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MINISTRY OF HEALTH · ETHIOPIA
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HEALTHIER CITIZENS FOR PROSPEROUS NATION!

ETHIOPIAN MEDICAL OXYGEN ROADMAP II (2022–2027) MID-TERM EVALUATION REPORT

Ministry Of Health - Ethiopia

December 2025

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Mid-term Evaluation Report

Ministry of Health- Ethiopia

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FOREWORD

The Ethiopian health system has made significant strides over the past decade in expanding access to life-saving medical oxygen, an essential medicine that underpins quality care across maternal, newborn, child health, emergency services, and critical care. The launch of the Ethiopian Medical Oxygen Roadmap II (2022–2027) marked a renewed national commitment to ensuring that no patient suffers preventable illness or death due to lack of oxygen. This Midterm Evaluation Report provides an objective and comprehensive assessment of our progress to date, the remaining challenges, and the strategic actions required to achieve the roadmap's goals within the next two years.

The findings of this evaluation demonstrate encouraging progress. National oxygen production capacity has expanded, the availability of core devices such as concentrators, cylinders and pulse oximeters has improved, and training efforts have reached thousands of healthcare workers. More than four out of five health facilities now provide medical oxygen therapy, an important milestone compared to the situation just a few years ago. These gains reflect the collaborative efforts of the Ministry of Health, Regional Health Bureaus, EPSS, EFDA, health facilities, and our development partners.

However, the report also highlights critical gaps that require urgent attention. Awareness and implementation of the roadmap remain uneven, especially at primary-level facilities. Only few facilities conduct regular oxygen purity checks, and maintenance systems for oxygen plants and devices are still insufficient. Clinical audits reveal that while hypoxemia screening has improved, adherence to rational oxygen use standards remains low, posing risks to patient safety and resource efficiency. Financing mechanisms, though evolving, continue to rely heavily on out-of-pocket spending, underscoring the need for sustainable cost-recovery and integration with health insurance schemes.

These insights underscore a central message: building oxygen infrastructure is only the first step; ensuring governance, quality, safety, and sustainability require sustained, coordinated action across the entire ecosystem. As we enter the second half of the roadmap's implementation period, the Ministry of Health remains fully committed to addressing these gaps. Our priorities will include strengthening leadership and accountability structures, expanding preventive and corrective maintenance systems, enhancing regulatory oversight, improving clinical practice through mentorship and continuous professional development, and solidifying sustainable financing mechanisms.

We extend our appreciation to the Regional Health Bureaus, health facilities, healthcare workers, and technical experts whose contributions made this evaluation possible. We are especially grateful to our partners for their continued leadership, support, and collaboration.

This Midterm Evaluation offers more than a reflection of progress; it serves as a roadmap for action. By embracing its recommendations, we can collectively accelerate progress toward a resilient, safe, and equitable national oxygen system that safeguards the lives of mothers, newborns, children, and all patients who depend on oxygen for survival.

Together, we reaffirm our commitment to ensuring that medical oxygen is accessible, affordable, and reliably available for every Ethiopian who needs it.

H.E Dr Dereje Duguma, State Minister of Health

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The Ministry of Health extends its deepest appreciation to all individuals and organizations who contributed to the realization of the Mid-Term Evaluation of the Ethiopian Medical Oxygen Roadmap II (2022–2027).

We sincerely thank the Regional Health Bureaus (RHBs), the Ethiopian Food and Drug Authority (EFDA), and the Ethiopian Pharmaceutical Supply Service (EPSS) for their active engagement and invaluable collaboration throughout this process.

Our heartfelt thanks go to the leadership and staff of the surveyed health facilities. Your cooperation during data collection and your commitment to providing transparency regarding service delivery were essential to the success of this study.

We are particularly grateful to our development partners, Clinton Health Access Initiative (CHAI), for their generous financial support and rigorous technical assistance. Your partnership continues to be instrumental in our collective effort to save lives and improve the health systems of Ethiopia.

The Ministry of Health would like to thank the following individuals for their technical support on the analysis and write-up of the mid-term revaluation report.

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Acronyms

CHAI	Clinton Health Access Initiative
EPSS	Ethiopian Pharmaceutical Supply Service
FDA	Food and Drug Administration
KII	Key Informant Interview
MCH	Maternal and Child Health
MOH	Ministry of Health
MSLEO	Medical Service Lead Executive Office
PMELEO	Pharmaceutical and Medical Equipment Lead Executive Office
RHB	Regional Health Bureau
EPRP	Emergency Preparedness and Response Plan

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Executive Summary

This Mid-term Evaluation of the Ethiopian Medical Oxygen Roadmap II (2022–2027), conducted in July–August 2025 by the Ministry of Health and the Clinton Health Access Initiative, surveyed 203 health facilities across all 12 regions and two city administrations to measure progress against the roadmap's seven strategic pillars and identify barriers to be addressed before its conclusion in 2027.

Progress in infrastructure has been substantial. National oxygen production capacity rose from 3,698 m^3/hr in 2021 to 5,497 m^3/hr in 2025; oxygen plants grew from 38 to 62, with 24 more in procurement. Facilities providing oxygen therapy increased from 48% to 89%, including 79% of health centers (up from 26%), and 93% of health centers now hold at least one functional concentrator.

Critical systemic gaps persist. Awareness of the roadmap is low — 52% of facilities, mostly health centers, report being unaware of it. Hypoxemia screening reached 72%, yet adherence to rational-use standards is only 20% of audited charts. Financing remains donor and out-of-pocket-dependent (62%), with limited integration into community-based health insurance (54%); none of the existing oxygen plants hold biannual regulatory licensing, maintenance, and purity-testing capacity is weak, and 70% of facilities have not yet incorporated oxygen into their Emergency Preparedness and Response Plans.

The report recommends shifting the focus of the roadmap's second half from infrastructure expansion toward system strengthening: targeted awareness campaigns for primary-care leadership, institutionalised clinical audits to enforce rational use, fully equipped biomedical workshops, standardised pricing, and inclusion of oxygen therapy in the health insurance framework. Acting on these priorities will consolidate the gains achieved and ensure medical oxygen is safely, reliably, and equitably available to every patient who needs it.

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1 Introduction

Medical oxygen is an important medicine essential across all levels of healthcare. Its role in treating hypoxemia, a life-threatening condition resulting from insufficient oxygen in the blood, is critical for managing a wide spectrum of illnesses, including severe pneumonia, chronic pulmonary diseases, cardiovascular conditions, and emergencies. Despite its proven necessity, access to medical oxygen remains a significant challenge in many parts of the world, particularly in low-resource settings[1]. The consequences of delayed or inadequate oxygen therapy can be dire, frequently leading to mortality. A recent analysis by The Lancet highlighted this disparity, revealing that in sub-Saharan Africa, only approximately 20% of healthcare facilities treating respiratory infections in countries like Mauritania and Niger had access to oxygen[2]. Similar findings were documented in South America and South Asia by surveys conducted by the former United States Agency for International Development (USAID).

Ethiopia faces a comparable challenge in ensuring consistent oxygen availability. A comprehensive end-term evaluation conducted by the Ministry of Health (MOH) in collaboration with the Clinton Health Access Initiative (CHAI) identified that there is still a substantial gap in oxygen access[3]. The study revealed that nearly half of deaths attributable to the top ten leading diseases are linked to hypoxemia. Notably, pneumonia emerged as the leading cause of morbidity and hospital admissions, accounting for 10% and 9.8%, respectively, according to recent health and health indicators report[4]. The end-term evaluation further substantiated these concerns, indicating that only 23% of health centers provided oxygen services and a mere 26% possessed functional oxygen cylinders. While access was relatively better at the hospital level, with improved availability and service provision observed, systemic challenges persisted[5].

Furthermore, lack of clear and optimal policies and guidelines, standard operating procedures/job aids and limited financing systems contribute to low levels of availability and utilization[6]. The USAID study underscored that enhanced oxygen access holds the potential to avert an estimated 100,000 deaths annually among newborns, children, and mothers in Ethiopia. Access to oxygen is a critical component of managing many life-threatening maternal, newborn, and child health (MNCH) issues including asphyxia, pneumonia, and obstetric complications. However, in 2016, reliable oxygen supply met only approximately 20% of the total need within the Ethiopian health system. Addressing this gap was projected to avert a 35% reduction in MNCH mortality and morbidity[7].

The findings from the end-term evaluation were key drivers in the development of the Ethiopian Medical Oxygen Roadmap II (2022-2027). This roadmap prioritized expanding access to medical oxygen in both health centers and hospitals, emphasizing rational use practices, the establishment of regional oxygen production facilities, and ensuring availability of essential medical devices and consumables across all levels of care. The ambitious roadmap set forth numerous targets and secured significant commitments

[1] WHO-UNICEF technical specifications and guidance for oxygen therapy devices© World Health Organization and the United Nations Children's Fund (UNICEF), 2019
[2] Oxygen availability in sub-Saharan African countries: a call for data to inform service delivery Vol 8 September 2020
[3] The Federal Democratic Republic of Ethiopia Ministry of Health, National Medical Oxygen and Pulse Oximetry Scale Up Road Map End-term evaluation Report. 2019.
[4] Ministry Of Health: Health and health related indicators report for fiscal year 2014 E.C
[5] The Federal Democratic Republic of Ethiopia Ministry of Health, National Medical Oxygen and Pulse Oximetry Scale Up Road Map End-term evaluation Report. 2019.
[6] Accelerating Policy Change, Translation and Implementation for Pneumonia and Diarrhea Commodities in Ethiopia, Mar 2016
[7] Identifying investment opportunities to strengthen the oxygen delivery ecosystem for newborn and child care in Ethiopia", 2018

from the government and its partners. These objectives were translated into actions under seven strategic pillars: (1) leadership and coordination, (2) equitable access to medical oxygen and diagnostic devices, (3) rational use of medical oxygen and patient safety, (4) medical oxygen consumables and device management, (5) regulatory system, (6) generating evidence, evidence-based practice and innovation, and (7) financing.

As the roadmap implementation neared its midpoint in 2027, the MOH and partners recognized the need for a mid-term evaluation to assess progress, identify implementation barriers and facilitators, and inform future strategies. The findings of this evaluation were intended to provide actionable recommendations to guide stakeholders and policymakers toward improving the implementation of the roadmap and ultimately enhancing healthcare services and population health outcomes.

2 Scope and Purpose of the Evaluation

This mid-term evaluation was conducted nationwide, encompassing all 12 regions and two city administrations of Ethiopia. The primary goal of the midterm evaluation of the roadmap was to assess the progress of its implementation, identify key challenges and enabling factors encountered thus far, and provide evidence-based recommendations on priority areas for emphasis, as well as actionable strategies to optimize outcomes during the remaining implementation period. This assessment provided a crucial foundation for developing practical solutions aimed at strengthening evidence generation, a critical element in enhancing the quality of oxygen services and achieving the strategic objectives outlined in the national medical oxygen roadmap.

The evaluation findings offer evidence for optimizing program efficiency, effectiveness, and long-term sustainability. This information equips policymakers and program implementers with the necessary insights to formulate tailored and actionable recommendations. Ultimately, this evaluation contributes to establishing a robust framework for scaling up and sustaining a nationwide medical oxygen system. This endeavor is expected to significantly reduce preventable deaths and disabilities associated with hypoxemia.

3 Objective of the Midterm Evaluation

3.1 General Objective

The mid-term evaluation of the Ethiopian Medical Oxygen Roadmap (2022-2027) aimed to assess implementation progress, measure key achievements, and identify significant barriers and facilitators. It also sought to capture critical lessons learned and provide forward recommendations to effectively achieve the roadmap's strategic objectives during the remainder of its implementation.

3.2 Specific Objective

To provide a focused framework for the evaluation, we established the following key study objectives:

1. To assess the progress of implementation of the strategic objectives as per the detailed plan of action in the roadmap
2. To identify the major challenges and gaps in the implementation process
3. To explore the best lessons during the implementation of the roadmap.
4. To inform corrective actions and recommendations for the remaining implementation period

3.3 Purpose of the Evaluation

This assessment focused on evaluating the implementation status of the Ethiopian Medical Oxygen Roadmap II's seven strategic objectives. The findings from this mid-term evaluation were intended to outline success and challenges of the implementation of the roadmap and inform recommendations for the subsequent phase of roadmap implementation. The assessment considered the following seven key domains outlined in the roadmap with their implementation period:

1. Strengthen leadership and coordination of the medical oxygen system.
2. Improve Equitable Access to Medical Oxygen and Devices.
3. Improve the quality of medical oxygen service.
4. Strengthen Medical Oxygen Product Management.
5. Strengthen the Medical Oxygen Regulation System.
6. Enhance Research and innovation in the medical oxygen system.
7. Ensure a sustainable financing mechanism for the medical oxygen system.

The following are the key indicators that were collected and analyzed:

Table 1 List of indicators of the oxygen roadmap

	STATEMENT	INDICATORS
Goal	To reduce preventable deaths and disabilities through ensuring a sustainable medical oxygen system.	- Institutional hypoxemia-related death rate - Percentage of hypoxemic patients who have been treated with oxygen
Objective 1	Strengthen leadership and coordination of the medical oxygen system.	- Proportion of health facilities with assigned or focal units for medical oxygen

Objective 2	Improve equitable access to oxygen and oxygen devices.	- Proportion of hospitals with central oxygen piping and/or manifold systems - Proportion of hospitals performing annual medical oxygen quantification - Proportion of facilities with functional medical oxygen services (disaggregated by facility type and service areas)
Objective 3	Improve the quality of medical oxygen services.	- Proportion of health facilities with trained health care providers on medical oxygen - Proportion of patients who have had their oxygen saturation monitored with pulse oximetry at their first point of contact at the facility
Objective 4	Strengthen medical oxygen device management.	- Proportion of technical staff trained on oxygen systems operation and maintenance at the facility level
Objective 5	Strengthen the medical oxygen regulation system.	The proportion of oxygen plants that are licensed biannually fulfilling the minimum requirements.
Objective 6	Enhance research and innovation on the medical oxygen system.	- Number of research and innovation hubs established
Objective 7	Ensure a sustainable financing mechanism for the medical oxygen system.	The proportion of the budget spent on medical oxygen as compared to the total budget spent

4 Methodology

4.1 Study Design and Settings

A facility-based mixed-methods cross-sectional study design was utilized, integrating both quantitative and qualitative data collection approaches. The quantitative survey component of this mid-term evaluation was designed to inform key strategic initiatives of the program, providing a baseline for comparison and enabling the tracking of progress and assessment of final program achievements.

4.2 Study Period

The evaluation was conducted from July 6th to August 30th, 2025, across all regions and two city administrations of Ethiopia. The quantitative data collection was primarily focused on health centers and hospitals, while the qualitative component incorporated desk reviews, key informant interviews, small group discussions, and direct observations.

4.3 Study Population

The mid-term evaluation employed a participatory methodology to ensure inclusiveness, engaging all relevant stakeholders. This included representatives from government bodies (primarily the Ministry of Health, Regional Health Bureaus, Ethiopian Pharmaceuticals Supply Service (EPSS), hospitals, health centers), professional associations utilizing oxygen in medical practice, and development partners. Key stakeholders and individuals involved in the evaluation included:

Table 2 List of organizations considered for qualitative data collection.

Level	Name of respondent	Tool	Remark
Federal	• MoH (MSLEO and PMDLEO) • EFDA • EPSS	• In-depth key informant interview • Document/report review	
All Regions	• RHBs • EPSS • Zonal/Woreda health office	• In-depth key informant interview • Document/report review	
Facilities	• Hospital or health center heads		
Professional Association	• Surgical Society of Ethiopia • Ethiopian Anesthesiology Society • Ethiopian Pediatric Society • Ethiopian society of obstetric and Gynecologists • Ethiopian society of emergency medicine • Ethiopian society of cardiac professionals • EPHA	• In-depth key informant interview • Document/report review	
Partners	• CHAI • UNICEF • Jhpiego • Assist International	• In-depth key informant interview • Document/report review	

Table 3 Distribution of facilities in sample frame by region in Ethiopia

S. No	Region	Health Center	Primary Hospital	General Hospital	Tertiary Hospital	Total Hospital	Grand Total
1	Addis Ababa	107	0	11	4	15	122
2	Afar	112	5	3	0	8	120
3	Amhara	895	71	17	8	96	991
4	Benishangul Gumuz	79	4	2	0	6	85
5	Central Ethiopia	252	22	4	4	30	282
6	Dire Dawa	17	0	2	0	2	19
7	Gambella	31	4	1	0	5	36
8	Harari	9	1	1	1	3	12
9	Oromia	1445	77	41	7	125	1570
10	Sidama	136	18	3	1	22	158
11	Somali	225	10	6	1	17	242
12	South Ethiopia	243	22	3	0	25	268
13	Southwest Ethiopia	135	8	4	0	12	147
14	Tigray	232	25	17	2	44	276
	Total	**3918**	**267**	**115**	**28**	**410**	**4328**

4.4 Sampling Procedure

A multi-stage sampling procedure was employed to select representative woreda clusters and health facilities (hospitals and health centers) across Ethiopia's diverse administrative landscape. Recognizing the logistical challenges posed by the geographical dispersion of facilities, woredas were selected as primary sampling units, followed by random selection of health facilities within each chosen woreda.

Given the disparity in the number of hospitals (410) and health centers (3,918), separate sample sizes were calculated to ensure adequate representation of both facility types, acknowledging their distinct roles in service provision. To account for potential intra-cluster correlation, the shared characteristics of facilities within the same woreda, a design effect of 1.2 was applied to the calculated sample sizes. This adjustment ensures the study maintains sufficient statistical power. The sampling strategy balances the need for rigorous data collection with practical fieldwork considerations, optimizing efficiency while ensuring reliable estimates for both hospital and health center populations.

The sample size for each facility type was determined using a finite population formula, incorporating the design effect to accommodate the multi-stage sampling approach.

Key Parameters:

Population (N):

- Hospitals = 410
- Health centers = 3918
- Confidence Level (CI): 95% → Z = 1.96
- Margin of Error (ME): 10%
- Population Proportion (p): 50% → p = 0.5
- Design Effect (deff): 1.2

$$n = \frac{(Z^2 \times p \times (1 - p) \times deff)}{ME^2}$$

$$\text{n adjusted} = \frac{\text{n}}{1 + \frac{\text{n} - 1}{\text{N}}}$$

The n-adjusted formula, which incorporates finite population correction, was applied to determine the required sample sizes for hospitals and health centers. This formula takes into account the total population size (N) of each facility type 410 for hospitals and 3,918 for health centers to yield more accurate estimates for relatively small populations. Key parameters used in the calculation include a 95% confidence level (Z = 1.96), a 10% margin of error, a population proportion of 50% (p = 0.5), and a design effect of 1.2.

Based on the above formula, the final sample sizes for the study population size of hospitals and health centers are shown in ***Table 4*** below. Thus, due to resource limitations, the margin of error was enhanced to 10% and the final total sample size of the study will be 204 health facilities.

Table 4. Determined sample size of known study population by health centers and hospitals.

Facility Type	N	ME = 10%
Hospitals	410	99
Health Centers	3918	104
Total	**4328**	**204**

Table 5 Distribution of facilities in sample frame and final sample selection, by region

		Health Center		Hospital		Total	
S. No	Region	Sample frame	Number selected	Sample frame	Number selected	Sample frame	Number selected
1	Addis Ababa	107	3	15	3	**122**	**6**
2	Afar	112	2	8	2	**120**	**4**
3	Amhara	895	21	96	21	**991**	**42**
4	Benishangul Gumuz	79	1	6	1	**85**	**2**
5	Central Ethiopia	252	6	30	6	**282**	**12**
6	Dire Dawa	17	1	2	2	**19**	**3**
7	Gambella	31	1	5	1	**36**	**2**
8	Harari	9	1	3	0	**12**	**1**
9	Oromia	1445	38	125	34	**1570**	**72**
10	Sidama	136	5	22	5	**158**	**10**
11	Somali	225	4	17	4	**242**	**8**
12	South Ethiopia	243	7	25	6	**268**	**13**
13	Southwest Ethiopia	135	3	12	3	**147**	**6**
14	Tigray	232	11	44	11	**276**	**22**
	Total	3918	104	410	99	4328	203

The study employed a mixed-methods approach to assess the availability and utilization of medical oxygen within the Ethiopian healthcare system. A key component of this methodology was a systematic random sampling strategy used to select both hospitals and health centers for data collection.

