An assessment of the newborn respiratory ecosystem, including newborn medical equipment, commodities, and provider capacity

Findings from public health facilities in the Northern and Upper West Regions of Ghana

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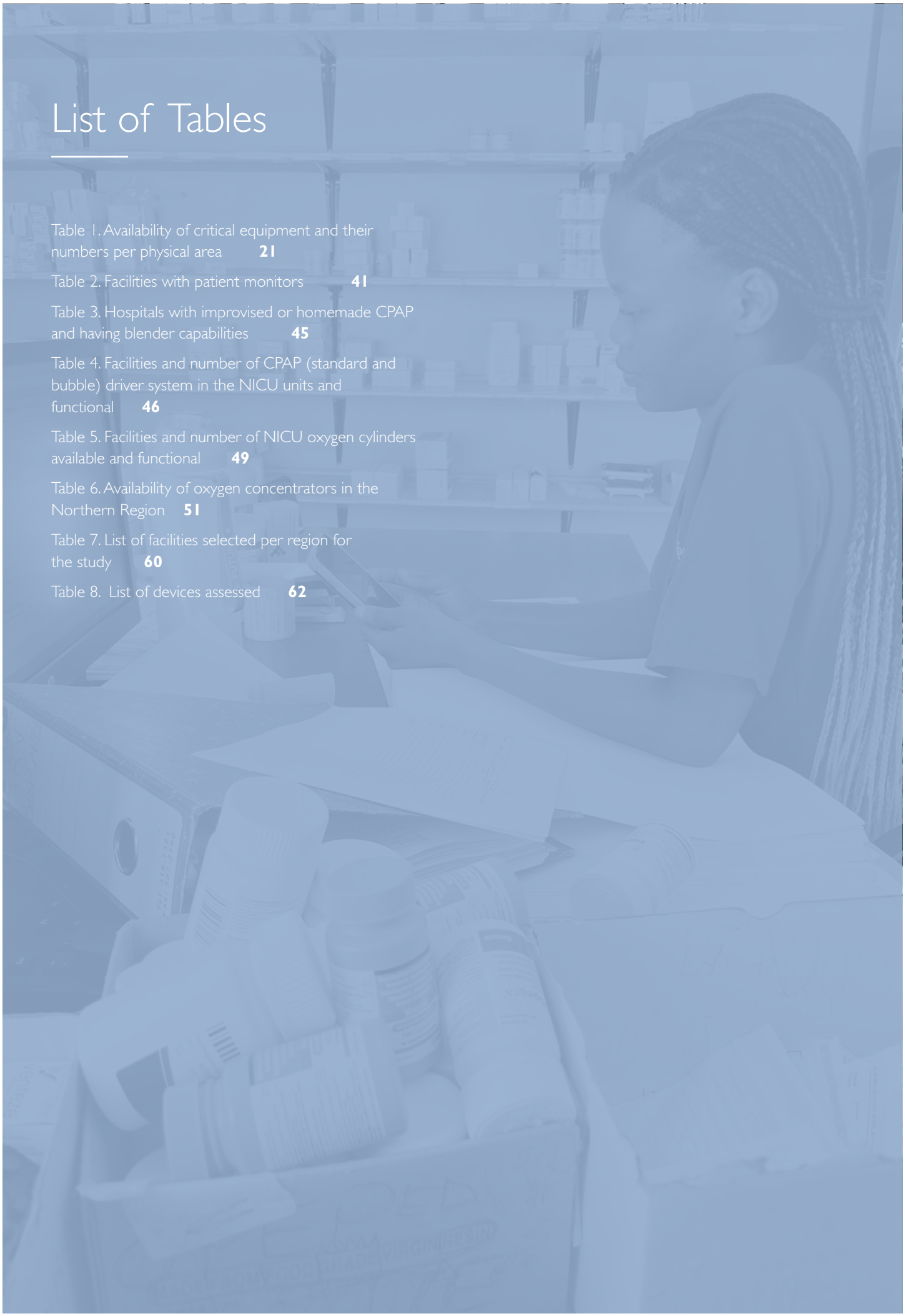

