Assessment of Liquid Oxygen Capabilities and Availability for Use in Medical Facilities in the Kyrgyz Republic

Local Health System Sustainability Project

Task Order 1, USAID Integrated Health Systems IDIQ

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Local Health System Sustainability Project

The Local Health System Sustainability Project (LHSS) under the USAID Integrated Health Systems IDIQ helps low- and middle-income countries transition to sustainable, self-financed health systems to support access to universal health coverage. The project works with partner countries and local stakeholders to reduce financial barriers to care and treatment, ensure equitable access to essential health services for all people, and improve the quality of health services. Led by Abt Associates, the five-year project will strengthen local capacity to sustain strong health system performance, supporting countries on their journey to self-reliance and prosperity.

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Acronyms

ICU	Intensive Care Unit
JSC	Joint-Stock Company
LHSS	Local Health System Sustainability Project
LLC	Limited Liability Company
LOX	Liquid Oxygen
MOH	Ministry of Health – Kyrgyz Republic
USAID	U.S. Agency for International Development
VIE	Vacuum Insulated Evaporator

Executive Summary

As part of ongoing efforts to reinforce, strengthen, and transform the nation's health infrastructure, in 2018 the Ministry of Health of the Kyrgyz Republic (MOH) began piloting the use of medical grade liquid oxygen (LOX) as a component of the country's medical oxygen ecosystem. In early 2020, the emergence of the novel coronavirus SARS-CoV-2 (COVID-19) put tremendous strain on the nation's health system, in particular the resources and structures providing oxygen in outpatient and inpatient settings. As national incidence of COVID-19 surged beginning in July 2020, the Kyrgyz Republic consistently registered high daily mortality and increasing numbers of moderate to severe cases requiring oxygenation interventions. Health facilities throughout the country experienced critical shortages of medical-grade oxygen, and bridging the severe gaps in oxygen use forecasting, production and procurement, and supply chain at the health facility level was of crucial importance.

To address these gaps and improve national oxygen supply and provision, the U.S. Agency for International Development's (USAID's) Mission in the Kyrgyz Republic and the MOH jointly identified the need to assess medical-grade liquid oxygen. To achieve this, the USAID Local Health System Sustainability Project (LHSS), USAID's flagship, five-year health system strengthening project, was tasked with evaluating the national medical oxygen ecosystem, with an emphasis on identifying strengths, weaknesses, and areas for scalability of the liquid oxygen supply chain. A team of three Kyrgyz Republic–based medical and health system regulatory specialists conducted this mixed methods assessment.

In collaboration with the MOH, the team identified 35 public hospitals currently equipped with liquid oxygen (see Annex A). The team conducted interviews with each of these facilities in addition to a broad range of health system stakeholders at all levels via in-person, email, and phone interviews using a formal questionnaire adapted from the "Oxygen and COVID-19 Response Rapid Assessment Tool: Hospital Facilities" (see Annex B). In addition to health facility personnel, the team interviewed government officials, liquid oxygen supply and transport companies, and private health sector representatives to provide a more comprehensive understanding of the national oxygen ecosystem. The project also assessed the legislative and regulatory landscape to understand current regulations relating to liquid oxygen and identify opportunities to strengthen national regulation.

Overall, the assessment found that insufficient regulatory oversight and national controls, monopolies by liquid and gaseous oxygen supply companies, and variations and fluctuations in price for liquid oxygen supply by region pose important challenges for the scale-up of liquid oxygen use throughout the country. While these challenges are clear, the assessment also found liquid oxygen to be more cost-effective and easier to transport, and to require less technical oversight than the traditional gaseous option. This report offers perspectives on and opportunities for using liquid oxygen more broadly in the Kyrgyz Republic health system as a potential lower-cost alternative to traditional use of gaseous oxygen. The key recommendations emphasize ways to locate liquid oxygen supply, better quantify needs, improve procurement, and supply processes, and otherwise stream liquid oxygen into existing medical networks.

This report and its findings are intended to provide the Government of the Kyrgyz Republic, USAID, and other donors with actionable recommendations to improve the country's oxygen ecosystem for the reliable provision of oxygen in routine care. They are also intended to prepare the country for future shocks that could put pressure on its health system resilience and oxygen supply.

Key Recommendations

1. Stakeholders agree the MOH should consider liquid oxygen as a strong alternative to the traditional gaseous oxygen currently in use throughout most health facilities. The ability to transport and store much larger quantities of oxygen at lower costs in liquid form greatly reduces facility storage requirements and maintenance needs at the distribution and facility levels.

2. National-level regulatory standards and quality controls must be strengthened to ensure that standards for liquid oxygen use in the country are adequate, well disseminated, and enforced. The Department of Drug Supply and Medical Equipment within the MOH and the national laboratory system of *Kyrgyzstandard* should have more regulatory power and autonomy to set, maintain, and enforce these standards.

3. The MOH of the Kyrgyz Republic should require liquid oxygen suppliers to register for pharmaceutical licenses and hold them to all corresponding standards and oversight, including routine quality checks, temperature control standards, and minimum storage requirements for safety of oxygen supply.

4. Higher transportation costs to reach more remote regions of the country will affect the feasibility of extending the use of liquid oxygen in the health system. The MOH should conduct a rapid feasibility assessment of providing liquid oxygen to all regions and facilities or a smaller subset based on evaluated cost-effectiveness and practicality. To control these costs, the MOH should consider fixing prices for liquid oxygen working with the mandatory health insurance fund, health facilities, and oxygen suppliers.

5. To increase liquid oxygen supply and diversify the national market from the current monopoly, the MOH should identify additional local, regional, and international suppliers of liquid oxygen. Given potential for surge demands, the MOH should identify numerous suppliers for both routine and surge needs, with increased local production considered for a long-term and sustainable supply solution.

6. In addition to strengthening national regulatory systems, the routine maintenance and repair of oxygen supply systems must be systematically addressed. The MOH should provide technical support to ensure that facilities have the resources to perform routine maintenance and quality control checks.

7. Health stakeholders should consider private industry as a source of alternate surge supply of oxygen during a crisis. In addition to the one supplier of liquid oxygen and one supplier of gaseous oxygen in country, two additional suppliers import liquid oxygen from Kazakhstan for industrial use, and they can, or should be called to, fill gaps in the supply until a surge has passed.

Background

Demographics of the Kyrgyz Republic

The Kyrgyz Republic is a country of more than 6.5 million people in Central Asia populating an area of more than 77,000 square miles. A former republic of the Soviet Union, the Kyrgyz Republic gained independence in 1991; membership in the United Nations and the Organization for Security and Cooperation in Europe followed shortly after. The Kyrgyz Republic is a mountainous, landlocked country bordered by Kazakhstan, Uzbekistan, Tajikistan, and China. Most of its population lives at an altitude of more than 2,600 feet above sea level.

Geographically, the Kyrgyz Republic is divided into seven *oblasts* (regions): Osh, Jalal-Abad, Bishkek, Chui, Batken, Issyk-Kul, Naryn, and Talas.

The population is concentrated mainly in urban areas, such as Osh and Bishkek, with nearly 40 percent of the entire population residing in these two regions alone (see Table 1). Of relevance to this assessment, this uneven population distribution has important impacts on the density of health care staff, physician-to-patient ratios, and regional supply chains in more rural areas of the country.

Table 1. Population Figures in the Kyrgyz Republic

Region	Population (2021)
Osh	1,403,200
Including Osh City	*327,900*
Jalal-Abad	1,271,400
Bishkek	1,086,300
Chui	980,200
Batken	553,500
Issyk-Kul	503,900
Naryn	293,200
Talas	272,500
Total Population	**6,692,100**

Source: eHealth Center, Kyrgyz Republic (2022).

Demographics from the Ministry of Health (MOH) and the National Statistics Committee (see Table 2) demonstrate that the Kyrgyz Republic has experienced a moderate level of population growth since independence. The country's population is expected to increase in the coming decades with improvements in the quality of health care services provided throughout the country and improvements in overall life expectancy. Leading causes of mortality have been dominated by non-communicable diseases in the last two decades, with heart disease, stroke, and cirrhosis as the leading risks, and communicable diseases such as tuberculosis falling to 16th place (Institute for Health Metrics and Evaluation 2022).

This epidemiological shift from communicable to non-communicable diseases also observed globally has placed a high burden on the health care system to care for critical patients with

long-term care needs, especially prolonged use of medical oxygen and long-term stays in intensive care units (ICUs). Sixty-three percent of the population is between the ages of 15-64, and just 5 percent of the population is aged 65 and above (World Bank 2021).