For hospital selection, based on power calculations and anticipated variability, a sample size of 99 hospitals was determined as representative. Employing a sampling interval of approximately 4, a random starting point was selected from the initial 4 hospitals, and subsequent hospitals were selected at intervals of 4 until the target sample size of 99 was achieved.

The selection process for health centers involved a similar approach. A sample size of 104 was deemed necessary to provide robust data. With a calculated interval of approximately 38, a random starting point was chosen from the first 38 health centers, and subsequent centers were selected at intervals of 38 until the required sample size was met. To enhance representativeness, health centers were specifically selected within the catchment areas of the hospitals already included in the study. This ensured a geographically dispersed and comprehensive overview of oxygen availability across different healthcare settings. The rationale for this approach was to facilitate efficient data collection while maintaining methodological rigor and minimizing potential bias.

4.5 Data Collection Methods and Tools

4.5.1 Quantitative Data Collection

The quantitative component utilized a structured questionnaire, clearly aligned with the strategic objectives of the Ethiopian Medical Oxygen Roadmap II. To assess clinical practice, it incorporated indicators on the rational use of oxygen, adapting the MOH and CHAI-Ethiopia's standardized "clinical audit tool." This ensured consistency with national monitoring systems. The instrument was programmed into SurveyCTO for electronic data collection, which enhanced efficiency and data integrity. The survey data were supplemented by review of facility records, including oxygen consumption logs, equipment inventories, and patient records from key wards, providing a robust, triangulated dataset for analysis.

4.5.2 Qualitative Data Collection

The qualitative inquiry employed in-depth key informant interviews and direct observation. Participants were purposively selected from the MOH, Regional Health Bureaus, development partners, regulatory bodies, and professional societies based on their expertise and involvement in oxygen-related activities. As for the health facilities, focus group discussions were conducted with key personnel (e.g., the medical director, heads of key in-patient departments, the quality officer, and the head of human resources). The final sample size was determined by the principle of saturation theory, concluding when new interviews no longer yielded novel thematic insights. This approach, while initially targeting 20-25 interviews, allowed us to pursue depth over a predetermined quota.

Interviews were conducted in-person, allowing the interviewer to get the required information. Furthermore, direct observation during facility visits provided critical, ground-truth data on the actual functionality and availability of oxygen equipment and related job aids. This often revealed the tangible gap between reported status and operational reality at the point of care. These methods were complemented by consultative meetings with task forces and a desk review of key documents, which together provided a comprehensive understanding of the implementation landscape, challenges, and enablers.

4.6 Quality Assurance and Review Mechanisms

A multi-layered quality assurance strategy was rigorously implemented throughout the evaluation to ensure the integrity and credibility of the findings. The cornerstone of this effort was the use of the SurveyCTO platform for quantitative data collection. The electronic scripting of the clinical audit and facility survey tools not only improved logistical efficiency but also allowed for the integration of automated consistency checks and prompts for unusual inputs. This proved instrumental in mitigating data entry errors at the source.

Prior to the main data collection, the tools underwent a thorough validation and pilot-testing process. The pilot phase, conducted with a small sample of facilities and individuals, was critical. It identified areas of participant confusion and allowed for the refinement of question phrasing for greater clarity and cultural appropriateness. This pre-emptive step significantly enhanced the reliability of the instruments and the validity of the data they subsequently captured.

For the qualitative component, a stringent protocol for data handling was followed. All interviews were audio-recorded with participant consent. The recordings were securely stored, transcribed verbatim, and, where necessary, translated into English for analysis. A dedicated cleaning process was employed where transcripts were checked for accuracy and anonymized to protect participant confidentiality. The final transcripts were then managed and coded using MAXQDA 24 software, which provided a systematic and auditable trail for the thematic analysis.

Beyond these technical measures, the human element of quality assurance was equally emphasized. We deployed a multidisciplinary team of data collectors with relevant expertise in public health, pharmacy, and monitoring and evaluation. This team participated in a comprehensive training to ensure a unified understanding of the evaluation objectives and data collection instruments. In the field, close supervision was maintained, with field coordinators assigned to each region. These coordinators held daily progress reviews with their teams to promptly address challenges and apply lessons learned, creating a dynamic feedback loop that continuously improved data quality.

Finally, the principle of triangulation was central to our methodology. By design, we captured perspectives from a diverse range of stakeholders and supplemented interview data with direct observation and document review. This approach allowed for the cross-verification of findings, strengthening the overall robustness of our conclusions. The iterative process of presenting preliminary findings to stakeholders and incorporating their feedback served as a final, vital quality check, ensuring the final report was both accurate and contextually grounded.

4.7 Data Management and Analysis

Data management prioritized security and confidentiality. All data were stored on secure, password-protected systems with access limited to authorized team members. Participant identifiers were removed and replaced with unique codes to ensure anonymity. A systematic backup protocol was followed using encrypted cloud storage to prevent data loss.

For the quantitative analysis, data underwent initial cleaning and screening to check quality and identify any outliers. The analysis proceeded with descriptive statistics, presenting frequencies and percentages disaggregated by geography and facility type. And the study team used STATA 17 software for the analysis.

Qualitative data were analyzed using a thematic approach. Interview transcripts were transcribed, translated, and imported into MAXQDA 24 software for systematic coding. The emergent themes provided critical context and a nuanced understanding of the implementation process. A key strength of the analysis was the deliberate triangulation of these qualitative insights with the quantitative survey results and secondary data, which created a coherent and evidence-rich narrative for the final evaluation.

4.8 Ethical Considerations

The evaluation was conducted under the guiding principle of "do no harm," with the safety, rights, and welfare of participants and the research team held as paramount. Formal ethical approval was secured from the AHRI/ALERT Ethics Review Committee (AAERC) on July 4, 2025 (approval number PO-042-25) prior to the commencement of any field activities.

Operationally, this commitment was upheld through several key practices. Informed consent was obtained from all participants before their involvement in interviews, surveys, or group discussions. This

process involved clearly explaining the study's purpose, the nature of their involvement, and any potential benefits or risks, ensuring participation was entirely voluntary and free from coercion. No material incentives were provided, preserving the voluntary nature of the engagement.

To protect participant confidentiality, all data were de-identified during the collection and management processes, with personal identifiers removed and replaced with unique study codes. Furthermore, all data collectors were carefully selected and underwent comprehensive training not only on methodological procedures but also on the ethical protocols essential for respectful and secure engagement with participants and their data. This foundational ethical framework was crucial in building the trust necessary for a successful and credible evaluation.

4.9 Reporting and Dissemination

The summary of preliminary findings was communicated to key stakeholders involved in the assessment framing and the taskforce team through a consultative workshop to verify the results and the recommendation of the assessment strategic objectives. Results may also be published as journal articles or presented at conferences.

SUMMARY OF MIDTERM EVALUATION FINDINGS AGAINST TARGETS AND ENDTERM EVALUATION OF THE FORMER RODMAP

Table 6. Shows the comparison of the midterm evaluation findings against targets and the end term evaluation of the former roadmap.

Indicator		Former Status (End-Term 2022)	Roadmap II Target (2027)	Current Mid-Term Status (2025)	Remark
Facilities with oxygen activities in the annual plan		—	100%	61.86%	
Patients with SpO_2 monitored at first contact		59%	90%	72%	
Adherence to Rational Use Standards		—	—	20%	
Facilities with trained HCWs on medical oxygen		43%	100%	77.83%	
Total PSA Oxygen Plants	Private	19	—	25	
	Public (Government)	19	32	37	The MoH has committed 24 additional numbers of oxygen plants to be planted across various health facilities.
Medical oxygen devices *(Target VS achievement)*	Concentrator	—	5,646	9,087	+60.97% (exceeded by 3,441 units)
	Cylinders	—	23,501	7,630	-67.53% (shortfall of 15,871 units)
	Pulse oximeter	—	17,668	20,370	+15.28% (exceeded by 2,702 units)
	Oxygen analyzers	—	567	76	-86.60% (shortfall of 491 units)
National Production Capacity	Private	2,613 m^3/hr.	3,698 m^3/hr.	2,803 m^3/hr	There are oxygen plants that are on pipeline which will add an additional 1,440 m^3/hr. of production capacity by mid-2026.
	Public (Government)	1,005 m^3/hr		2,694 m^3/hr	
Facilities with Cost Recovery/Sales		11%	—	55%	

5 Results

5.1 Basic Demographic Characteristics

Table 7 presents the basic characteristics of the sampled facilities. Of the 203 facilities randomly selected for the roadmap evaluation, 104 (51.2%) were health centers (HCs), 46 (22.7%) were primary hospitals, 43 (21.2%) were general hospitals and the remaining 10 (4.9%) were tertiary hospitals. Due to their large geographical areas and the substantial number of health facilities under their jurisdiction, approximately 56% of the sampled facilities were in the Amhara and Oromia regions. Specifically, Oromia accounted for 71 facilities (35.47%), while Amhara contributed 42 facilities (20.69%).

Table 7. Number of health facilities assessed, by region and type, for the mid-term evaluation.

	FACILITY TYPE				
REGION	Health Center	Primary hospital	General hospital	Tertiary hospital	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Addis Ababa	3 (2.88)	-	1 (2.33)	2 (20)	6 (2.96)
Afar	2 (1.92)	1 (2.17)	1 (2.33)	-	4 (1.97)
Amhara	21 (20.19)	14 (30.43)	7 (16.28)	-	42 (20.69)
Benishangul	1 (0.96)	-	1 (2.33)	-	2 (0.99)
Central Ethiopia	6 (5.77)	1 (2.17)	4 (9.3)	1 (10)	12 (5.91)
Dire Dawa	1 (0.96)	-	2 (4.65)	-	3 (1.48)
Gambella	1 (0.96)	-	1 (2.33)	-	2 (0.99)
Harari	1 (0.96)	-	-	-	1 (0.49)
Oromia	38 (36.54)	15 (32.61)	12 (27.91)	7 (70)	72 (35.47)
Sidama	5 (4.81)	3 (6.52)	2 (4.65)	-	10 (4.93)
Somali	4 (3.85)	1 (2.17)	3 (6.98)	-	8 (3.94)
South Ethiopia	7 (6.73)	4 (8.7)	2 (4.65)	-	13 (6.4)
South-West Ethiopia	3 (2.88)	1 (2.17)	2 (4.65)	-	6 (2.96)
Tigray	11 (10.58)	6 (13.04)	5 (11.63)	-	22 (10.84)

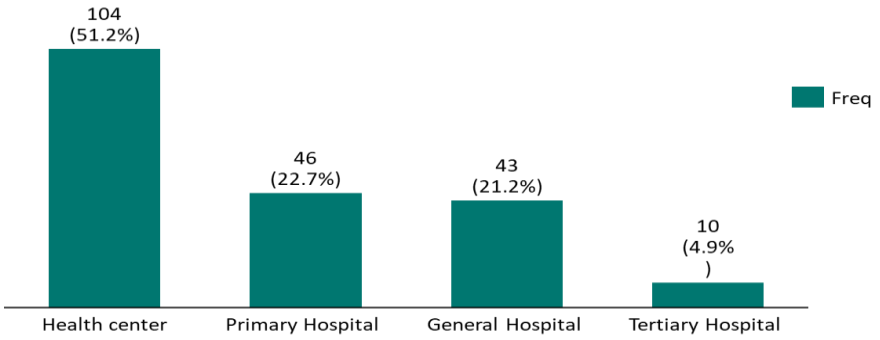


Figure 1. Showing number of health facilities by type included in the survey.

The departments' availability in the sampled health facilities indicated that all departments assessed were available in tertiary hospitals, while in primary hospitals operating rooms were available in all but around 11 (24%) of them had Intensive care units (ICUs).

Table 8 shows the average number of beds across surveyed departments for all facility types. The departments with the highest average number of beds were Medical (22), Gyn/Obs and Pediatric (19), and Surgical (18). In contrast, departments with the lowest average number of beds were Recovery and OR (3), followed by ICU (5) and Neonatal (15). The mean number of beds in the Emergency department was 13. Of the 104 health centers assessed only 12 health centers had Obstetrics and Gynecology services (also known as OR blocks).

Table 8. Average number of inpatient and emergency beds of each department by facility type of surveyed facilities

	Health Center			Primary Hospital			General Hospital			Tertiary hospital			For all types		
	facility number (n)	mean	SD	facility number (n)	mean	SD	facility number (n)	mean	SD	facility number (n)	mean	SD	facility number (n)	mean	SD
Emergency	104	11	70	46	10	4	42	16	8	10	26	12	202	13	51
Gyn/Obs[1]	12	3	2	46	12	7	43	21	12	10	58	70	111	19	26
Neonatal	.	.	.	46	10	8	43	16	9	10	31	14	99	15	11
Pediatric	.	.	.	46	10	7	42	22	11	10	52	30	98	19	18
Medical	.	.	.	46	12	6	42	24	13	10	60	27	98	22	19
Surgical	.	.	.	45	8	4	42	21	12	10	51	28	97	18	18
Recovery	.	.	.	44	3	2	41	4	3	10	5	2	95	3	2
OR[2]	.	.	.	42	2	3	40	3	1	10	6	4	92	3	3
ICU[3]	.	.	.	17	3	2	35	5	3	10	9	8	62	5	4
Other[4]	.	.	.	1	5	.	13	16	20	7	32	30	21	21	24

[1] Gyn/Obs= Obstetrics and Gynecology

[2] OR = Operating Room

[3] ICU = Intensive Care Unit

[4] Other= MDR-TB (multidrug-resistant tuberculosis), Oncology, HDU (high dependency unit, Neurosurgery

Table 9 shows the number of health care professionals available by facility type. There are notable differences in the median number of health care workers (HCWs) among the various facility types. Tertiary hospitals had the largest median number of HCPs of 339.5 (IQR=528; range 250-1,344). On the other hand, Health Centers had the lowest median 37 (IQR=26; range 0-195). The median number of HCWs at General Hospitals was 237 (IQR=174; range 73-979), whilst the median number of HCPs in Primary Hospitals was 120.5 (IQR=52; range 46-230).

Table 9.The number of health care professionals by facility type

HF	n	Sum	Mean	SD	Min	Max	p50	IQR
Health Center	104	4780	45.96	33.62	0	195	37	26
Primary Hospital	46	5743	124.85	40.54	46	230	120.5	52
General Hospital	43	11808	274.6	154.83	73	979	237	174
Tertiary hospital	10	6016	601.6	395.2	250	1344	339.5	528
Total	203	28347	139.64	178.59	0	1344	86	137

n= number of health facilities; SD = standard deviation; Min = minimum; Max = maximum; p50 = median

5.2 Oxygen Services and Inputs to Provide Medical oxygen

Of the surveyed health facilities, 89% (n=181) provided medical oxygen therapy (MOT) services to patients. All tertiary hospitals, general hospitals, and primary hospitals offered MOT services. In contrast, 21% (n=22) of the assessed health centers did not. Furthermore, among the 22 facilities that did not provide oxygen therapy, 19 (86.4 %) had an oxygen device available and only 3 (13.6 %) had no device at all. See Table 10 and Table 11 for more information.

Respondent from one health center mentioned the resolution of a critical issue, stating that *"There were referrals of patients due to lack of oxygen before, but recently solved". (HC-50)*

Table 10. Supplemental medical oxygen therapy service availability in surveyed health facilities among 203 health facilities,

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
No	22 (21)	0	0	0	22 (11)
Yes	82 (79)	46 (100)	43 (100)	10 (100)	181 (89)

Ethiopia

Table 11. Availability of oxygen devices and provision of medical oxygen therapy services among 203 health facilities, Ethiopia

Health facility provides oxygen therapy services	Medical oxygen source utilization		
	No utilization gap, n (%)	Has oxygen device(s) but not providing therapy, n (%)	Total
No	3 (2)	19 (100)	22 (11)
Yes	181 (98)	0	181 (89)

Of the 203 health facilities surveyed, all primary, general and tertiary hospitals are connected to the national power grid. Almost all of the health facilities assessed also have a back-up generator source, with all 100% primary hospitals, 98% of general hospitals and 90% of tertiary hospitals. Although 99% of Health Centers were connected to the national grid, only 63% of them had back-up generators. Health centers 17% (n=18) had solar power.

The main source of medical oxygen was oxygen cylinders and oxygen concentrators. Oxygen concentrators were available in nearly all facilities across all types, oxygen cylinders were available in 100% of primary and tertiary hospitals and 98% of general hospitals, but in only 60% of health centers. Among the assessed facilities, medical oxygen plants were available in 12% (n=5) of general hospitals and 40% (n=40) of tertiary hospitals. See Table 12 for more information.

Table 12. Supplemental medical oxygen sources and power sources of health facilities surveyed

Type of service	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Sources of electric power at the facility					
National grid	103 (99)	46 (100)	43 (100)	10 (100)	203 (100)
Generator	66 (63)	46 (100)	42 (98)	9 (90)	162 (80)
Solar	18 (17)	2 (4)	3 (7)	-	22 (11)
Medical oxygen sources of the health facility					
Medical Oxygen Plant	NA	0	5 (12)	4 (40)	10 (5)
Oxygen Concentrator	103 (99)	46 (100)	42 (98)	10 (100)	201 (99)
Oxygen Cylinder	62 (60)	46 (100)	42 (98)	10 (100)	164 (81)

NA= Not applicable

The majority of health facilities reported that they held orientation workshops for their staff on medical oxygen. The highest percentages were observed in primary hospitals (67.4%), tertiary hospitals (70%) and general hospitals (74.4%). Only half of the health centers (50%) had held these sessions. Among the documents that were developed by the MoH, the health facilities provided orientation on the rational use of medical oxygen training manual constituted 75% and Flow Charts 62% were the most common ones. Monitoring formats (47%) and SOPs (53%) were also widely provided. Pocket handbooks and brochures were the least common. See Table 13 below for more information.

Table 13. Advocacy works carried out on medical oxygen of the surveyed facilities by type.

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Conducted orientation sessions to create awareness on medical oxygen-related documents					
No	52 (50)	15 (32.6)	11 (25.6)	3 (30)	81 (39.9)
Yes	52 (50)	31 (67.4)	32 (74.4)	7 (70)	122 (60.1)
If the answer to the above question is 'Yes', which documents?					
SOPs*	21 (40)	19 (61)	19 (59)	6 (86)	65 (53)
Pocket handbooks	1 (2)	1 (3)	2 (6)	2 (29)	6 (5)
Flow charts	32 (62)	19 (61)	22 (69)	3 (43)	76 (62)
Brochures	3 (6)	5 (16)	4 (13)	2 (29)	13 (11)
Monitoring formats	11 (21)	18 (58)	23 (72)	5 (71)	57 (47)
Safety manual	12 (23)	6 (19)	9 (28)	4 (57)	31 (25)
Training manuals	36 (69)	28 (90)	23 (72)	5 (71)	92 (75)
Others[1]	6 (12)	1 (3)	1 (3)	0	9 (7)

* Standard operating procedures

[1] On Treatment protocol, old oxygen therapy in children and adults, 2017, On device utilization and technical orientation on service area

Most health centers reported a lack of awareness or availability of the materials prepared by the MoH. One respondent highlighted the need to address this gap, stating that

> *"The ministry should develop and distribute SOPs, job aids, and checklists to support consistent practices." (HC-56)*

5.3 Medical Oxygen Coordination

Table 14 below shows the availability of the Ethiopian oxygen Roadmap II. The roadmap's availability was assessed in all selected health facilities that were included in the study. A total of 48% (n=97) of the

health facilities reported having a copy of the roadmap. Availability varied by facility type with 61 % of Primary Hospitals, 56% of General Hospitals and 40 % of Tertiary hospitals reported availability. However, health centers exhibited the highest non-availability at 64%.

