81	Malawi National Medical Oxygen Roadmap 2021-2026	Yes	EN	Guidance Document	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	10/1/2021	Country-Specific	Malawi
82	Malawi MOH oxygen indicators list	No	EN	Data Collection Tool	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	NA	Country-Specific	Malawi
83	Interview guide for LOX Rapid Assessment Tools	No	EN	Data Collection Tool	LOX Facility Assessment	IPs, USAID	NA	Generic	
84	Assessing Medical Oxygen Ecosystem: Tools from National to Primary Health Care Levels - LOX Assessment Tools & Oxygen and COVID19 Response Rapid Assessment Tools	Yes	EN	Data Collection Tool	LOX Facility Assessment	IPs, USAID	3/1/2022	Generic	
85	Addendum of indicator reference sheets for covid-19 reporting by USG projects	Yes	EN	Data Collection Tool	Medical Oxygen Systems	IPs, USAID	10/31/2022	Generic	
86	Call for expressions of interest for the delivery of LOX in Mozambique	Yes	EN	Press Release/Advert	Medical Oxygen Systems	Country-level stakeholders	6/20/2023	Country-Specific	
87	USAID Press release T2T and O2 Programming Countries	Yes	EN	Press Release/Advert	Medical Oxygen Systems	General Public	9/23/2022	Generic	Mozambique
88	USAID COVID-19 Saving Lives Now - Oxygen Indicators	No	EN	Data Collection Tool	Medical Oxygen Systems	IPs, USAID	10/31/2022	Generic	

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
89	PATH Assessment Report on the Availability of Oxygen and Biomedical Equipment in Health Facilities: DRC Facility Survey Report	Yes	EN, FR	Report	LOX Facility Assessment	IPs, Country-level stakeholders, MOHs	3/1/2022	Country-Specific	DRC
90	PATH Malawi National Medical Equipment Baseline Inventory Report 2022	Yes	EN, FR	Report	LOX Facility Assessment	IPs, Country-level stakeholders, MOHs	3/1/2022	Country-Specific	Malawi
91	Malawi LOX Facility Assessment Tool	No	EN	Data Collection Tool	LOX Facility Assessment	IPs, USAID	NA	Country-Specific	Malawi
92	Planning guide: setting up LOX systems in hospitals in LMICs	Yes	EN	Guidance document	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	8/1/2023	Generic	
93	EpiC Oxygen Quality Assurance Tool	Yes	EN	Data Collection Tool	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	12/1/2021	Generic	
94	Ghana Health Service / Jhpiego Supportive Supervision Checklist Basic Critical Care Training for Health Facility Staff	No	EN	Data Collection Tool	Facility Assessment	IPs, Country-level stakeholders	NA	Country-Specific	Ghana
95	National Oxygen Assessment Report - Mozambique - Chemonics	No	EN	Report	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	11/23/2022	Country-Specific	Mozambique
96	Firm Fixed Price Technical Services Contract	No	EN	RFP/Contract	Medical Oxygen Systems	IPs	7/20/2023	Country-Specific	Ghana
97	Liquid Medical Oxygen (LMO) Cryogenic Storage Tanks RFP	No	EN	RFP/Contract	Medical Oxygen Systems	IPs	2/1/2022	Country-Specific	Ghana