Table 2. Key Demographic Statistics in the Kyrgyz Republic (2021)

Annual births (number of persons)	178,269
Annual deaths (number of persons)	42,298
Annual population growth (%)	1.67
Population literacy (%)	99.5

Source: eHealth Center, Kyrgyz Republic (2022).

Organization of the National Health System

At independence, the Kyrgyz Republic inherited the predominantly tertiary-level (hospital-based) health care system from the former Soviet Union. Since independence in 1991, national health care has undergone large-scale reforms focused on decentralizing care at the administrative level to increase primary care and decrease the overreliance on tertiary care. The Kyrgyz Republic created the mandatory national health insurance fund and a single payer system.

With these reforms, measures have been taken to improve health care infrastructure throughout the country using domestic government financing. By optimizing and restructuring the network of national public medical institutions, the health care system in the Kyrgyz Republic has been reoriented from cost-intensive tertiary inpatient care to primary health care services. In 2012 the family medicine system was established within the Healthcare Reform Program of the Kyrgyz Republic "Den-Sooluk" 2012-2016 to provide outpatient care as part of this transition to a primary health care model. The Kyrgyz State Medical Institute for Retraining and Continuing Education oversees training primary health care physicians and generalists who diagnose and treat at the primary level as well as provide preventive services. The generalists are the main link in the Kyrgyz health care system, connecting routine primary care for patients with specialized and hospital care when needed.

Today, a comprehensive and integrated health care system operates in the Kyrgyz Republic, consisting of public health facilities financed entirely from the MOH budget and municipal health facilities jointly funded by MOH and municipal city budgets. Private health facilities financed by private capital and licensed by MOH are also operating. Three levels of health care services are delineated: primary, secondary, and tertiary. At the primary level, the foundation of the health care system is a network of primary health care facilities and services: family medicine centers, family group practices, *feldsher*-obstetric stations,[1] emergency medical services, and diverse public health organizations. Of note, emergency services such as ambulances are attached to family medicine centers, except for Bishkek and Osh where emergency ambulance services operate as a separate structural unit within the PHC system. As the health system has evolved away from tertiary care, primary health care facilities and services have become the most geographically and logistically accessible to the population, as reported during the interviews conducted in this study.

Secondary-level health care services include organizations providing specialized outpatient and inpatient care at territorial and district hospitals, general practice centers, and city clinical hospitals. Given these are specialized services, all inpatient treatment requires a co-payment for

[1] A *feldsher* is a medical practitioner without full professional qualifications or status in some Eastern European countries and especially Russia.

service. Levels of co-pay are defined in the State Guaranteed Benefits Package, which also outlines categories of patients who are exempt or eligible for reduced rates.

National hospitals and research centers provide specialized tertiary-level care in their inpatient wards and intensive care units. This includes, for example, the National Center for Cardiology and Therapy, which performs coronary angiography, stenting of the coronary arteries, and research and treatment of cardiac arrhythmias by radio-frequency ablation.

Human resources for health in the Kyrgyz Republic are varied throughout its regions. According to the eHealth Center (2022), the Kyrgyz Republic has a nationwide physician-to-patient ratio double the World Health Organization recommendation, with 20.0 physicians per 10,000 people, and one and a half times the standard for direct health care providers per 10,000 people of 16.7 (see Table 3). However, despite this surplus in number of providers, the density of health care professionals is not consistent among the seven regions of the country. Much of the workforce (in particular, specialists) reside in the large urban areas.

Table 3. Physician-to-Patient Ratios in the Kyrgyz Republic

	Total number	Number per 10,000 population
Number of physicians in all specialties*	13,490	20.0
Number of clinical physicians	11,261	16.7

Source: eHealth Center (2022).
**Inclusive of dentists, laboratory physicians, and other non-clinician physicians.*

In the Kyrgyz Republic, the number of health care personnel and staff-to-patient ratios are regulated by the MOH. As reported by interviews with MOH staff, the typical staffing structure of health care facilities is one physician for six patients and one nurse for two patients. While these ratios were stretched during the COVID-19 pandemic, the staffing structure, especially in ICUs providing oxygenation interventions, remains under tight oversight by the MOH. Intensive care physicians and nurses are present in the ICU wards of tertiary-level hospitals, as are technical maintenance staff to support the oxygen systems.

Image 1. In Jalal-Abad, relatives of patients in the oblast hospital supply oxygen themselves to the wards

Impact of COVID-19 on Medical Oxygen Supply and Provision

In March 2020, the Kyrgyz Republic declared a state of emergency as a result of the COVID-19 pandemic. Despite national lockdowns and public health restrictions, COVID-19 case incidence, morbidity, and mortality continued to increase. By July 2020, a major crisis in the supply of medical oxygen developed, threatening the sustained and reliable provision of oxygenation interventions across all levels of the health system.

At this time, hospitals across the country were vastly overcrowded with moderate and severe cases of COVID-19 requiring oxygenation. A shortage in standard and surge availability of gaseous oxygen supply, oxygen concentrators, and ventilators further compounded challenges to managing

critical cases. To provide surge support, temporary hospitals were opened in a phased approach in Bishkek, with day clinics opened first then transitioned to providing overnight patient care. To assist with staffing needs for surge supply, volunteer groups were established across the country to deliver oxygen cylinders, rent oxygen concentrators free of charge, and refill empty cylinders (see Image 1). In the context of this immense public health emergency and lack of oxygen surge supply, throughout July 2020 the Kyrgyz Republic topped global COVID-19 statistics for daily mortality rate per capita on at least six different dates.

Acknowledging gaps in the national oxygen ecosystem, the overreliance on an undersupply of gaseous oxygen, and the need to prepare for a prolonged pandemic, on August 19, 2020, the Government of the Kyrgyz Republic issued Decree No. 282-R. That ruling allowed the MOH to install centralized liquid oxygen supply systems in 27 national, oblast (regional) and district level hospitals. This effort was undertaken in conjunction with the State Agency for Architecture, Construction, Housing, and Communal Services under the Cabinet of Ministers of the Kyrgyz Republic and financed by the Ministry of Economy and Finance. To combat the acute shortage of traditional gaseous oxygen, oxygen concentrators were purchased for nearly all hospitals in the Kyrgyz Republic through the USAID Local Health System Sustainability Project (LHSS) in the Kyrgyz Republic and other humanitarian funding sources.

About This Assessment

To address these gaps and improve national oxygen supply and provision, the USAID Mission in the Kyrgyz Republic and the MOH jointly identified the need to conduct an assessment of medical-grade liquid oxygen.

To achieve this, the LHSS Project was tasked with evaluating the national medical oxygen ecosystem, with an emphasis on identifying strengths, weaknesses, and areas for scalability of the liquid oxygen supply chain. The goal of this assessment is to build upon the achievements made in August 2020 toward scaling up the Kyrgyz Republic's use of liquid oxygen and strengthening overall oxygen supply capacity.

The findings of the assessment are intended to provide concrete recommendations for the MOH and other government stakeholders on the current system's strengths and weaknesses as well as areas for scalability to prepare for the next health emergency.

Types of Oxygen Supply

Concentrator – Both portable and stationary, concentrators supply gaseous oxygen to patients' bedsides through the hospital oxygen system.

Cylinder – The traditional storage container for gaseous oxygen, cylinders store large quantities of oxygen, which are transported to patient bedsides through the hospital network.

Liquid – Liquid oxygen is stored in tanks instead of cylinders and converted to gaseous oxygen for medical use through the gasification process.

Methods

Study Team

The LHSS team consisted of three expert consultants from the Kyrgyz Republic. All three experts had specific experience participating in international public health projects and technical working groups as well as writing analytical reports. Specific examples of their past work include German Agency for International Cooperation-funded assessments of COVID-19 medical equipment, MOH-led working groups to develop the technical specifications for medical equipment for COVID-19, and a UNICEF-led study on all-cause childhood mortality in the Kyrgyz Republic.

At the time of the study, the group members occupied the following positions:

- **Sergey Tseplukhov,** Group Leader, Director of MedConcept Alliance
- **Mirlan Orozbekov,** Chief Engineer of the National Hospital under the MOH
- **Rakhat Churmukova**, Lead Specialist of the Dean's Office of the Medical Faculty of the Kyrgyz-Russian Slavic University

Methodology

This assessment used a mixed methods design to capture both quantitative and qualitative data from the 35 health facilities identified (see Annex A) and national stakeholders.