Table 14. Availability soft or hard copy of the Ethiopian medical Oxygen Roadmap II across the health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
No	67 (64)	18 (39)	15 (35)	6 (60)	106 (52.22)
Yes	37 (36)	28 (61)	28 (65)	4 (40)	97 (47.78)

n= number of health facilities

Despite the availability of the roadmap, many staff members from both hospital and health centers reported a lack of knowledge or physical access to the roadmap document and its strategic objectives.

According to one of the respondents

"Many staff are not aware of the details of the National Oxygen Roadmap, hindering local alignment with national priorities." (Hosp-12)

Table 15 presents the number of health facilities that included medical oxygen-related activities in their annual plan, specifically among the 97 facilities that reported having the Ethiopian Medical Oxygen Roadmap II. Out of the 97 health facilities, 60 (62%) included medical oxygen-related activities in their annual plans. Most were general hospitals at 37% (n= 22), followed by primary hospitals and health centers at 32% and 27% respectively, while tertiary hospitals accounted for the smallest share at 3% (n=5).

Table 15. Number of health facilities that Included medical oxygen-related activities in their annual plan.

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
No	21 (56.76)	9 (24.32)	6 (16.22)	1 (2.7)	37 (38.14)
Yes	16 (26.67)	19 (31.67)	22 (36.67)	3 (5)	60 (61.86)

n= number of health facilities

The limited dissemination of the oxygen roadmap was repeatedly highlighted during the interviews with health facility staff.

One respondent from a health center noted:

"The oxygen roadmap was not adequately shared with all relevant staff, resulting in low awareness and weak ownership at the facility level". (Hosp-03)

As per the Ethiopian Medical Oxygen Roadmap II, it recommends that there should be focal persons from the national level up to health facilities. The focal person at health facilities should be part of the drug and therapeutic committee to coordinate medical oxygen related activities. Accordingly, of the 203 health facilities assessed, over two-thirds of the surveyed facilities had an assigned focal person for medical oxygen, while the remaining 32% had not. All tertiary hospitals, 93% (n=40) of general hospitals, 80.4% (n=37) of primary hospitals and 49% (n=51) of health centers have assigned a medical oxygen coordinator for their facility.

The most common units from which a focal person was selected were Outpatient Departments (OPDs), Emergency, OR and nursing unit, accounting 39% and the Biomedical Unit 33.3%. A biomedical unit focal person is assigned by more than half of general hospitals (57.5%) and tertiary hospitals (50%). A respondent from the Ministry of Health described the current structure and ongoing efforts:

> *"There are assigned experts who serve as focal person for medical oxygen-related work at the national level. We have also integrated these recommendations into the system to enable assignment of focal persons for medical oxygen at health facility level. For instance, this is included in the Ethiopian Hospital Service Improvement Guidelines". (MoH-01)*

However, other respondents from partners described a different reality. One respondent from implementing partners noted that

> *"Coordination needs to be improved, especially within the Ministry of Health." (Partners-01)*

Another respondent from implementing partner explained that

> *"Experts at the MoH are tasked with so many activities and challenged with firefighting works; they focus on those activities and miss strategic thinking and not seeing from a larger perspective. The Ministry needs an expert with a capacity of both clinical and technical skills and who understands the oxygen ecosystem." (Partners-02)*

According to the midterm evaluation, the majority of assigned focal persons 81.9% had received medical oxygen training. This was particularly true for the case of health centers (82.4%) and general hospitals (92.5%). Additionally, 68.8% of health facilities' oxygen focal persons are members of the Drug Therapeutics Committee (DTC). In terms of profession, biomedical engineers/technicians were the most commonly assigned focal person (34.1%), particularly in general hospitals 60% and tertiary hospitals 50%. While Nurses were the next most common profession (31.2%), especially in health centers 52.9%.

Two interrelated governance gaps emerged as major barriers to institutionalizing medical oxygen services. The lack of awareness among facility leadership that medical oxygen requires specific accountability. As one health center head admitted:

> *"We have not realized that whether focal person is needed for medical oxygen." (HC-24)*

Leadership commitment emerged as another critical bottleneck. As respondents explicitly reported low prioritization by management:

> *"The management body didn't give attention" or "Poor attention about oxygen therapy." (Hosp-03)*

Another reported problem was dysfunctional or contested governance mechanism. Even where drug therapeutic committees exist or oxygen focal persons exist, they were described as weak, inactive, or incapacitated by ownership dispute:

> *"The issue of ownership for management of oxygen is still controversial between biomedical professionals and pharmacists." (Hosp-15)*

The latest roadmap recommends identifying and using key performance indicators (KPIs) or adopting the proposed indicators in the roadmap by health facilities. Overall, 58.1% of facilities reported not using KPIs. However, the use of KPIs was higher in general hospitals (74.4%), tertiary hospitals (70%), and primary hospitals (63%), while it was notably low in health centers (16.4%). See Table 16 for more information.

Table 16. Medical oxygen coordination across health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Assigned focal person for medical oxygen					
No	53 (51)	9 (19.6)	3 (7)	0	65 (32)
Yes	51 (49)	37 (80.4)	40 (93)	10 (100)	138 (68)
If 'Yes' to Q, from which unit is assigned and select one that apply.					
Other, please specify[1]	39 (76.5)	9 (24.3)	6 (15)	0	54 (39.1)
Biomedical unit	1 (2)	17 (46)	23 (57.5)	5 (50)	46 (33.3)
Matron office	8 (15.7)	5 (13.5)	6 (15)	1 (10)	20 (14.5)
Pharmacy unit	0	5 (13.5)	4 (10)	4 (40)	13 (9.4)
Quality unit	2 (3.9)	1 (2.7)	1 (2.5)	0	4 (2.9)
Administration wing	1 (2)	0	0	0	1 (0.7)
If 'Yes,' is the assigned focal person a member of the Drug Therapeutics Committee (DTC)					
No	15 (29.4)	14 (37.8)	10 (25)	4 (40)	43 (31.2)
Yes	36 (70.6)	23 (62.2)	30 (75)	6 (60)	95 (68.8)
If 'Yes,' was the assigned person trained on medical oxygen					
No	9 (17.7)	11 (29.7)	3 (7.5)	2 (20)	25 (18.1)
Yes	42 (82.4)	26 (70.3)	37 (92.5)	8 (80)	113 (81.9)
If the answer to question number is 'Yes,' What is his/her profession					
Biomedical engineer/T	1 (2)	17 (46)	24 (60)	5 (50)	47 (34.1)
Nurse	29 (56.8)	9 (24.3)	7 (17.5)	0	43 (31.2)
Health Officer	14 (27.5)	2 (5.4)	0	0	16 (11.6)
Pharmacist	0	5 (13.5)	4 (10)	4 (40)	13 (9.4)
Medical doctor	3 (5.9)	2 (5.4)	5 (12.5)	0	10 (7.3)
Other, please specify[2]	4 (7.84)	2 (5.4)	0	1 (10)	9 (6.5)
Use medical oxygen-related indicators (KPIs) for monitoring and improvement					
No	87 (83.7)	17 (37)	11 (25.6)	3 (30)	118 (58.1)
Yes	17 (16.4)	29 (63)	32 (74.4)	7 (70)	85 (41.9)

[1] Emergency Unit, NCD unit, Nursing unit, OPD, Surgical unit and Triage unit
[2] Midwife, nurse, anesthetists and supporting staff.

Following COVID-19 pandemic, world leaders have emphasized access to medical oxygen. During the pandemic, it was witnessed that there was a global oxygen shortage on the global stage during surges, such as those experienced with COVID-19. Taking that lesson, in 2023 the WHO, in its guide titled "Strengthening health emergency prevention, preparedness, response and resilience", explicitly emphasized the integration of medical oxygen in emergency preparedness and responses. Similarly, Ethiopia's medical oxygen roadmap has put this recommendation beforehand and recommends that every facility to include oxygen in the health care facility emergency preparedness and response plan. According to the mid-term evaluation, out of the total facilities assessed, 70% (n=143) did not include medical oxygen in their EPRP. Tertiary hospitals showed the highest inclusion rate 60% (n=6), followed by General Hospitals 51% (n=22). And the inclusion decreases as the level of the tier in the health system decreases.

It is common that the lower health facilities refer patients requiring medical oxygen to a higher level just for the medical oxygen. And it is expected that this practice will decrease as access to medical oxygen increases. Accordingly, overall, in terms of oxygen-dependent patient referrals, the majority of facilities 76% (n=154) had not taken part in catchment referral meetings. Despite being the main referring

institutions, 81% of the health centers did not participate in those meetings. See Table 17 below for more information.

Overall, 65% of all facilities did not provide mentorship or support on medical oxygen to catchment health facilities. Although this was lower across all hospitals, general hospitals reported a somewhat higher rate of support provided 44.2%.

Table 17. Medical oxygen Emergency Preparedness and Catchment Meetings

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Included medical oxygen preparedness in the Emergency preparedness and response plan					
No	87 (83.7)	31 (67.4)	21 (48.8)	4 (40)	143 (70.4)
Yes	17 (16.4)	15 (32.6)	22 (51.2)	6 (60)	60 (29.6)
Participated in catchment referral meetings on oxygen related to the referral of patients on oxygen					
No	84 (80.8)	35 (76.1)	31 (72.1)	4 (40)	154 (75.9)
Yes	5 (4.8)	8 (17.4)	10 (23.3)	6 (60)	29 (14.3)
NA	15 (14.4)	3 (6.5)	2 (4.7)	0	20 (9.9)
Provided any mentorship or other support with respect to medical oxygen to catchment health facilities					
No	NA	34 (73.9)	24 (55.8)	6 (60)	64 (64.7)
Yes	NA	12 (26.1)	19 (44.2)	4 (40)	35 (35.4)
Supervised by the MoH/RHB/Zonal Health Department/Woreda health office/Partners					
No	46 (44.2)	18 (39.1)	12 (27.9)	2 (20)	78 (38.4)
Yes	58 (55.8)	28 (60.9)	31 (72.1)	8 (80)	125 (61.6)
Participated in oxygen-related review meetings					
No	98 (94.2)	33 (71.7)	24 (55.8)	3 (30)	158 (77.8)
Yes	6 (5.8)	13 (28.3)	19 (44.2)	7 (70)	45 (22.2)

5.4 Equitable Access to Medical Oxygen and Devices

According to the midterm evaluation, most of the health facilities have included medical oxygen in their facility-specific medicine list, with majority of the facilities reporting 64% (n=129) including medical oxygen in the list. The performance was highest at tertiary hospitals (90%) and lowest at health centers (47%).

The overall medical oxygen forecasting tool availability was 53.5%. However, among those that perform annual quantification, the usage was 89.9%, and all general and tertiary hospitals reported 100% usage, while lower health facilities had less usage of medical oxygen forecasting tool and practice. Only 31% of all facilities examine and revise their supply plans on a quarterly basis, with 70% of tertiary hospitals and 15.4% of health centers are practicing it.

Despite some positive initiatives, poor inventory management and documentation emerged as a major barrier to accountability and planning. Facility staff repeatedly highlighted deficiencies in basic record-keeping and reporting:

> *"We have a documentation problem and lack of training, which affects forecasting and quantifying oxygen requirements" (merged quotation from HC-17 and Hosp-04).*

The availability of logistics management manuals or SOPs for medical oxygen is low, with only 36% of all facilities reporting having them. See Table 18 below for more information.

Table 18. Inclusion of medical oxygen into the health facility medicine list and quantification and forecasting practice in the surveyed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Facility included medical oxygen in its facility-specific medicine list					
No	55 (52.9)	11 (23.9)	7 (16.3)	1 (10)	74 (36.5)
Yes	49 (47.1)	35 (76.1)	36 (83.7)	9 (90)	129 (63.6)
If 'Yes', medical oxygen quantification and forecasting tool available					
No	30 (61.2)	14 (40)	15 (41.7)	1 (11.1)	60 (46.5)
Yes	19 (38.8)	21 (60)	21 (58.3)	8 (88.9)	69 (53.5)
If 'Yes', do you make annual quantifications					
No	5 (26.3)	2 (9.5)	-	-	7 (10.1)
Yes	14 (73.7)	19 (90.5)	21 (100)	8 (100)	62 (89.9)
Review and update the oxygen and related device supply plan quarterly in line with other supply plans					
No	88 (84.6)	26 (56.5)	23 (53.5)	3 (30)	140 (69)
Yes	16 (15.4)	20 (43.5)	20 (46.5)	7 (70)	63 (31)

Majority of the surveyed health facilities have a high percentage of access to basic medical devices such as oxygen concentrators, pulse oximeters and oxygen cylinders. When looking at the availability of oxygen concentrators, its availability overall was 97% across all facilities. Similarly, Pulse Oximeters are available in 98% of all facilities, and Oxygen Cylinders in 91.1%.

A critical finding was that the unavailability of medical devices was exclusively reported by health centers, with 6.7% (n=7) lacking oxygen concentrators, 3.9% (n=4) lacking pulse oximeters, and 17.3% (n=18) lacking oxygen cylinders; in contrast, all hospitals reported 100% availability for all three devices. See Table 19 below for more information.

Even when medical oxygen is available, major equipment gaps prevent its administration. Facilities at all levels reported shortages of oxygen cylinders of the correct type and size, compounded by incompatibility between cylinders and essential accessories.

A hospital medical director highlighted the persistent cylinder and its accessories shortage:

> *"There is a persistent shortage of oxygen cylinders, particularly the required types. In addition, we seek a supply of spare parts like humidifier bottles, gate valves etc." (Hosp-12).*

The problem of accessory mismatch was repeatedly raised as a major technical barrier:

> *"The availability of essential accessories such as medical regulators (gauges) are also a concern. Many of the regulators received from suppliers are incompatible with existing cylinders, rendering them unusable and creating further gaps in service delivery" (Hosp-05).*

Health centers echoed the same constraints, with one respondent noting that:

> *"Lack of adequate resources like cylinders and concentrators incapacitates the effective implementation of oxygen services" (HC-29).*

As per the medical oxygen roadmap II, tertiary and general hospitals are expected to have an oxygen plant. Of the surveyed health facilities, 20.8% (n=11) owned an oxygen plant, 72.7% (n=8) were functional during the site visits by the data collectors. Majority of the oxygen plants were found in tertiary hospitals 40% (n=4), followed by general hospitals 16.3% (n=7). Central pipelines and manifold systems are also uncommon, available in only 9.4% and 13.2% of facilities, respectively.

Of the surveyed health facilities, 20.8% (n=11) owned an oxygen plant. 72.7% (n=8) were functional during the site visits. Regarding their functionality, 75% (n=3) of the oxygen plants found in tertiary and 71.4% (n=5) of oxygen plants found in general hospitals were functional. Central pipelines and manifold systems were available in only 9.4% and 13.2% of facilities, respectively. See Table 19 below for more information.

According to one of the respondents at the Ministry of Health, advocacy efforts played a critical role in securing international funding for oxygen infrastructure:

> *"Due to our advocacy efforts, funders such as the Global Fund and the World Bank have supported the procurement of oxygen-related equipment. The World Bank funded the procurement of 16 plants with central piping and backup manifold. The Global Fund supported 10 units, with an additional 8 units in progress. Central oxygen piping systems will be installed in 15 health facilities. Of the oxygen plants procured, all 10 supported by the Global Fund have been installed, with only one not yet operational. As for the World Bank-supported plants, eight are being shipped, and the remaining ones are still in production." (MoH-1)*

Table 19. Availability and functionality of medical oxygen sources in the surveyed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Facility has a medical oxygen plant					
No	NA	NA	36 (83.7)	6 (60)	42 (79.3)
Yes	NA	NA	7 (16.3)	4 (40)	11 (20.8)
Is the medical oxygen plant currently functional					
No	NA	NA	2 (28.6)	1 (25)	3 (27.3)
Yes	NA	NA	5 (71.4)	3 (75)	8 (72.7)
Facility has oxygen concentrator					
No	7 (6.7)	0	0	0	7 (3.5)
Yes	97 (93.3)	46 (100)	43 (100)	10 (100)	196 (96.6)
Facility has Pulse oximeters					
No	4 (3.9)	0	0	0	4 (2)
Yes	100 (96.2)	46 (100)	43 (100)	10 (100)	199 (98)
Facility has oxygen cylinders					
No	18 (17.3)	0	0	0	18 (8.9)
Yes	86 (82.7)	46 (100)	43 (100)	10 (100)	185 (91.1)
Are there logistics management manuals/SOPs for medical oxygen					
No	88 (84.6)	20 (43.5)	19 (44.2)	3 (30)	130 (64)
Yes	16 (15.4)	26 (56.5)	24 (55.8)	7 (70)	73 (36)
Facility has a central pipeline					
No	NA	NA	40 (93)	8 (80)	48 (90.6)
Yes	NA	NA	3 (7)	2 (20)	5 (9.4)
Facility has manifold systems					
No	NA	NA	39 (90.7)	7 (70)	46 (86.8)
Yes	NA	NA	4 (9.3)	3 (30)	7 (13.2)

5.4.1 Oxygen plants

According to the MoH report, as of September 2025, Ethiopia has a total of 62 medical oxygen plants distributed across the country. Of these, 60% (n=37) are owned and operated by the public sector (government), while the remaining 40% (n=25) belong to private entities. The national medical oxygen production capacity currently stands at 5,497 m^3/hr. Private-sector plants contribute 51% of this total (2,803 m^3/hr), whereas government-owned plants account for the remaining 49% (2,694 m^3/hr). Recent and ongoing investments by the MoH are significantly expanding public-sector capacity. An additional 24 government plants (each 60 m^3/hr) are at various stages of deployment: 6 have already been delivered to health facilities, increasing national production by 360 m^3/hr (13.4%), and 18 are under procurement, which further increases the national capacity by 1,080 m^3/hr (40%). Together, these represent a committed increase of 1,440 m^3/hr, equivalent to a 53.4% expansion of current public-sector oxygen production capacity. By mid-2026, the national capacity is projected to reach 6,937 m^3/hr, with government plants accounting for approximately 60% (4,134 m^3/hr) of total production. See Table 20 for more information.

