Assessment Report on the Availability of Oxygen and Biomedical Equipment in Health Facilities

City Province of Kinshasa, DRC, Facility Survey Report

April 2021

PATH

This report is based on research funded by the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

The work described in this report was carried out as part of PATH's COVID-19 Respiratory Care Response Coordination project, which is a partnership between PATH, the Clinton Health Access Initiative, and Every Breath Counts Coalition to support country decision-makers in the development and execution of a comprehensive respiratory care plan to meet the demands of COVID-19. The project is also pursuing strategies to help prioritize and improve access to oxygen therapy and other essential equipment involved in respiratory care as an integral part of health systems strengthening, beyond the pandemic response.

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Suggested citation: PATH. *Assessment Report on the Availability of Oxygen and Biomedical Equipment in Health Facilities: City Province of Kinshasa, DRC, Facility Survey Report*. Seattle: PATH; 2021.

April 2021

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Abbreviations

BMES	Biomedical Equipment Survey
CM	*centre médical* [medical center]
CME	Centre Mère et Enfant [de Bumbu]
COVID-19	coronavirus disease 2019
CS	*centre de santé* [health center]
DRC	Democratic Republic of the Congo
DGOGSS	Direction Générale de l'Organisation et de Gestion des Services et des Soins de Santé [General Directorate for the Organization and Management of Health Care Services]
ECG	electrocardiogram
HGR	*hôpital général de référence* [general reference hospital]
ICU	intensive care unit
LPM	liters per minute
MOH	Ministry of Health
NGO	nongovernmental organization
PSA	pressure swing adsorption
TVC	Tatete Vein Center
WHO	World Health Organization

Executive summary

In response to the COVID-19 pandemic, PATH, in collaboration with the Democratic Republic of the Congo (DRC) Ministry of Health, conducted a Biomedical Equipment Survey (BMES) in health facilities in the DRC from October 2020 to April 2021. This initiative was carried out as part of the COVID-19 Respiratory Care Response Coordination project, a partnership between PATH, the Clinton Health Access Initiative, and Every Breath Counts Coalition to support country decision-makers in the development and execution of a comprehensive respiratory care plan to meet the demands of COVID-19 cases. The project is also pursuing strategies to help prioritize and improve access to oxygen therapy and other essential equipment involved in respiratory care as an integral part of health systems strengthening, beyond the pandemic response.

This report analyzes data from 93 health facilities in the city/province of Kinshasa, collected during the first round of facility assessments.[a] The purpose of this work is to quantify existing oxygen delivery and production equipment, consumables for administering oxygen therapy, and bed capacity, as well as ascertain facility infrastructure characteristics. The BMES included a mix of public and private health facilities of multiple levels, including primary (health posts and *centres de santé* [health centers]), secondary (*hôpitaux général de référence* [general reference hospitals]), tertiary (general or university hospitals), and treatment centers dedicated to COVID-19 / infectious disease treatment.

Intensive care treatment capacity is critical to providing respiratory care to patients with COVID-19 and other respiratory illnesses across disease areas. **Data from facility assessments show that proliferation of critical care services, oxygen, and respiratory care equipment is very limited in health care facilities in Kinshasa. Only 55% of secondary health care facilities are equipped with intensive care unit (ICU) beds, and more than one-third of ICU wards lack electricity. Additionally, 40% of facilities lacked any pulse oximeters, and in the vast majority of facilities where they were present, the quantity was proportionally low for the number of beds.** Only 8 out of 47 facilities with ICU beds had as many patient monitors as ICU beds.

Oxygen supply systems were also limited. Only 2 facilities reported possessing on-site pressure swing adsorption plants for continuous reliable oxygen delivery to patients. **Fully 40% of facilities indicated they did not offer any oxygen therapy, and the majority of the remaining facilities that did offer it reported a limited supply of concentrators and cylinders. Only 136 concentrators were reported across the sample of 93 facilities, with most of these devices located at a small number of larger facilities**. Cylinder use was also not widely reported, with few facilities keeping large stocks of cylinders to provide reliable supply. The reported weekly cylinder capacity across all surveyed facilities was 277,960 L—equivalent to just 41 type “J” (6,800L) cylinders.

An immediate next step is to compare the equipment totals with estimated equipment needs for baseline and COVID-19 scenarios to determine the equipment gap and identify required procurement needs. This can then be used to advocate to donors, partners, and other decision-makers to inform policy responses and funding decisions that increase the availability of respiratory care equipment. In the medium term, the data will be entered into District Health Information Software 2 to be used by decision-makers. Furthermore, BMES data will inform equitable allocation and redistribution of equipment to ensure that it is placed in facilities where it can be maximally utilized. It is important to note that, since data collection was completed in October 2020, additional equipment has been procured, and this will be taken into account when developing policy and procurement recommendations.

[a].Data collection in Kinshasa took place in October 2020.

Background

Data and demographics

The Democratic Republic of the Congo (DRC) is the second-largest country in Africa, spanning 2.3 million square kilometers.[1,2] Located in the heart of Africa and straddling the equator, the DRC comprises 26 provinces across two time zones (Figure 1). The population totaled nearly 90 million in 2020, and the annual growth rate was 3.2%.[2] As of 2019, 45% of people lived in an urban setting, and 55% lived in rural areas.[3,4] The DRC has had a tumultuous contemporary history, with two major armed conflicts between 1996 and 2002 and continued latent unrest in the east (primarily Nord-Kivu, Sud-Kivu, and Ituri Provinces) and in Haut-Katanga Province.

Figure 1. Map of the Democratic Republic of the Congo.

Sources: Creative Commons/Moyogo; Office fédéral des migrations – Confédération suisse.

Social, economic, and health indicators are as follows:

- In 2019, the DRC was ranked 175th out of 189 countries and territories in the Human Development Index and in the bottom one-third with regard to quality of health.[5] The country has fallen increasingly behind other sub-Saharan African nations, especially since the 1990s.[5]
- Gross national income per capita in 2019 was estimated to be US$530.00.[6]
- In 2018, 76.6% of the Congolese people lived on less than $1.90 a day (the international poverty line as adopted by the United Nations Development Programme).[5]
- Infant mortality rate, as reported in 2019, is 66 per 1,000 live births.[7]
- Life expectancy in 2018 was estimated at 60 years, just below the 61.2-year average for sub-Saharan Africa.[8]

Organization of the health system

The country's health system is organized as a three-level pyramid, with health zones as the operational base.[12] Headed by a chief medical officer, each health zone covers a population of approximately 100,000 to 150,000.[12] Each of the 516 health zones in the DRC are stipulated to be equipped with a general reference hospital (*hôpital général de référence*, or HGR), though currently only about 76% possess one.[12] Health zones are further subdivided into health areas which cover 5,000 to 10,000 inhabitants and are stipulated to have a primary health center (*centre de santé*, or CS).[12] Most recent data suggest that of the 8,504 health areas in the DRC, 8,266 possess a CS.[12]

The private (for-profit and nonprofit) sector operates roughly 40% of the country's health care facilities, including a significant proportion of CSs in Kinshasa.[12,13]

Challenges within the health sector include equipment shortages and infrastructure that does not meet national standards. Nearly nine in ten (88%) of CSs have structural/infrastructure issues; only

1,006 (12%) of the 8,266 CSs are constructed of durable materials—and even then, some are in an advanced state of disrepair.

Public facilities are “largely in a state of disrepair.” Many have little capacity in key areas: fewer than 1 in 100 HGRs has a full laboratory; two out of three have no running water; and fewer than one in two possesses an X-ray machine.[12]

Barriers to amelioration of health care facilities include inadequate application of standards, lack of maintenance and maintenance surveillance units, and noninclusion of maintenance costs in health care investment projects by government and donors.

City/province of Kinshasa

The city/province of Kinshasa (Figure 2) is the capital of the DRC and simultaneously its most populous city and province, with an estimated population of 14.3 million in 2020. It is the third-most populous city in Africa after Cairo and Lagos and the largest Francophone urban area in the world.[9]

Figure 2. Map of Kinshasa.

Source: Office fédéral des migrations – Confédération suisse.

Economically, Kinshasa has the lowest incidence of poverty among provinces in the DRC at 25.9% of households and 36.8% of individuals in contrast to the national incidence of 54.2% and 63.4%, respectively.[10] The most recent available estimate for gross domestic product per capita for Kinshasa is $632.70 (2010).[7]

Kinshasa is subdivided into 35 health zones. Health care human resources in the city/province remain quite constrained. Per 2013 data, there were 2.2 physicians and 6.8 nurses per 10,000 inhabitants.[11] This contrasts with an Organisation for Economic Co-operation and Development average of 35 physicians and 88 nurses required per 10,000 inhabitants.[12]

Survey scope and sampling

Overview

A cross-sectional study was conducted in tertiary-level hospitals, provincial hospitals, HGRs, and CSs in Kinshasa as part of a nationwide Biomedical Equipment Survey (BMES) of health facilities in the DRC that ran from October 2020 to April 2021.

The DRC Ministry of Health (MOH) provided PATH with a list of 12,050 health facilities, not including health posts. A total of 1,343 health facilities were selected from the list using probabilistic random sampling. Approximately 100 facilities were selected in Kinshasa and 50 on average for each of the other 25 provinces. Distribution of the exact number of health facilities by province was weighted by the total number of facilities in each province.

For Kinshasa, 93 facilities contributed data to the BMES. According to the Système National d'Information Sanitaire (National Health Information System), 1,018 health facilities have been identified in Kinshasa. This facility assessment covered 9% of the total number (93). Figure 3, Figure 4, and Figure 5 characterize the health facilities in the dataset by facility type, geographic distribution, and management category.

Figure 3. Facilities surveyed, aggregated by facility type.