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
98	WHO SARI Toolkit	Yes	EN, FR, SP, PT	Job Aid	Clinical Management	General Public	4/1/2022	Generic	
99	Rapid Oxygen and COVID-19 Response Assessment Tool: Provincial and Site Readiness	No	VN, EN	Data Collection Tool	Facility Assessment	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
100	MOH - Medical oxygen systems at health facilities presentation	No	VN	Presentation	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	NA	Country-Specific	Vietnam
101	MOH Decision on establishing medical oxygen coordination working group	No	VN	Report	Medical Oxygen Systems	IPs, MOHs, Country-Level Stakeholders	NA	Country-Specific	Vietnam
102	MOH Guideline on COVID-19 diagnosis and treatment (ver 2022)	No	VN	Guidance document	Clinical Management	IPs, Country-level stakeholders, MOHs, Clinicians	NA	Country-Specific	Vietnam
103	MOH Oxygen estimation guidance	No	ENG	Guidance document	Medical Oxygen Systems	IPs, MOHs, Country-Level Stakeholders	NA	Country-Specific	Vietnam
104	MOH_Ensuring medical oxygen for COVID treatment and intensive care	No	VN	Presentation	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs, Clinicians	NA	Country-Specific	Vietnam
105	Prime Minister's Draft Guidelines - "Safely Adapting to COVID-19	No	EN	Guidance document	Medical Oxygen Systems	MOHs, Country-Level Stakeholders	NA	Country-Specific	Vietnam
106	MOH Oxygen Equipment list and prices	No	VN	Guidance document	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs, Clinicians	NA	Country-Specific	Vietnam
107	MOH Proposal of enhancing oxygen capacity in health facilities	No	VN	Guidance document	Medical Oxygen Systems	IPs, MOHs, Country-Level Stakeholders	NA	Country-Specific	Vietnam

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
108	Regulations and safety for LOX in Vietnam - Online Course (Outline)	No	EN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
109	Regulations and Safety for LOX in Vietnam - Course Manual	No	EN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
110	Regulations and safety for LOX in Vietnam - Course slides	No	VN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
111	Introduction to medical oxygen and oxygen ecosystems - Course Manual	No	EN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
112	Introduction to medical oxygen- Course outline	No	EN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
113	Introduction to medical oxygen and oxygen ecosystems - Course Slides Lessons 1-4	No	VN	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Vietnam
114	RISE Oxygen Dashboard: Goals, inputs and findings	No	EN	Presentation	Medical Oxygen Systems	IPs, Country-level stakeholders	6/1/2022	Country-Specific	Mozambique
115	RELATÓRIO DE IMPLEMENTAÇÃO DO DASHBOARD DE OXIGÉNIO DE 02 FASE I	No	PT	Guidance document	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Mozambique
116	RISE O2 MER Indicators	No	EN	Presentation	Medical Oxygen Systems	IPs, Country-level stakeholders	10/9/2023	Generic	

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
117	Instruction Manual for Oxygen Ecosystems	Yes	PT	Guidance document	Medical Oxygen Systems	IPs, Country-level stakeholders, MOHs	1/1/2024	Country-Specific	Mozambique
118	Oxygen Concentrators Management Course	Yes	PT	Presentation	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Mozambique
119	Oxygen Concentrators Management Course - guide	Yes	PT	Training Material	Medical Oxygen Systems	IPs, Country-level stakeholders	NA	Country-Specific	Mozambique
120	Nampula Clinical Training Trip Summary	No	EN	Report	Medical oxygen systems	IPs	2/16/2021	Country-Specific	Mozambique
121	Ministry of Health - Evaluation and management of patients with COVID19	No	PT	Guidance document	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	4/1/2021	Country-Specific	Mozambique
122	Hospital discharge criteria for cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique
123	Hospital admission criteria for adult cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique
124	Hospital admission criteria for pediatric cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique
125	Management of adult cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique
126	Management of pediatric cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique

#	Document Name	Publicly Available	Language	Category	Subject Matter	Audience(s)	Date	Generic or Country-Specific	Country (if applicable)
127	Management of critically ill cases of COVID19	No	PT	Job Aid	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	11/27/2020	Country-Specific	Mozambique
128	Skills for initial care of critical or unstable patients	No	PT	Guidance document	Clinical Management	HCWs, MOHs, Country-Level Stakeholders	NA	Country-Specific	Mozambique