However, a respondent from implementing partners highlighted concerns about the long-term sustainability of the current oxygen infrastructure:

> *'For now, oxygen availability is good, but we are not planning for the long run. We need to ask how long these investments will last and address sustainability issues seriously. Almost all of the oxygen plants are funded by NGOs or external donors. These are machines with a defined lifespan, and many are already approaching the end of their service life. In some cases, they may fail even earlier due to improper handling, poor adherence to timely maintenance practices, and limited access to spare parts" (Partners-02)*

Table 20. Current and projected oxygen production capacity by the government

	Current capacity	Projected mid-2026	% Increase from current
Total national capacity (m^3/hour)	5,497	6,937	-
Government-owned capacity (m^3/hour)	2,694	4,134	53.4%
Share of national capacity (government)	49%	60%	-

Figure 2. Currently installed oxygen plants across regions by type of ownership (Source: MoH)

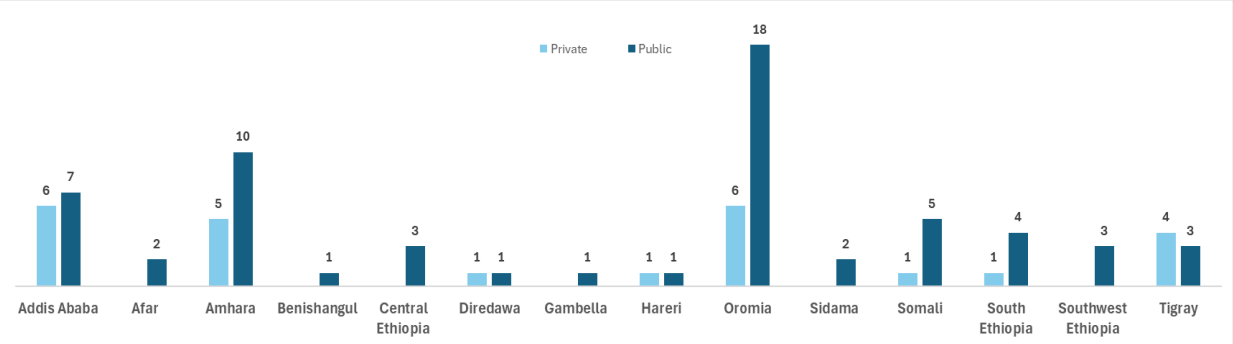
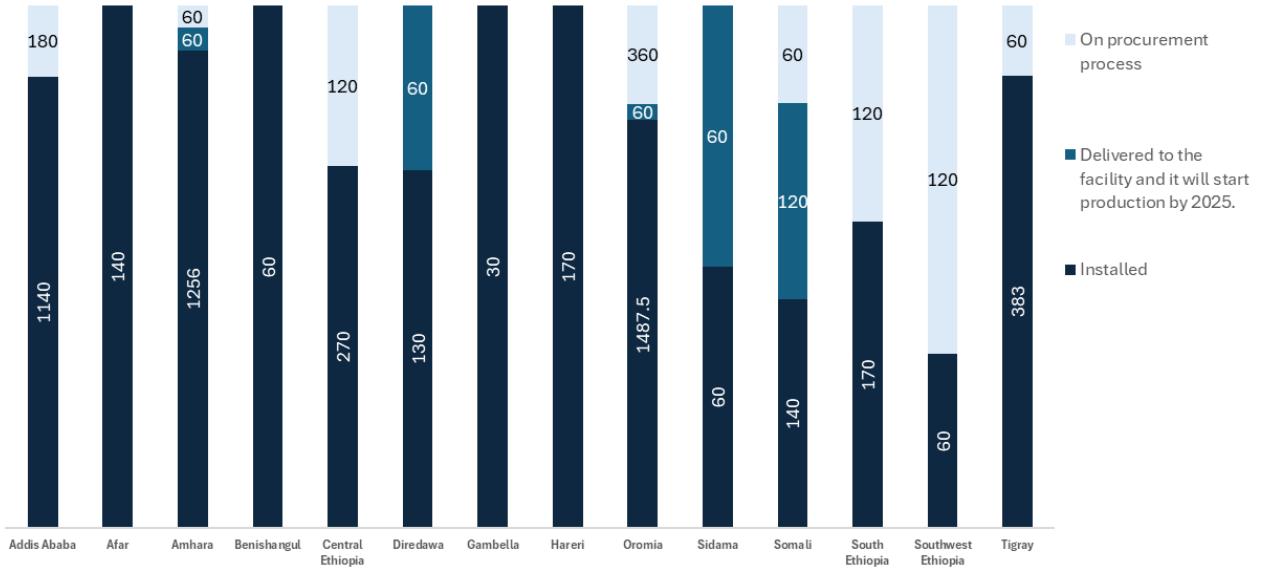


Figure 3. Shows oxygen plants' current oxygen production capacity by regions and future expansion plans (Source: MoH)



The survey also highlighted the oxygen production efficiency of hospitals with an oxygen plant (n=11), revealing variable utilization rates. Individual efficiencies ranged from -100% (n = 2) to 100% (n = 3), with a median of -38% across units. The median oxygen plant design and current/actual capacity for assessed oxygen plants were 60 M³/Hr and 22 M³/Hr, respectively. The overall efficiency was lower at 49%, based on total actual output (409 M³/Hr) relative to designed capacity (803 M³/Hr), indicating substantial underperformance. See Figure 4 for more information.

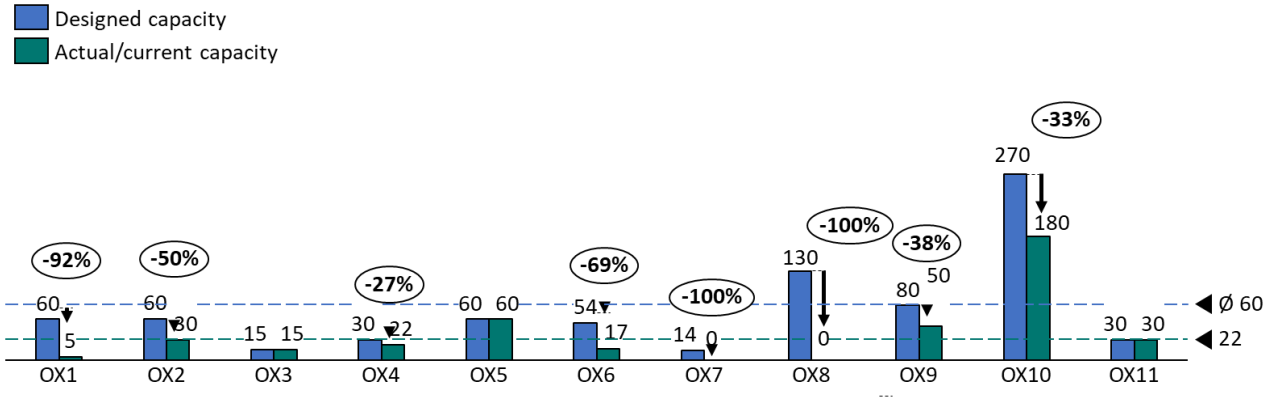


Figure 4. Medical oxygen plants design and actual production capacity of surveyed health facilities
OX- Oxygen plant

Table 21 presents the designed and current oxygen production capacities of the surveyed health facilities (n = 11). The median designed oxygen production capacity for general hospitals and tertiary hospitals was 60 m^3/hr and 92 m^3/hr, respectively. The minimum size (designed capacity) of the oxygen plants installed in general hospitals was 14 m^3/hr, with a maximum of 80 m^3/hr; for tertiary hospitals, the minimum was 30 m^3/hr and the maximum was 270 m^3/hr.

Table 21. Medical oxygen design and current actual production capacity by type of health facility

	General Hospital		Tertiary hospital	
Statistics	Design capacity	Actual/current capacity	Design capacity	Actual/current capacity
Mean	45.6	27.1	121	54.8
SD	25.8	22.3	108	84
Min	14	0	30	0
Max	80	60	270	180
p50	60	30	92	19.5
IQR	45	45	158	92.5

Note- the production capacities are in M3/hr.
SD = standard deviation; Min = minimum; Max = maximum; p50 = median; IQR = Inter quartile range

5.4.2 Oxygen concentrators

Table 22 shows percentages derived from summed counts and expressed in percentages of functionality status of medical oxygen concentrators per facility type. The availability of functional oxygen concentrators was 65% in service areas, 22% in the store, and yielded an aggregate functionality rate of 87%.

When looking at the facility level patterns, health centers have shown the highest overall functionality (95%) with substantial storage reserves (36%). In contrast, primary hospitals showed balanced deployment with 63% in service but a dip in overall functionality to 87%. General hospitals displayed service-area utilization of 68%, yet overall functionality declined to 84%. Similarly, tertiary hospitals have similar trends, with the highest deployment (68%) but the lowest overall functionality (81.2%). See Table 22 for more information.

Table 22. Oxygen Concentrator Functionality by Health Facility Type

Variables	Health center (n=97)	Primary hospital (n=46)	General hospital (n=43)	Tertiary hospital (n=10)	Average
Functional in-Service Area (%)	60.19	62.83	67.67	67.94	65
Functional in Store (%)	35.67	24.29	16.39	13.24	22
Overall Functional (%)	95.86	87.12	84.06	81.18	87
Total units (aggregate number)	314	1,017	1,324	627	3,282

Note. Percentages reflect the distribution of total concentrators (3,282 units) by functionality category within each facility type.

In Health centers, a median of 2 concentrators were available in the service area, at least 1 in the store, and non-functionality was rare. In primary hospitals, the median number of functional concentrators in service area was 14, with an additional 4 in storage, and non-functional concentrators were 2. The distribution was more skewed in larger hospitals. In general hospitals, the median number of oxygen concentrators in the service area was 19, with 3 in storage, and 5 were non-functional. In tertiary hospitals, the median number of functional devices in service areas was 37, with 3 in storage and 8 non-functional. See Table 23 for more information.

Table 23. Summary of concentrators' availability and functionality by facility types of surveyed facilities

	N	Sum	Mean	SD	Min	Max	p50	IQR
Health Center								
Functional in the service area	97	189	2	1	0	8	2	2
Functional in the store	97	112	1	1	0	6	1	2
Non-functional	97	13	0	0	0	2	0	0
Primary Hospital								

	Functional in the service area	46	639	14	6	4	35	14	7
	Functional in the store	46	247	5	6	0	25	4	5
	Non-functional	46	131	3	3	0	13	2	3
General Hospital									
	Functional in the service area	43	896	21	10	1	50	19	15
	Functional in the store	43	217	5	7	0	27	3	6
	Non-functional	43	211	5	4	0	12	5	5
Tertiary Hospital									
	Functional in the service area	10	426	43	24	18	96	37	23
	Functional in the store	10	83	8	15	0	50	3	6
	Non-functional	10	118	12	12	0	36	8	18
Total									
	Functional in the service area	196	2150	11	13	0	96	5	15
	Functional in the store	196	659	3	6	0	50	2	4
	Non-functional	196	473	2	4	0	36	0	3

N = sample size; SD = standard deviation; Min = minimum; Max = maximum; p50 = median; IQR = Inter quartile range

According to a report obtained from the Ethiopian Pharmaceutical Supply Service (EPSS), the MoH and its partners have procured and distributed various types of medical oxygen concentrators to health facilities and RHBs to enhance access to medical oxygen services across the country. To date, a total of 9,087 oxygen concentrators has been distributed: 7,262 in 2022/23, 8 in 2023/24, 1,588 in 2024/25, and 229 in 2025 (up to December).

5.4.3 Pulse oximeters

Table 24 shows percentages derived from summed counts and expressed in percentages of functionality status of pulse oximeters (including those embedded in patient monitors) per facility type. The availability of functional pulse oximeters was 64% in service areas, 26% in the store and yielded an aggregate functionality of 90%.

Facility-level analyses further show these trends: Health centers had the highest overall functionality of 95% and characterized by moderate deployment in service areas 54% alongside significant storage reserves 41%. Conversely, primary hospitals reported the lowest overall functionality at 86%, with only 45% of devices in active service areas and the highest non-functionality rate 14%. General hospitals demonstrated strong service-area utilization 71% and the second-best overall functionality 90%. Finally, tertiary hospitals exhibited the highest placement of pulse oximeters 77% but a slightly diminished overall functionality of 89%. See Table 24 for more information.

Table 24. Pulse Oximeter Functionality by Health Facility Type

Health facility type	Health center	Primary hospital	General hospital	Tertiary hospital	Total
N Facilities	100	46	43	10	199
Functional in-Service Area (%)	54	45	71	77	64
Functional in Store (%)	41	41	19	12	26
Overall Functional (%)	95	86	90	89	90
Total Units	552	799	2002	466	3819

Note. Detailed analysis excludes 4 health centers with missing pulse oximeters (n = 199). Percentages reflect the distribution of total pulse oximeters (3,819 units) by functionality category within each facility type.

Of the 199 health facilities, a median of 5 pulse oximeters were available in-service areas, in-store, there were 3, and non-functional pulse oximeters were rare. In primary hospitals, the median number of functional pulse oximeters in service area was 8, with an additional 6 in storage and non-functional pulse oximeters of 2. The distribution was more skewed in larger hospitals. In general hospitals, the median number of oxygen pulse oximeters in the service area was 15, with 5 in storage, and 4 were non-functional. In tertiary hospitals, the median number of functional devices in service areas was 36, with 5 in storage, and 4 non-functional. See Table 25 for more information.

Table 25. Summary of pulse oximeters availability and functionality by facility types of surveyed facilities

	N	Sum	Mean (SD)	Median (IQR)	Min	Max
Health Center						
Functional in the service area	100	297	3 (2)	2 (3)	0	14
Functional in the store	100	228	2 (3)	2 (4)	0	13
Non-functional	100	27	0 (1)	0	0	3
Primary Hospital						
Functional in the service area	46	358	8 (3)	8 (5)	1	18
Functional in the store	46	329	7 (6)	6 (9)	0	25
Non-functional	46	112	2 (2)	2 (3)	0	9
General Hospital						
Functional in the service area	43	1419	33 (107)	15 (12)	0	712
Functional in the store	43	374	9 (11)	5 (12)	0	54
Non-functional	43	209	5 (4)	4 (5)	0	12
Tertiary hospital						
Functional in the service area	10	358	36 (22)	36 (20)	7	86
Functional in the store	10	55	6 (6)	5 (10)	0	14
Non-functional	10	53	5 (6)	4 (3)	0	20
Total						
Functional in the service area	199	2432	12 (51)	5 (8)	0	712
Functional in the store	199	986	5 (7)	3 (7)	0	54
Non-functional	199	401	2 (3)	0 (3)	0	20

According to a report obtained from the EPSS, the MoH and its partners have procured and distributed various types of pulse oximeters to health facilities and RHBs to enhance access to hypoxemia diagnostics across the country. To date, a total of 20,370 pulse oximeters has been distributed: 15,994 in 2022/2023, 1 in 2023/2024, 3,693 in 2024/2025, and 682 in 2025 (up to December).

5.4.4 Medical oxygen cylinders

Table 26 shows percentages derived from summed counts and expressed in percentages of functional medical oxygen cylinders per facility type. The availability of functional cylinders was 81% in service areas, 10% in the store and yielded an aggregate functionality of 91%.

Facility-level analyses further shown these trends: Health centers had the highest overall functionality of 97%, and deployment in service areas 57% alongside significant storage reserves 39%. Conversely, primary hospitals reported an overall functionality at 95%, with strong service area utilization of 88% of cylinders in active service areas. General hospitals exhibited a good service-area utilization 78% and an overall functionality of 91%. Finally, tertiary hospitals availed cylinders in service areas 85% but had the lowest overall functionality of 88%.

Table 26. Medical Oxygen Cylinders Functionality by Health Facility Type

Health facility type	Health center	Primary hospital	General hospital	Tertiary hospital	Total
N Facilities	86	46	43	10	185
% Functional In-Service Area	57.3	88.4	77.6	85.1	81.4
% Functional in Store	39.3	6.7	13.2	3.2	9.9
% Overall Functional	96.6	95.2	90.8	88.3	91.3
Total Units	494	3217	6455	3750	13916

Note. Percentages reflect the distribution of total medical oxygen cylinders (13,916 units) by functionality category within each facility type.

When looking at the overall functionality of cylinders, median of 104 medical oxygen cylinders were available in-service areas, in store there were 23 and non-functional were 27. In health centers, there were median of 6 functional cylinders in service areas, with an additional 2 in storage and there were few non-functional. The distribution was more skewed in larger hospitals. Tertiary hospitals had the highest median number of functional medical oxygen cylinders in the service area (177), the highest median number in storage (24), and the highest median number of non-functional cylinders (92). See Table 27 for more information.

Table 27. Summary of medical oxygen cylinders availability and functionality by facility types of surveyed facilities

Health Center	N	Sum	Mean (SD)	Median (IQR)	Min	Max
Functional in the service area	86	283	3(6)	6(2)	0	28
Functional in the store	86	194	2(2)	2(3)	0	15
Non-functional	86	17	0(1)	1	0	4
Primary Hospital						
Functional in the service area	46	2845	62(74)	74(51)	0	515
Functional in the store	46	216	5(8)	8	0	37
Non-functional	46	156	3(6)	6(1)	0	28
General Hospital						
Functional in the service area	43	5007	116(97)	97(77)	15	400
Functional in the store	43	853	20(44)	44	0	210
Non-functional	43	595	14(28)	28(5)	0	172
Tertiary hospital						
Functional in the service area	10	3190	319(177)	177(337)	55	559
Functional in the store	10	121	12(24)	24(1)	0	70
Non-functional	10	439	44(92)	92(9)	0	290
Total						
Functional in the service area	185	11325	61(104)	104(20)	0	559
Functional in the store	185	1384	7(23)	23(1)	0	210
Non-functional	185	1207	7(27)	27	0	290

According to a report obtained from the EPSS, the MoH and its partners have procured and distributed various types of medical oxygen cylinders to health facilities and RHBs to enhance access to medical oxygen services across the country. To date, a total of 7,630 oxygen cylinders of various sizes have been distributed: 967 in 2022/23, 6,272 in 2024/25, and 391 in 2025 (up to December).

5.4.5 Medical oxygen consumables

For the management of patients with hypoxemia, oxygen must first be produced and concentrated to a safe level for administration. Once the source has been determined by the healthcare provider based on the patient's medical condition and level of consciousness, oxygen can be delivered via various methods. Among these, the most common are nasal prongs and face masks. Accordingly, this evaluation assessed the number of nasal prongs and face masks provided to institutions for providing supplemental medical oxygen therapy to patients with low blood oxygen levels during the last three years of implementation.

Table 28 summarizes the procurement or support of nasal prongs and face masks by the Ministry of Health (MoH) and its partners over the past three years for the surveyed health facilities (n = 202 for nasal prongs; n = 203 for face masks). A total of 27,591 nasal prongs were distributed to all facilities except one, with a median of 15 per facility. Notably, general hospitals received nearly 39% of the total, highlighting a concentration of resources in higher-level facilities. For face masks, all facilities reported receipt, and a total of 17,901 units were reported by health facilities, with a median of 5 per facility; tertiary hospitals accounted for 43% of the allocation.

Table 28. Medical Oxygen consumables that were procured/received by donation in the past three years by facility type

HF	N	Sum	Percent	Mean	SD	Min	Max	p50	IQR
Nasal Prongs									
Health Center	103	1936	7	18.8	88.0	0	888	5	10
Primary Hospital	46	4783	17.3	104.0	234.1	0	1500	50	83
General Hospital	43	10740	38.9	249.8	397.3	0	1900	120	165
Tertiary hospital	10	10132	36.7	1013.2	1204.1	1	3016	275	1970
Total	202	27591	100	136.6	403.0	0	3016	15	66
Face Mask									
Health Center	104	1165	6.5	11	54	0	470	0	3
Primary Hospital	46	2642	14.8	57	91	0	504	24.5	53
General Hospital	43	6437	36	150	233	0	1143	50	180
Tertiary hospital	10	7657	42.8	766	956	0	2511	139	1580
Total	203	17901	100	88	287	0	2511	5	45

N = sample size; SD = standard deviation; Min = minimum; Max = maximum; p50 = median; IQR = Inter quartile range

5.5 Medical Oxygen Safety and Quality Assurance Practices in Healthcare Facilities

With the increase in knowledge on medical oxygen, the roadmap has also recommended regular purity checks of oxygen sources by health facilities. Accordingly, this survey highlighted that overall, 57% (n=103) of health facilities did not perform regular medical oxygen purity checks. And this was highly observed in health centers at 89% (n=72). On the contrary, higher tier-level facilities performed regular quality checks, with general hospitals at 74.4% (n=32) and tertiary hospitals at 70.0% (n=7).