The LHSS team adapted the "Oxygen and COVID-19 Response Rapid Assessment Tool: Hospital Facilities" (see Annex B) to conduct in-person, email, and phone interviews of 56 key respondents at all levels of the health care system as outlined below:

- **In-person meetings** with key hospital personnel:
    - Hospital staff (34) in Bishkek, Chui, and Osh regions
    - Management personnel of the MOH's Department of Drug Supply and Medical Equipment
    - Management personnel at medical oxygen suppliers
    - Management personnel in the standardization department of *Kyrgyzstandard* under the Ministry of Economy
    - Management personnel of the Crisis Management Center under the Ministry of Emergency Situations
- **Email questionnaires** to all hospitals that were not able to participate in in-person interviews (due to geography or availability). Of note, the response rate to the email survey was quite low (only 2 out of 20 hospitals responded), and written responses were of poor quality. As a result, the study team conducted additional telephone interviews to ensure collection of sufficient information at the local level.
- **Telephone interviews** with management personnel and technical staff in hospitals responsible for maintaining oxygen systems:
    - Hospital personnel such as chief physicians and hospital directors in Jalal-Abad, Naryn, Issyk-Kul, and Talas regions

- No information from hospital management in the Batken region due to border instability with neighboring Tajikistan

The project also conducted a **desk review** to assess the legislative and regulatory landscape to understand current regulations relating to liquid oxygen and opportunities to strengthen national oversight and regulatory control.

Finally, the project also conducted a brief **survey** with suppliers of non-medical liquid oxygen in country. The intent of this survey was to assess the landscape of non-medical uses of liquid oxygen in the Kyrgyz Republic to understand supply and potential for scalability.

Sampling Criteria

The total institutional sample reached through in-person, email, and phone interviews was 32 out of the 35 national and oblast (regional) level facilities across the Kyrgyz Republic that had a centralized liquid oxygen supply system installed at the time of the assessment in July-September 2022 (see Annex A). The institutional sample coverage of national secondary and tertiary care facilities was therefore 91 percent.

At the secondary level of care, the study team interviewed personnel from seven hospitals: Issyk-Kul Oblast Merged Hospital; Naryn Infectious Diseases Hospital; Jalal-Abad Oblast Merged Hospital; Bishkek City Clinical Emergency Hospital for Children; Sokuluk General Practice Center; Bishkek City Clinical Hospitals No. 1 and No. 6. A further 24 regional hospitals participated by email or phone.

At the tertiary level of care, the study team interviewed four hospitals of national or republic status: National Hospital; National Center for Maternal and Child Health; Republican Clinical Infectious Diseases Hospital; and Southern Regional Scientific Center for Cardiovascular Surgery in Jalal-Abad.

Two private health facilities were also sampled; however, they were excluded from the findings for the following reasons:

- The LHSS team identified one private microsurgery eye clinic as using liquid oxygen, but upon interviewing a staff physician, the team discovered the facility does not use liquid oxygen and indeed lacks the required infrastructure to do so.
- The study team also identified a second non-governmental Kyrgyz-Turkish hospital and contacted leadership at this facility for an interview. However, the leadership declined to participate, citing confidentiality.

Limitations

As the LHSS Kyrgyz Republic Activity will end on November 30, 2022, the study adhered to an abbreviated timeline. Against that deadline, the study team relied on additional telephone interviews to reach as many facilities as possible without extensive travel outside of the three regions visited. The team carried out in-person interviews in Bishkek, Chui, and Osh regions only. While this did not affect the quality or quantity of data collected in this report, facility-level informants expressed a desire to expand in-person data collection and site visits to the entire country as part of future MOH feasibility assessments.

A further limitation involved rising border tensions, which prevented data collection from facilities in the Batken region. While the study team pursued email and phone contact, health facilities in

this region were busy attending to casualties of this conflict. The study team was therefore able to interview facilities in only six of the seven regions.

Results

The findings of the in-person, email, and phone data collection as well as the desk review provide insights into the operability, feasibility, and regional variability of the use of liquid oxygen for medical purposes throughout the Kyrgyz Republic. With a specific focus on the production, transportation, and cost of liquid oxygen as a viable substitute for traditional gaseous oxygen, the findings of this assessment outline current and future strengths and weaknesses.

Results demonstrated several key factors to consider in the feasibility of liquid oxygen use, including:

- The cost of liquid oxygen products and transportation
- The in-country production and reliance on importation from neighboring countries
- Resource requirements (e.g., storage, staff, and maintenance) compared to gaseous oxygen

Health Facility Infrastructure

The LHSS team surveyed facility infrastructure and medical equipment, which are critical to the provision of medical oxygen, throughout the health system in the Kyrgyz Republic. Focusing on inpatient care such as ICU beds, where most of the medical-grade oxygen is used, and medical equipment needed to support oxygen use, the assessment used data from the MOH and key informant interviews to understand the ecosystem of facility infrastructure nationwide.

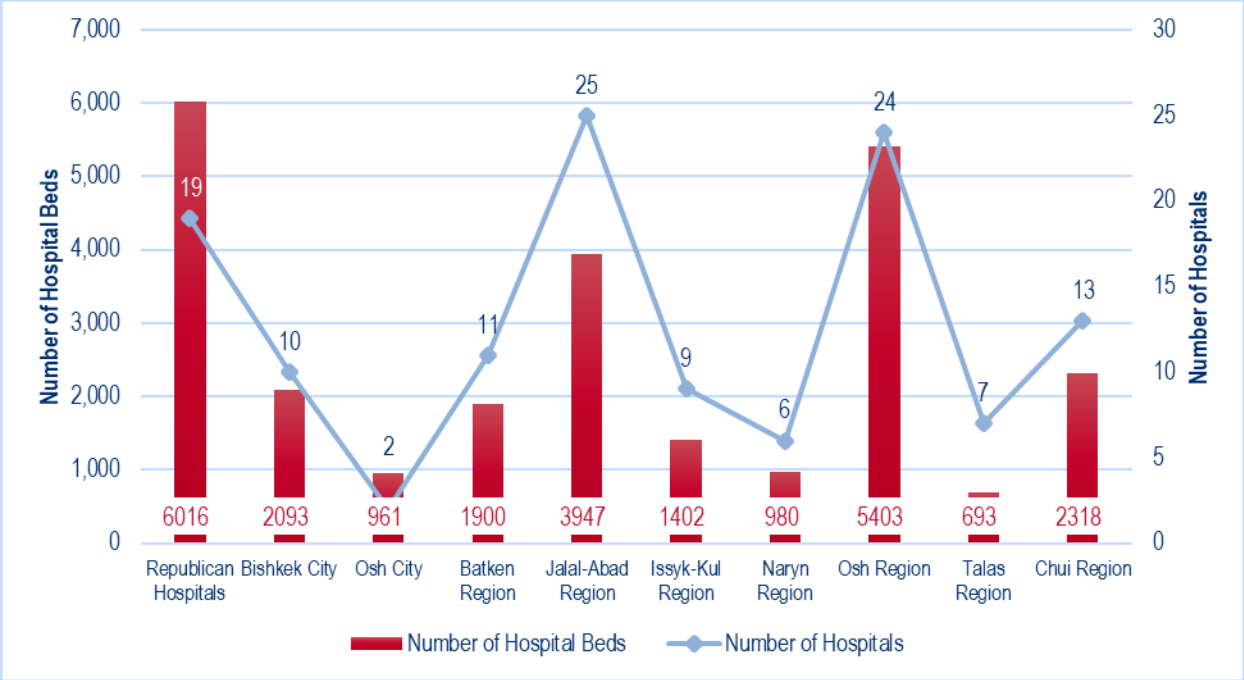
Facilities and Number of Beds

According to data from the Kyrgyz Republic eHealth Center (2022), the following facilities are operating in country as of the end of 2021:

- 17 family medicine centers
- 61 centers for general medical practice
- 686 family group practices
- 1057 *feldsher*-obstetric stations
- 126 hospitals

In the 126 hospitals providing inpatient care to the Kyrgyz population, there are **25,713 beds available in total**. The breakdown by region is shown in Figure 1, including Bishkek and Osh cities. Of the total hospital beds available in country, there are **758 ICU beds** across the 126 hospitals of the Kyrgyz Republic that have the capability to provide oxygenation interventions (see Annex C). However, only 35 of these hospitals are equipped to provide liquid oxygen supply; the remaining beds are served by traditional gaseous oxygen.

Figure 1. Hospital Beds and Tertiary-Level Hospitals by Region in the Kyrgyz Republic



Source: eHealth Center, Kyrgyz Republic (2022).

Electricity

Electrical supply to health facilities in the Kyrgyz Republic is relatively stable and well resourced. All medical facilities in the country, including hospitals, are provided with uninterrupted power supply from the centralized grid. According to the findings of the assessment, all 35 facilities with liquid oxygen supply that were contacted have functional emergency generators onsite to use in the event of an emergency. Interruptions are possible, but for most shutdowns, the emergency generators present can support emergency electric grid needs until power is restored. Only during major emergency shutdowns in the energy system are temporary interruptions a problem at the facility level.