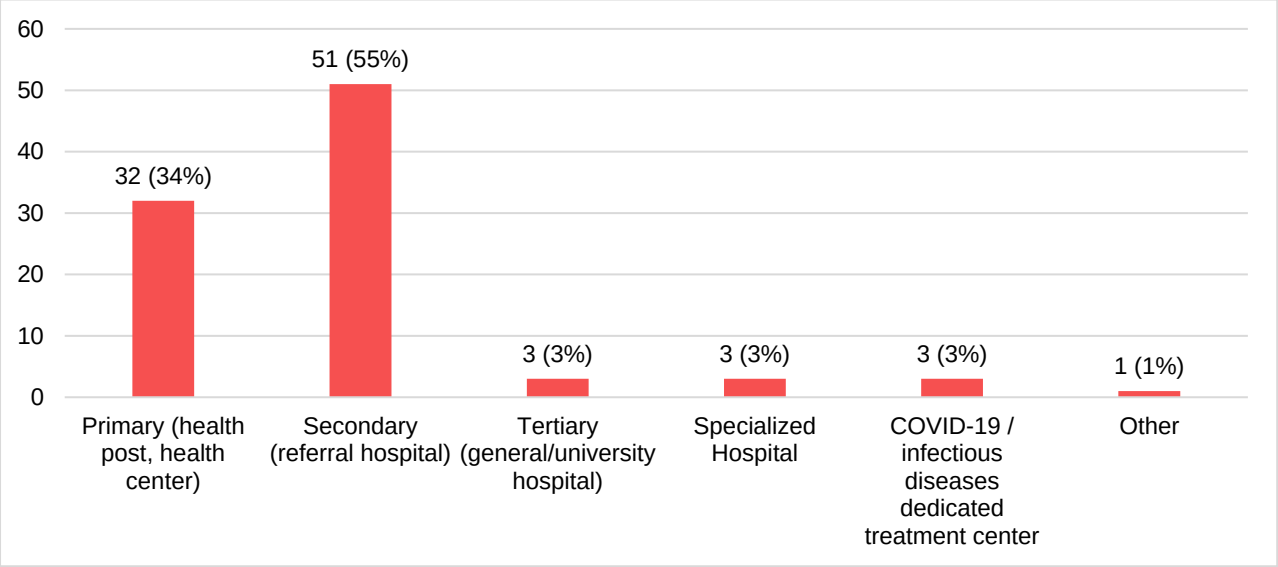


Figure 4. Geographic distribution of facilities.

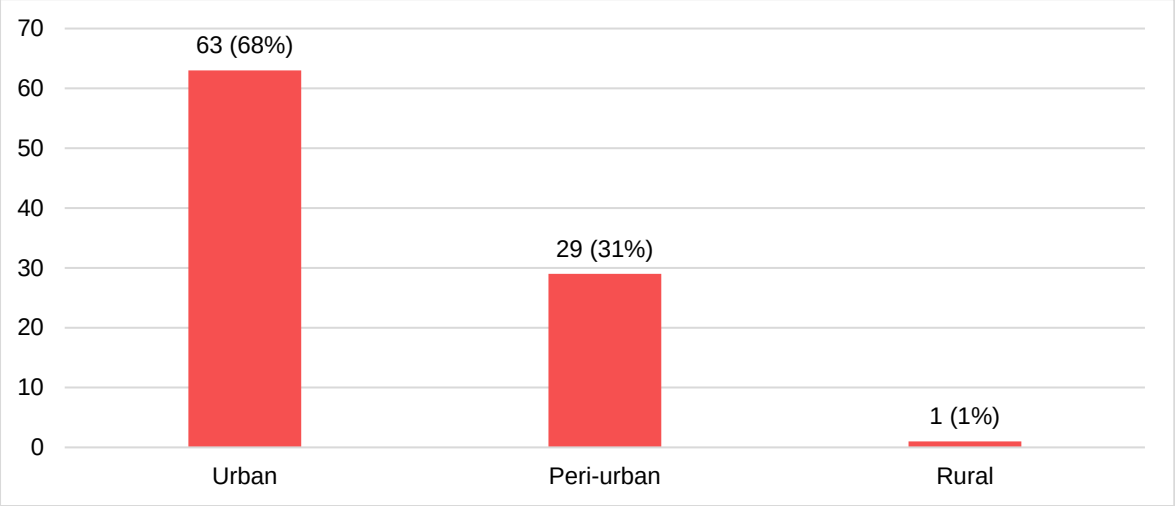
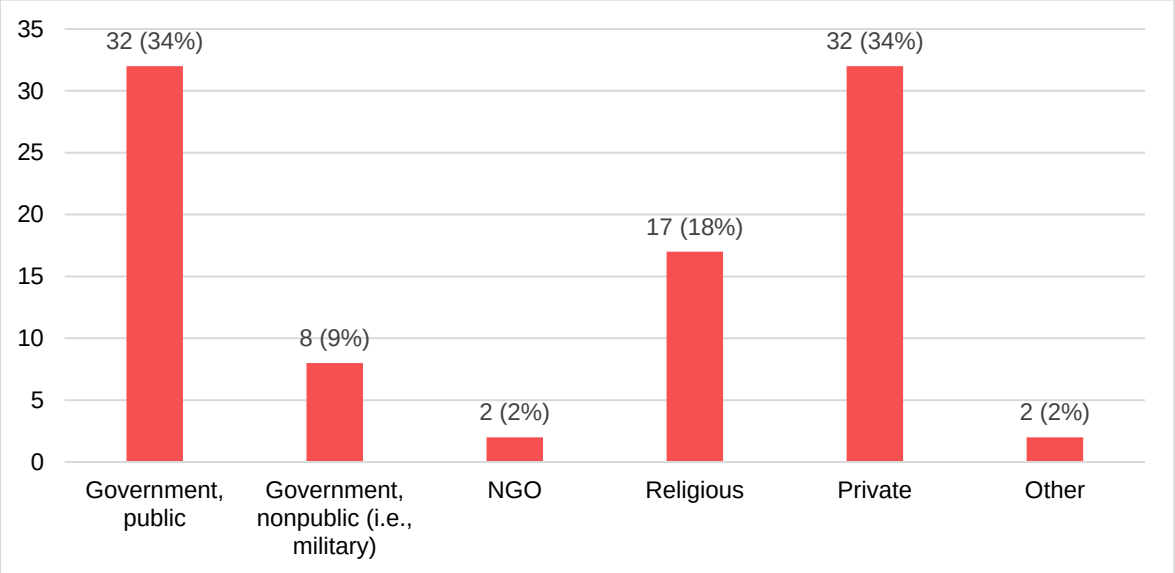


Figure 5. Facilities surveyed, aggregated by management category.



Abbreviation: NGO, nongovernmental organization.

A summary of the figures is as follows:

- Figure 3 shows that, out of all facilities surveyed, secondary-level hospitals were the most prevalent in the dataset, followed closely by primary health care facilities. All other facility types (excluding “other”) were equally represented but comprised a small percentage of the overall total.
- Kinshasa is overwhelmingly urban and peri-urban, with the urban zone covering 600 sq. km (out of 9,965) and 43% of the population.[11] Figure 4 shows that, of the total facilities surveyed, 63 were designated as urban, 29 as peri-urban, and only 1 as rural.
- Figure 5 shows that public government facilities and private facilities make up the majority of facilities surveyed, at 34% of the sample (32 facilities) each.

Data collection methods

The World Health Organization (WHO) biomedical equipment for COVID-19 case management inventory tool[b] was adapted by PATH for use in the DRC with support from the DRC MOH's General Directorate for the Organization and Management of Health Care Services (Direction Générale de l'Organisation et de Gestion des Services et des Soins de Santé, or DGOGSS) and the DRC's National Program for the Fight Against Acute Respiratory Infections. The questions included in the BMES were informed in part by the WHO list of priority medical devices for COVID-19 case management.[13] The BMES also included additional sections on COVID-19 and malaria, developed by PATH at the request of the Ministry of Health.

PATH completed data collection in partnership with the DRC MoH/DGOGSS. The study collected data through interviews with an administrative officer from the critical care department, an administrative officer from the COVID-19 care unit (if present), a member of the biomedical engineering department, and a member of the malaria management team at each health facility. In small facilities, only one person (often a nurse) answered all questions, as they oversaw all aspects of the facility's operation.

Study teams

Data collection for the Kinshasa phase of the study was completed over a span of 15 days. 22 physicians, 2 biomedical engineers, and 1 managing director were recruited and trained for four days as data collectors. The training consisted of two phases: one theoretical and one practical (in a health facility). The aim of the theoretical was to familiarize the investigators with data collection techniques and tools. This practical phase identified possible technical and logistical problems, which were then discussed and corrected. Analysis and report writing were completed by the PATH team under the supervision of DGOGSS director, Dr. Body Ilonga Bompoko, MD, MPH.

Limits of the study

Data collection for the Kinshasa phase of the study was completed in October 2020. Since then, additional medical equipment has been purchased to strengthen the DRC's health system and COVID-19 response.

For a more comprehensive understanding of health care access and health system development in the DRC, the 2016–2020 National Health Care Development Plan can be consulted, in addition to this report.

[b] The tool can be accessed at: https://www.who.int/publications/i/item/WHO-2019-nCov-biomedical-equipment-inventory-2020.1.

Results

This section describes the scope of the facility assessments, key characteristics observed (e.g., intensive care unit [ICU] bed counts), and a discussion of other factors that could constrain respiratory care treatment capacity. Observations on the current availability of oxygen delivery equipment, oxygen production equipment, and consumables within health facilities are highlighted throughout the report. Other devices described include ventilators, pulse oximeters, oxygen concentrators, pressure swing adsorption (PSA) plants, and various types of oxygen masks and airways.[c]

Facility characteristics

Services and staffing

Services available at the facilities surveyed are detailed in Table 1.

Table 1. Percentage of surveyed facilities providing different services, by facility type.

Service type	All facilities (n = 93)	Primary (n = 32)	Secondary (n = 51)	Tertiary (n = 3)	Specialized hospital (n = 3)	COVID-19 treatment center (n = 3)	Other (n = 1)
Emergency	72%	50%	84%	100%	67%	100%	0%
Intensive care	40%	22%	45%	100%	33%	100%	0%
Resuscitation*	31%	9%	37%	100%	67%	67%	0%
Internal medicine	89%	81%	98%	100%	33%	100%	0%
Pediatrics	89%	78%	96%	100%	67%	100%	100%
Surgery	90%	81%	98%	100%	33%	100%	100%
Gynecology	94%	97%	92%	100%	67%	100%	100%
Medical imaging	78%	56%	90%	100%	67%	100%	100%
Medical biology	87%	75%	94%	100%	100%	100%	0%
Other	22%	19%	24%	33%	33%	0%	0%

* Resuscitation and intensive care in health facilities in the DRC are distinct ward types.