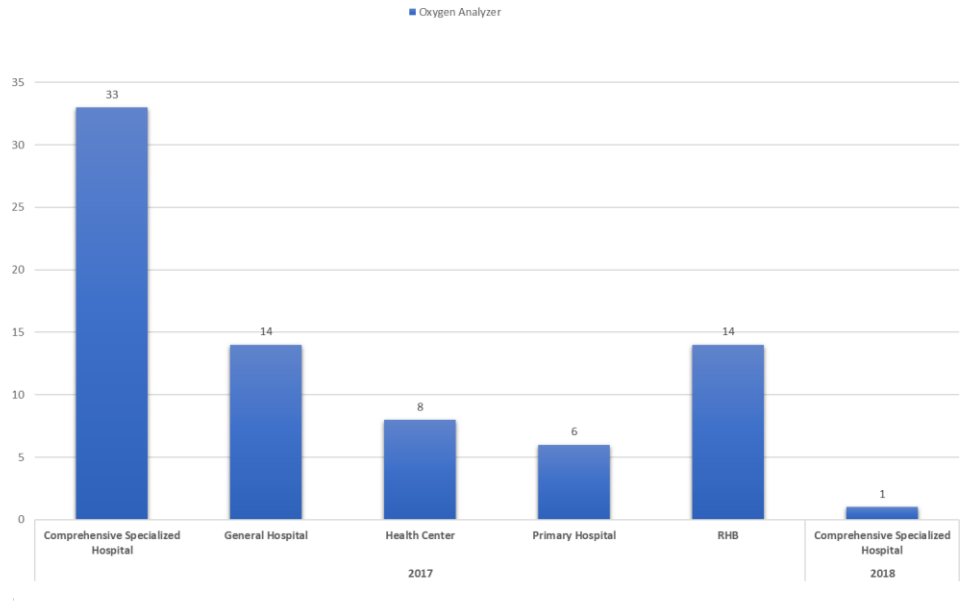
Many facilities reported a lack of basic equipment and dedicated personnel required to conduct essential quality and safety checks, particularly measuring the purity of oxygen from concentrators or cylinders.

According to one of the health care facility staff respondents:

"The purity of oxygen at facility level is not checked by oxygen analyzer. This is due to lack of biomedical staff."

A critical challenge reported by facilities is the shortage of trained biomedical staff and a general lack of awareness among clinical staff regarding crucial aspects of oxygen quality and safety. A hospital medical director noted the impact of staff turnover on technical checks:

"Currently we are not checking oxygen purity in the hospital since the biomedical staff left the hospital."



According to a report obtained from the EPSS, the MoH and its partners have procured and distributed oxygen analyzers to health facilities and RHBs. To date, a total of 76 oxygen analyzers has been distributed: 75 in 2024/25, and 1 in 2025 (up to December).

Figure 5. Medical oxygen analyzers provided by type of facility (Source: EPSS database)

A health center participant summarized the issue comprehensively:

"The health center is currently incapable in measuring the purity of oxygen produced by its concentrators due to the reason that there is no resource and required training together with committed action for this process. Another quality issue mentioned was the lack of routine cylinder cleaning: "there is a lack of access to facilities that provide cylinder cleaning services, preventing routine maintenance of the equipment."

WHO guidelines emphasize that medical oxygen cylinders need regular cleaning to get rid of impurities (such as grease, grime, or residues) that could react with oxygen and cause contamination or fire. This is mandatory for healthcare setups. From the assessed health facilities, 80% (n=116) did not regularly wash their oxygen cylinders. Tertiary-level hospitals had relatively better cylinder washing practice (40%). And the practice decreases as the level of the tier in the health system decreases. See Table 29 for more information.

Table 29. Medical Oxygen Quality and Maintenance Practices Across Healthcare Facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Regularly check the purity of oxygen (n=181) *i.e. those providing medical oxygen service*					
No	72 (87.8)	17 (37)	11 (25.6)	3 (30)	103 (56.9)
Yes	10 (12.2)	29 (63)	32 (74.4)	7 (70)	78 (43.1)
Wash oxygen cylinders*					
No	42 (85.7)	36 (78.3)	32 (76.2)	6 (60)	116 (78.9)
Yes	7 (14.3)	10 (21.7)	10 (23.8)	4 (40)	31 (21.1)

*33 of the health centers that were assessed did not provide information.

5.6 Strengthen Medical Oxygen Device Management

The midterm evaluation also tried to assess the availability of maintenance workshops in the healthcare facilities, and significant disparities were observed. Overall, the availability of maintenance workshops at health facilities was 65% of the responding (n=55) health facilities.

The mid-term evaluation assessed the availability of standard operating procedures (SOPs) or manuals for medical oxygen device maintenance. Overall, 50% (n=101) of health facilities had these SOPs or manuals. Availability was highest in tertiary-level hospitals, where it reached 100%, followed by general hospitals at 84% and primary hospitals at 78%. However, the majority of health centers, 82% (n=85), lacked SOPs or manuals for medical oxygen device maintenance during the survey.

Of the 203 health facilities evaluated, 50% (n=102) lacked BME/Ts. All tertiary hospitals had BME/Ts, followed by general hospitals 95% (n=41) and primary hospitals 83% (n=38). In contrast, the majority of health centers at 89% (n=92) did not have BME/Ts.

The midterm evaluation also aimed to assess the availability of preventive maintenance schedules for selected key medical oxygen devices, namely concentrators, continuous positive airway pressure (CPAP), mechanical ventilators, pulse oximeters, and oxygen plants across various facility types. Accordingly, the surveyed health facilities revealed that, of the listed oxygen-related medical devices, concentrators had the highest preventive maintenance schedule at 98% (n=92), followed by pulse oximeters at 85% (n=80). The preventive maintenance schedule for concentrators, CPAP, and mechanical ventilators was found to be exemplary, achieving 100% (n=10) in tertiary hospitals. In contrast, the practice was significantly lower for oxygen plants, at only 40% (n=4). Overall, the preventive maintenance schedule practice was deemed good for almost every medical device; however, it was notably lower in primary hospitals, where CPAP preventive maintenance reached just 59% (n=22), and mechanical ventilators had a preventive maintenance schedule at only 32% (n=12). See Table 30 below for more information.

Table 30. Biomedical workshops, manuals and SOPs, and professional availability in surveyed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Availability of maintenance workshop					
No	16 (84.2)	6 (20.7)	6 (23.1)	0	28 (32.9)
Yes	1 (5.3)	23 (79.3)	20 (76.9)	11 (100)	55 (64.7)
NA	2 (10.5)	-	-	-	2 (2.4)
Oxygen device maintenance SOPs or manuals					
No	85 (81.7)	10 (21.7)	7 (16.3)	0	102 (50.3)

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Yes	19 (18.3)	36 (78.3)	36 (83.7)	10 (100)	101 (49.8)
Do you have BME/Ts in your facility?					
No	92 (88.5)	8 (17.4)	2 (4.7)	0	102 (50.3)
Yes	12 (11.5)	38 (82.6)	41 (95.4)	10 (100)	101 (49.8)
Availability of preventive maintenance schedule for Medical Oxygen Devices (MODs)					
Concentrator	9 (90)	37 (100)	36 (97)	10 (100)	92 (98)
CPAP	NA	22 (59)	33 (89)	10 (100)	65 (69)
Mechanical ventilator	NA	12 (32)	35 (95)	10 (100)	57 (61)
Pulse oximeter	10 (100)	31 (84)	30 (81)	9 (90)	80 (85)
Oxygen Plants	NA	0	3 (8)	4 (40)	7 (7)

From the assessed health facilities, 55% (n=112) conducted their own equipment preventive maintenance, while 33% (n=67) contacted the Regional Health Bureau (RHB), Zonal, or Woreda Health Offices for preventive maintenance. Other methods were reported by 14% (n=28), and 7% (n=14) contacted manufacturers, agents, or suppliers. Only 4% (n=7) used third-party private companies, and 7% (n=14) were unsure of preventive maintenance processes ("Don't know"). All tertiary level hospitals (100%, n=10) conducted their own preventive maintenance, followed by general hospitals 90.70% (n=39) and primary hospitals 86.96% (n=40). In contrast, the majority of health centers, 44% (n=46) relied on RHB/Zonal/Woreda Health Offices, with only 22% (n=23) conducting their own maintenance. Notably, 13% (n=13) of health centers reported "Don't know," indicating uncertainty in maintenance processes. See Table 31 below for more information.

Table 31. Routine preventative maintenance practice of surveyed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Availability of preventive maintenance schedule for Medical Oxygen Devices (MODs)					
Facility conducts its own maintenance	23 (22)	40 (87)	39 (91)	10 (100)	112 (55)
Contacts the RHB, Zonal Health Office, or Woreda Health Office	46 (44)	11 (24)	10 (23)	0	67 (33)
Other	25 (24)	2 (4)	1 (2)	0	28 (14)
Contacts the manufacturer, agent, or supplier	3 (3)	3 (7)	7 (16)	1 (10)	14 (7)
Contacts a third-party private company to conduct maintenance	0	2 (4)	1 (2)	4 (40)	7 (3)
Don't know	13 (13)	0	1 (2)	0	14 (7)

Among the health facilities evaluated, 60% (n=122) contacted the RHB, Zonal, or Woreda Health Offices for equipment repairs, making it the most prevalent method, followed by 51% (n=103) that performed their own repairs. Additionally, 20% (n=41) reached out to manufacturers, agents, or suppliers, 14% (n=28) engaged third-party private companies, 8% (n=16) used other methods, and 5% (n=10) were uncertain about repair processes ("Don't know"). All tertiary hospitals (100%, n=10) conducted their own repairs. Conversely, the majority of health centers 69% (n=72) depended on RHB/Zonal/Woreda Health Offices, with only 12% (n=12) handling their own repairs. See Table 32 below for more information.

Table 32. Definitive repair practice of assessed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Contacts the RHB, Zonal Health Office, or Woreda Health Office	72 (69)	27 (59)	21 (49)	2 (20)	122 (60)
Conducts its own repairs	12 (12)	40 (87)	41 (95)	10 (100)	103 (51)
Contacts the manufacturer, agent, or supplier to repair	5 (5)	12 (26)	19 (44)	5 (50)	41 (20)
Contacts a third-party private company to conduct the repair	5 (5)	7 (15)	9 (21)	7 (70)	28 (14)
Other	16 (15)	0	0	0	16 (8)
Don't know	8 (8)	1 (2)	1 (2)	0	10 (5)

Of the 203 health facilities surveyed, 50% (n=101) reported the presence of Biomedical Engineers, Biomedical Technicians, or Mechanical Engineers. Among these, 51% (n=52) had 1–3 such professionals, 7% (n=7) had 4–8, and 42% (n=42) had none. Conversely, health centers showed the highest absence rate at 83.33% (n=10), followed by primary hospitals at 50% (n=19).

For Biomedical Technicians, 69% (n=70) of facilities employed 1–3 professionals, 5% (n=5) employed 4–8 professionals, and 26% (n=26) had none. The absence of biomedical technicians was most notable in health centers, with 33% (n=4), followed by tertiary hospitals at 30% (n=3). Facilities with 1–3 biomedical technicians were prevalent across all hospital types, with general hospitals, primary hospitals, and health centers at 73%, 74%, and 67%, respectively. Similar to biomedical engineers, facilities with 4–8 biomedical technicians were concentrated in 30% (n=3) of tertiary hospitals.

For Mechanical Engineers, the presence was notably limited, with 98% (n=99) of facilities reporting none and only 2% (n=2) employing 1–3 professionals. All facility types except tertiary level hospitals reported a complete absence of Mechanical Engineers. 20% (n=2) of the tertiary hospitals reported availability of 1–3 professionals, indicating that Mechanical Engineers are almost exclusively found in tertiary facilities. See Table 33 below for more information.

Table 33. Availability of BME/T in the surveyed health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Biomedical Engineer					
None	10 (83)	19 (50)	13 (32)	0	42 (42)
1-3	2 (17)	19 (50)	24 (59)	7 (70)	52 (51)
4-8	0	0	4 (10)	3 (30)	7 (7)
Biomedical Technician					
None	4 (33)	10 (26)	9 (22)	3 (30)	26 (26)
1-3	8 (67)	28 (74)	30 (73)	4 (40)	70 (69)
4-8	0	0	2 (5)	3 (30)	5 (5)
Mechanical Engineer					
None	12 (100)	38 (100)	41 (100)	8 (80)	99 (98)
1-3	0	0	0	2 (20)	2 (2)

The midterm evaluation assessed the implementation of maintenance mechanisms for these oxygen plants. According to the Ethiopian Medical Oxygen Roadmap II, safe operation, maintenance, and

calibration of medical oxygen devices are essential. To ensure the functionality of oxygen plants, it recommends establishing maintenance contract management (outsourcing) arrangements by the MoH, RHBs, and partners. However, of the health facilities with an oxygen plant, 55% (n=6) did not have any maintenance agreements with third parties, while 46% (n=5) had signed contracts during the survey. Among the health facilities with maintenance arrangements, it was notable that tertiary hospitals had a higher frequency, with 75% (n=3) having such agreements, while 71% (n=5) of general hospitals did not have maintenance agreements.

The Ethiopian Medical Oxygen Roadmap II planned to integrate oxygen regulation with the routine regulatory system and establish a licensing mechanism for medical oxygen production (oxygen plants) and distribution systems. However, during the survey, it was noted that none of the hospitals with an oxygen plant had obtained biannual licensing from the regulatory body. See Table 34 below for more information.

Table 34.Outsourcing of maintenance for oxygen plant practice of health facilities with an oxygen plant

	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Outsourcing practice for maintenance of oxygen plants			
No	5 (71)	1 (25)	6 (55)
Yes	2 (29)	3 (75)	5 (46)
Oxygen plant is licensed biannually, fulfilling the minimum requirements			
No	7 (100)	4 (100)	11 (100)

5.7 Sustainable Financing Mechanism for the Medical Oxygen System

Table 35 presents the availability and use of an approved sustainable oxygen financing directive in health facilities with an oxygen plant. As part of the Ethiopian Medical Oxygen Roadmap II, it was planned to develop a business plan with sustainability criteria and to conduct ongoing measurements and gap analyses for long-term financing of medical oxygen systems for enterprises and facilities. Accordingly, the roadmap recommended that the MoH devise a sustainable financing scheme for oxygen plants that are already installed and those in the pipeline. And MoH needs to prepare a directive ensuring its implementation in Federal institutions, while the regional health bureaus are expected to adopt it to their own context. In this regard, the mid-term evaluation assessed health facilities for the availability of this directive. It was found that 73% (n=8) of the hospitals confirmed its availability. Among those that confirmed, tertiary hospitals had the highest proportion at 75% (n=3), followed by general hospitals at 71% (n=5).

The other strategic way to improve equitable access to medical oxygen is mapping facilities and creating a collaboration for a resource-sharing platform within a catchment. To strengthen this, a hub-and-spoke model has been introduced, and regions are implementing it.

The roadmap also recommended that oxygen plants, whether currently installed or planned for installation in government hospitals, should adopt a hub-and-spoke approach. Under this model, excess oxygen can be supplied to catchment health facilities, enabling hospitals to generate revenue by selling the surplus. This income can be used to procure necessary spare parts, cover operational costs, and, in the long term, save funds to purchase a new plant. Accordingly, among health facilities with oxygen plants

(n = 11), 55% (n = 6) provided refilling services or sold excess oxygen to nearby health facilities, whereas 45% (n = 5) did not engage in selling. Additionally, three of these plants were non-functional. In contrast, 71% (n = 5) of general hospitals sold their oxygen, while 75% (n = 3) of tertiary hospitals did not.

A participant from region 03 said

> *"The RHB has implemented a hub-and-spoke model, utilizing a cluster-based approach to distribution. And to ensure the long-term sustainability of oxygen services, the RHB developed a sustainable financing directive, along with comprehensive guidelines and manuals."*

Overall, half of the facilities with an oxygen plant sell their excess oxygen to their catchment health facilities. 50% (n = 3) fall under the medium category (supplying 11–30 health facilities), 33% (n = 2) of the six health facilities were classified in the Low category (supplying ≤ 10 health facilities) and 17% (n = 1) in the High category (supplying > 30 health facilities). Among the general hospitals, 60% (n = 3) are in the medium category.

Table 35. Availability of approved sustainable oxygen financing directive by facility type

	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Availability of sustainable oxygen financing directive			
No	2 (29)	1 (25)	3 (27)
Yes	5 (71)	3 (75)	8 (73)
Selling excess oxygen to catchment health facilities			
No	2 (29)	3 (75)	5 (46)
Yes	5 (71)	1 (25)	6 (55)
Distribution of catchment facility categories by facility type for oxygen dispensing or selling*			
Low (≤ 10)[1]	1 (20)	1 (100)	2 (33)
Medium (11–30)[2]	3 (60)	0	3 (50)
High (> 30)[3]	1 (20)	0	1 (17)

*This metric is operationalized as a categorical variable with three levels based on the median number of facilities served (18.50). The categorization is derived from survey data on the number of facilities served, reflecting the number of facilities to which oxygen is sold, and is used to assess the scope of oxygen refilling services across different facility types.
1. Low (≤ 10 facilities), indicating minimal outreach
2. Medium (11–30 facilities), representing a moderate outreach
3. High (> 30 facilities), denoting wide-ranging outreach

Table 36 shows of the availability of an approved sustainable oxygen financing directive in health facilities with oxygen plants across seven regions in Ethiopia that reported owning an oxygen plant. The regions included Afar, Amhara, Benishangul, Gambella, Oromia, South Ethiopia, and South-West Ethiopia, with a total of 11 health facilities that reported owning an oxygen plant. The sustainable oxygen financing directive was observed in six of the seven regions, with an overall prevalence of 73% (n = 8) of facilities confirming its availability, while 27% (n = 3) did not have the directive.

While looking at regions where an oxygen plant was reported during the survey, almost all had at least one health facility with the directive. Of the health facilities assessed that had an on-site oxygen plant, all reported availability of the oxygen directive except for a single facility in the Amhara region (100%, n = 1). This was the only oxygen-plant equipped facility evaluated in Amhara, making it the sole region where the directive was entirely unavailable in facilities possessing an oxygen plant. Oromia, with the largest number of reported availability of an oxygen plant, four facilities, had the highest number of facilities with the directive 75% (n = 3), while one facility (25%) lacked it. South Ethiopia, with two facilities, showed an even distribution, with 50% (n = 1) having the directive and 50% (n = 1) not having it.

Table 36.. Availability of approved sustainable oxygen financing directive by region

	Afar	Amhara	Benishangul	Gambella	Oromia	South Ethiopia	South-West Ethiopia	Total
No	0	1	0	0	1	1	0	3
	0	100	0	0	25	50	0	27
Yes	1	0	1	1	3	1	1	8
	100	0	100	100	75	50	100	73

First row has frequencies and second row has column percentages.

For general hospitals (N = 5), the median oxygen cost was 55 ETB, a minimum of 50 ETBs and a maximum of 71 ETB. For tertiary hospitals (N = 2), the median oxygen cost was 62 ETBs, a minimum of 60 ETBs, a maximum of 63 ETB. Across all seven facilities, the median cost was 55 ETBs, Costs ranged from 50 to 71 ETB.

Table 37. The selling price in ETB of oxygen in hospitals with oxygen plants and having their respective region directive

HF	N	Mean	p50	Min	Max	SD
General Hospital	5	57	55	50	71	8
Tertiary Hospital	2	62	62	60	63	2
Total	7	58	55	50	71	7

Note. N = sample size; M = mean; SD = standard deviation; Min = minimum; Max = maximum

Of the hospitals selling excess oxygen, the median cost was 55 ETB per cubic meter (m^3) and 373 ETB per cylinder, respectively. These figures are based on 11 observations for price per m^3 and 10 for per cylinder. See Table 38 for more information.