Emergency Medical Services

Key informants from the health facilities reported that emergency medical services in the Kyrgyz Republic are not of high quality nor do they meet the needs of the population. Availability of emergency services and the quality of emergency care are below standards in most regions. As reported by the facilities, most Kyrgyz Republic's emergency medical services serve to stabilize and transport patients to health facilities. Technical equipment (such as that required for sustained oxygenation) and other medical supplies are lacking on most emergency vehicles, including oxygen supply for emergency use. In rural areas outside the most urbanized regions, there is a significant problem of low emergency coverage and delayed or limited access.

National Medical Oxygen Supply and Production

Supply and Suppliers

According to the executive director of the liquid oxygen company who was interviewed for this assessment, BishkekTechGas LLC is the sole identified producer and supplier of liquid oxygen (LOX) to all healthcare facilities in the country. The company and its local subsidiaries have an agreement with MOH to produce 210 tons of LOX per month, however due to aging equipment and other capacity constraints the company is only producing (on average) 60 tons per month. As discussed further below the remaining ~150 tons per month are imported by BishkekTechGas from Kazakhstan and Uzbekistan. Liquid oxygen was recently introduced to the national oxygen ecosystem in 2018, and BishkekTechGas LLC has supplied and installed all units for the centralized liquid oxygen supply and delivery of liquid oxygen in the 35 hospitals equipped thus far.

Only one company, JSC Kislorod, produces and supplies **gaseous oxygen** in the Kyrgyz Republic. It produces gaseous oxygen at its plant in the Chui region, with a staff of more than 25 employees. The LHSS team interviewed the chief technologist from Kislorod for the assessment.

National Production Capabilities

Liquid Oxygen

BishkekTechGas LLC and their subsidiaries currently provide national LOX production of ~60 tons per month as below:

- A Bishkek liquid oxygen production plant with a capacity of 42 tons per month
- A liquid oxygen supply contract with Emgek LLC (Leninskoye village, Alamedin district) to provide an additional 10 tons per month
- A liquid oxygen supply contract with Marcha Industry LLC (Mailu-Suu, Jalal-Abad region) to provide an additional 8 tons per month
- A liquid oxygen supply contract with Bai Industry LLC in the amount of 2.5 tons annually (as of 2021)
- About 150 tons per month imported from Kazakhstan (LLP Linde Gas Kazakhstan) and Uzbekistan (Uzbek Metallurgical Plant, Bekabad City)

According to BishkekTechGas LLC, the total demand for liquid oxygen in the Kyrgyz Republic is 210 tons per month.[2] Given the current supply as outlined above, BishkekTechGas LLC can meet current routine demand through local production and regional import; however, its ability to rapidly surge production or supply in the event of a health emergency is extremely limited given that local production capacity is already maximized.

[2] *Source*: Official statement from BishkekTechGas LLC dated September 2022.

The production of liquid oxygen is different from that of gaseous oxygen

During production of liquid oxygen, air is cooled to −183 degrees Celsius, which causes oxygen to condense and separate from the air mixture. The liquid oxygen is then stored in special tanks and transported to hospitals. There it is poured into a thermally insulated tank, also known as a vacuum insulated evaporator (VIE) for storage. Through gasification, the oxygen is converted back into a gaseous state and can be routed through a hospital's central distribution system to be delivered to hospital beds.

Gaseous Oxygen

According to the chief technologist, the Kislorod production plant has a monthly production capacity of 2,500-3,000 cylinders. This includes the following production capabilities:

- Oxygen booster compressor: 20 cylinders per hour
- Automotive oxygen-nitrogen producing stations: two units with five cylinders per hour capacity each (for a total of 10 cylinders per hour)

The plant's total production capacity is 250 liters of liquid oxygen per hour, which is then converted into gaseous oxygen and stored in cylinders. There is one main high-volume tank for storing liquid oxygen with a volume of 8 cubic meters.

Medical Oxygen Storage and Handling

In the Kyrgyz Republic, health care facilities receive their medical oxygen supply via three modes: oxygen concentrators, cylinders (gaseous oxygen), and liquid oxygen systems.

Concentrators

Oxygen concentrators are used to provide oxygenation interventions through facility-based oxygen stations, which supply oxygen to the bedside. Tertiary-level hospitals, which require the greatest supply of medical oxygen to deliver inpatient care, use the following types of oxygen concentrators:

- **Portable**: with a capacity of up to 10 liters per minute at a pressure of 0.6 atmospheres
- **Stationary**: with a capacity of up to 10 liters per minute at a pressure of 4 atmospheres, equipped with 210-liter receivers and designed for artificial lung ventilation devices

Many portable oxygen concentrators were added to the MOH's oxygen ecosystem during the COVID-19 response, as surge oxygen supply was required at all health facilities. Stationary concentrators were purchased under international loans and grant financing programs from the World Bank, the German Development Bank, the Asian Development Bank, the Swiss Red Cross, and the Japanese Embassy in the Kyrgyz Republic. During this scale-up in 2020 and 2021, the USAID LHSS Project also purchased six high-capacity oxygen concentrators for use in ICUs. Funding was used to install portable oxygen concentrators that produce oxygen from the ambient air at the bedside of the patient. There are only two facilities in the Kyrgyz Republic that produce oxygen in this fashion: National Hospital in Bishkek and Osh Oblast Merged Clinical Hospital. Portable oxygen concentrators produce 210 liters per minute. However, according to hospital staff interviewed, the significant drawback with these compact oxygen concentrators is that they require continuous ventilation.

Such solutions, while imperative in helping the Kyrgyz Republic provide surge options during the COVID-19 pandemic, are not sufficient to support oxygenation or ventilation needs on a mass scale.

Cylinders (Gaseous Oxygen)

The use of cylinders to provide gaseous oxygen supply is typically more expensive than the less expensive oxygen tanks that are used to store liquid oxygen. This is due to purchasing at lower volumes (due to cost), high transportation costs, and significant storage and handling considerations at the facility level.

Oxygen ramps (see Image 2) have been installed in all hospitals of the Kyrgyz Republic to connect the cylinders that store the oxygen to the supply network of the hospitals to deliver oxygen to patients. A standard ramp for 10 cylinders with a volume of 40 liters each can provide a hospital, on average, 15 cubic meters per day for about four or five days.

This oxygen supply is greatly below the estimated need during a surge crisis, as the current supply is just meeting national demand. The technology and infrastructure in the Kyrgyz Republic to support gaseous oxygen via cylinders at scale are outdated in many regions and often fail, having been produced more than 30 years ago. This was reported by numerous key informants.

Image 2. Oxygen ramp in Bishkek

Liquid Oxygen

Medical-grade liquid oxygen provides a more compact source of facility-level gaseous oxygen. After undergoing gasification to convert the liquid oxygen to a gaseous state for use, liquid oxygen can be used for ventilation and other medical purposes per standard protocols (see Image 3). Because of this gasification process, liquid oxygen can be procured, transported, and stored in much larger volume with less complex logistics requirements than gaseous oxygen can.

A centralized supply of liquid oxygen was first installed in January 2018 at a maternity hospital in the Bishkek region, with the financial support of the German Development Bank KfW. From 2018 to 2020, seven more hospitals in the Kyrgyz Republic were equipped with a liquid oxygen supply system through funding from the national government.

During the height of the COVID-19 pandemic (2020-21), the public sector's "Social Partnership Fund for the Development of Regions," mentioned under Government of the Kyrgyz Republic Decree No. 282, allocated funds to equip 27 additional hospitals with a centralized liquid oxygen supply system in phases. According to the eHealth Center under the MOH (2022), as of January 1, 2022, 73 tertiary hospital facilities in the Kyrgyz Republic had ICU beds when specialized facilities such as tuberculosis treatment centers and psychiatric hospitals were subtracted. Of those 73 facilities with ICU beds, 35 (48 percent) had been equipped with a centralized liquid oxygen supply system.

Image 3. Tank for the liquid oxygen gasification process installed in the Infectious Disease Hospital in Osh

This study interviewed all 35 government facilities with liquid oxygen supply systems. The findings below outline respondent perspectives on the liquid oxygen ecosystem and supply in these facilities:

- All 35 hospitals employ at least two individuals with secondary technical education. These are the staff responsible for the infrastructure and maintenance of medical oxygen in their facility. These staff are graduates of technical colleges who have completed a certification course in the operation of oxygen systems. They typically fill the role of head electrician in the hospital.
- Staff responsible for oxygen supply are routinely trained and certified for safe oxygen handling and supply by the State Inspectorate for Environmental and Technical Safety under the Government of the Kyrgyz Republic.
- There were no complaints among the 35 facilities regarding the current oxygen supplier BishkekTechGas LLC or its subsidiary companies including Marcha Industry LLC and Bai Industry LLC.