As can be seen from the table, fewer than 50% of facilities at the secondary level and very few facilities at the primary level provide critical care services (intensive care and resuscitation). This could imply that a shortage of critical care exists in Kinshasa, with patients having to turn to tertiary facilities.

[c] The survey data used to inform these observations can be accessed upon request to PATH at oxygen@path.org.

Percentage of surveyed facilities with available personnel, by type, is as follows:

- Specialist physician: 75%.
- Generalist physician: 98%.
- Nurse: 99%.
- Caregiver: 44%.
- Other: 10%.
- Staff with experience in basic resuscitation: 60%.
- Staff with experience in medical equipment installation and maintenance*: 35%.

* Only facilities which reported offering oxygen therapy were asked this question.

Treatment beds

Treatment capacity can be greatly constrained by the number of available beds (both general and ICU). ICU beds are especially important for the treatment of severe and critical COVID-19 cases as they are needed to provide consistent oxygen therapy at higher flow rates.[d] ICU bed requirements are not standardized around the world, and health care worker perceptions about what constitutes an intensive care bed can vary. In this survey, an ICU bed was defined as a bed capable of providing mechanical ventilation and/or sustained oxygen for severe acute respiratory illness.[e] It is critical to note that even if a bed may be capable of providing mechanical ventilation and/or sustained oxygen, a facility may not have sufficient ventilators and/or oxygen supply to provide those services to patients.

The total number of beds across all 93 facilities surveyed in Kinshasa was 9,228. Table 2 below shows summary statistics for the beds by facility type.

Table 2. Average number of beds in surveyed facilities, by facility type.

	Primary (n = 32)	Secondary (n = 51)	Tertiary (n = 3)	Specialized hospital (n = 3)	COVID-19 treatment center (n = 3)	Other (n = 1)
Average # of total beds	35	109	680	50	112	30
Standard deviation	28	144	552	53	85	N/A

There is significant variation in facility bed count within each of the different facility types, as evidenced by the relatively large standard deviations. For instance, the largest secondary facility, HGR Provinciale de Kinshasa, reported 1,000 beds, whereas the smallest, Centre Médical (CM) la Colombe, only reported 15 beds.

Of the 9,228 total surveyed beds, 528 were identified by facilities as ICU beds. Table 3 below shows the summary statistics for ICU beds by facility type. Just over 50% of facilities reported possessing ICU beds. Tertiary facilities, on average, held the most ICU beds, followed by COVID-19 treatment

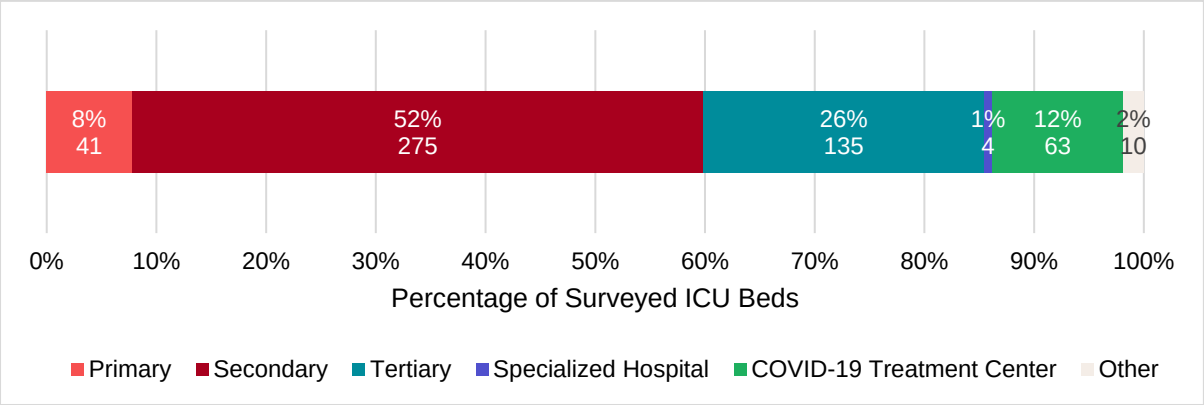
[d] WHO defines oxygen requirements as 10 liters per minute for severe patients and 30 liters per minute for critical patients.
[e] An additional survey question asking respondents to define ICU bed requirements will be implemented as part of data collection in the remaining 25 provinces.

centers. Although individual tertiary facilities contain the largest counts of ICU beds, as can be seen in Figure 6 6 below, the plurality of ICU beds are scattered among secondary facilities.

Table 3. Number of intensive care unit (ICU) beds, by facility type.

	All Facilities (n = 93)	Primary (n = 32)	Secondary (n = 51)	Tertiary (n = 3)	Specialized hospital (n = 3)	COVID-19 treatment center (n = 3)	Other (n = 1)
# (and %) of facilities reporting ICU beds	47 (51%)	10 (31%)	28 (55%)	3 (100%)	2 (67%)	3 (100%)	1 (100%)
Average # of ICU beds in facilities reporting them	6	1	5	45	1	21	10

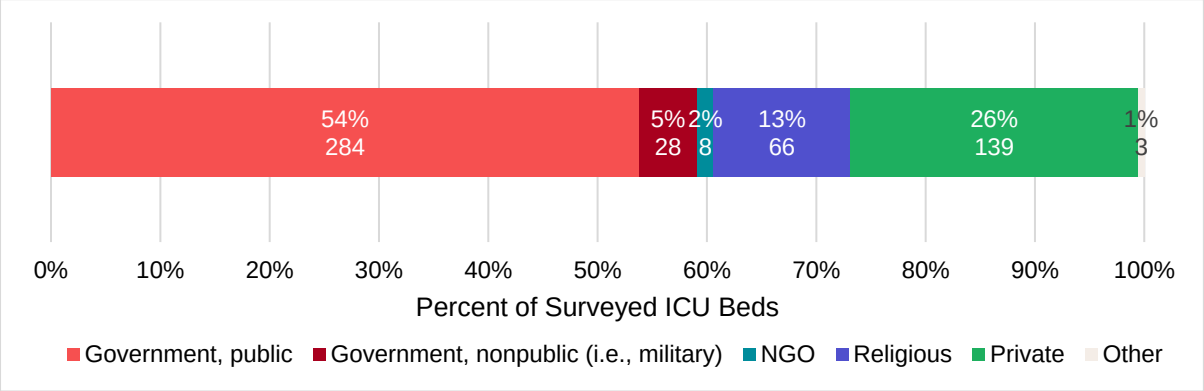
Figure 6. Total ICU bed counts, by facility type.



Of surveyed ICU beds in Kinshasa, 54% are in public government facilities (see Figure 7). It is critical to note that, of the 284 ICU beds in public government facilities, 125 (44%) are located in 2 tertiary facilities (Cliniques Universitaires de Kinshasa and Hôpital du Cinquantenaire), with the remaining 159 split between 16 lower-level facilities. This underscores that there are limited public options for intensive care in the city/province of over 14 million.[f]

[f] Bed counts by facility are available in Appendix A.

Figure 7. Total ICU bed counts by facility management.



Abbreviation: ICU, intensive care unit; NGO, nongovernmental organization.

Infrastructure

While bed counts are extremely important for evaluating health facility treatment capacity, several additional characteristics can impact effective provision of care. For instance, ICU beds that rely on piped medical oxygen can be constrained by the number of wall units installed in the ward. Other limitations that influence treatment capacity include type of electricity source, ability to provide power to multiple wards, and the variety and number of clinical staff. Where these constraints are an issue, it is especially important to have reliable alternative oxygen sources and medical devices readily available, such as bedside cylinders, ventilators, and oxygen concentrators.

Key findings related to facility infrastructure characteristics are as follows:

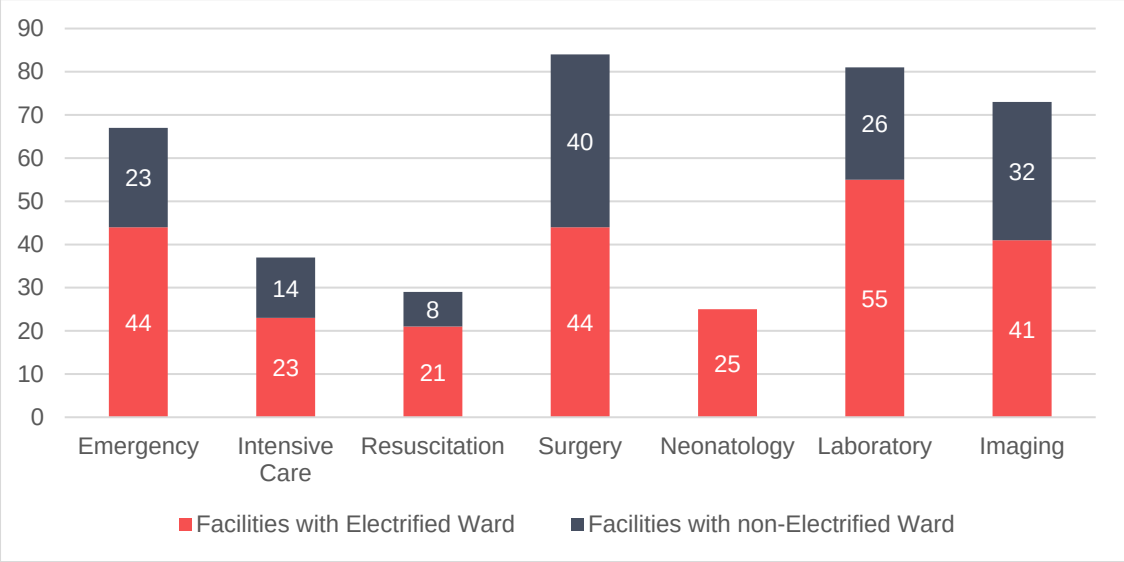
- A total of 88 of the 93 facilities assessed (95%) report having access to running water.
- 91 of the 93 surveyed facilities (97.8%) report central grid access, either on its own or with additional power sources, such as solar panels and/or generators.
- 7 of the 93 facilities (7.5%) report having a VSAT (very-small-aperture terminal) signal, a locally relevant measure of Internet access.