EN = English; FR = French; PT = Portuguese; VN = Vietnamese; ES = Spanish

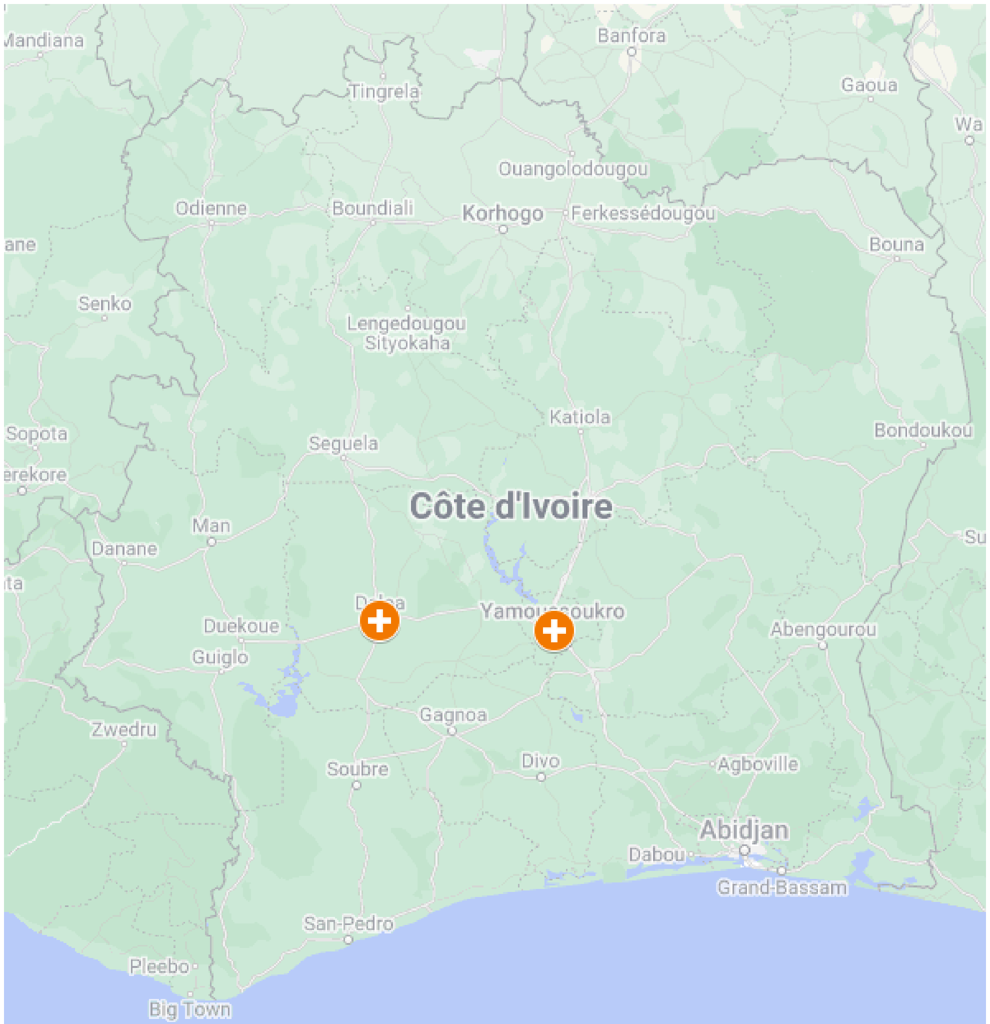
10. Appropriateness and Feasibility Ratings of 24 WHO Medical Oxygen Ecosystem KPIs