Table 38. Oxygen refilling price by type of hospitals selling oxygen.

	Mean	Median	SD	Min	Max
Price per m^3 (ETB)	48.91	55	29.04	0	98
Per cylinder (ETB)	310.45	373	244.41	0	753

Note. N = sample size; M = mean; SD = standard deviation; Min = minimum; Max = maximum

Table 39 shows the revenue generated by selling excess oxygen to catchment health facilities. Among health facilities with an oxygen plant (n = 11), 55% (n = 6) provided refilling services or sold excess oxygen to nearby health facilities. The evaluation examined the practice of selling excess oxygen produced by on-site plants to nearby health facilities. This practice was assessed starting from 2013 E.F.Y. (2020/21 G.C.) at a few facilities and became widespread by 2015 E.F.Y. (2022/23 G.C.), at which point nearly all facilities with oxygen plants reported selling their surplus production. In the first year, the median revenue collected was 74,944 ETB. The median revenue in 2016 was approximately 4.93 times that of 2015, and the median revenue in 2017 was approximately 1.41 times that of 2016. The median revenue grew by 163% annually over the two-year period. The maximum revenue was recorded in 2017 E.F.Y. See Figure 6 for more information.

Table 39. Revenue collected by selling excess oxygen to catchment health facilities.

Year	N	Mean	Median	SD	Min	Max
2015 E.F.Y	6	314,570	74,944	441,065	0	1,000,000
2016 E.F.Y	6	1,010,000	369,513	1,560,000	0	4,000,000
2017 E.F.Y	6	777,053	519,500	854,193	0	2,000,000

Note. N = sample size; SD = standard deviation; Min = minimum; Max = maximum

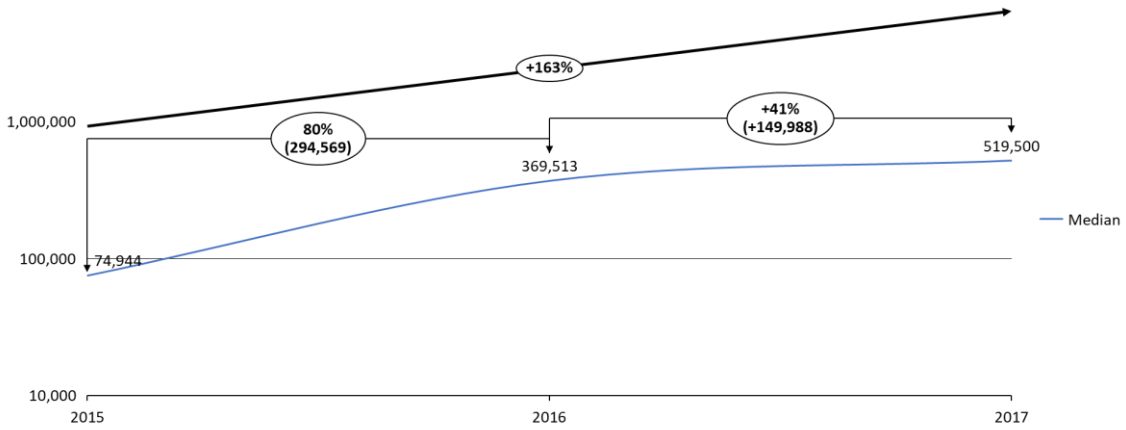


Figure 6. Showing the median revenue earned by health facilities (n=6)

According to the end-term evaluation of the previous medical oxygen roadmap, medical oxygen was not included in Ethiopia's existing health insurance schemes. The evaluation recommended recovering the costs of oxygen services incurred by healthcare facilities to establish a sustainable financing mechanism for the medical oxygen system, along with devising a cost recovery strategy to support ongoing oxygen supply. To assess the implementation of this recommendation, the midterm evaluation examined cost recovery practices across health facilities. Accordingly, of the (n=181) health facilities that are providing supplemental medical oxygen service, the most common method still in use across all facilities was out-of-pocket expenditure by patients, accounting for 62% (n = 113), followed by community-based health insurance (CBHI) at 54% (n = 98). These figures reflect the number of facilities that selected each mechanism rather than the number of facilities overall, as respondents were permitted to select multiple cost recovery options simultaneously. See Table 40 for more information.

The lack of clear financial policies to cover the cost of oxygen forces facilities to absorb unexpected expenditures or struggle to maintain a continuous supply. Facilities often lack functional mechanisms for cost-recovery or dedicated budget lines that fully reflect the actual expense of providing oxygen therapy.

A hospital representative reported that the high costs are not covered, stating,

"The hospital does not have sustainable financing mechanisms to cope with the high recurrent costs associated with oxygen procurement and maintenance. This financial gap leads to continuous pressure on facility budgets. And the medical oxygen reimbursement cost is not considering the current price or cost." (Hosp-07)

The hospital respondent added that

"It is difficult to set a proper reimbursement mechanism for oxygen services in our hospital, which limits revenue generation and ongoing procurement of supplies." (Hosp-05)

Another hospital medical director highlighted the challenges they faced with standardizing the price of oxygen for all types of patients they see at the facility. He responded that:

"The implementation of sustainable financing and service fee reimbursement mechanisms was significantly challenged by the Community-Based Health Insurance (CBHI) modality and the high number of internally displaced persons (IDPs), both of which made it difficult to standardize prices for medical oxygen and other chargeable services." (Hosp-10)

Table 40 provides a detailed breakdown of these cost recovery methods by facility type. As shown, out-of-pocket payments were the predominant approach in primary (87%) and general hospitals (88%), while exempted services were more evenly distributed across facility levels. Notably, the "Others" category (free of charge) was most prevalent in health centers (49%).

Table 40. Methods for Oxygen Service Cost Recovery by Facility Type

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
CBHI[1]	26 (32)	36 (78)	28 (65)	8 (80)	98 (54)
Out of Pocket	27 (33)	40 (87)	38 (88)	8 (80)	113 (62)
Credit Service Fee	3 (4)	12 (26)	17 (40)	5 (50)	37 (20)
Third Party	5 (6)	7 (15)	7 (16)	1 (10)	20 (11)
Exempted Service	27 (33)	29 (63)	25 (58)	7 (70)	88 (49)
Other*	40 (49)	2 (4)	5 (12)	1 (10)	48 (27)

***They provide oxygen service for free (no payment requested)**

[1] CBHI- Community Based Health Insurance

The midterm evaluation also examined how health facilities quantify oxygen usage to determine patient charges, highlighting disparities in measurement practices across facility types. Among the 181 facilities, the "Other" category, including alternative quantification approaches such as per hour, flat rate until patient is charged or fixed fees, and most did not charge patients for oxygen service, was predominant overall, 46.41% (n=84), especially in health centers 71.95% (n=59). Cylinder measurements were more commonly used in higher-level facilities, such as primary 46% (n=21), general 40% (n=17), and tertiary hospitals 40% (n=4), representing 27% of total cases (n=48) and the second most commonly used method by health facilities. Volume-based estimates via liters 18% (n=33), and cubic meters 11% (n=19) were less prevalent, with limited adoption outside of general and tertiary hospitals. See Table 41 for more information.

According to the response from health facility staff, they emphasized that there is a gap in the documentation of oxygen consumption by healthcare workers and its associated limitations. They reported that:

Oxygen issuance is not properly recorded using bin cards, nor is it measured in cubic meters. Instead, it is tracked by simply counting the number of cylinders, which limits accurate monitoring of usage and inventory control. (Hosp-17)

A respondent from a health center identified poor documentation of medical oxygen use as a major challenge, attributing it primarily to resistance from healthcare workers. He explained:

"There is strong resistance from staff when it comes to registering medical oxygen consumption." (HC-69)

Table 41. How health facilities estimate the price of oxygen provided to patients (n=184)

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Cylinder	6 (7)	21 (46)	17 (40)	4 (40)	48 (27)
Liters	11 (13)	12 (26)	9 (21)	1 (10)	33 (18)
Cubic meters	6 (7)	4 (9)	7 (16)	2 (20)	19 (11)
Other*	59 (72)	11 (24)	11 (26)	3 (30)	84 (46)

***Free of charge, per hour and flat rate until discharge**

Note. f = frequency. Percentages are column specific.

The midterm evaluation of the Ethiopian Medical Oxygen Roadmap included an analysis of oxygen pricing practices across 181 facilities, focusing on how costs are determined based on common measurement units. Overall, cylinder-based pricing was the most frequently reported method among the 48 facilities using it, with a median price of 485 ETB. The median price in cylinders was high in primary hospitals, and the cost generally lowers as the tier level increases.

Transportation and associated costs emerged as one of the most significant costs associated with medical oxygen service delivery across facilities. Respondents consistently reported that high logistics expenses often outweigh the value of oxygen itself, particularly when procurement volumes are low.

A respondent from a hospital explained the combined impact on both reimbursement and operational costs:

"Medical oxygen service fee reimbursement is based on cylinder use. However, the high transportation costs for collecting filled cylinders from the oxygen center result in very high operational costs for oxygen service delivery." (Hosp-08)

This challenge was echoed by another Hospital, where a participant emphasized the upstream burden:

"Medical oxygen transportation costs are a major challenge right from the source." (Hosp-21)

At the primary care level, the issue becomes even more pronounced due to fragmented, small-volume procurement. A respondent from a health center described the disproportionate financial strain:

"The health center often procures oxygen in small quantities, resulting in transportation costs that exceed the value of the oxygen itself, partly because of the low volume and partly due to limited awareness among transporters about handling oxygen cylinders safely and efficiently." (HC-68)

For health facilities that used liter-based pricing (n=33), the median cost was 3 ETB, suggesting lower and more variable costs. Again, the price was high in primary hospitals compared with the rest. The Cubic meter pricing, used by 19 facilities, showed a median of 65 ETB.

Table 42. Medical Oxygen (in ETB) by Costing Method and Facility Type

Health Facility type	N	Mean	p50	Min	Max	SD
Price by cylinder						
Health Center	6	434	364	5	1200	427
Primary Hospital	21	580	516	58	1250	254
General Hospital	17	470	458	150	750	136
Tertiary Hospital	4	432	398	180	753	240
Price by liter						
Health Center	11	14	1	0	75	26
Primary Hospital	12	8	9	0	20	7
General Hospital	9	12	6	0	65	21
Tertiary Hospital	1	5	5	5	5	.
Price by cubic meter						
Health Center	6	214	63	17	999	386
Primary Hospital	4	74	73	60	90	14
General Hospital	7	65	55	45	129	29
Tertiary Hospital	2	140	140	128	152	17

Note. N = sample size; SD = standard deviation; Min = minimum; Max = maximum; ETB = Ethiopian Birr.

5.8 Improving Quality of Medical Oxygen Service

5.8.1 Capacity building

The roadmap explicitly identified substantial knowledge gaps among healthcare professionals in three critical areas: (a) rational use of medical oxygen, (b) medical oxygen supply chain management, and (c) preventive and curative maintenance of oxygen devices. It was also highlighted that a similar knowledge gap among hospital leaders regarding strategic oversight of oxygen therapy and supply chain systems.

To address these gaps, the Ministry of Health, in collaboration with RHBs and implementing partners, conducted nationwide capacity-building initiatives. According to the consolidated training database, a total of 6,526 healthcare professionals received training on medical oxygen-related topics. Of these, 82% (n = 5,358) were trained on the rational use of medical oxygen, whereas 14% (n = 913) received leadership orientations focused on oxygen therapy and supply chain management. The remaining participants received training on equipment maintenance and safety protocols. See Figure 7 for more information.

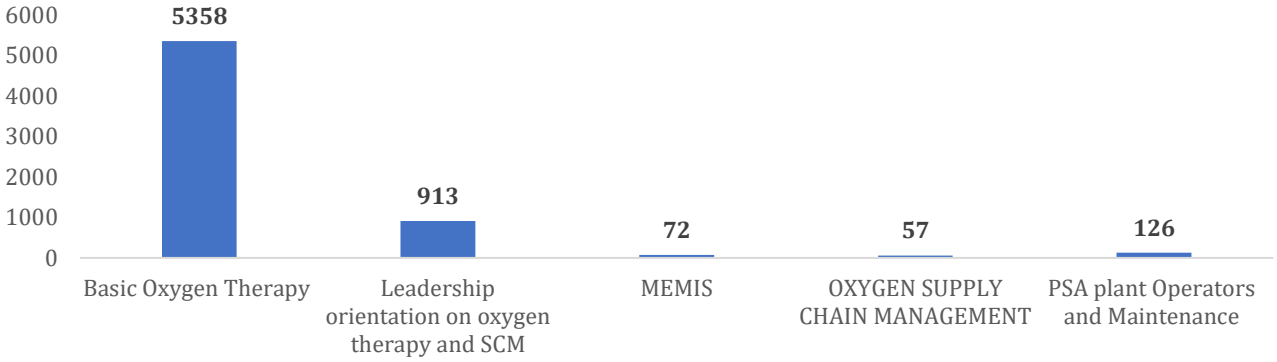


Figure 7. Capacity-Building Initiatives on Medical Oxygen by the Ministry of Health and Implementing Partners, 2022 to Present

The availability of trained health care workers on medical oxygen therapy is shown in Table 43. The availability of at least one healthcare worker trained in supplementary medical oxygen from the facility has been confirmed by 158 (78%) of the 203 evaluated healthcare facilities. However, 45 (22%) of them reported that their facilities do not have any trained staff.

When looking into the availability of trained professionals across different facility types, tertiary, general and primary hospitals had the highest percentages of having at least one trained staff, 10 (100%), 40 (93%) and 41 (91%), respectively. While the number of trained staff at health centers is relatively low compared to higher-level facilities, 66 (64%) of the health centers surveyed reported having trained professionals.

Table 43.Availability of trained health care workers on supplemental medical oxygen therapy in sampled health facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
No	38 (36.54)	4 (8.7)	3 (6.98)	-	45 (22.17)
Yes	66 (63.46)	42 (91.3)	40 (93.02)	10 (100)	158 (77.83)

n= number of health facility

Table 44 below shows the mean and median number of staff trained on supplemental medical oxygen by facility type. Health centers had the lowest median number of trained professionals with median of 2

(range 1–10), whereas general hospitals had the most trained staff median of 7 (range 2–150). While tertiary hospitals had a median of 6 (range 1–32), and primary hospitals had a median of 4 (range 0–38). The overall median number of trained staff per facility was 3 (range 0-150).

Table 44. Health Facilities with trained staff on supplemental medical oxygen

HF type	n	Mean	p50	SD	Min	Max
Health Center	66	2	2	1	1	10
Primary Hospital	42	5	4	6	0	38
General Hospital	40	20	7	31	2	150
Tertiary Hospital	10	9	6	9	1	32
Total (average)	158	8	3	17	0	150

n= number of health facility; SD = standard deviation; Min = minimum; Max = maximum; p50 = median

In one health center with no staff trained in supplemental oxygen therapy, the facility manager described how they were managing the gap:

> *"The absence of trained personnel in oxygen therapy within our facility has posed additional challenges in delivering optimal care. Despite this, efforts have been made to bridge the gap by seeking support from trained professionals at nearby health facilities. Their assistance has been instrumental in sustaining the provision of oxygen services, even under constrained conditions." (HC-57)*

5.8.2 Availability of resource documents and support systems for oxygen therapy

The midterm evaluation evaluated the availability of standardized documents developed by the MoH to improve medical oxygen service and management (e.g., SOPs, pocket handbooks, flow charts, brochures, IPD O2 sat monitoring formats, safety manual and training manuals), the support that the MoH, RHB, and implementing partners provided, and the educational tools that the health facilities used to prepare their medical staff. As a result, of the 203 health facilities that were assessed, pocket handbooks and training manuals were the most common reference materials in 62% of the facilities, while pocket handbooks were the least common (2%).

The Ministry of Health, regional health bureaus and implementing partners are expected to provide various types of support to health facilities. The support can be either in-kind support or technical assistance. When we say in-kind support, it involves direct provision of essential medical devices and supplies to healthcare facilities to enable them provide the services. Technical assistance involves the provision of expert knowledge, advisory services, training, and capacity-building exercises to healthcare facilities.

Out of the 203 health facilities, 75% of them reported receiving in-kind assistance, 67% said they received technical assistance, and 3% said they received financial assistance. Approximately 12% of those surveyed reported that they didn't receive any kind of support.

Several Regional Health Bureaus have also reported actions to strengthen oxygen access at facility level. A respondent from region 06 reported tangible in-kind support provided to health facilities:

> *"Around 50 cylinders were purchased, along with pulse oximeters and face masks, and these were distributed to hospitals, health centers, and even one health post."*

Similarly, a participant from region 03 described broader investment in oxygen-related infrastructure by the RHB:

"The Regional Health Bureau procured a range of medical devices necessary for the production and distribution of oxygen, ensuring the infrastructure is well-equipped to meet healthcare demands."

RHBs also reported that they are actively supporting health facilities in strengthening the medical oxygen ecosystem through supportive supervision, capacity building, and quality assurance activities. According to key informants from the RHBs, regular supportive supervision visits are conducted with a focus on proper medical oxygen utilization, preventive maintenance practices, and safety protocols.

In addition, RHBs collaborate closely with the Food and Drug Authority (FDA) to conduct routine inspections of medical oxygen production sites. A respondent from region 11 emphasized the systematic nature of this oversight:

"In the region, in collaboration with the FDA of the RHB, there is a regular program for inspection and feedback to ensure the quality of the produced medical-grade oxygen."

Capacity-building efforts are also a priority. A participant from region 09 described the impact of on-site training initiatives supported by partners such as CHAI:

"Oxygen device management, supply chain management, and oxygen therapy are the topics covered during on-site orientation. This initiative must continue without interruption. The majority of health centers received the training, which was delivered in collaboration with CHAI. The clinical staff who participated were extremely pleased; many had forgotten material covered in college or university, and some had not been adhering to protocols and standards. Consequently, they regarded the training as a valuable gap-filling opportunity."

Recognizing the increasing need for home oxygen services, the Ethiopian Medical Oxygen Roadmap II recommended developing a handbook. Accordingly, the midterm evaluation attempted to evaluate the availability of this guidance. Nearly all facilities (90.6%) reported lacking guidelines for home care, and 94.1% reported they have not adapted health education materials into their local languages.

Medical oxygen was identified as a critical topic in clinical training in 62% of the health institutions evaluated; this percentage was greater in primary hospitals and health centers (62% and 61%, respectively). Additionally, among those who indicated that medical oxygen was a major topic of conversation, with 36% and 30% of respondents reported their primary platforms were clinical audits and seminars, respectively.

Only 22% of facilities performed clinical audits on oxygen use, despite tertiary hospitals being the most common only half of the facilities carried out audits. Additionally, just 5% of hospitals implemented quality improvement programs; tertiary hospitals once again demonstrated higher involvement rates of 20%. There is at least one completed project on oxygen in every type of facility, and 73% of the 11 healthcare facilities that designed quality improvement projects stated that their facilities had adopted the project's recommendations.

Most hospitals have reported that there is a clear gap in clinical audits, stating that;

"No clinical auditing exercise for medical oxygen therapy or related practices."

These results point to important gaps in the supply of instructional resources and efforts aimed at improving quality. See Table 45 below for more information.