The breakdown of electricity source type for surveyed facilities is as follows:

- Central electricity, generator, and solar panel: 18%.
- Central electricity grid and generator: 47%.
- Central electricity grid and solar panel: 13%.
- Central electricity only: 20%.
- Generator only: 2%.

Additionally, 81 (87%) of facilities had laboratories, albeit only 55 (59%) reported electrified laboratories. Similarly, 67 (72%) of facilities reported providing emergency services, but only 44 reported electrified emergency wards (Figure 8).

Figure 8. Wards by electrification status.



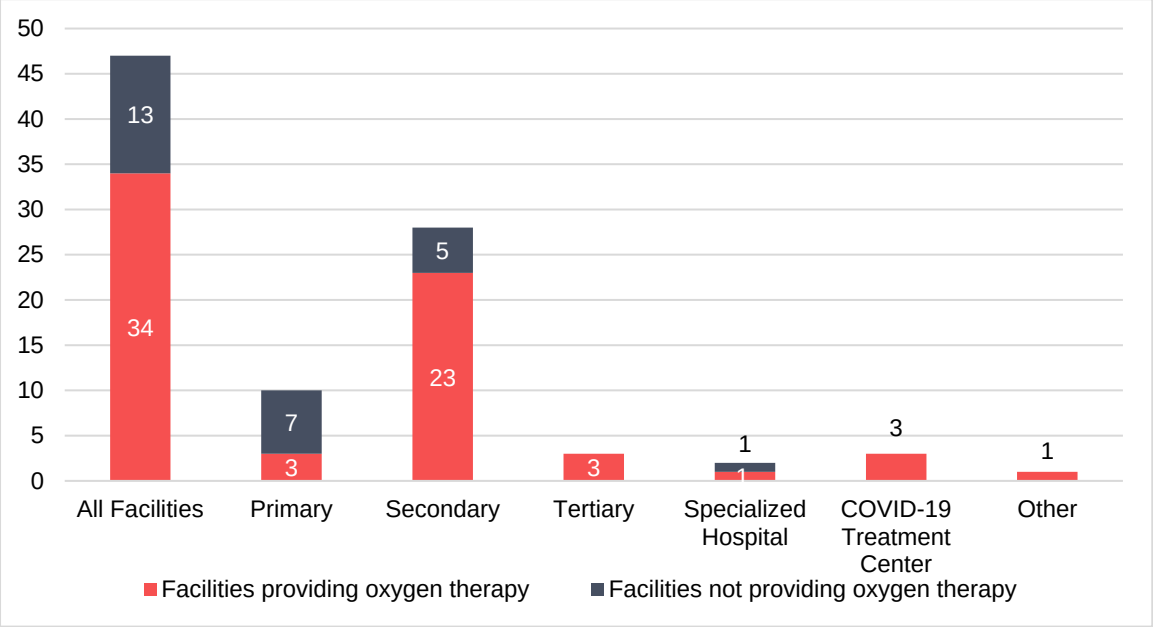
Electrification of wards is a serious concern for many facilities in Kinshasa. For example, 38% of reported intensive care wards and 28% of reported resuscitation wards lack electrification, which could be a serious impediment to appropriately operating biomedical equipment like oxygen concentrators.

Respiratory care treatment capacity

Oxygen provision

The overall provision of oxygen among surveyed facilities in Kinshasa is limited. Only 56 of the 93 facilities assessed (60%) reported use of oxygen. Figure 9 9 below shows that 13 of 47 facilities (28%) with ICU beds (7 primary facilities, 5 secondary facilities, 1 specialized hospital) reported no provision of oxygen therapy. This highlights that even if a facility may have beds set up for critical care, it may not have oxygen to treat patients.

Figure 9. Number of facilities with intensive care unit beds, by oxygen therapy provision and facility type.



Only 11 facilities reported piping infrastructure for oxygen, further underscoring the overall limited access to oxygen in health care facilities in Kinshasa.

The breakdown of surveyed facilities regarding piped oxygen is as follows:

- No provision of oxygen therapy: 40%.
- No piping: 48%.
- Oxygen only: 7%.
- Oxygen, air, and vacuum: 3%.
- Oxygen and air: 2%.

Oxygen equipment

Existing functional and nonfunctional respiratory care equipment of various device types was quantified, including ventilators, pulse oximeters, and patient monitors. Data on other respiratory care equipment—such as continuous positive airway pressure, suction devices, high-flow nasal cannula, and resuscitation devices—are available from PATH upon request.

Ventilators

Ventilators pump air with supplemental oxygen into patients' airways in cases of severe respiratory distress, during which they are unable to breathe on their own. Ventilators require intubation. These devices are often key components of ICU beds. Facilities were assessed for three types of ventilators: transport/portable, adult intensive care, and pediatric intensive care. Ventilators are in shortage in medical facilities in Kinshasa. Only 15 of 93 facilities (16%) reported possessing ventilators. Critically, 34 facilities possessing ICU beds reported zero ventilators. Figure 10 quantifies reported ventilators

by type and functionality, and Table 4 shows the distribution of ventilators across the 15 facilities in Kinshasa that possess them. All current facilities with ventilators reported offering oxygen therapy.

Figure 10. Ventilators by type and functionality.

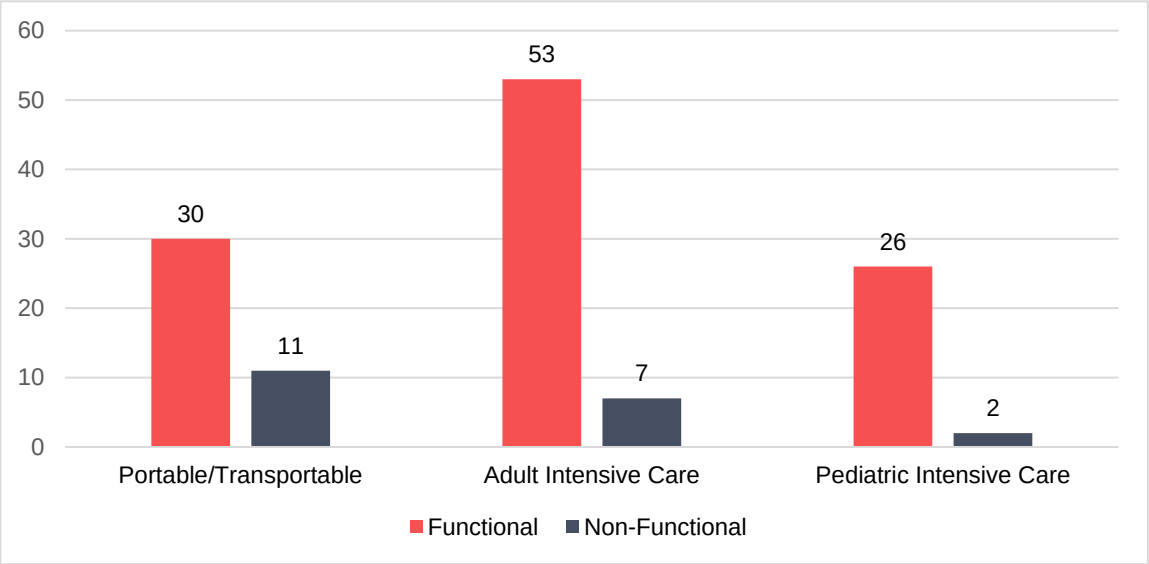


Table 4. Distribution of ventilators in Kinshasa, by facility.

Facility name	Type	Management	# ICU beds	Staff trained in basic resuscitation practices	Total # functional ventilators	Total # non-functional ventilators
HGR Provinciale de Kinshasa	Secondary	Government	13	Y	2	0
Centre Hospitalier la Borne	Secondary	Religious	0	Y	1	0
Clinique Effort	Primary	Private	2	Y	3	0
Clinique Riviera	Primary	Private	0	Y	1	1
Centre Hospitalier Nganda	Secondary	Private	5	Y	8	14
Ngaliema Medical Center	Secondary	Private	6	Y	14	0
TVC Medical	Specialized hospital	Private	2	Y	5	0
Voici l'Homme Hospitalier	Secondary	Private	12	Y	2	0
Clinique Ngaliema	Secondary	Government	5	Y	1	2
Cliniques Universitaires de Kinshasa	Tertiary	Government	25	Y	10	3
Hôpital du Cinquantenaire	Tertiary	Government	100	Y	15	0
Hôpital de l'amitie Sino-Congolaise	Secondary	Government	8	Y	2	0
CM de Kinshasa	COVID-19 treatment center	Private	13	Y	29	0
CM Diamant	COVID-19 treatment center	Private	5	Y	11	0
HJ Hospitals	COVID-19 treatment center	Private	45	Y	5	0
Kinshasa total					**109**	**20**

Abbreviations: CM, *centre médical*; HGR, *hôpital général de référence*; ICU, intensive care unit; TVC, Tatete Vein Center.

The intensive care ventilator for adults was the predominant type across surveyed facilities, followed by transport/portable ventilators. When comparing total ventilators to total ICU beds across all 93 facilities, only 109 functional ventilators were reported for 528 ICU beds—well below standard. Furthermore, there was unequal distribution across health facilities as 3 facilities (CM de Kinshasa, Hôpital du Cinquantenaire, and Ngaliema Medical Center) held 53% (58) of the functional ventilators. As well, although most of the 15 facilities reported fewer ventilators than ICU beds, 5 private facilities (Centre Hospitalier Nganda, Ngaliema Medical Center, Tatete Vein Center Medical, CM de Kinshasa, and CM Diamant) possessed more ventilators than ICU beds.

In addition, 20 nonfunctional ventilators were reported. As shown in the table above, Centre Hospitalier Nganda (which has a bed capacity of 100 general beds and 5 ICU beds) reported 14 nonfunctional ventilators (70% of the total). “No funds for maintenance” was the primary reason cited for ventilators’ being nonfunctioning. Cliniques Universitaires de Kinshasa and Clinique Ngaliema also reported “no funds for maintenance,” as well as “no spare parts” as reasons for nonfunctional ventilators.