Key Performance Indicator	Sum of appropriateness/ feasibility	Product of appropriateness /feasibility
1. Total amount of medicinal oxygen produced and/or stored (in m3) by the commissioned oxygen system (new/repaired) per 24 hours out of all the medicinal oxygen that is needed (in m3) per 24 hours at a given facility.	8	16
2. Number of health facilities that received technical support (e.g. biomedical or mechanical engineering) for maintaining oxygen systems out of the total number of health facilities with oxygen systems.	8	16
3. Number of hours per day that the oxygen system (new/repaired) is operating.	8	16
4. Number of oxygen systems (new/repaired) that remain functional 1 year after installation/repair.	8	16
5. Number of oxygen systems that are non-functional due to a lack of reliable and continuous electricity out of the total number of oxygen systems that are non-functional (for any reason)	8	16
6. Amount of medicinal oxygen consumed (in m3) per 24 hours out of all the medicinal oxygen that is produced and/or stored (in m3) by the commissioned oxygen system (new/repaired) per 24 hours at a given facility.	8	16
7. Inclusion of oxygen on the Essential Medicines List (EML) in countries with oxygen investments.	10	25
8. Number of beds at the facility equipped with a functional oxygen supply out of the total number of beds at the facility.	10	25
9. Number of clinical staff trained on oxygen therapy at the facility level out of the total number of clinical staff at the facility level.	9	20
10. Number of countries that have oxygen included as part of national health strategy documents and/or plans.	10	25
11. Number of countries that include aspects of the oxygen ecosystem in their health financing.	8	16
12. Number of health facilities with functional oxygen systems out of the total number of health facilities.	9	20
13. Number of technical staff trained on oxygen systems operation and	9	20

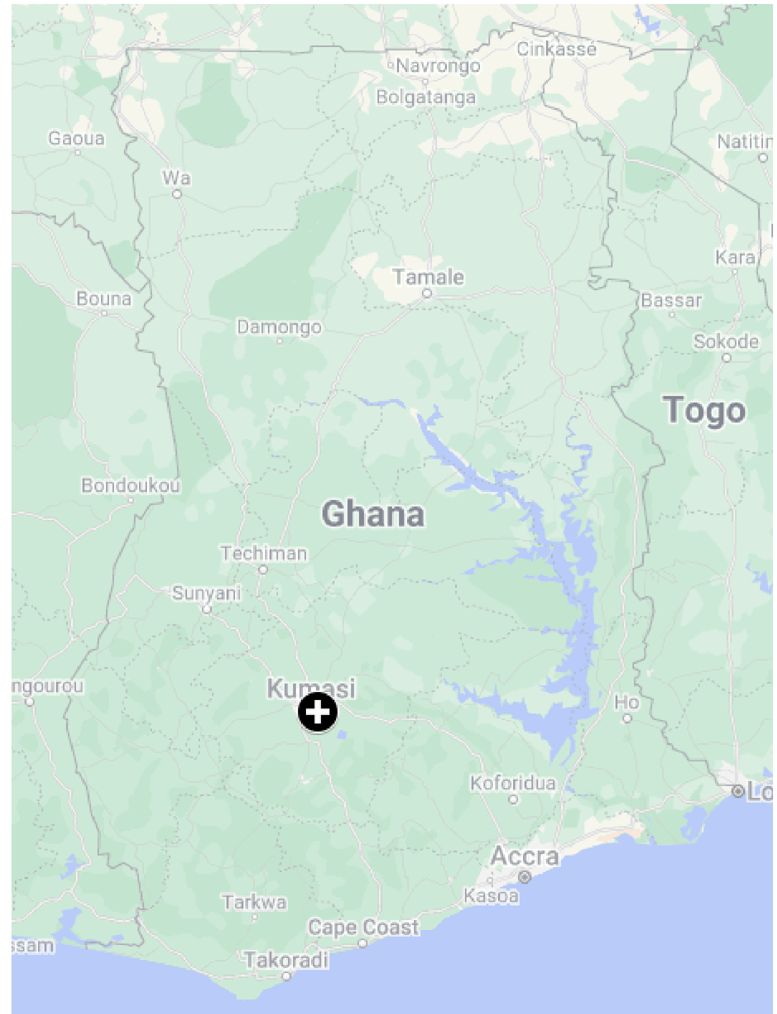
Key Performance Indicator	Sum of appropriateness/ feasibility	Product of appropriateness /feasibility
maintenance at the facility level out of the total number of technical staff at the facility level.		
14. Number of health facilities that have functional oxygen analyzers and other testing and maintenance tools out of all health facilities supplying oxygen.	8	16
15. Number of hospitalized patients receiving oxygen therapy and having their oxygen saturation monitored at least twice per 24 hours out of the number of hospitalized patients receiving oxygen therapy.	7	14
16. Number of COVID-19 patients treated with oxygen therapy (by any delivery device; including nasal canula; HFNC; BiPAP; CPAP; IMV; etc.) at the facility out of all COVID-19 patients needing oxygen therapy.	8	16
17. Number of patients that have had their oxygen saturation monitored with pulse oximetry at their first point of contact at facility per 24 hours out of the total number of patients evaluated at first point of contact per facility.	8	16
18. Number of patients treated with oxygen therapy (by any delivery device; including nasal canula; HFNC; BiPAP; CPAP; IMV; etc.) at the facility out of all patients needing oxygen therapy at the facility.	8	16
19. Number of health facilities that have functional pulse oximeters out of all facilities.	8	16
20. Number of hospitalized patients receiving oxygen with $SpO_2 < 93\%$ at 24 hours post-admission out of the total number of hospitalized patients receiving oxygen therapy.	7	12
21. Time it takes for the items to arrive at the facility from the destination agreed to in the purchase order (for orders where destination agreed in purchase order is not facility).	6	9
22. Number of goods that have been delivered out of all goods ordered.	8	16
23. Value of funds awarded for the procurement of oxygen supplies out of all funds made available for procurement of oxygen supplies.	6	9
24. Value of funds spent for procurement of oxygen supplies out of the total funds awarded for procurement of oxygen supplies.	7	14