- In rural facilities, however, the increased transportation costs associated with liquid oxygen compared to traditional gaseous oxygen with a wider distribution network were a concern for respondents at the facility level. As a result, in rural areas some smaller facilities reported they had plans to abandon liquid oxygen and return to oxygen concentrators for their cost-saving potential.
- All 35 hospitals purchase liquid oxygen from one supplier.
- All 35 hospitals reported that funding for liquid oxygen supply comes from the hospital's general operating budget and is funded by national government funds.

Facility-Level Liquid Oxygen Supply Considerations

Respondents from the facilities interviewed provided numerous perspectives on the relative advantages and disadvantages of using liquid oxygen over other methods of supplying gaseous oxygen (see Table 4).

Table 4. Advantages and Disadvantages of Using Liquid Oxygen over Gaseous Oxygen

Advantages

• A greater volume of oxygen can be stored in the same cubic space as liquid than as gas, which greatly reduces the number of deliveries required for a particular volume and avoids bulky and expensive supply via traditional cylinders.
• Safety and maintenance requirements are greatly simplified since liquid oxygen is stored and transported under low pressure, rather than the high pressure of gaseous oxygen in cylinders. The low pressure also reduces safety concerns and maintenance costs for facility-based personnel.
• Eliminating the need for heavy cylinders reduces costs:
  ○ The tare weight – i.e., the weight of transport cargo that is the basis for calculating shipping costs – is 10 times less for liquid oxygen (according to the gas companies).
  ○ The market value of an empty oxygen cylinder ranges from approximately US$59 to US$85 (5,000–8,000 *soms*), making the cost of the cylinder itself 10–20 times higher than the cost of the gaseous oxygen stored inside.
  ○ The weight during transportation is reduced by about 18 times. Tanks used for transporting liquid oxygen in the Kyrgyz Republic have a capacity of 1200 liters of liquid oxygen but weigh just 700 kilograms, which yields a weight-to-use ratio of 0.53.
• Liquid oxygen is less sensitive to temperature and other environmental factors. It does not contain moisture and can be used at low temperatures without special measures such as piping below freezing depth, thermal insulation, and installation of condensation drains.
• Liquid oxygen generates 10-12 percent less product waste than gaseous oxygen does (as reported by the liquid oxygen supplier). With gaseous oxygen, it is necessary to leave enough oxygen in the cylinder after use to generate at least 5 atmospheres of pressure, which is not true of liquid oxygen supply systems.
• A liquid oxygen supply is more reliable because it requires less routine maintenance and oversight from trained professionals.
• Eliminating cylinders reduces the risk of impurities or contamination of the oxygen supply. With prolonged exposure, moisture can build up in the cylinders and form rust, which affects the purity of oxygen and is harmful to patients.

Disadvantages
• Production of 1 kilogram of liquid oxygen consumes more power than gaseous supply options, which also leaves production susceptible to variations in power supply costs. • Irrespective of mode of delivery, transportation costs for oxygen to remote areas are a significant concern. Liquid oxygen remains more expensive to transport in many rural regions of the country, posing a critical financial barrier to implementation. • Only one domestic company supplies liquid oxygen in the Kyrgyz Republic (BishkekTechGas LLC). At present, there is a relative monopoly controlling price. • BishkekTechGas LLC does not have production capacity to meet the full routine demand of 210 tons per month. With current production capacity of 60 tons per month, and importation of a further 150 tons per month from regional suppliers there is currently no surge in LOX production capacities in the country. Respondents have argued that two additional oxygen production plants are needed in the country (in the south and north) to reduce reliance on imports for routine demands and to better position the country for surge production needs in future.

Transportation and Logistics

According to the study's hospital informants, the transportation and logistics considerations for liquid oxygen versus gaseous oxygen are quite different. As reported by MOH officials, this has critical implications for budgeting at both the national and sub-national levels.

- **Liquid oxygen**: BishkekTechGas LLC owns its own transportation vehicles for the delivery of liquid oxygen. Its delivery capabilities include one refueling truck with a tank capacity of 26 cubic meters and three smaller refueling trucks with tank capacities of 16 cubic meters each.
- **Gaseous oxygen:** Kislorod does not have its own transportation for the delivery of gaseous oxygen across the country, instead relying on third-party transportation companies at the expense of the hospital client. This lack of in-house transportation increases both the total costs of transportation and the variability of these costs depending on transportation suppliers and market fluctuation. Both increase the overall budget implications of traditional gaseous oxygen compared to liquid.

Costs of Liquid Oxygen

The MOH reported that cost is one of the most fundamental considerations it takes into account regarding development of the Kyrgyz Republic's oxygen ecosystem. The cost of one kilogram of liquid oxygen ranges from US$0.39 (32.50 *soms*) in Bishkek to US$0.94 (78 *soms*) in more rural regions. Rural hospitals reported that prices can vary greatly depending on national demand, the distance from a major city to the end delivery point, and the type of transportation needed to reach the region.

As demonstrated in Table 4, regional variation in pricing is a major concern in the country's oxygen ecosystem; in particular, disparities between urban and rural pricing. As reported by smaller facilities, rural facilities pay more for liquid oxygen itself and then additionally for costs of transport and logistics. The administrators of some hospitals in remote regions reported that the purchase of liquid oxygen, while preferable in some ways (e.g., storage requirements), is very expensive for them compared to other options, given their small hospital operating budgets.

Table 5. Price per Kilogram of Liquid Oxygen across the Kyrgyz Republic

Region	Price per kilogram (US$)	Price per kilogram (*soms*)
Bishkek	0.39	32.50
Tokmok, Chui	0.72	60.00
Ak-Talinsky, At-Bashinsky, Jumgalsky districts, Naryn region	0.94	78.00

Source: Self-reporting of price per kilogram paid by hospitals interviewed.

The table highlights a stark example of this urban-versus-rural price differential (provided during one of the key informant interviews): At one hospital in At-Bashi, hospital staff had to allocate about US$7,600 (630,000 *soms*) from their 2021 annual operating budget for just three separate refuelings of a 3 cubic meter evaporator. The price per kilogram of liquid oxygen was US$0.94 (78 *soms*) despite nearby regional prices being US$0.72 per kilogram (60 *soms*) and nearly half the cost (US$0.39, or 32.50 *soms*) in the capital of Bishkek.

As demonstrated above, the price for liquid oxygen can vary greatly. In the absence of any price controls from the MOH, the assessment identified this price variation as an important barrier.

Regional Availability

As demonstrated in Figure 2, liquid oxygen is generally available in all regions of the Kyrgyz Republic.

Figure 2. Distribution of Hospitals Supplied with Liquid Oxygen across the Regions of the Kyrgyz Republic

Although liquid oxygen is used in health facilities throughout all seven regions of the country, as shown above, use is most concentrated in densely populated urban areas. Most liquid oxygen

systems are in the Bishkek and Chui regions, whereas systems in more rural regions are much more spread out.

Owing most likely to the higher transportation costs and smaller facility size of hospitals in more rural regions such as Talas, regional availability varies greatly throughout the country. Key informant interviews revealed the following:

- **Liquid oxygen consumption within equipped facilities varies greatly.** Among the 35 hospitals interviewed, the spectrum of liquid oxygen use was broad, ranging from 7 percent to 100 percent use of existing supply. For example, one facility in Bishkek reported that it uses only about 7 percent of its monthly supply of liquid oxygen. This was due to a recurring leak from its vaporizer, which reduced volume and wasted resources. That hospital defaulted on gaseous oxygen for cost savings. Following data collection and preparation of this report the supplier met with hospital management and the issue was resolved. It was determined that the vaporizer was functioning properly, but staff did not have the requisite skills to utilize it correctly. Training was conducted and the facility is reporting they are now thinking of expanding use of LOX.
- **Nearly 50 percent of the Kyrgyz Republic's total liquid oxygen supply is consumed by two hospitals.** As reported by these facilities, they are Issyk-Kul Oblast Merged Hospital and Bishkek City Clinical Hospital No. 6.
- **Some hospitals reported that they rely almost completely on liquid oxygen.** Liquid oxygen as the primary source accounted for 94-100 percent of medical oxygen consumption in the following hospitals interviewed: Naryn Infectious Diseases Hospital, Ak-Tala territorial hospital, At-Bashi territorial hospital, Jumgal territorial hospital, as well as the Talas Family Medicine Center (an outpatient primary care facility). However, a key challenge driving this high use of liquid oxygen is that these hospitals lack the necessary logistics for the delivery of gaseous oxygen.
- **In some hospitals, liquid oxygen consumption has decreased since being introduced.** In Bishkek City Clinical Hospital No. 1, liquid oxygen accounted for 93.7 percent of total oxygen consumption in 2021; that figure has decreased to 43.3 percent in 2022. According to key informants at this facility, including the hospital director, chief accountant, and deputy director for economic affairs, this decline in consumption was due to their perspective that liquid oxygen would be useful only as an emergency stopgap measure during the pandemic. During the height of the crisis, liquid oxygen was attractive because it was convenient, readily available, and did not require technicians to be available 24/7 during a massive staffing shortage. As the acute phase of the pandemic and need for surge oxygen supply subsided, the hospital conducted an economic cost analysis and concluded that using gaseous oxygen was overall less expensive.