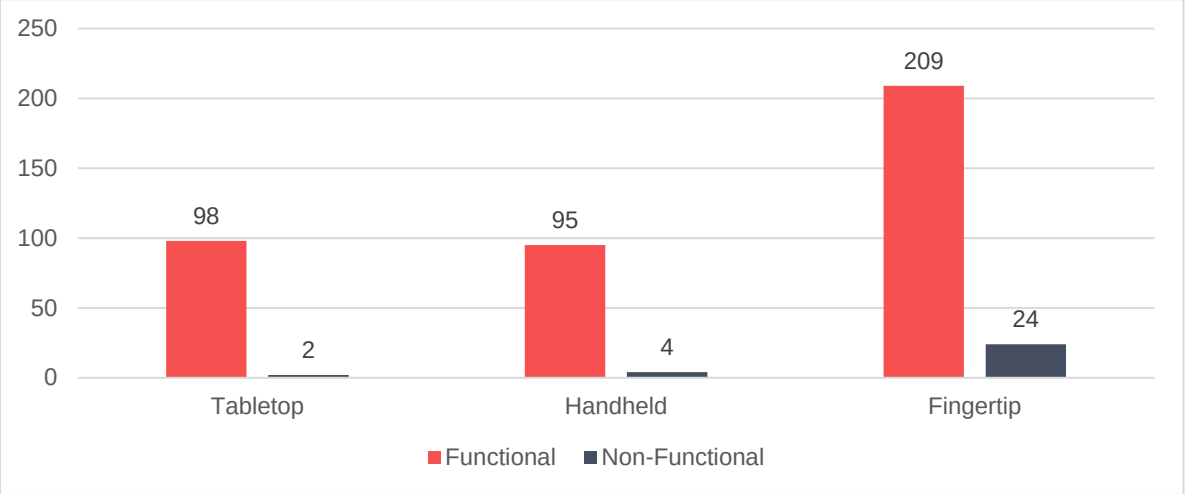
Pulse oximeters

Pulse oximeters are key to providing timely diagnosis of hypoxemia (low levels of oxygen in the blood) and are extremely important for safe administration of oxygen therapy across various applications, including but not limited to COVID-19 treatment, surgery, pediatric and adult pneumonia treatment, and neonatal care. Ideally, oxygen therapy is always administered with pulse oximetry; therefore, it is useful to compare pulse oximeter quantities to bed counts and other respiratory care equipment counts. BMES respondents reported use of three types of pulse oximeters: tabletop, handheld, and fingertip (Figure 11).

Figure 11. Pulse oximeters: tabletop, handheld, and fingertip, respectively.


Pulse oximeters are in shortage across medical facilities in Kinshasa. Only 56 facilities (60%) reported possessing any. Additionally, 13 facilities which reported use of oxygen therapy had no pulse oximeters. A total of 402 functional oximeters were reported across the surveyed facilities, with fingertip being the most common (Figure 122).

Figure 12. Surveyed facilities' reported availability of pulse oximeters, by type and functionality.



The histogram below (Figure 13) shows the distribution of facilities by pulse oximeter functionality per bed. Only 1 facility, CM de Matonge, a private eight-bed facility, reported having as many pulse oximeters as beds.

Figure 13. Number of facilities by functional pulse oximeters per bed.

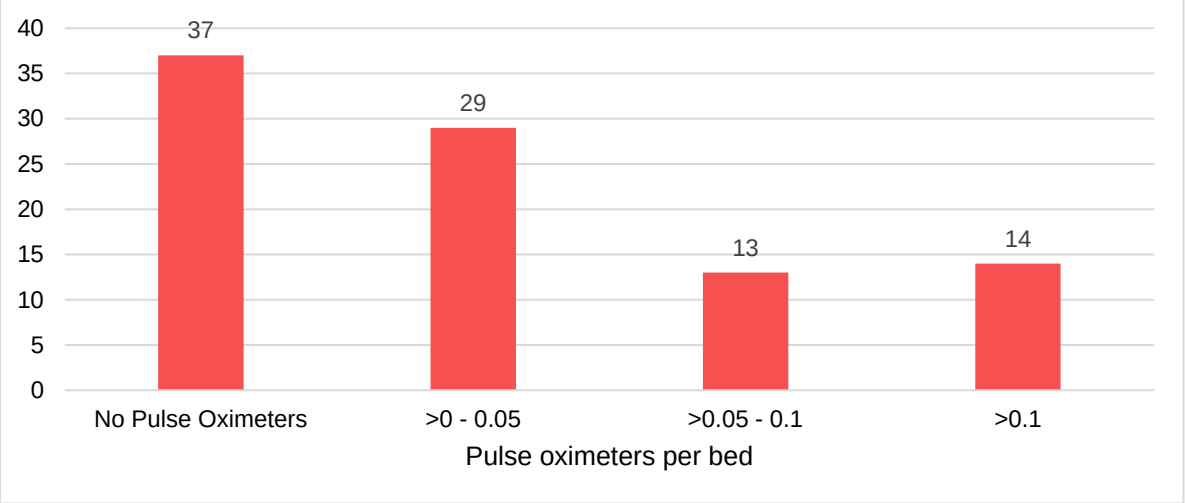
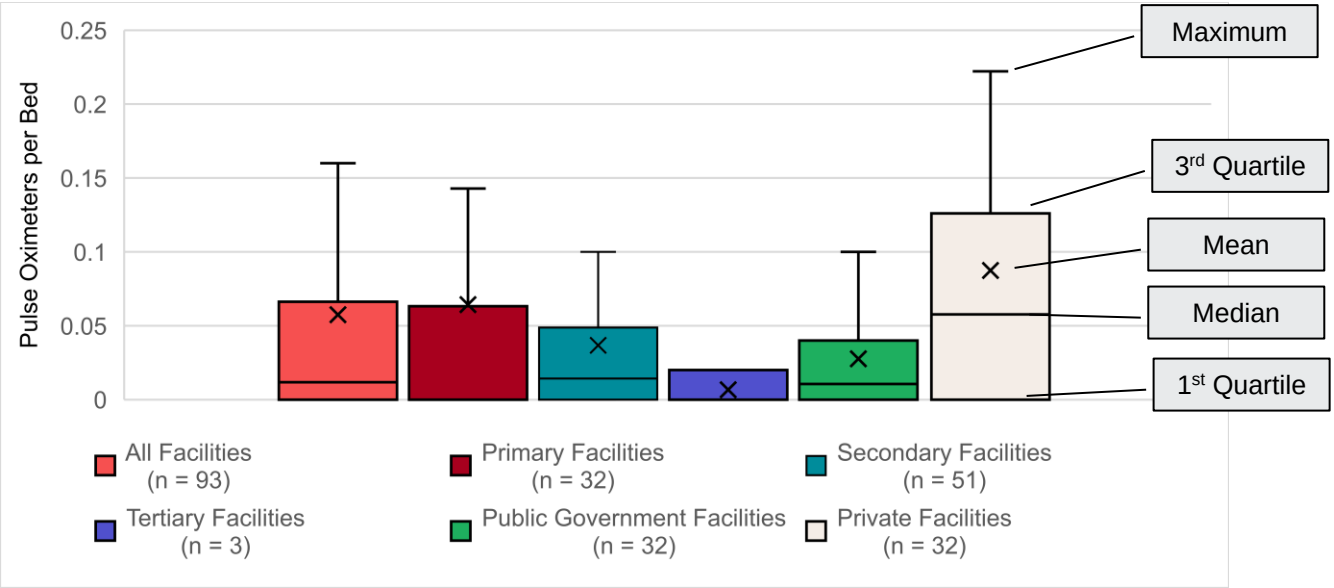


Figure 144 below highlights the stark difference in availability between public government facilities (in green), which had an average of 0.03 devices per bed, and private facilities (in beige), which had an average of 0.09 devices per bed. Additionally, while all facility types have a shortage of devices, tertiary facilities have the least number of devices proportional to their bed counts.

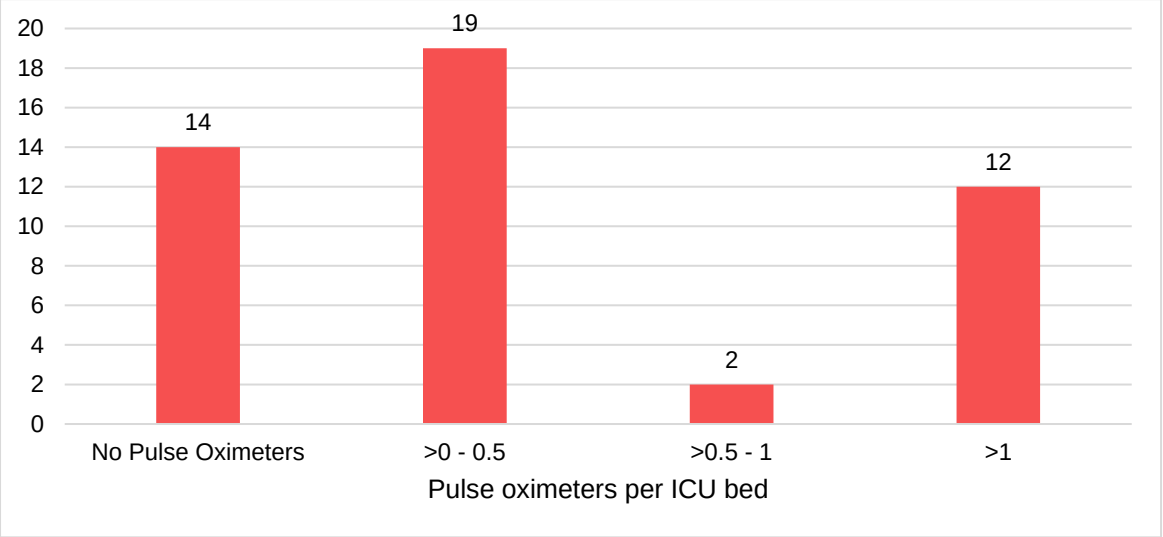
Figure 14. Distribution of functional pulse oximeters, per bed by facility type.



Note: "X" position indicates average number of devices per bed; "n" equals number of facilities for each facility category.