11. Maps of Oxygen Health Facilities Included in the Interim Program Review

Health facilities (2) included in the Review in Côte d'Ivoire, May 2023.

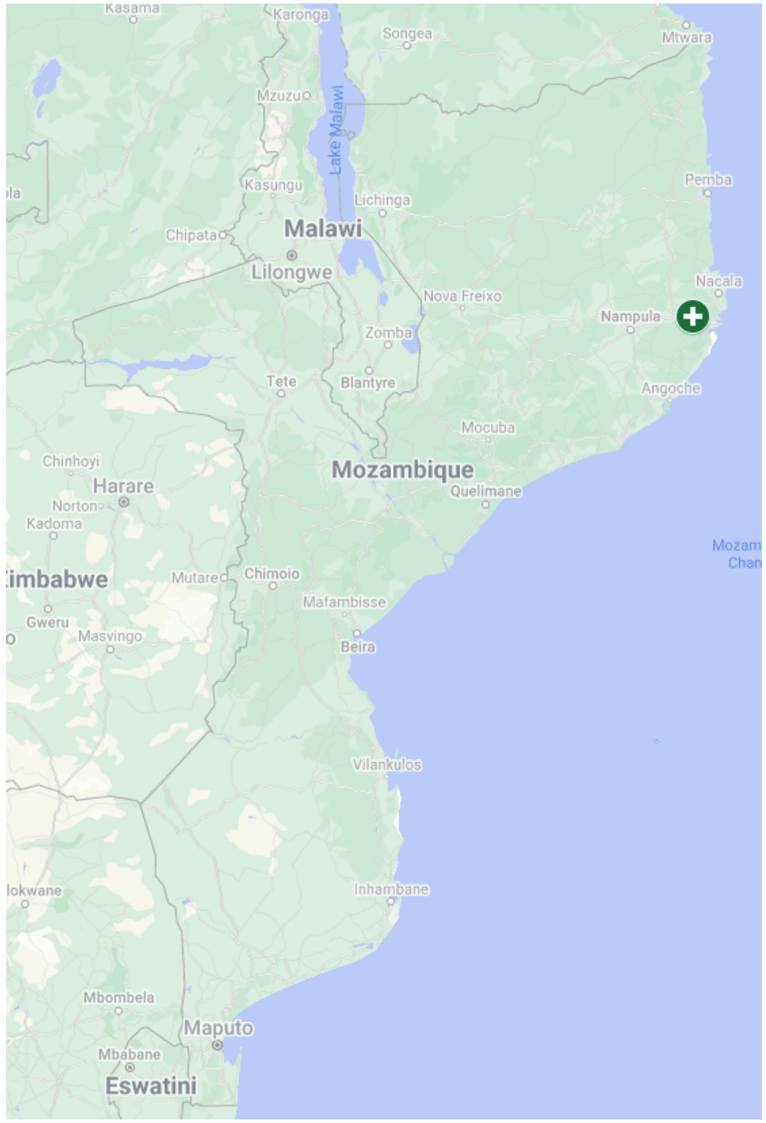


Health facility (1) included in the Review in Ghana, January 2024.

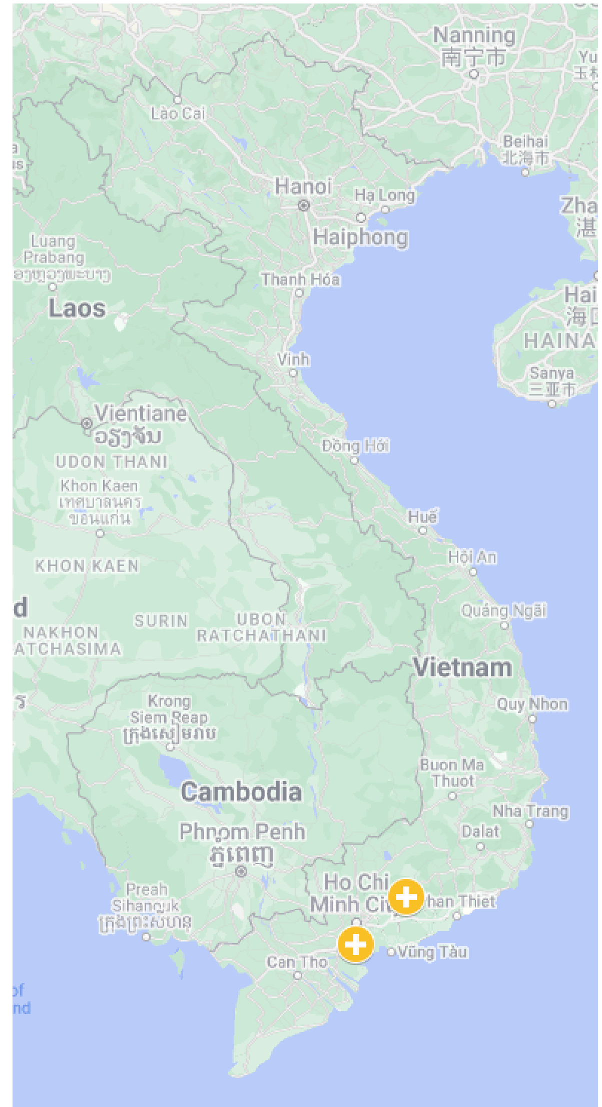


Health facilities (2) included in the Review in Malawi, September 2023.

Health facility (1) included in the Review in Mozambique, September 2023.



Health facilities (2) included in the Review in Vietnam, August 2023.



12. LOX Sites in Interim Program Review Countries

Côte d'Ivoire						
Facility name	*Type of health facility*	*Consumption of medical oxygen*	*Predicted oxygen consumption*	*Oxygen gap*	*Capacity (# of beds)*	*LOX tank size to be procured (liters)*
Centre Hospitalier Regional Bouaké	Regional hospital	0	540	540	150	5,000
Centre Hospitalier Regional Korhogo	Regional hospital	40	80	40	463	3,000
Centre Hospitalier Regional Yamoussoukro	Regional hospital	65	105	40	140	5,000
Centre Hospitalier Regional Daloa	Regional hospital	182	578	396	268	5,000
Centre Hospitalier Regional Man	Regional hospital	120	180	60	164	5,000
Centre Hospitalier Regional San Pedro	Regional hospital	36	96	60	110	3,000
Hôpital Général San Pedro	General hospital	0	120	120	185	3,000