This information from respondents demonstrates how variable the national oxygen ecosystem is in its supply, availability, consumption, and preferences for liquid oxygen across the regions of the country. It also showcases where many respondents believed liquid oxygen fits in the oxygen ecosystems during different phases of a health emergency.

Non-Medical Supply and Consumption of Liquid Oxygen in the Kyrgyz Republic

Private Sector Consumption of Liquid Oxygen

Along with this assessment, the LHSS team conducted a brief survey to identify additional private suppliers of non-medical liquid oxygen used for industrial production in the country. Two

additional suppliers were identified: EvrazMetalKomplekt LLC and TOO Kazmetservice LLC. Additionally, Marcha Industry LLC, which has a small subsidiary contract with BishkekTechGas, also produces non-medical liquid oxygen for industrial use. The organizations provided the following information in interviews:

EvrazMetalKomplekt LLC is a universal supplier of rolled metal products in the Kyrgyz Republic but also is a provider of technical gases including liquid oxygen. It imports liquid oxygen from Kazakhstan: approximately 124 oxygen cylinders per month at a price of US $111 (9,283 *soms*) per tank.

TOO Kazmetservice LLC declined to be interviewed, citing lack of available time. No contact was established with this supplier.

Marcha Industry LLC supplies technical gases such as argon, carbon dioxide, acetylene, and medical and non-medical oxygen that is imported from Kazakhstan: about 150 liquid oxygen tanks per month at a price of per kilogram of US$0.45 (37.5 *soms*).

Opportunities for Surge Provision

These companies are non-traditional suppliers of liquid oxygen and (excluding Marcha Industry LLC) are not thought of to provide supply for medical uses. Still, these suppliers have existing supply chain networks to import liquid oxygen in the country for industrial use. While the liquid oxygen imported through these suppliers is not for medical purposes, with proper quality and safety testing it can be used as an additional supply. In the event of a surge in demand for oxygen as a result of a health or other emergency, these companies could help source supply to fill immediate gaps in supply and help meet demand until the surge has passed.

Regulatory and Legislative Framework

Based on the findings of the desk review, regulatory oversight, and quality control of medical-grade oxygen in the Kyrgyz Republic is a critical area of capacity strengthening. The Department of Drug Supply and Medical Equipment under the MOH is mandated by Decree No. 274 (dated June 6, 2018) to oversee regulatory control of all oxygen use in the country. However, as respondents reported, in practice no licensing is required and quality control of each import or production batch occurs rarely.

Critically, the two suppliers of medical oxygen in the country, Kislorod (gaseous oxygen) and BishkekTechGas LLC (liquid oxygen), do not have a license for pharmaceutical activities. A license would require that the suppliers meet important regulatory and safety standards, including adequate space in their production facilities (at least 140 square meters), a full-time pharmacist on staff, and compliance with strict sanitary standards, with the investment of appropriate resources. The absence of the requirement of a license for pharmaceutical activities for these oxygen suppliers negates the requirement that samples of oxygen batches supplied to the end user be certified by the laboratory of the Department of Drug Supply and Medical Equipment.

Of note, medical-grade oxygen is included on the national Essential Medicines List. The list does require that each batch of oxygen supplied to hospitals must be certified by the Department. To circumvent these requirements, oxygen suppliers have referenced the *Law of the Kyrgyz Republic "On the Circulation of Medicines" dated August 2, 2017.* Its chapter 3, paragraph 6, article 10 states “pharmaceutical substances are not subject to state registration on the territory of the Kyrgyz Republic.” By choosing to claim oxygen as a pharmaceutical

substance, suppliers have been able to avoid the quality control process and are not technically breaking any national laws. Of further note, there are no independent laboratories for assessing the quality of oxygen in the Kyrgyz Republic. Hospitals only receive copies of the certificate from the manufacturer. Several respondents noted that closing these gaps in the regulatory framework and critical areas of medical regulatory oversight will be important to set standards for medical grade oxygen and enforce compliance with those standards to improve the provision, safety, and quality of medical oxygen in the Kyrgyz Republic moving forward.

Several key pieces of national legislation affect the use and supply of oxygen for medical uses in the Kyrgyz Republic.

- **Decree of the Government of the Kyrgyz Republic No. 274** (dated June 6, 2018) "on approval of the national list of vital medicines and medical devices," stipulates that medical oxygen is classified as an essential medicine.
- **Decree of the Government of the Kyrgyz Republic No. 312** (dated July 5, 2018) "on approval of the procedure for assessing the quality of medicines," codifies that oxygen suppliers must be licensed and conduct a quality check.
- **Decree of the Government of the Kyrgyz Republic No. 165** (dated August 2, 2017) introduced the concept of "pharmaceutical substances" not subject to state registration, and therefore not required to be certified by a licensed medical supplier. As highlighted above, local oxygen suppliers refer to this to avoid a regulated quality control process.
- **Decree of the Government of the Kyrgyz Republic No. 282-R** (dated August 19, 2020) was a ruling by which the government began to install centralized liquid oxygen supply systems in 27 hospitals of the country to combat the shortage of traditional gaseous oxygen.
- **GOST[3] of the USSR No. 6331-78, International Technical Standards for Medical Oxygen** (dated May 26, 1978; last amended October 12, 1995) is a resolution that set minimum technical standards for oxygen supply, production, and use among eight former Soviet countries. However, the Kyrgyz Republic did not sign this resolution, and is therefore not held to these standards or expected to adopt the latest changes.

The regulatory and legislative landscape in the Kyrgyz Republic outlines several governing bodies and compliance requirements, but clearly, in practice, no real oversight occurs. This lack is a critical issue facing the medical oxygen ecosystem in the country today. The lack of clarity on the need for pharmaceutical licensure status, oxygen classification as a pharmaceutical substance, and the lack of quality checks or safety measures are crucial gaps in the current oxygen ecosystem.

[3] GOST is a Russian acronym for *gosudarstvennyy standard*, meaning state or government standard.

Key Findings

Respondents provided numerous insights on the status of the Kyrgyz Republic's oxygen ecosystem. Prior to and during the COVID-19 pandemic, the government and its partners invested heavily in advancing regulatory and legislative, financial, and technical opportunities to deliver sustained supply of liquid oxygen and other medical-grade oxygen throughout the country. Yet, despite the investment and political commitment, the LHSS team's assessment demonstrates specific challenges that must be addressed if the Kyrgyz Republic is to sustain routine medical oxygen use needs while preparing for future surge demands.

Key Finding 1: Liquid oxygen is a strong alternative to traditional gaseous oxygen for medical use in health facilities.

Across all the health facilities sampled, the strengths of liquid oxygen as an alternative to gaseous oxygen are the ability to transport and store larger quantities of oxygen as well as the reduced need for complex storage and technical staff to maintain the systems. Additional fixes to the liquid oxygen supply chain system can allow access for a larger number of patients across the country with reduced medical costs.

> Recommendation: The MOH of the Kyrgyz Republic should expand the use of liquid oxygen in medical facilities across the country, considering the feasibility and context for each region and health facility.

Key Finding 2: Nationally, there is no quality control system for medical-grade oxygen, and liquid oxygen in particular.

Hospitals and patients currently rely on quality analysis data produced by manufacturers in the country of origin (typically Kazakhstan or Uzbekistan). Local suppliers of oxygen who are not required to obtain pharmaceutical licensure utilize ambiguous national legislation that exempts them from undergoing routine quality and safety controls.

> Recommendation: In order to fully equip the Kyrgyz Republic with a strong, resilient oxygen ecosystem, regulatory and legislative contradictions must be addressed; regulatory controls must be put in place to regulate safety of medical oxygen supply; and more autonomy and regulatory powers regarding oxygen should be given to the Department of Drug Supply and Medical Equipment under the MOH.

Key Finding 3: Liquid oxygen suppliers are not required to register for licensing status, which would require quality and safety checks.

Although liquid oxygen is a medical product, the lack of clarity around liquid oxygen providers as pharmaceutical companies creates a licensing loophole. This uncertainty allows suppliers to maintain their lack of pharmaceutical licensing in the Kyrgyz Republic, exempting them from required standards and checks for quality and safety.