Pulse oximeter counts also fell short when compared to total ICU bed counts (528), pointing to an unmet need for these devices in intensive care (see Figure 15). For example, 14 facilities with ICU beds reported zero pulse oximeters. Data on individual facilities can be made available from PATH upon request.

Figure 15. Number of facilities by functional pulse oximeters per intensive care unit (ICU) bed range.



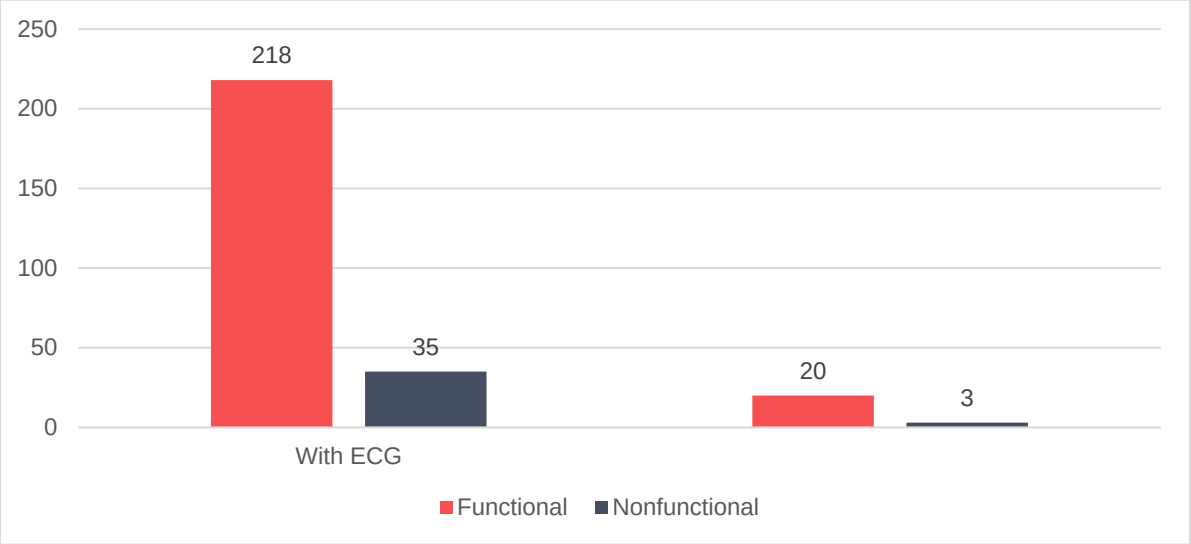
Note: n = 47 facilities reporting ICU beds.

In total, 30 nonfunctional pulse oximeters were reported, of which 24 were fingertip. Voici l'Homme Hospitalier reported 36% of the total nonfunctional devices. Reasons reported by facilities were "no spare parts," "no consumables" (cables, sensors), and no distributor in-country.

Patient monitors

Similar to pulse oximeters, patient monitors provide important information on patient vitals, which is needed to deliver oxygen therapy effectively. They are critical pieces of equipment for ICUs. The types surveyed were monitors with and without integrated electrocardiogram (ECG). Figure 16 summarizes the patient monitors reported by surveyed facilities by their type and functionality status. Monitors with ECG were far more prevalent in health facilities than those without ECG.

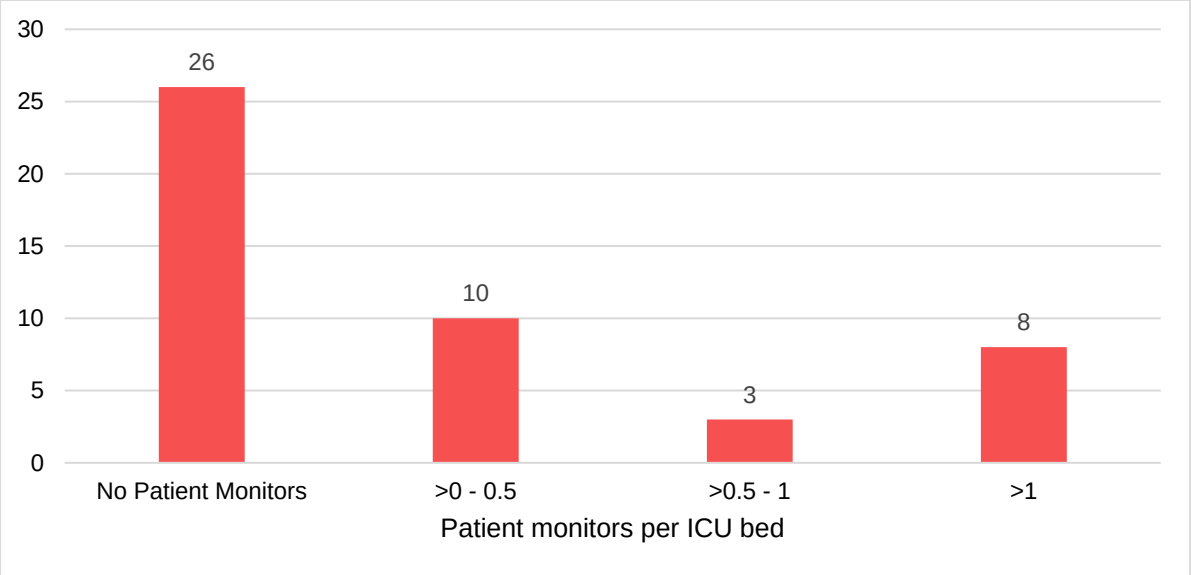
Figure 16. Patient monitors in surveyed facilities in Kinshasa, by type and functionality.



Abbreviation: ECG, electrocardiogram.

A total of 32 facilities (34%) in Kinshasa reported possessing functional patient monitors. Notably, 26 of 47 facilities with ICU beds reported possessing no functional patient monitors. In the remaining 21, there was on average of one functional patient monitor per ICU bed (see Figure 17).

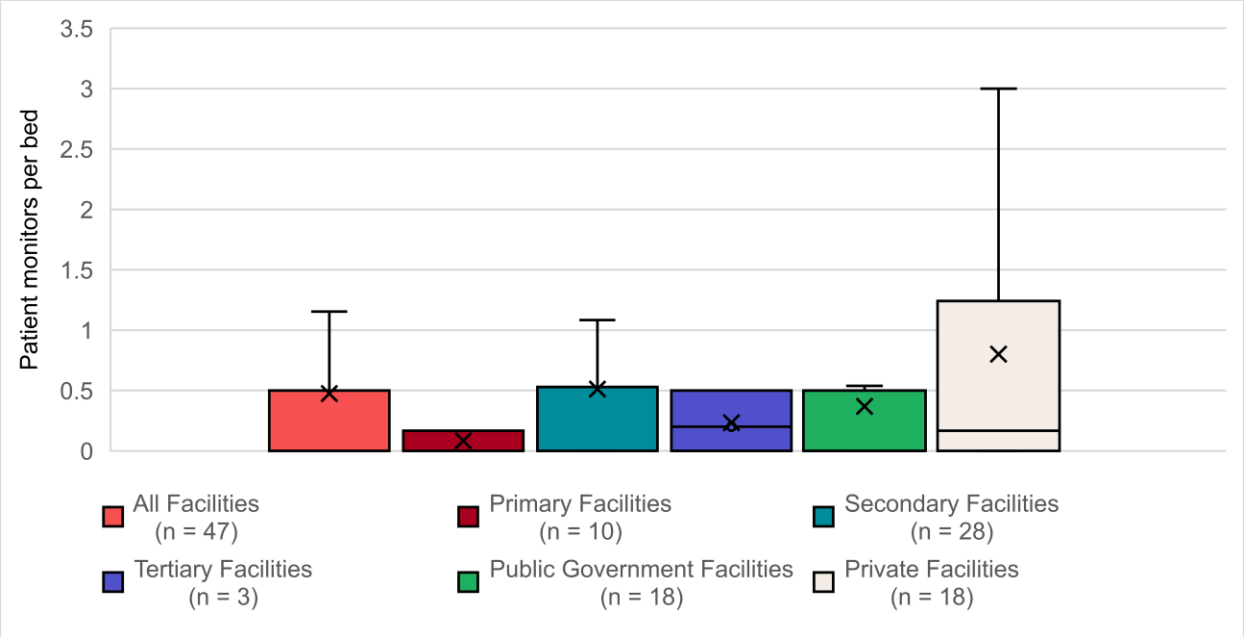
Figure 17. Functional patient monitors per intensive care unit (ICU) bed.



Note: n = 47 facilities reporting ICU beds.

Similar to pulse oximeters, distribution of patient monitors per ICU bed by facility type (Figure 18) showed that private facilities tended to have more functional monitors proportional to their ICU bed count than public government facilities. Additionally, tertiary facilities had on average the least number of monitors proportional to bed counts. These findings demonstrate a clear and vast unmet need for patient monitors across facilities.

Figure 18. Distribution of functional patient monitors per bed, by facility type.



Note: "X" position indicates mean number of devices per bed; "n" equals number of facilities reporting ICU beds for each facility category.

A total of 38 nonfunctional patient monitors were reported among surveyed facilities. Three facilities accounted for 79% of these nonfunctional monitors, Hôpital de l'Amitie Sino-Congolaise (40%), Clinique Ngaliema (26%), Centre Hospitalier Nganda (13%). Reported reasons for their being nonfunctioning included "no spare parts," "no consumables," and "no funds for maintenance." Bringing these devices back to functionality would be an important start to improving provision of these critical devices.

Oxygen production and supply

Overview

This subsection summarizes BMES data on equipment that can produce oxygen for patient care. This includes oxygen concentrators and PSA plants, which can purify atmospheric oxygen for medical use, as well as oxygen cylinders, which store medical oxygen.

Access to oxygen is limited in the surveyed facilities, with only 58% having some sort of oxygen production or storage equipment. At the primary level, a mere 25% of surveyed facilities had oxygen equipment. Furthermore, PSA plants are limited to two surveyed facilities, thus leaving the vast majority of facilities reliant on cylinders and concentrators. Oxygen is essential not only to the provision of critical care but also to many other applications, including surgery and maternal care. Table 5 below summarizes the availability of oxygen equipment in the surveyed facilities.

Table 5. Availability of oxygen by facility type.