The Democratic Republic of the Congo*						
Facility name	*Type of health facility*	*Existing piping system*	*% of beds to be piped (# of beds)*	*Cylinder storage size and procurement amount*	*Capacity (# of beds)*	*LOX tank size to be procured (liters)*
Kinshasa University Clinic	University hospital	Yes, but requires major upgrade	24% (138)	500	565	30,000
Centre Hospitalier Roi Baudoin	Referral hospital	No piping	N/A	200	120	N/A
Kintambo General Hospital	Referral hospital	No piping	N/A	200	268	N/A
Centre Distribution Regional Cameskin	Cylinder distribution center	N/A	N/A	1,000	N/A	N/A
* 85 facilities with a total 7,486 beds will also benefit from the Program through a hub-and-spoke oxygen distribution model. EpiC is preparing Cliniques Universitaires de Kinshasa to become a LOX filling station (hub) that will ultimately serve a network of 85 facilities in Kinshasa (spokes). See Case Study.						

Ghana					
Facility name	*Type of health facility*	*Oxygen supply (LPH)*	*Oxygen demand (LPH)*	*Oxygen gap (%)*	*Capacity (# of beds)*
St. Martin's Hospital - Agormanya	Faith-based hospital	180	2,000	91%	154
Nsawam Government Hospital	Primary hospital	2,142	4,464	62%	175
Battor Catholic Hospital - Volta	Faith-based hospital	275	1,417	81%	289
Ledzokuku-Krowor Municipal Assembly Hospital - Accra	Primary hospital	300	1,583	81%	151
Tema General Hospital - Accra	Secondary hospital	534	1,867	72%	409
Ashanti Mampong Government Hospital	Primary hospital	59	1,250	99.8%	200
Oti Regional Hospital - Worawora	Regional hospital	122	1,250	91%	150
Margret Marquart Hospital - Kpando	Faith-based hospital	58	1,450	96%	Unknown
Half Assini Government Hospital	Primary hospital	150	1,350	89%	78
Yendi Government Hospital	Regional hospital	387	11,629	67%	170

Malawi				
Facility name	*Type of health facility*	*# of beds to be piped*	*Capacity (# of beds)*	*LOX tank size to be procured (liters)*
Kamuzu Central Hospital	Central hospital	214	2,000	30,000
Mzimba South District Hospital	District hospital	138	256	20,000
Ntcheu District Hospital	District hospital	190	344	20,000
Mulanje District Hospital	District hospital	125	350	7,000
Salima District Hospital	District hospital	122	200	10,000
Dedza District Hospital	District hospital	117	300	N/A
Mchinji District Hospital	District hospital	146	220	N/A
Rumphi District Hospital	District hospital	97	220	N/A

Mozambique				
Facility name	*Type of health facility*	*Distance from LOX supplier center (km)*	*Capacity (# of beds)*	*LOX tank size to be procured (tonnes)*
Quelimane General Hospital	General hospital	740	251	6
Chokwe Rural Hospital	Rural hospital	215	104	6
Vilanculos Rural Hospital	Rural hospital	300	150	6

Vietnam			
Facility name	*Type of health facility*	*# of beds to be piped*	*Capacity (# of beds)*
Cai Nuoc District General Hospital	District hospital	20-88 per site	780
Buon Don DHC	District health center		190
Ha Giang Provincial General Hospital	Provincial hospital		800
Tay Nam Regional General Hospital	Regional hospital		360
Thanh Chuong District General Hospital	District hospital		464
Le Thuy District General Hospital	District hospital		478
Bo Trach District General Hospital	District hospital		465
Tho Xuan District General Hospital	District hospital		410
Nong Cong District General Hospital	District hospital		350
Dien Chau DHC	District health center		406