Table 45. Availability of resources and support for medical oxygen management in surveyed healthcare facilities

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Check the availability of standardized documents on the rational use of medical oxygen.					
SOPs	18 (17.3)	28 (60.9)	28 (65.1)	6 (60)	80 (39.4)
Pocket handbooks	2 (1.9)	0	1 (2.3)	1 (10)	4 (2)
Flow charts	37 (35.6)	21 (45.7)	24 (55.8)	3 (30)	85 (41.9)
Brochures	7 (6.7)	7 (15.2)	6 (14)	2 (20)	22 (10.8)
IPD O_2 sat monitoring formats	32 (30.8)	25 (54.3)	32 (74.4)	8 (80)	97 (47.8)
Safety manual	20 (19.2)	11 (23.9)	14 (32.6)	6 (60)	51 (25.1)
Training manuals	51 (49)	34 (73.9)	32 (74.4)	8 (80)	125 (61.6)
None	12 (11.5)	0	0	0	12 (5.9)
Supports received by health facility from either the MoH or the RHB or partners					
Technical	60 (57.7)	31 (67.4)	37 (86)	8 (80)	136 (67)
Financial	1 (1)	1 (2.2)	3 (7)	1 (10)	6 (3)
In Kind	72 (69.2)	37 (80.4)	35 (81.4)	9 (90)	153 (75.4)
None	19 (18.3)	3 (6.5)	2 (4.7)	0	24 (11.8)
Developed guide on the safe use of medical oxygen in home care services available at your organization					
No	103 (99)	40 (87)	36 (83.7)	5 (50)	184 (90.6)
Yes	1 (1)	6 (13)	7 (16.3)	5 (50)	19 (9.4)
Prepared health education materials on medical oxygen					
No	102 (98.1)	43 (93.5)	36 (83.7)	10 (100)	191 (94.1)
Yes	2 (1.9)	3 (6.5)	7 (16.3)	0	12 (5.9)
Medical oxygen a key topic in discussions and training during clinical attachments and other learning platforms					
No	NA	18 (39.1)	14 (32.6)	6 (60)	38 (38.4)
Yes	NA	28 (60.9)	29 (67.4)	4 (40)	61 (61.6)
If the answer to question number is 'Yes', how (n=61)					
Seminars	NA	4 (14.3)	12 (41.4)	2 (50)	18 (29.5)
Morning sessions	NA	19 (67.9)	23 (79.3)	1 (25)	43 (70.5)
Clinical audits	NA	10 (35.7)	9 (31)	3 (75)	22 (36.1)
Others	NA	13 (46.4)	6 (20.7)	1 (25)	20 (32.8)
Conducted clinical audits on the rational use of medical oxygen					
No	96 (92.3)	32 (69.6)	26 (60.5)	5 (50)	159 (78.3)
Yes	8 (7.7)	14 (30.4)	17 (39.5)	5 (50)	44 (21.7)
Designed quality improvement projects on medical oxygen					
No	103 (99)	41 (89.1)	40 (93)	8 (80)	192 (94.6)
Yes	1 (1)	5 (10.9)	3 (7)	2 (20)	11 (5.4)
Were recommendations from the Quality Improvement (QI project implemented) (n=11)					
No	0	1 (20)	1 (33.3)	1 (50)	3 (27.3)
Yes	1 (100)	4 (80)	2 (66.7)	1 (50)	8 (72.7)

5.8.3 Reviewed Charts on Rational Use Practice

Table 46 shows the sampled charts by facility type, region and unit/department, secondary-level care is predominant, as seen by the diverse distribution among institution types. The majority of the charts 40% (n=1,697) were from general hospitals, with primary hospitals coming in second 39% (n=1,638). Tertiary

hospitals made up the smallest share 10% (n=402), whereas health centers made up a moderate amount 11% (n=495).

Breakdowns by department show that pediatric and adult care are prioritized, with pediatric wards accounting for the largest volume 24% (n = 1,015). It was evenly distributed across general (25%), primary (30%), and tertiary (25%) hospitals. Neonatal intensive care units 23% (n=964) and medical wards 24% (n=1,008), with each kind surpassing 24%. Since health centers were not expected to have regular admission wards that is disaggregated by these unit, it was primarily reported as general admissions 65% (n=324).

Table 46. Number of Reviewed Charts by Health Facility Type, Region, and Department/Unit in the Midterm evaluation

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Region					
Addis Ababa	31 (6.26)	0	40 (2.36)	81 (20.15)	152 (3.59)
Afar	20 (4.04)	40 (2.44)	40 (2.36)	0	100 (2.36)
Amhara	111 (22.42)	471 (28.75)	281 (16.56)	0	863 (20.39)
Benishangul	11 (2.22)	0	41 (2.42)	0	52 (1.23)
Central Ethiopia	21 (4.24)	40 (2.44)	160 (9.43)	41 (10.2)	262 (6.19)
Dire Dawa	10 (2.02)	0	40 (2.36)	0	50 (1.18)
Gambella	0	0	41 (2.42)	0	41 (0.97)
Harari	10 (2.02)	0	41 (2.42)	0	51 (1.21)
Oromia	205 (41.41)	585 (35.71)	483 (28.46)	280 (69.65)	1553 (36.7)
Sidama	50 (10.1)	120 (7.33)	80 (4.71)	0	250 (5.91)
Somali	0	40 (2.44)	122 (7.19)	0	162 (3.83)
South-Ethiopia	0	131 (8)	80 (4.71)	0	211 (4.99)
South-West Ethiopia	16 (3.23)	30 (1.83)	67 (3.95)	0	113 (2.67)
Tigray	10 (2.02)	181 (11.05)	181 (10.67)	0	372 (8.79)
Department/unit					
Adult ICU	NA	100 (6.11)	375 (22.1)	100 (24.88)	575 (13.59)
General Admission *	324 (65.45)	-	-	-	324 (7.66)
Medical Ward	NA	469 (28.63)	437 (25.75)	102 (25.37)	1008 (23.82)
NICU	NA	442 (26.98)	424 (24.99)	98 (24.38)	964 (22.78)
Pediatric ward	NA	484 (29.55)	429 (25.28)	102 (25.37)	1015 (23.98)
Other	171 (34.55)	143 (8.73)	32 (1.89)	-	346 (8.18)

Note: *Applicable for Health Centers
Note. f = frequency. Percentages are column-specific.

- *Patient demographics*

During the midterm evaluation, 4,232 patients' medical records were reviewed to assess the rational use of medical oxygen in health facilities and the application of standards by healthcare professionals in the surveyed health facilities. When looking at age distributions, 70 health facilities did not document age of patients. Overall, age profiles show a noticeable adult skew, at 36% (n=1,497). The second largest age group was neonates, at 30% (n=1,256). In contrast, the smallest age group was Children/Adolescents category, at 9% (n=373). A significant proportion of neonates' charts were reviewed in primary hospitals 37% (n=601), then by general and tertiary hospitals, each at 30%, followed by health centers, at 5%.

Meanwhile, in general and tertiary hospitals, adult cases were predominant, at 34% (n=556) and 33% (n=130), respectively.

Of the 4,222 charts reviewed, males comprised 52% (n=2,207) and females 48% (n=2,015), with a male-to-female ratio of 1.1:1, indicating a slight male majority. Health centers exhibited a marked female increase, at 55% (n=268). Males slightly edged out in higher-tier facilities (52.54%–56.11%). See Table 47 for more information.

Table 47. Patient demographics in the chart reviewed

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Age group					
< 1 m	27 (5.45)	601 (37)	509 (30.7)	119 (30.5)	1,256 (30)
≥ 1 m to < 5 yrs	55 (11)	253 (15.6)	259 (15.6)	61 (15.6)	628 (15)
≥ 5 to < 15 yrs	61 (12.3)	135 (8.3)	142 (8.6)	35 (8.9)	373 (8.9)
≥ 15 to < 60 yrs	303 (62.2)	508 (31.3)	556 (33.6)	130 (33.3)	1,497 (35.9)
≥ 60 yrs	49 (9.9)	123 (7.6)	191 (11.5)	45 (11.5)	408 (9.8)
Sex					
Male	220 (45.08)	860 (52.54)	902 (53.18)	225 (56.11)	2207 (52.27)
Female	268 (54.92)	777 (47.46)	794 (46.82)	176 (43.89)	2015 (47.73)

Note. f = frequency. Percentages are column-specific. Age group totals exclude 70 charts with missing data and Sex totals exclude 10 cases with missing data.
M=Month
Yrs=Years

- *Clinical Practice/Adherence to clinical standards*

To assess the provision of supplemental medical oxygen, the "Rational Use of Medical Oxygen" guideline developed by the MoH was used to determine the oxygen use compliance. The guideline states that every patient presenting to a health facility shall be assessed for signs and symptoms of hypoxemia, which must be confirmed using a medical device. Depending on the saturation measurement, the patient will be classified as having a normal saturation level (usually >90% SpO2) or, if low, the patient will be classified as hypoxemic. If a patient is hypoxemic, the clinician shall provide supplemental medical oxygen by prescribing the flow rate, delivery method, target saturation level, and frequency of saturation level monitoring.

In the context of this chart audit, the proper initiation and rational use of supplemental medical oxygen is operationally defined as the timely, evidence-based, and documented prescription and administration of oxygen therapy only when clinically indicated (i.e., for hypoxemia), with all essential components specified to ensure safe and effective delivery. This excludes prophylactic use in normal patients and requires adherence to standards or guidelines.

Operational Definition:

1. **Compliance:** to qualify as appropriate, the following criteria must all be met
   - SpO2 measurement at initial contact and SpO2 reading recorded
   - SpO2 measurement <90% to initiate supplemental medical oxygen therapy or oxygen was not prescribed for a patient without hypoxemia ($SpO_2 \geq 90\%$)

- The prescription record includes explicit values for all three of the following: flow rate, target SpO_2 Range and frequency of SpO_2 Monitoring.
- The delivery method (e.g., nasal cannula, face mask) is specified in the patient's chart.

2. Non- Compliance

- The prescription is missing one or more of above listed details of optimal oxygen therapy.
- Exceptions- if the data includes a specific physician's note documenting a valid clinical rationale for prophylactic oxygen (e.g., treatment for carbon monoxide or other poisoning).

Table 48 presents facility-level audit data on early detection of hypoxemia and supplemental oxygen provision practices across 4,232 patient charts from health centers, primary hospitals, general hospitals, and tertiary hospitals. Overall, SpO_2 was assessed and documented in 72% of charts (n=3,047), of which hypoxemia (SpO_2 < 90%) was identified in 37% (n=1,120). Oxygen was prescribed in 41% of all charts (n=1,256), representing a slightly higher-prescription relative to the hypoxemic rate; these aggregate masks a key discrepancy wherein prescriptions exceeded hypoxemic cases by 136, attributable to instances of over-prescription. Among prescribed cases, documentation quality was suboptimal: flow rates were specified in 68% (n=1,000), target SpO_2 in only 33% (n=475), monitoring frequency in 30% (n=433), and delivery methods in 31% (n=1,322), excluding saturation not screened, not hypoxemic, undocumented or non-prescribed cases. Facility-level variations were most pronounced at health centers and hospitals, with the lowest rate of SpO_2 assessment (39%) and the highest rate of medical oxygen prescription to non-hypoxic patients, respectively.

Table 48. Early detection and supplemental medical oxygen provision practice audit by facility

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
SpO_2 assessed and documented					
No	303 (61)	483 (29.49)	338 (20)	61 (15)	1185 (28)
Yes	192 (39)	1155 (70.51)	1359 (80)	341 (85)	3047 (72)
Hypoxemic by facility type (Among those with SpO2 reading)					
No	111 (58)	712 (62)	862 (63)	242 (71)	1927 (63)
Yes	81 (42)	443 (38)	497 (37)	99 (29)	1120 (37)
Prescribed O_2 for patient that were hypoxemic					
No	124 (65)	686 (59)	767 (56)	214 (63)	1791 (59)
Yes	68 (35)	469 (41)	592 (44)	127 (37)	1256 (41)
O_2 Flow Rate Specified					
No	37 (44)	166 (28)	212 (32)	45 (35)	460 (32)
Yes	48 (56)	418 (72)	450 (68)	84 (65)	1000 (68)
Target SpO2 Specified					
No	58 (68)	372 (64)	468 (71)	87 (67)	985 (67)
Yes	27 (32)	212 (36)	194 (29)	42 (33)	475 (33)
Supplemental medical oxygen delivery method specified					
No	417 (84)	1,100 (67)	1,112 (66)	281 (70)	2,910 (69)
Yes	78 (16)	538 (33)	585 (34)	121 (30)	1,322 (31)
Frequency of SPO_2 monitoring specified					
No	61 (72)	362 (62)	511 (77)	93 (72)	1,027 (70)
Yes	24 (28)	222 (38)	151 (23)	36 (28)	433 (30)

Note. f = frequency. Percentages are column-specific.

When we see the association between being hypoxemic after initial assessment by a pulse oximeter and receipt of supplemental medical oxygen. Among 3,047 patients, 27% non-hypoxemic patients received medical oxygen. In contrast, 6% of hypoxemic patients (SpO_2 < 90%) did not receive any medical oxygen.

See Table 49 for more information.

Table 49. Hypoxemia Status and Oxygen Administration: A Cross-Tabulation Analysis (N = 3,047)

Hypoxemic (SpO_2 < 90%)	Received Oxygen		Total
	No	Yes	
No	1,544 (93.58%)	383 (27.42%)	1,927 (63.24%)
Yes	106 (6.42%)	1,014 (72.58%)	1,120 (36.76%)

Table 50 summarizes the classification of supplemental medical oxygen care service as either "compliant" (according to the operational definition set for the chart audit as per the national and international guidelines) or "non-compliant" (opposing from those standards) across healthcare facilities. Of the total reviewed charts, only 951 patient charts fulfilled the standard (the denominator for this analysis consists of patients who were assessed for SPO2, were hypoxemic, and were provided with supplemental medical oxygen). Of these, 764 patients (80%) were classified as non-compliant. The overall adherence/compliance to standards for supplemental medical oxygen provision, based on the chart audit was very low.

Table 50. Adherence to oxygen therapy guidelines by facility type (N=951)

	Health Center n (%)	Primary hospital n (%)	General hospital n (%)	Tertiary hospital n (%)	Total n (%)
Non-compliant	51 (80)	286 (75)	367 (86)	60 (77)	764 (80)
Compliant	13 (20)	96 (25)	60 (14)	18 (23)	187 (20)

Note. f = frequency. Percentages are column-specific.

6 Strengths and Limitations of the Evaluation

This section outlines the strengths and limitations of the mid-term evaluation of the Ethiopian Medical Oxygen Roadmap II (2022–2027). Acknowledging both is essential for interpreting the findings and for guiding the design of future evaluations within the roadmap's implementation period.

6.1 Strengths

The mixed-methods design, quantitative facility surveys triangulated with qualitative key-informant interviews, strengthened the depth, reliability, and contextual relevance of the findings.

The assessment covered 203 health facilities across all 12 regions and the two city administrations, spanning hospitals and health centers at every level of the system, supporting the generalizability of the results.

Data were collected by trained teams using standardized, pre-tested tools with structured quality assurance throughout fieldwork, entry, and analysis; the assessment was structured around the roadmap's seven strategic pillars, producing findings that align with national priorities and are immediately actionable for the Ministry of Health, Regional Health Bureaus, and partners.

Strong engagement by MoH, Regional Health Bureaus, EPSS, EFDA, health facilities, and development partners strengthened ownership of the findings and improved access to information at every level.

6.2 Limitations

The evaluation drew partly on self-reported data, which may be subject to recall and social-desirability bias, particularly on adherence to clinical guidelines and roadmap implementation.

Some facilities had incomplete or inconsistent records on oxygen production, consumption, maintenance, and financing; where documentation was missing, the evaluation relied on respondent recall, which may have affected accuracy.

The cross-sectional design captures services at a single point in time and does not reflect seasonal variations or short-term disruptions; although the sample is nationally representative, regional and facility-type sub-group findings should be interpreted with caution, given limited sub-sample sizes.

Security and access constraints in some areas required substitution of a small number of facilities, which may have introduced minor selection effects. The evaluation also focused on the public health system and did not comprehensively assess the role of private health facilities.

7 Discussion

This midterm evaluation demonstrates that, two and half years after the launch of the Ethiopian medical oxygen roadmap II, significant improvements have been achieved in its implementation across health facilities and there are still gaps that need attention by all stakeholders. Despite efforts made by MoH and its partners in advocating the current roadmap, 52% of health facilities remain unaware of the roadmap, with awareness particularly low in health centers and tertiary hospitals. Among facilities aware of the roadmap, 61% have incorporated medical oxygen activities into their annual plans, while 70% have not included oxygen in their emergency preparedness and response plans (EPRP). The national oxygen production capacity has nearly doubled since 2021 (from 3,698 to 5,497 m^3/hr), and training coverage appears adequate (78% of facilities have ≥3 trained staff)(MoH 2022). However, there are still weaknesses in governance, quality assurance, and rational use that undermine these gains: only 43% of facilities regularly monitor oxygen concentration, none of the oxygen plants are biannually licensed, and 80% of reviewed patient charts showed non-compliance with national prescribing standards. These findings indicate that, while infrastructure and production have progressed, systemic integration of medical oxygen into routine health service delivery remains incomplete.

Ethiopia acted proactively even before the World Health Assembly resolution WHA76.19 (May 2023), which recommended integrating medical oxygen into existing health systems and emergency preparedness frameworks. One of the roadmap's strategies was to embed oxygen into the national health plan and all relevant health strategies. Accordingly, desk review confirmed that medical oxygen has been successfully incorporated into the Health Sector Development and Investment Plan (HSDIP, MoH 2023) and the Ethiopian Hospital Service Improvement Guidelines. Among facilities that are aware of the roadmap, 61% have already included oxygen-related activities in their annual plans, 68% have assigned a medical oxygen focal person (mostly from Emergency, OPD or Triage units), 82% of these focal persons have received training, and 69% are active members of the facility's DTC. These changes show marked improvement over the previous end-term evaluation, in which 79% of facilities lacked any focal person at all. Although the roadmap targets 100% focal-person coverage by 2027, the current trajectory clearly demonstrates that governance, leadership, and coordination are going in the right direction.

The end-term evaluation report indicated that there were 38 oxygen plants in the country, of which 50% belonged to the public/government sector(MoH 2022). The number of oxygen plants has increased to 62, and the government has committed to installing an additional 24 plants by mid-2026, pushing projected national capacity to nearly 6,937 m^3/hr. The overall efficiency was lower at 49%, based on total actual output (409 M3/Hr) relative to designed capacity (803 M3/Hr), indicating substantial underperformance. These findings highlight opportunities for maintenance interventions to optimize supply. The roadmap proactively recommended that there should be a sustainable financing mechanism for the facilities with an oxygen plant and 73% of hospitals with an oxygen plant reported having the sustainable oxygen financing directive. Accordingly, 55% of health facilities have started selling their excess oxygen to their catchment facilities, and this has increased significantly when compared to the end term evaluation, which was 11%(MoH 2022). This is expected to improve the supply chain of oxygen, increase access and lower the cost of medical oxygen. And such initiatives need to be scaled up and need to ensure the collected revenues are used for the costs related to operating and maintenance of the oxygen plant, and if possible, to plan for replacement. It is expected that with an increase in oxygen production capacity, access to medical oxygen and oxygen service will also increase. And the midterm evaluation demonstrated this by an increased number of health facilities providing medical oxygen services when compared to the end term evaluation. In 2022, only 48% of facilities were providing

medical oxygen services (MoH 2022). While nearly all hospitals offered these services, only 26% of health centers did so. The midterm evaluation shows significant improvement: currently, 89% of facilities provide medical oxygen therapy, including 79% of health centers. This notable increase among health centers may be partly due to the selection of health centers located in urban areas and larger towns close to hospitals.