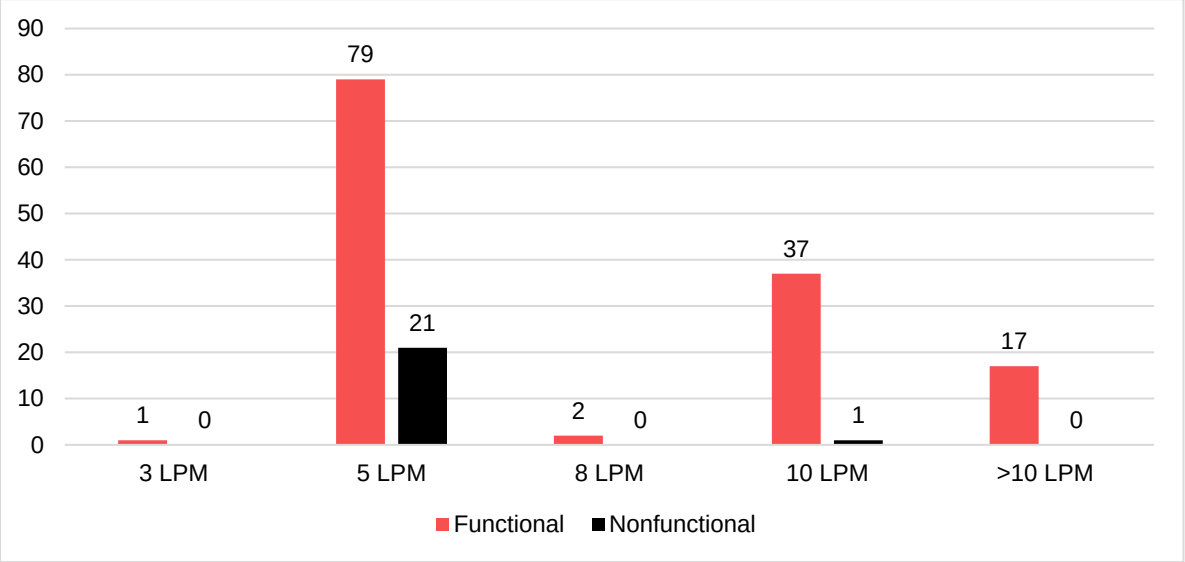
Facility characteristic	Primary	Secondary	Tertiary	Specialized hospital	COVID-19 treatment center	Other	Total
Facility count	32	51	3	3	3	1	**93**
Facilities with oxygen resources (%)	8 (25%)	37 (73%)	3 (100%)	2 (67%)	3 (100%)	1 (100%)	**54 (58%)**
Facilities with oxygen concentrators (%)	6 (19%)	25 (49%)	2 (67%)	2 (67%)	3 (100%)	0 (0%)	**38 (41%)**
Facilities with oxygen cylinders (%)	5 (16%)	23 (45%)	1 (33%)	1 (33%)	2 (67%)	1 (100%)	**33 (57%)**
Facilities with PSA plant (%)	0 (0%)	1 (2%)	1 (33%)	0 (0%)	0 (0%)	0 (0%)	**2 (2%)**

Abbreviations: PSA, pressure swing adsorption.

Oxygen concentrators

Oxygen concentrators produce medical oxygen from atmospheric air. They are an inexhaustible source of oxygen, assuming proper and routine maintenance and availability of needed consumables and delivery devices (such as masks and tubing). WHO recommends high flow rates for severe and critical COVID-19 patients (upward of 10 liters per minute [LPM]).[14] Oxygen provided at lower flow rates is critical for treatment of respiratory distress and other illness. Figure 19 below shows the various flow rates of functional and nonfunctional concentrators in the facilities surveyed.

Figure 19. Oxygen concentrators in surveyed facilities in Kinshasa by type, by functionality.

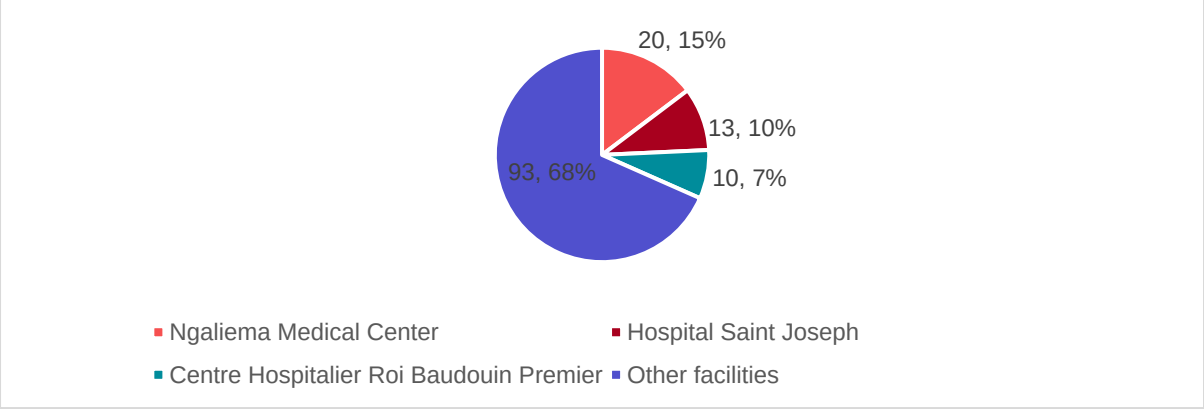


Abbreviation: LPM, liters per minute.

Health facilities in Kinshasa have a severe shortage in oxygen concentrators. For 528 ICU beds and 9,228 total beds, a total of only 136 functional oxygen concentrators were reported. Only 38 facilities (41%) held concentrators, and only 11 of those facilities owned high-flow concentrators with 10 LPM or greater flowrate capacity—flowrates potentially necessary to treat COVID-19 patients. Among the 47 surveyed facilities with ICU beds, 11 reported owning no oxygen concentrators.

Oxygen concentrators were far more prevalent in a select few facilities, with 32% (43) of the reported concentrators in just 3 facilities (see Figure 20): Ngaliema Medical Center (15%), Hôpital Saint Joseph (10%), and Centre Hospitalier Roi Baudouin Premier (7%). These same facilities also carry 60% of the reported high-flow concentrators (≥10 LPM). Whether patients are being referred or not to these facilities for oxygen therapy is unclear.

Figure 20. Distribution of functional oxygen concentrators.



A total of 22 nonfunctional concentrators were also reported across all facilities. The primary reported reasons for their being nonfunctioning included “no spare parts,” “no consumables,” and “no funds for maintenance.” Bringing these nonfunctional devices up to functional status would provide much needed additional respiratory care capacity.

Oxygen cylinders

Oxygen cylinders are metal canisters that must be refilled regularly and delivered to health facilities by an oxygen supplier. They need minimal maintenance and no electricity, making them a suitable oxygen source in some settings with poor infrastructure. However, like other oxygen delivery and production devices, they are dependent on availability of oxygen consumables, such as refills, masks, tubing, and cylinder assembly units to facilitate oxygen delivery. Table 6 shows the total quantities of cylinders by size and connection type across the 93 facilities surveyed in Kinshasa.

Table 6. Oxygen cylinder sizes and connection types.

Size, connection type	Total #
“D” (120 L), pin-index	350
“D” (340 L), pin-index	20
“D” (340L), bullnose	316
“E” (680 L), pin-index	0
“E” (680 L), bullnose	0
“F” (1,360 L), pin-index	0
“F” (1,360 L), bullnose	2
“G” (3,400 L), pin-index	3
“G” (3,400 L), bullnose	4
“J” (6,800 L), pin-index	14
“J” (6,800 L), bullnose	0

Note: Total weekly cylinder capacity = 277,960 L (41 “J” cylinders).

From the dataset, it was observed that size “D” cylinders were most often used across Kinshasa health facilities, particularly the 120 L pin-index and 340 L bullnose. Size “J” (6,800 L) pin-index cylinders were reported as the next most common. Very few facilities in the dataset reported buying more than one cylinder size. For example, the facilities reporting the largest numbers of cylinders consumed per week were CM de Kinshasa, Clinique Ngaliema, and HGR Provinciale de Kinshasa. All three reported consuming an average of 100 cylinders per week and using only one kind of cylinder. Reported total costs per week for cylinders were different between the 3 facilities, with CM de Kinshasa and HGR Provinciale de Kinshasa paying on average $1,500 per week and Clinique Ngaliema paying $1,000. More data points on pricing would be helpful to better understand costs for cylinder procurement.

Cylinder manifolds allow oxygen to be piped to various wards. They can hold multiple cylinders and switch from depleted to full cylinders to maintain a steady oxygen flow. Only 2 facilities reported having cylinder manifolds, HGR Provinciale de Kinshasa (one manifold) and Centre de Santé de Référence Pere Nsadi (two manifolds). Both facilities’ manifolds are manual switch, two-cylinder capacity.

PSA plants

PSA plants are health facility–based factories that use pressure to separate oxygen from the atmosphere and purify it to medical grade oxygen. Two facilities reported having PSA oxygen plants: Hôpital du Cinquantenaire and Clinique Ngaliema. Both facilities were piped for oxygen delivery to bedside terminals. Details of plants are below.

Table 7. Surveyed PSA plants by facility.

Facility	Facility Type	Model	Maximum production capacity of the plant in cubic meters per hour
Hôpital du Cinquantenaire	Tertiary	-	-
Clinique Ngaliema	Secondary	-	40 Nm^3/H

Liquid oxygen tanks

Liquid oxygen tanks hold cryogenic liquid oxygen, which is vaporized into gaseous oxygen for medical use. No facilities in Kinshasa reported use of liquid oxygen.

Oxygen consumables

Oxygen consumables refer to devices or oxygen delivery interfaces that facilitate administration of oxygen therapy to the patient—typically single use, though some are reusable. Their life span is short compared to medical devices, and they require different management practices. Because consumables are not like capital assets, their availability can greatly fluctuate over time. For this report, this means that quantities could be lower or higher than average for a facility, depending on whether it had recently ordered new inventory. Table 8 shows how much variation there was in consumable stock across facilities by reporting the average number of consumables and the standard deviation in quantities reported. All measured consumables are in short supply in facilities in Kinshasa. The majority of surveyed facilities report not having a stock of each consumable.