Acronyms

bCPAP	Bubble continuous positive airway pressure
CHPS	Community-based health planning and services
CPAP	Continuous positive airway pressure
EmONC	Emergency obstetric and newborn care
GHS	Ghana Health Service
GHSC-PSM	USAID Global Health Supply Chain-Procurement and Supply Management
GNNHSAP	Ghana National Newborn Health Strategy and Action Plan
HAN	Health Access Network
HFA	Health Facility Assessment
IPC	Infection prevention and control
KMC	Kangaroo mother care
LHIMS	Lightwave Health Information Management System
LMICs	Low- and middle-income countries
MOH	Ministry of Health
NGO	Non-governmental organization
PPM	Procurement planning and monitoring
PSA	Pressure swing adsorption
RMS	Regional medical store
SDG	Sustainable Development Goal
SpO2	Peripheral oxygen saturation
SSNBs	Small and sick newborns
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organization

Executive summary

Background

Over the years, Ghana has made progress in reducing neonatal mortality rates. A 2018 statistical survey showed a 14% reduction in the neonatal mortality rate, from 29 per 1,000 live births in 2014 to 25 per 1,000 live births in 2017. However, neonatal mortality rates in Ghana remain high. The inadequate availability of newborn medical equipment in Ghana's health facilities cannot be overemphasized, impeding effective management of newborn medical complications and contributing to newborn deaths.

PHOTO CREDIT: GHSC-PSM

Goal and objectives

The goal of this study is to increase stakeholder understanding of the newborn health landscape and identify opportunities to enhance newborn health programming. Additionally, this assessment seeks a comprehensive look at the respiratory ecosystem to document gaps across a patient's oxygen journey, with a particular focus on small and sick newborns (SSNBs).

Methodology

A mixed-method design was adopted, using a quantitative and qualitative data collection technique. The Northern and Upper West Regions were purposively selected for the study based on a predetermined agreement between GHSC-PSM and its counterparts. A census of all hospitals (n=24) and polyclinics (n=5) in the two regions was selected. The health centers (n=19) and CHPS compounds (n=3) that recorded at least 300 deliveries in 2022 were also selected. Overall, 51 health facilities were enrolled for the quantitative assessment.

Key findings

Data on the availability and maintenance of key equipment, provider capacity to manage this equipment, information on key medical devices such as CPAP machines, pulse oximeters, and oxygen concentrators/blenders for management and care of SSNBs, and maintenance protocols were drawn from the 51 health facilities across the two regions.

All 51 facilities had labor and delivery units; however, not all the facilities had a dedicated post-natal unit and other recommended amenities like a general operating unit, pediatric ward, maternity theatre, kangaroo mother care (KMC) ward, special baby care unit, and neonatal and intensive care unit (NICU). Some facilities lacked adequate areas where mothers can receive treatment for moderate posthemorrhagic anemia and provision of information and counselling on home self-care, nutrition, safe sex, breastfeeding and care, and family planning can take place. Insufficient space for postnatal observations can affect service delivery as a mother and her newborn can be discharged without adequate observation or counseling. This reality is especially detrimental to preterm infants who may need prolonged care. Also, lack of specialized physical areas and associated infrastructure in the hospitals could result in inadequate intermediate and intensive care for SSNBs.

CPAP machines were available and functional only in hospitals (levels 2 and 3). However, none of the hospitals had sufficient CPAP devices and accessories to cover all babies that require respiratory support. Of the 24 hospitals studied, only 21 percent had a functional standard (non-bubble) CPAP driver system with blended oxygen, 29 percent had a bubble CPAP driver system, and 38 percent had an improvised/homemade CPAP machine. Over 50 percent of these facilities with improvised/homemade CPAP did not have blended oxygen. With the high cost of oxygen blenders compatible with bubble CPAP, facilities are challenged to provide blended oxygen, although there is evidence that CPAP use compared with low-flow oxygen systems in preterm infants with respiratory distress significantly reduces treatment failure. The results suggest that hospitals are unable to care adequately for newborns in need of oxygen therapy and respiratory support. This reality is especially critical for preterm infants.