> Recommendation: The MOH of the Kyrgyz Republic should require liquid oxygen suppliers to register for pharmaceutical licenses as part of efforts to strengthen quality control and regulatory systems overall. These suppliers should be held to all corresponding standards and oversight, including routine quality checks, temperature control standards, and minimum storage requirements for safety of supply.

Key Finding 4: Purchase and transport costs are prohibitively high for health facilities in remote areas of the country.

In most urban areas, the use of liquid oxygen is significantly more cost-effective due to greater quantity that can be stored and shipped; however, the price of liquid oxygen itself and associated transportation costs vary greatly across the country depending on an area's remoteness. Despite its benefits at the facility level, liquid oxygen can become a much more expensive option for more rural and remote health facilities.

> Recommendation: The MOH should work with the mandatory health insurance fund, liquid oxygen suppliers, and health care facilities to fix transportation costs by establishing a set price and help offset the additional costs accrued by longer travel distances. Fixing prices for liquid oxygen across the board will increase the feasibility of liquid oxygen rollout for greater reach throughout the country.

Key Finding 5: There is currently a local market monopoly in the national supply of both liquid oxygen and gaseous oxygen.

In the Kyrgyz Republic, there is only one current local supplier of gaseous oxygen and one local supplier of liquid oxygen; thus, the two companies are able to control prices, imports, and supply. These companies also are limited by their own production and transportation capabilities. Scaling to meet increased demand during a surge is less possible without diversification in the oxygen ecosystem supply chain.

> Recommendation: To strengthen the Kyrgyz Republic's oxygen supply, the MOH should consider identifying additional local, regional, and international suppliers. The MOH should work to identify ways to support the in-country registration and establishment of local production to diversify the local market. Local production is a long-term solution to significantly reduce production costs, increase sustainable supply, and bolster the country against severe shortages in the availability of global supply and export restrictions that can occur during a health emergency.

Key Finding 6: Regular maintenance and repair of liquid oxygen distribution systems is needed.

While the infrastructure for traditional gaseous oxygen is outdated in many health care facilities, the recently equipped systems for liquid oxygen across the country also require routine maintenance and repair. As reported at one facility, a leak in its liquid oxygen supply system creates challenges, not least resource waste and higher overall costs of the liquid oxygen system compared to alternatives.

> Recommendation**:** The same systems that are established for national regulatory controls should be used for quality checks of the maintenance of supply systems. Technical support and technicians should be supported by the MOH to ensure that facilities have both the know-how and resources to repair issues with supply systems and perform routine maintenance.

Key Finding 7: The nation currently lacks the ability to ramp up medical-grade oxygen supply in the event of surge demand.

Local LOX production capacities of 60 tons per month are not sufficient to meet routine demands and leave the nation reliant on regional importation of ~150 tons of LOX per month. Respondents reported that this current state of medical-grade oxygen supply is sufficient for routine demands across the country, but in the event of an emergency and surge demand

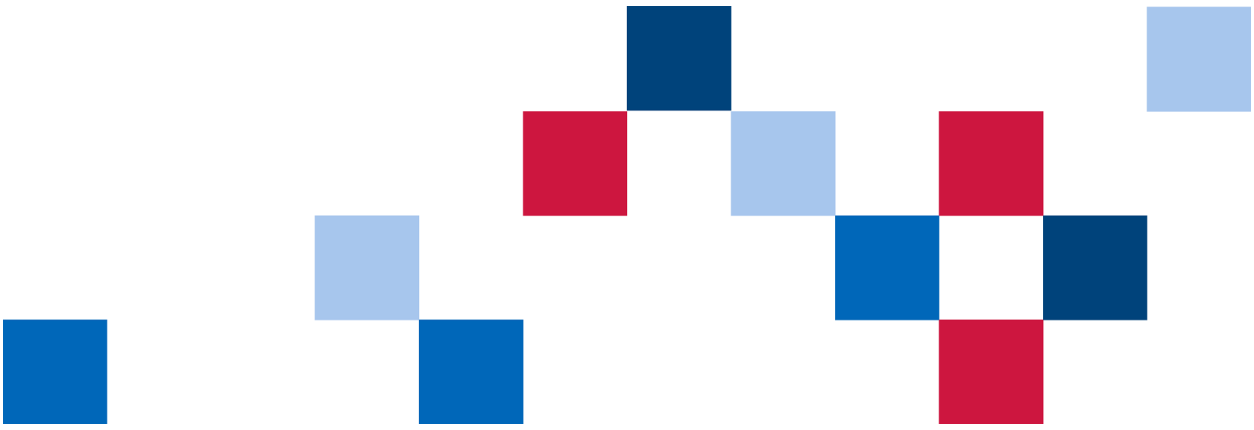
similar to COVID-19, the Kyrgyz Republic would be extremely susceptible due to already maximized local production capacities, reliance on importation for routine demands, and the inability to ramp up local production in times of critical urgency . A health emergency is not an opportune time to source additional supply, to seek scaled-up production, or to seek out new regional or international sources. By having only one liquid oxygen supplier in country, and no means of domestic production, the national oxygen ecosystem likely would not be able to scale provision in the event of acute increase in demand.

> Recommendation**:** Health stakeholders should support the scale-up of local production of liquid oxygen in country through the diversification of the supply market – with new suppliers or by creating additional production capabilities from existing suppliers. The MOH should identify non-medical suppliers of liquid oxygen to engage in the event of a surge and engage these suppliers through surge contracts during the steady-state period.

Readiness and Scalability

As a strong step toward readiness and preparedness for the next health emergency, the MOH should consider connecting all hospitals in the Kyrgyz Republic that currently use gaseous oxygen as their main medical oxygen supply to a liquid oxygen supply system.

Much of the required infrastructure already in place for gaseous oxygen can be used to install liquid oxygen supply. In many locations, the only additional funding needed for the change to liquid oxygen would pertain to 1) seeking necessary approvals from Kyrgyzstandard for installation of VIE -storage tanks, 2) procure appropriate VIE storage tank per hospital needs and regulatory allowances; 3) infrastructure to house the VIE storage tank; and 4) installation of the tank and connection to the hospital's centralized oxygen system. If the funding is made available to health facilities that lack these storage tanks, the Kyrgyz Republic can transform a significantly larger portion of its oxygen ecosystem to liquid oxygen supply to reduce overall healthcare costs and scale the availability of oxygen supply. However, the nuances of higher transportation costs for more rural areas of the country should be considered, and the feasibility of liquid oxygen supply should be evaluated in each context.



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Annex A: Liquid Oxygen–Supported Facilities in the Kyrgyz Republic

	Bishkek
1	National Hospital under the MOH of the Kyrgyz Republic (JOB building, building of the neurosurgical and eye buildings, building of the Akhunbaev clinic, and urological building)
2	City Clinical Hospital No. 1
3	Construction of an experimental prefabricated infectious diseases hospital
4	City Children's Clinical Emergency Hospital
5	City Clinical Hospital No. 6
6	Clinic of Motherhood and Childhood (micro district Jal)
7	City perinatal center
8	Clinical maternity hospital No. 6
	Chui region
9	Capital repairs of the hospital in Tokmok on the Orozbekova street
10	Sokuluk CGP [4]
11	Base Gansi (located on conservation in case of emergency)
	Osh region
12	Construction of an experimental prefabricated infectious diseases hospital in Osh
13	Territorial hospital of Kara – Kulzhinsky district
14	Overhaul of vocational school No. 64 in Kara-Suu district for 250 beds
15	Territorial hospital of Alai region
16	Territorial hospital of Uzgen region
17	Nookat CGP (maternity hospital, children's and infectious diseases department)
	Batken region
18	Batken Oblast Merged Hospital
19	Territorial hospital of Leilek region in Isfana
20	CGP, Kyzyl-Kiya
	Jalal-Abad region
21	Jalal-Abad Regional Clinical Hospital (children's department and maternity hospital)
22	Infectious Diseases Department of the Territorial Hospital named after Zholdoshev, Suzak village, Suzak region
23	Overhaul of the surgical center in Jalal-Abad
24	Major overhaul of the Medical Service Center in Kok-Jangak (CGP)

[4] *Center for all-medical practice in the Kyrgyz Republic.*

	Bishkek
25	Infectious disease department of the territorial hospital in the Kanysh-Kiya village, Chatkal region
26	Infectious Diseases Department of the Territorial Hospital of Toktogul, Toktogul District
	Naryn region
27	Construction of an experimental prefabricated infectious diseases hospital in Naryn
28	Naryn Oblast Merged Hospital
29	Territorial hospital of At-Bashi district
30	Territorial hospital of Jumgal region
31	Territorial hospital of Ak-Tala region
	Talas region
32	Overhaul of the Family Medicine Center of the Talas region in the Kok-Oy village
	Issyk-Kul region
33	The head of department of Issyk Kul Oblast Merged Hospital
34	Jeti-Oguz tuberculosis hospital in the Kyzyl- Suu village
35	Infectious Diseases Hospital in Cholpon-Ata