One of the objectives of the latest roadmap was to mitigate the critical shortage of trained professionals on medical oxygen and the provision of effective oxygen management. In that regard, the midterm evaluation confirms the marked progress from the former roadmap evaluation and target set in the current. The proportion of facilities confirming at least one trained healthcare worker (HCW) increased to 77.83%, moving closer to the ambitious 100% target. This figure represents a considerable improvement over the former status reported in the end-term evaluation (2021), where only 43% of health facilities(MoH 2022). Additionally, the screening of peripheral capillary oxygen saturation (SpO_2) at the first point of contact showed improvement, rising from 59% in 2021 to 72% in the current mid-term status. This positive trend indicates improved access and utilization of diagnostic devices like pulse oximeters, which are crucial for the timely diagnosis and monitoring of hypoxemia. However, systemic inequity persists, as SpO_2 screening was notably lowest at HCs (39% of charts reviewed), reflecting the persistent challenge of strengthening diagnostic practice at the primary care level, where availability and screening historically lagged significantly behind hospitals. Despite the increase in detection of hypoxemia patients, adherence to oxygen prescription standards for rational use of medical oxygen therapy remains critically low at 20% of audited charts. This indicates that even when hypoxemia is identified and oxygen is prescribed, the clinical process is often unsafe or non-standardized.

It is recommended by the roadmap that oxygen quality checks be carried out at the production site and for clinical use. Accordingly, the end-term evaluation revealed a major gap in access to oxygen analyzers: these were predominantly found in tertiary hospitals, with only 8% of facilities reporting that they had one(MoH 2022). In contrast, the midterm evaluation demonstrates marked improvement, with 43% of facilities now reporting that they perform oxygen purity checks. However, some facilities that possess oxygen analyzers are still not conducting quality checks, primarily due to the attrition of biomedical staff, absence of biomedical personnel, or lack of battery replacements.

Cost-recovery for the clinical provision of medical oxygen therapy is also evolving. While 27% of facilities still provide oxygen free of charge, the majority have introduced CBHIs. The most common mechanism is direct out-of-pocket payment (62%), followed closely by CBHI, 54%. The most frequently applied costing models are per-hour billing or a flat rate until discharge (46%), with per-cylinder charging used in 27% of facilities. Although the roadmap explicitly recommends protecting patients from catastrophic expenditure by expanding CBHI coverage for oxygen therapy, uptake of CBHI as a payment system remains incomplete. High transportation costs are still cited as a major cost driver, often exceeding the value of oxygen itself. This gap represents an important opportunity to strengthen the registration of oxygen services under CBHI, combined with clear national fee guidelines, which would simultaneously improve financial sustainability for facilities and enhance equitable access to services, in line with the roadmap's vision and Ethiopia's broader journey toward universal health coverage.

Similar challenges have been observed in Rwanda (Kizza et al., 2022). In Rwanda, although the CBHI reimburses medical oxygen therapy, the fee-for-service tariff model has notable limitations: fees are calculated solely based on the duration of patient oxygen use at a fixed hourly rate, regardless of the volume consumed or other relevant factors. This approach exposes health facilities to financial losses

during periods of high demand, such as in ICUs or pandemics, and underscores the need for a hybrid volume-and-duration model to optimize costs and reduce losses.

Oxygen cylinders and concentrators are the primary sources of medical oxygen across assessed health facilities. Remarkable progress has been achieved in the availability of functional equipment. At the end-term evaluation, all surveyed hospitals possessed functional oxygen cylinders, while 74% of health centers did not. A substantial improvement was seen in the mid-term evaluation, 82% of health centers reported functional cylinders. Similarly, concentrator availability increased dramatically: at end-term, only 10% of health centers had at least one functional concentrator, compared to 93% at mid-term evaluation. These gains can be attributed to stronger support from the Ministry of Health (MoH) and partners, coupled with the expansion of oxygen refilling centers and improved procurement and distribution mechanisms. Despite this progress, important gaps remain in both utilization and maintenance. Notably, among the assessed facilities, several health centers that possessed functional cylinders and/or concentrators were not actively providing oxygen services to patients. In addition, 80% of facilities did not perform regular cylinder washing, primarily due to lack of awareness and limited access to qualified vendors for cleaning and maintenance services. Addressing these gaps in washing, resource allocation and effective utilization will help improve the availability of medical oxygen service and safe oxygen therapy to patients.

The findings from the mid-term evaluation demonstrate meaningful progress in preventive and curative maintenance practices, availability of maintenance infrastructure, and presence of standard operating procedures (SOPs). Preventive maintenance practices showed encouraging improvement. Health facilities conducting their own routine preventive maintenance rose from 52% to 55% in 2025, when compared with the end-term evaluation(MoH 2022). This shift reflects successful capacity-building efforts, likely reinforced by repeated supportive supervision and on-the-job training. Similarly, health facilities conducting curative repairs by themselves increased from 35% to 51% of facilities. In contrast, health centers remain heavily dependent on external support from Regional Health Bureaus, Zonal, or Woreda Health Offices (74% reliance in both evaluations), with only marginal improvement in self-repair capacity (from 9% to 12%). The sharp increase in the physical availability of maintenance workshops from 24% to 65% is a notable programmatic achievement(MoH 2022). However, functionality remains critically low, with only 26% of existing workshops reported as adequately equipped and operational in 2025. This disparity highlights the limited impact of building infrastructure without concurrent investments in equipment, supplies, and qualified workers.

Moreover, health facilities having maintenance SOPs or job aids have increased significantly from 22% to 50% that likely contributed to efforts from the MoH and partners in strengthening maintenance proactively at health facilities. However, half of the facilities still operate without standardized guidance, increasing the risk of inconsistent or incorrect maintenance procedures.

The midterm evaluation of Ethiopia's national medical oxygen roadmap reveals substantial progress alongside persistent challenges. National oxygen production capacity has nearly doubled, the number of plants increased from 38 to 62, functional equipment availability surged, particularly in health centers, and SpO_2 screening rose from 59% to 72%, with 89% of facilities now providing oxygen therapy. Governance improvements include greater focal person assignment and training coverage nearing 78%. However, critical gaps remain in awareness (52% of facilities are unaware), rational prescribing (only 20% compliance), oxygen quality monitoring (43%), plant licensing (none biannually), maintenance functionality, and sustainable financing. While infrastructure and access have advanced markedly, full

systemic integration, equitable primary care strengthening, and standardized clinical practices require urgent, coordinated action from all stakeholders to realize the roadmap's vision.

8 Conclusion

The mid-term evaluation of the Ethiopian Medical Oxygen Roadmap II (2022–2027) demonstrates that meaningful progress has been achieved in expanding access to medical oxygen across the health system. National oxygen production capacity has grown substantially, the number of functional oxygen plants has increased, availability of core devices such as concentrators, cylinders, and pulse oximeters has improved, and a large majority of health facilities now provide oxygen therapy. Training coverage has expanded, hypoxemia screening practices have strengthened, and governance arrangements at facility level have improved through the assignment of oxygen focal persons and integration of oxygen activities into annual plans.

At the same time, the evaluation highlights persistent gaps that require focused attention during the remaining implementation period. Awareness of the roadmap remains uneven, particularly at primary-level facilities; rational use of oxygen in line with clinical standards is still limited; routine quality assurance and biannual licensing of oxygen plants are not yet consistently implemented; preventive and corrective maintenance systems remain weak; and financing continues to depend heavily on out-of-pocket payments, with limited integration into health insurance and cost-recovery mechanisms.

Taken together, these findings indicate that the foundations of a national medical oxygen system are increasingly in place, but that the next phase of implementation must shift from infrastructure expansion toward system strengthening. Sustaining the gains achieved will require deliberate action to deepen governance and coordination, improve regulatory oversight and quality assurance, build resilient maintenance and supply systems, strengthen rational clinical practice, and secure sustainable financing. Coordinated effort by the Ministry of Health, Regional Health Bureaus, EPSS, EFDA, health facilities, healthcare workers, and development partners will be essential to translate the recommendations of this evaluation into measurable improvements before the conclusion of the roadmap in 2027.

The findings of this mid-term evaluation therefore provide both a record of progress and a strategic basis for accelerating action in the second half of the roadmap, with the ultimate goal of ensuring that medical oxygen is reliably available, safe, affordable, and equitably accessible for every patient who needs it.

9 Recommendations

1. Strengthen Leadership, Governance, and Strategic Awareness

- Conduct targeted awareness campaigns for the Medical Oxygen Roadmap II, specifically targeting the Health Centers currently unaware of the roadmap.
- Ensure every facility assigns a dedicated Medical Oxygen Focal Person who is a member of the Drug and Therapeutics Committee (DTC).
- Ensure the adoption of oxygen-related Key Performance Indicators (KPIs) with a requirement for all facilities to submit monthly reports.

2. Optimize Production and Supply Chain (Hub-and-Spoke)

- Operationally formalize the model where "Hubs" (facilities with plants) sell excess oxygen to "Spokes" (receiving facilities).
- Address the production efficiency gap by providing technical maintenance interventions for plants currently operating below their capacity to reach their designed output.
- Prioritize the supply of cylinders and analyzers to health centers and underserved regions to ensure geographical equity.
- Strengthen the capacity for oxygen quantification, focusing on health centers where the use of forecasting tools is currently weak.

3. Enhance Clinical Quality and Rational Use

- Institutionalize SpO_2 screening at the first point of patient contact, particularly in health center settings.
- Enforce strict adherence to national prescription standards, ensuring documentation of flow rate, target SpO_2, monitoring frequency, and delivery methods.
- Conduct regular clinical mentorship and strict audit practices to prevent unsafe or non-standardized therapy.
- Prioritize the distribution of pulse oximeters alongside clinical training for clinical staff.

4. Maintenance and Infrastructure Functionality

- Equip existing biomedical workshops with the necessary tools, spare parts, and calibration kits to move them from non-functional to functional status.
- Establish and enforce strict preventive maintenance schedules for concentrators, ventilators, CPAPs, and oxygen pipelines.
- Distribute standardized maintenance job aids and SOPs to all biomedical units.
- Provide battery replacements and support for oxygen analyzers to ensure facilities can perform regular purity monitoring.
- Launch a national campaign and develop standards for regular cylinder washing and internal cleaning.

5. Strengthen Regulatory Systems and Standards

- Activate a strict regulatory schedule to ensure 100% of oxygen plants undergo biannual licensing and inspection.
- Develop and enforce national standards for supply chain safety, cylinder maintenance, and oxygen purity testing.

6. Ensure Financial Sustainability

- Transition from flat-rate billing to a volume-time-based model.
- Include oxygen therapy in the Community-Based Health Insurance (CBHI) framework to prevent facility losses and protect patients from out-of-pocket costs.
- Mandate that revenue generated from the sale of surplus oxygen be retained by the facility for the operation, maintenance, and eventual replacement of oxygen plants.

7. Data, Documentation, and Digitalization

- Introduce uniform recording tools for consumption logs, cylinder movement, and refill tracking.
- Integrate oxygen logistics and maintenance reporting into existing digital systems like MEMIS and EPSS LMIS.
- Train facility staff on documentation to overcome resistance and bridge knowledge gaps in recordkeeping.

8. Emergency Preparedness and Resilience

- Ensure 100% of health facilities incorporate oxygen requirements into their Emergency Preparedness and Response Plans (EPRP) to handle surges (e.g., pandemics).
- Establish regional coordination platforms for regular referral and resource-sharing meetings between hubs and spokes.
- Develop and disseminate guidelines for home-based oxygen care.

9. Training, Research, and Knowledge Management

- Embed oxygen therapy and device maintenance modules into the curricula for physicians, nurses, health officers, and anesthetists.
- Promote operational research, including cost-effectiveness of hub-and-spoke models, plant efficiency, and clinical adherence.
- Document and disseminate success stories from high-performing hospitals to encourage peer-to-peer learning.

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11 Annexes

List of selected hospitals for data collection.

S. No	HF Name	Region	Zone	Woreda
1	Abe Dongor Primary Hospital	Oromia	Horo Gudru Wellega Zone	Abe Dengoro
2	Agaro General Hospital	Oromia	Jimma Zone	Agaro Town
3	Ameya Primary Hospital _Oromia	Oromia	South West Shewa	Amaya
4	Arsi University Asella General Hospital	Oromia	Asella Town	Asella Town
5	Batu General Hospital	Oromia	Batu Town	Batu Town
6	Balegesgar Primary Hospital	Oromia	Arsi zone	Bale Gasgar
7	Bule Hora University Teaching Hospital	Oromia	West Guji Zone	Bule Hora Town
8	Chelenko Primary Hospital	Oromia	East Hararge Zone	Meta
9	Darimu Primary Hospital	Oromia	Ilu Aba Bora Zone	Darimu
10	Fitche Comprehensive Specialized Hospital	Oromia	North Shewa Zone	Fitche Town
11	Garamuleta General Hospital	Oromia	East Hararge Zone	Girawa
12	Gimbi General Hospital	Oromia	West Wellega Zone	Gimbi Town
13	Gobessa Primary Hospital	Oromia	Arsi zone	Shirka
14	Guder Primary Hospital	Oromia	West Shoa	Toke Kutaye
15	Hirna Primary Hospital	Oromia	West Hararge	Tulo
16	Jimma University Specialized Hospital	Oromia	Jimma Zone	Jimma
17	Sude Primary Hospital	Oromia	Arsi zone	Sude
18	Loke Ada Hospital	Oromia	West Arsi Zone	
19	Meki Primary Hospital	Oromia	East Shewa Zone	Dugda
20	Metu Comprehensive Specialized Hospital	Oromia	Ilu Aba Bora Zone	Metu Town
21	Arsi Negele Primary Hospital	Oromia	West Arsi Zone	Arsi negele
22	Olenchiti Primary Hospital	Oromia	East Shewa Zone	Boset
23	Sendafa Hospital	Oromia	Finifine Special	Senadafa
24	Shenen Gibe General Hospital	Oromia	Jimma Zone	Jimma Town
25	Tore Priamary Hospital	Oromia	West Guji Zone	Gelana
26	Wonji Primary Hospital	Oromia	East Shewa Zone	Adama
27	Chora Primary Hospital	Oromia	Buno Bedele Zone	Chora
28	Woliso general Hospital	Oromia	Woliso Town	Woliso Town
29	Adi Grat General Hospital	Tigray	Eastern	Adigrat
30	Adishuhu Primery Hospital	Tigray	Southern	Emba Alaje
31	Aksum Referal Hospital	Tigray	Central	Axum Town
32	Dewhan Hospital	Tigray	Eastern	Erop
33	Fireweyni primary Hospital	Tigray	Eastern	Saesie Tseada Emba
34	Kahsay Abera zonal Hospital	Tigray	Tigray	
35	Maiani Hospital	Tigray	Tigray	Maiani
36	Mekhoni Hospital	Tigray	Southern	Raya Azebo
37	Samre Primary Hospital	Tigray	South Eastern	Seharti Samre
38	Welkayit Primary Hospital	Tigray	Western	Wolkayit
39	Mekelle zonal Hospital	Tigray	Tigray	Mekele
40	Adisalem Primary Hospital	Amhara	Bahirdar Town Administration	Bahir Dar Town

S. No	HF Name	Region	Zone	Woreda
41	Akeseta General Hospital	Amhara	South Wollo Zone	Legambo
42	Ataye Primary Hospital	Amhara	North Shewa Zone	Efratana Gidim
43	Borumeda Hospital	Amhara	Dessie Town Administration	Dessie
44	Dangla Primary Hospital	Amhara	Awi Zone	Dangla Town
45	Debrework Primary Hospital	Amhara	East Gojjam Zone	Enarge Enawga
46	Dembia Primary Hospital	Amhara	Central Gondar Zone	East Dembia (kola diba)
47	Ebnat Primary Hospital	Amhara	South Gondar Zone	Ebinat
48	Finote Selam General Hospital	Amhara	West Gojam Zone	Finote Selam Town
49	Hayik Primary Hospital	Amhara	South Wollo Zone	Tehulederie
50	Kemissie Hospital	Amhara	Oromia Special Zone	Kemisie Town
51	Liben Primary Hospital	Amhara	West Gojam Zone	North Achefer
52	Mekane Eyesus Primary Hospital	Amhara	South Gondar Zone	Estie
53	Metema General Hospital	Amhara	West Gondar Zone	Gendawuha Town
54	Sayint Primary Hospital	Amhara	South Wollo Zone	Amhara Sayint
55	Shedeho Mekete Primary Hospital	Amhara	North Wollo Zone	Meket
56	Tenta Primary Hospital	Amhara	South Wollo Zone	Tenta
57	Wegidi Primary Hospital	Amhara	South Wollo Zone	Amhara Sayint
58	Quara Primary Hospital	Amhara	West Gondar Zone	Quara
59	Abderafi Hospital	Amhara	North Gondar Zone	Abderafi
60	Hakim Gizaw Debrebirhan Univ General Hospital	Amhara	North Shewa Zone	Debere Birhan Town
61	Dagmawi Minilik Comp Spec Hospital	Addis Ababa	Yeka Sub City	Woreda 4
62	Ras Desta Damitew General Hospital	Addis Ababa	Arada Sub City	Woreda 4
63	Yekatit 12 General Hospital Medical College	Addis Ababa	Arada Sub City	Woreda 6
64	Abaala Primary Hospital	Afar	Zone 2	Abala City Administration
65	Kelewan Primary Hospital	Afar	Zone 4	Gulina
66	Menge Primary Hospital	Benishangul Gumuz	Assosa Zone	Menge Woreda
67	Besheno primery Hospital	SNNP	Halaba Zone	Wera Dijo Woreda
68	Doctor Bogalech Gebere Memorial General Hospital	SNNP	Kembata Tembaro Zone	Durame Town Administration
69	Halaba Kulito General Hospital	SNNP	Halaba Zone	Halaba Kulito City Administration
70	Saja primary Hospital	SNNP	Yem Special	Yem Woreda
71	Wolkite University Specialized Hospital	SNNP	Gurage Zone	Wolkite Town Administration
72	Angacha Primary Hospital	SNNP	Kembata Tembaro Zone	Angacha
73	Mehalamba Primary Hospital	SNNP	Gurage Zone	Gedebano Gutazer Welene
74	Dilchora General Hospital	Dire Dawa	Dire Dawa Operational	Diredawa
75	Gambella General Hospital	Gambella	Gambella Town Administration	Gambella Town Administration
76	Jugel General Hospital	Harari	Amir Nur	Harar
77	Aleta Wondo Primary Hospital	Sidama	Zone 1	Aleta Wondo Town Administration Health Office
78	Daye Primary Hospital	Sidama	Zone 1	Daya Town Administration Health Office
79	Hula Primary Hospital	Sidama	Zone 1	Hulla Woreda Health Office
80	Motite Furra Primary Hospital	Sidama	Hawassa City Administration	Mehal Sub City

S. No	HF Name	Region	Zone	Woreda
81	Yaye Primary Hospital	Sidama	Zone 1	Arbegona Woreda Health Office
82	FIK Primary Hospital	Somali	Erar	Fik
83	Hargele General Hospital	Somali	Afder	Hargele
84	Karamara General Hospital	Somali	Fafan	Jigjiga Town
85	Warder Primary Hospital	Somali	Dollo	Warder
86	Bitena Primary Hospital	SNNP	Wolayita Zone	Duguna Fango
87	Dilla General Hospital	SNNP	Gedeo Zone	Dilla Town Administration
88	Gerese Primary Hospital	SNNP	Gamo Zone	Gerese Town Administration
89	Kamba Primary Hospital	SNNP	Gamo Zone	Kamba Town Administration
90	Koybe Primary Hospital	SNNP	South Omo Zone	Malie
91	Yirgachefe Primary Hospital	SNNP	Gedeo Zone	Yirgachefe Town Administration
92	Ameya Primary Hospital	South West	Konta Zone	Ameya Town Administration
93	Maji Primary Hospital	South West	West Omo zone	Maji Tum Town Administration
94	Teppi General Hospital	South West	Sheka Zone	Teppi Town Administration