Generally, resuscitation devices across the two regions were inadequate as well as the availability of back-up electrical power supply to facilities. Only 12 percent of facilities reported no impact of power outage on their operations. The main reasons for newborn admission were respiratory distress, high risk of infection, hypoglycemia, asphyxia, low birthweight, and preterm. For all facilities assessed, 34 percent indicated midwives, 26 percent mentioned general nurses, and 19 percent reported that pediatric/neonatal nurses were responsible for assessment and discharge of newborns.

Conclusion

The study brought to light several challenges health facilities face that impact effective management and provision of care for all newborns, especially SSNBs. Key challenges include:

- Lack of adequate physical areas required for newborn care at all newborn care levels
- Non-availability of newborn medical equipment and their limited numbers
- Inadequate staff capacity, gauged by the number and competence of staff required to provide newborn care and their lack of training in using devices
- Inadequate forecasting and procurement of medical equipment
- Lack of effective maintenance protocol for medical equipment, leading to poor maintenance
- Harmful practices due to lack of safe and effective oxygen provision

Lack of funding and inadequate management of limited resources available for newborn care were key drivers of these challenges. A considerable number of neonatal services were provided by various facility types for the care of SSNBs amidst some challenges, including limited human resource capacity and lack of equipment. The quality of neonatal services should be regularly monitored and assessed to address these challenges.

To improve the maintenance culture and ensure medical device longevity, several initiatives are needed: supportive supervision, leadership, communication, teamwork, education, planning, empowerment, and motivation. Facilities also need to have 1) dedicated workshop areas with qualified personnel and well-documented maintenance protocols, 2) allocated budget for maintenance and procurement of basic tools and spare parts, and 3) proper maintenance records to improve infant care, procurement, and evidence-based maintenance.

Most health staff lacked the capability to use and maintain most of the newborn care equipment due to a lack of regular and adequate training. Facilities need to organize regular pre-service training, in-service training, on-the-job training, and frequent continuous development courses for staff to update their knowledge and improve their capabilities and competence.

Recommendations

Facility infrastructure/physical areas

MOH and GHS: Expand infrastructure for maternal and newborn care (NICU, postnatal unit, maternal theatre, KMC unit, and special baby care unit) in health facilities to ensure equitable access to all levels of services critical for protecting the health of SSNBs as well as women seeking maternal health services. Ensure that future development of health facilities includes all the physical areas needed for effective maternal and newborn care.

Availability of improvised bubble CPAP, oxygen use, and pulse oximetry monitoring

GHS: Support health facilities in acquiring and ensuring effective use of newborn care devices and equipment, including CPAP, pulse oximeter, and safe oxygen sources (such as oxygen concentrators, bulk liquid oxygen, oxygen generators, and PSA plants) that are recommended for use in NICUs. This effort should include advocacy with development partners and stakeholders to support the provision of critical equipment for optimized treatment and management of newborns.
Provide support for acquiring oxygen analyzers to facilitate routine oxygen purity checks in facilities that generate oxygen. This will improve access to safe oxygen to prevent long-term complications and ensure better treatment outcomes for SSNBs.

> To improve the poor maintenance culture and ensure medical device longevity, several initiatives are needed: supportive supervision, leadership, communication, teamwork, education, planning, empowerment, and motivation.

Neonatal services

GHS: Review and implement a standardized referral and feedback system for SSNBs to ensure continuity of care when facilities lack human resources, devices, and equipment that are needed for effective clinical management outcomes.

Neonatal unit electricity supply

Government of Ghana through GHS: Budget and acquire funding for procuring backup power supply (e.g., solar power and battery inverters) for health facilities to prevent disruption in newborn care and related health services that rely on uninterrupted electricity supply. Although solar power and battery inverters have an initially high cost, they can serve as a cost-effective backup power source in the long term.

Infection prevention and control (IPC) and waste management

GHS: Continue to sensitize health facilities to strengthen systems for IPC as well as waste management. Efforts to achieve this goal should include funding and technical support for installing and maintaining backup portable water sources and incinerators, considered safe methods for managing waste.