Annex B: Interview Questionnaire

Adapted from the "Oxygen and COVID-19 Response Rapid Assessment Tool: Hospital Facilities" to assess the use of liquid oxygen in medical institutions of the Kyrgyz Republic

Name of organization / Medical institution:
Legal address:
Supervisor:
Other persons responsible for the use of medical oxygen (Engineer, Supply Manager, Head Nurse, etc.):
Contact number:
Email:

1. Does your organization use both gaseous and liquid oxygen?
    - Gaseous - volumes (per month, per year)
    - Liquid - volumes (per month, per year)

2. Cost
    - Liquid oxygen – (standard volume 1 m3)
    - Gaseous oxygen - (standard volume 1 cylinder 8l.)

3. When was the liquid oxygen system introduced? Month, year

4. How do you evaluate the quality of medical liquid oxygen (who or what organization provides quality control?)
    A. Good
    B. Bad (if yes, why?)
    C. Difficult to answer

5. What type of oxygen is convenient to transport and use?
    A. Liquid oxygen
    B. Gaseous

6. Availability of service personnel (engineers) of oxygen equipment (persons)
    A. Trained
    B. Those without education

7. Does your technician or the person replacing him have all the skills to maintain and provide the hospital with liquid oxygen?

   A. Yes

   B. No

   C. Not in full

8. Are you satisfied with the quality of technical service from the supplier of liquid oxygen?

   A. Yes

   B. No (if not, why not?)

   C. Not in full (what exactly does not satisfy in service?)

9. Are there interruptions in the supply of liquid oxygen?

   If yes, for how long?

10. In the event of breakdowns or malfunctions in the liquid oxygen supply system, how quickly does the supplier's service department respond?

    A. Within 1 day

    B. 3-4 days

    C. More than 4 days

11. Which departments and how many hospital beds are connected to the oxygen supply system?

12. What is the volume of the tank for liquid oxygen?

13. For what time period is this volume sufficient?

14. How long does it take for liquid oxygen to be delivered to you after submitting your application?

    A. 24 hours

    B. 3-4 days

    C. More than 7 days

15. What is more profitable for you to buy? Which oxygen is cheaper for you?

    A. Liquid oxygen (why?)

B. Cylinders gaseous (why?)

16. How much liquid oxygen do you need per month?

17. How many oxygen pumps and gasifiers does your facility have?

18. How does your health care facility purchase oxygen?
    A. At the expense of the Ministry of Health of the Kyrgyz Republic
    B. At the expense of own funds of the medical institution
    C. Other, (state, commercial organizations, etc.)

19. What suggestions do you have for improving the organization of medical oxygen supply to medical institutions?

Annex C: Number of Hospital and ICU Beds in the Kyrgyz Republic

Region	Number of ICU beds as of December 31, 2021	Number of total hospital beds as of December 31, 2021
Kyrgyz Republic	**758**	**25,713**
Bishkek	**138**	**2,093**
City Clinical Hospital No. 1	36	294
City Clinical Hospital No. 6	10	191
Emergency Clinical Hospital	24	445
City Children's Clinical Emergency Hospital	21	470
Maternity Hospital No. 1	6	85
Clinical Maternity Hospital No. 2	6	160
City Gynecological Hospital	5	50
City Perinatal Center	30	230
Republican Organizations	**225**	**6,016**
National Center for Maternal and Child Health	44	684
National Center for Pathobiology	6	350
National Center for Cardiology and Therapy	48	373
National Center for Oncology and Hematology	22	421
Kyrgyz Scientific Center for Human Reproduction	7	70
National Hospital	32	1,070
National Surgical Center	15	255
Railway Hospital	6	100
Republican Infectious Diseases Clinical Hospital	30	500
Research Institute of Cardiac Surgery and Organ Transplantation	9	68
Republican TB Clinic - Karabalta	6	100
Batken Oblast	**40**	**1,900**
Batken district	**6**	**445**
Batken Oblast Merged Hospital	6	360
Kyzyl-Kiya district	**6**	**580**
Kyzyl-Kiya CGP	6	510
Sulukta district	**3**	**70**
Sulukta CGP	3	70

Region	Number of ICU beds as of December 31, 2021	Number of total hospital beds as of December 31, 2021
Kadamzhai district	**20**	**427**
Kadamzhai CGP	11	229
Uch-Korgon CGP	6	108
Aidarken village CGP	3	90
Leilek district	**5**	**378**
Leilek TB	5	258
Jalal-Abad Oblast	**70**	**3,947**
Jalal-Abad oblast health care facilities	**12**	**1,234**
Jalal-Abad Oblast Merged Hospital	6	575
Southern Regional Scientific Center for Cardiovascular Surgery	6	94
Mailuu-Suu CGP	**5**	**130**
Tash-Kumyr district	**5**	**162**
Tash-Kumyr CGP	5	100
Ala-Buka district	**6**	**198**
Ala-Bukinskaya CGP	6	198
Bazar-Korgon district	**16**	**298**
Bazar-Korgon CGP	16	268
Nooken district	**8**	**506**
Nooken CGP	5	191
Kochkor-Ata CGP	3	210
Suzak district	**9**	**487**
Suzak CGP	9	346
Toguz-Toro district	**3**	**70**
Kazarman CGP	3	70
Toktogul district	**6**	**237**
Toktogul CGP	6	186
Issyk-Kul Oblast	**46**	**1,402**
Karakol city	**14**	**607**
Issyk Kul Oblast Merged Hospital	14	547
Balykchy district	**6**	**170**
Balykchy CGP	6	170
Ak-Suu district	**6**	**155**
Ak-Suu CGP	6	155

Region	Number of ICU beds as of December 31, 2021	Number of total hospital beds as of December 31, 2021
Jeti-Oguz district	**4**	**100**
Zhety-Oguz CGP	4	100
Issyk-Kul district	**9**	**160**
Issyk-Kul CGP	6	135
Ananyevo CGP	3	25
Ton district	**4**	**85**
Tonskaya CGP	4	85
Tyup district	**3**	**125**
Tyup CGP	3	125
Naryn Oblast	**25**	**980**
Naryn city	**7**	**558**
Naryn Oblast Merged Hospital	7	528
Ak-Tala district	**3**	**76**
Ak-Tala CGP	3	76
At-Bashy district	**6**	**120**
At-Bashy CGP	6	120
Jumgal district	**3**	**100**
Zhumgal CGP	3	100
Kochkor district	**6**	**126**
Kochkor CGP	6	126
Osh Oblast	**99**	**5,403**
Osh oblast health care facilities	**33**	**2,262**
Osh Interregional Merged Clinical Hospital	21	952
Osh Interregional Children's Clinical Hospital	12	540
Alai district	**6**	**263**
Alai CGP	6	263
Aravan district	**12**	**335**
Aravan CGP	12	335
Kara-Kulzhinsky district	**12**	**323**
Karakulzhinskaya CGP	12	252
Kara-Suu district	**12**	**825**
Kara-Suu CGP	12	500
Nookat district	**12**	**645**
Nookat CGP	12	605

Region	Number of ICU beds as of December 31, 2021	Number of total hospital beds as of December 31, 2021
Uzgen district	**12**	**570**
Uzgen CGP	12	380
Osh City	**37**	**961**
Osh City Clinical Hospital	37	891
Talas Oblast	**21**	**693**
Talas city	**9**	409
Talas Oblast Merged Hospital	9	314
Bakai-Ata district	**3**	**83**
Bakai-Ata CGP	3	83
Kara-Buura district	**3**	**96**
Kara-Buura CGP	3	96
Manas district	3	45
Manas CGP	3	45
Talas district	**3**	**60**
Talas CGP	3	60
Chui Oblast	**57**	**2,318**
Tokmok CGP	**7**	**421**
Alamudin district	**12**	**640**
Chui Oblast Merged Hospital	12	350
Zhaiyl district	**9**	**345**
Zhaiyl CGP	9	330
Keminsky district	**6**	**121**
Keminskaya CGP	6	121
Moskovsky district	**6**	**171**
Moscow CGP	6	171
Panfilovsky district	**4**	**85**
Panfilovka CGP	4	85
Sokuluk district	**4**	**195**
Sokuluk CGP	4	195
Chui district	**3**	**140**
Chui CGP	3	140
Issyk-Ata district	**6**	**200**
Issyk-Ata CGP	6	200