Table 8. Summary statistics of oxygen consumables reported across surveyed facilities.

Consumable type/category	Facilities reporting >0 units	Total # across facilities	Average # across facilities reporting consumables	Standard deviation
Nasal cannula / prongs - Adult	13	648	38	44
Nasal cannula / prongs - Pediatric	11	477	28	37
Nasal cannula / prongs - Neonate	8	351	21	36
Nasal catheter - Adult	10	626	37	45
Nasal catheter - Pediatric	8	500	29	52
Nasal catheter - Neonate	7	505	30	55
Oxygen mask - Adult	13	511	30	39
Oxygen mask - Pediatric	14	566	33	54
Venturi mask - Adult	4	313	18	50
Venturi mask - Pediatric	2	205	12	34
Macintosh - Curved blade	36	259	7	17
Miller - Straight blade	18	192	5	19
Adult - Endotracheal tube and guide (stylet or bougie)	26	1,591	57	133
Adult - Laryngeal mask	20	630	23	39
Adult - Colorimetric end-tidal CO_2 detector	6	40	1	4
Pediatric - Endotracheal tube / guide (stylet or bougie)	19	906	32	61
Pediatric - Laryngeal mask	14	379	14	29

Consumable type/category	Facilities reporting >0 units	Total # across facilities	Average # across facilities reporting consumables	Standard deviation
Pediatric - Colorimetric end-tidal CO_2 detector	5	18	<1	2
Nasopharyngeal airway - Single use	15	1,930	47	163
Nasopharyngeal airway - Reusable	17	259	6	19
Oropharyngeal (Guedel) airway - Single use	19	576	14	30
Oropharyngeal (Guedel) airway - Reusable	33	236	6	7

Total quantities of each consumables varied significantly. Cannula, catheters, and oxygen masks were reported to be in very high quantities across facilities, with moderate averages and standard deviation, which suggests they are commonly purchased. Adult endotracheal tubes, which were reported in the highest quantity out of all the listed consumables, also had the highest standard deviation, suggesting a few facilities likely had a very large stock, while others had a very low stock. Comparing the relationship of oxygen consumables to oxygen delivery equipment is important in evaluating how effectively medical equipment is being used in facilities. For instance, if a facility has a very large number of oxygen concentrators but very few masks for oxygen delivery, then treatment capacity is constrained. Additional data on consumable counts can be made available from PATH upon request.

Conclusion

The data collected through this BMES assessment yield new insight into the respiratory care treatment capacity of health facilities in Kinshasa. This report provides a view into availability of oxygen delivery equipment, oxygen production equipment, and consumables that are critical to providing respiratory care treatment for COVID-19 and beyond. Understanding the availability of respiratory care equipment is the first step in accurately estimating the gap in equipment supply and understanding health facility capabilities and limitations for treating hypoxemic patients. An overall scarcity of critical equipment and unequal distribution across surveyed facilities were observed in Kinshasa. Equitable allocation of new equipment will be a complex task requiring more thoughtful distribution than simply purchasing equipment to fill the gap and then dividing it between facilities.

Key recommendations for next steps are to:

- Perform a gap analysis and oxygen-need estimation to develop costed operational plans to increase the availability of respiratory care equipment.
- Develop specific requests and advocacy directed to donors and partners to backstop potential budget shortfalls for respiratory care equipment procurement and maintenance.
- Estimate long-term national oxygen need, inclusive of COVID-19 and non-COVID-19 respiratory care, to contribute to the development of a national oxygen infrastructure development policy (oxygen road map).

Ongoing data collection in the remaining 25 provinces of the DRC will add to this initial knowledge base and provide insight into national-level needs for respiratory care.

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Appendix A. Bed counts by facility and type

Table 9. General and ICU bed counts, by facility.

Facility name	All Beds	ICU beds
BON BERGER	30	10
CENTRE DE SANTÉ DE REFERENCE BANGU	20	0
CENTRE DE SANTÉ PILOTE ET MATERNITE DE MASINA	50	3
CENTRE MEDICALE TELECOM/OMECO	14	0
CENTRE DE MEDECINE MIXTE ET D'ANEMIE SS	66	0
CENTRE DE SANTÃ ET MATERNITY D'AFRIQUE	15	1
CENTRE DE SANTÃ ET MATERNITY O.M.E.C.O	12	0
CENTRE DE SANTÉ DE REFERENCE PERE NSADI	32	8
CENTRE DE SANTÉ DE REFERENCE CASOP	30	3
CENTRE DE SANTÉ DE REFERENCE DES ANCIENS COMBATTANTS	84	0
CENTRE DE SANTÉ ET MATERNITE BOMOI	80	8
CENTRE DE SANTÉ ET MATERNITE LISANGA	42	0
CENTRE DE SANTÉ ET MATERNITE SAINT VINCENT DE PAUL	18	0
CENTRE DE SANTÉ MATERNITE BINZA	78	0
CENTRE DE SANTÉ MATERNITE SAINT AMAND	29	0
CENTRE DE SANTÉ MIRIA	10	0
CENTRE DE SANTÉ DE REFERENCE VIJANA	50	2
CENTRE HOSPITALIER AKRAM	98	0
CENTRE HOSPITALIER CLÃMENCE	11	0
CENTRE HOSPITALIER DE BANDALUNGWA	14	0
CENTRE HOSPITALIER DE LA LEGION NATIONALE D'INTERVENTION (LNI)	67	0
CENTRE HOSPITALIER DE REFERENCE KABILA	70	0
CENTRE HOSPITALIER D'ETAT DE NGIRI-NGIRI	53	0
CENTRE HOSPITALIER D'ETAT MAMA PAMELA	27	0
CENTRE HOSPITALIER DU MONT AMBA (CHMA)	100	20
CENTRE HOSPITALIER LA BORNE	50	0
CENTRE HOSPITALIER LEMBA MEDICAL CENTER	30	0
CENTRE HOSPITALIER LIZIBA LYA BOMOI	90	6
CENTRE HOSPITALIER MERE ET ENFANT DE NGABA	80	0
CENTRE HOSPITALIER NGANDA	100	5
CENTRE HOSPITALIER NGONDO MARIA	110	10
CENTRE HOSPITALIER ROI BAUDOUIN PREMIER	120	3
CENTRE HOSPITALIER SAINT GABRIEL	76	0
CENTRE HOSPITALIER YOLO MEDICAL	85	6
CM DE MATONGE CNSS	8	0
CM BETHANIE	20	0
CM DE KINSHASA	60	13
CM DIAMANT	65	5
CM OPERATIONNEL TYPE A 111EME BASE NAVALE	30	0
CENTRE MERE ET ENFANT DE BARUMBU	84	3

CENTRE PEDIATRIQUE DEBORAH	10	2
CH DE LA PROVINCE SAINT-JOSEPH	50	0
CH KINGASANI	139	0
CH MIXTE ESCAPADE	42	7
CH MODERNE HONORABLA ATHU	40	0
CH RENE DE HAES	80	0
CLINIQUE LA CANDEUR	38	6
CLINIQUE BONDEKO	160	20
CLINIQUE DES ANGES	25	2
CLINIQUE EFFORT	12	2
CLINIQUE NGALIEMA	270	5
CLINIQUE RIVIERA	76	0
CLINIQUE RUTH	20	2
CLINIQUES DES ANGES/VIP	22	0
CLINIQUES UNIVERSITAIRES DE KINSHASA	500	25
CM KIKIMI	106	0
CM LA COLOMBE	15	0
CM MAMAN WA BOSAWA	14	0
CME DE BUMBU	120	0
CENTRE DE SANTÉ MATER DEI	12	0
CENTRE DE SANTÉ SAINT PAUL	8	0
FONDATION PEDIATRIQUE DE KIMBONDO MAMA KOKO	120	17
HÔPITAL GENERAL DE RÉFÉRENCE DE KINTAMBO	249	7
HOSPITAL PEDIATRIQUE DE KALEMBELEMBE	142	16
HÔPITAL GENERAL DE RÉFÉRENCE DE N'DJILI	165	5
HÔPITAL GENERAL DE RÉFÉRENCE MATADI MAYO	41	0
HJ HOSPITALS	210	45
HÔPITAL CENTRAL MILITAIRE KOKOLO	240	10
HÔPITAL DE LA RIVE	60	50
HÔPITAL DE L'AMITIE SINO-CONGOLAISE	188	8
HÔPITAL DE L'ONATRA	53	0
HÔPITAL GENERAL DE RÉFÉRENCE PROVINCIALE DE KINSHASA	1,000	13
HÔPITAL GENERAL DE RÉFÉRENCE KISENSO	96	0
HÔPITAL GENERAL DE RÉFÉRENCE DE MAKALA	280	6
HÔPITAL GENERAL DE RÉFÉRENCE DE MALUKU	95	0
HÔPITAL GENERAL DE RÉFÉRENCE DE MATETE	95	5
HÔPITAL GENERAL DE RÉFÉRENCE DE MBANKANA	70	0
HÔPITAL GENERAL DE RÉFÉRENCE KABINDA	21	10
HÔPITAL GENERAL DE RÉFÉRENCE PIERRE FOKOM	30	3
HÔPITAL MEDICAL OPERATIONNEL TYPE A 111 BASE NAVAL	25	0
HÔPITAL MILITAIRE DE GANISON	50	10
HÔPITAL MILITAIRE TSHATSHI	65	8
HÔPITAL SAINT JOSEPH	300	12
HÔPITAL SAINT MICHEL	18	3
HÔPITAL DU CINQUANTENAIRE	1,300	100
MATERNITY ESENGO	100	0

MATERNITE DE KINTAMBO	110	0
MERCY CLINIC	5	3
NGALIEMA MEDICAL CENTER	95	6
POLYCLINIQUE INKA	25	0
PROVIDENCE OF GOD HOSPITAL	16	0
TVC MEDICAL	30	2
VOICI L'HOMME HOSPITALIER	67	12
Grand total	**9,228**	**528**

Abbreviations: CM, *centre médical*; CME, Centre Mère et Enfant; HGR, *hôpital général de référence*; ICU, intensive care unit ; TVC, Tatete Vein Center.