Inventory and forecasting of consumables at the neonatal unit

Health Administration and Support Services of GHS: Identify and build the capacity of health facilities that lack the skills and knowledge to effectively forecast and apply standard inventory management procedures for newborn medical devices. This will contribute to the management of SSNB conditions through improved availability of newborn medical devices and consumables.

Maintenance and repairs

Health Administration and Support Services of GHS: Establish a strong maintenance culture for newborn care devices and oxygen equipment by 1) bridging capacity gaps and 2) conducting routine monitoring and supervision to promote adherence to standard protocols and planned preventive maintenance schedules. Most maintenance contracts were not managed at the facility level.

Regional Health Directorates: Support health facilities in acquiring basic tools and equipment that are needed for routine management of newborn medical devices and oxygen equipment. This support will help deepen the culture of maintenance and improve the availability of functional devices and equipment needed for treating and managing SSNB care.

Human Resources

Family Health Division: Conduct regular in-service training and supervision for relevant health staff (midwives and general nurses) as part of efforts to improve and sustain the delivery of high-quality care for SSNBs. Also, the MOH and GHS should prioritize the training of pediatric nurses, pediatricians, and neonatologists to improve access to intermediate and advanced newborn care services in health facilities.

01.
Background

Background

Globally, each year, an estimated 2.5 million newborns die during the first 28 days of life. Of that group, an estimated 80 percent had a low birthweight and two-thirds were born prematurely. Newborns who are born too soon or too small, or who become sick, are at the greatest risk of death and disability.

One study estimated 1 million small and sick newborns (SSNBs) survive with a long-term disability. Globally, up to 30 million newborns require some level of inpatient care each year. These include newborns with complications of prematurity, intrapartum-related complications, severe bacterial infection, or pathological jaundice, and those with congenital conditions. Substantial human potential for lifelong health and well-being is lost through newborn morbidity, disability, and long-term disease.

Improving the quality of care for women and children is a World Health Organization (WHO) priority for reducing preventable maternal, newborn, and child deaths. WHO has developed standards of care to guide the quality of care in countries, including the availability and use of quality equipment and devices.

The Ministry of Health (MOH) and the Ghana Health Service (GHS) have made progress toward reducing newborn mortality including through the National Newborn Health Strategy and Action Plan (GNNHSAP). Ghana experienced a 14 percent reduction in the neonatal mortality rate, from 29 per 1,000 live births in 2014 to 25 per 1,000 live births in 2017. Nevertheless, neonatal mortality rates in Ghana remain high. (Child Health Standards and Strategy 2017–2025, May 2018, Ghana Health Service) If trends remain consistent, Ghana will not meet Sustainable Development Goal (SDG) 3.2.2, which aims to reduce neonatal mortality to 12 per 1,000 live births. Important obstacles are the inadequate availability in health facilities of medical equipment for treatment of newborns and the limitations of the national respiratory ecosystem in Ghana—both of which impede effective management of newborn medical complications and contribute to newborn deaths.

A 2010 assessment of emergency obstetric and newborn care (EmONC) recommended that health facilities across Ghana be strengthened to fully functioning status to meet national and international standards, including in the procurement and availability of medical equipment for newborns. The 2019–2023 GNNHSAP has proposed a set of interventions to help expand essential newborn care to the care of SSNBs, and ensure the continuous availability of a skilled workforce, essential medicines, equipment, and other commodities. However, there are important gaps in data needed to inform this expansion. Data are needed, for instance, on the extent of availability of devices to treat newborns and the capacity of health staff to manage them, two key issues that hinder progress toward the achievement of SDG 3.2.2.

One important device required to reduce neonatal mortality is the continuous positive airway pressure (CPAP) device; its use is widely seen as a method whose

introduction at scale would be effective in reducing neonatal mortality, especially that of preterm newborns with respiratory distress syndrome, a common cause of neonatal death. (Lategan et al. 2022) Scaling up the availability and use of CPAP is addressed in the global Every Newborn Action Plan (ENAP), launched in 2014 by the WHO, which provides a road map of strategic actions for ending preventable newborn mortality and stillbirth and supporting the reduction of maternal mortality and morbidity. ENAP sets a target of 80 percent of districts (or equivalent subnational units) having at least one inpatient unit to care for SSNBs with respiratory support, including the use of CPAP, by 2025.

Resulting efforts in low- and middle-income countries (LMICs) have emphasized the need for safe and effective use of CPAP devices, but the global newborn community has identified these ongoing concerns:

- A large number of bubble CPAPs in these countries lack essential components, such as blenders to provide safe levels of oxygen.
- These devices are often used in facilities with inconsistent access to electricity, where set-ups can often be improvised, resulting in uncontrolled deviations in pressure.
- A large number of bubble CPAPs in LMICs rely exclusively on 100 percent oxygen, whose use can lead to oxygen toxicity, which in turn can lead to long-term disabilities from childhood blindness/visual impairments and an increased risk of pulmonary complications, especially among preterm newborns.
- Data are needed to inform prioritization of updates in respiratory guidelines, demand for investments in innovative safe delivery of oxygen, and continued creative solutions that will help neonates survive and thrive.

To achieve high-quality newborn health care, adequate availability and proper use of CPAP and other key newborn medical equipment should be part of an integrated, resilient health system, with multidisciplinary teams and innovation. Care for SSNBs should be organized to serve population size and need, with a network of facilities and connections among health system levels through functional referral systems. High-quality care also requires investment in sufficient numbers of health care providers with the skills to care for SSNBs—particularly, trained and motivated nurses—working in partnership with parents and families. Good-quality care services involve evidence-based practices; are well-organized, accessible, and adequately resourced; are safe, efficient, equitable, timely, and people-centered; and ensure optimal clinical, developmental, and social outcomes for small and sick newborns.

The USAID Global Health Supply Chain Program-Procurement and Supply Management (GHSC-PSM) project, in collaboration with the Family Health Division and the Health Administration and Support Services Division of the Ghana Health Service (GHS), worked together to conduct the assessment.

1.1 Study Purpose and Objectives

1.1.1 Purpose

The goal of this study is to increase stakeholder understanding of the newborn health landscape in Ghana and identify opportunities to enhance newborn health programming. Additionally, this assessment seeks a comprehensive look at the respiratory ecosystem to document gaps across a patient's oxygen journey, with a particular focus on small and sick newborns (SSNBs).

1.1.2 Objective

The main objective of the activity was to assess availability and functionality of newborn medical devices, associated commodities, and provider capacity with a focus on a comprehensive review of the respiratory ecosystem.

Specific objectives were to:

- Conduct a situational analysis of the prevalence of improvised bubble continuous positive airway pressure (bCPAP) therapy, 100 percent oxygen use, and pulse oximetry monitoring use
- Identify data gaps in the respiratory support and oxygen ecosystem for the care of SSNBs
- Investigate health staff capacity to manage and maintain devices critical to ensuring adequate respiratory support for SSNBs
- Evaluate maintenance protocols for medical devices for newborn care

02.
Methodology

Methodology

2.1 Study Design and Methodology/Approach

2.1.1 Study design

Northern and Upper West Regions were purposively selected based on a predetermined agreement between GHSC-PSM and its counterparts. The study used a mixture of qualitative and quantitative methods.

Quantitative approach: The study included a census of all hospitals and polyclinics within the two regions. Health centers and community-based health planning and services (CHPS) compounds in the two regions that each recorded at least 300 deliveries in 2022 were purposively selected. Overall, 51 health facilities comprising 24 hospitals, 5 polyclinics, 19 health centers, and 3 CHPS compounds were enrolled for the study.

Qualitative approach: A semi-structured questionnaire was used for individuals with knowledge and experience in newborn care, such as providers and district health directorates. It gathered information on numbers/quantities of identified equipment and accessories, and key challenges affecting availability of these key medical and resuscitation devices for care of SSNBs. It also provided contextual information around the hard numbers, as well as captured perspectives and insights on the newborn and medical devices landscape.

2.1.2 Sampling and Selection of Health Facilities

The team used a randomized sampling approach to select the allocated number of hospitals, polyclinics, and health centers to achieve the sample number per region, as shown in Table 7 in Appendix 6.

2.2 Data Collection Instrument

This section covers quantitative and qualitative tools deployed to collect data from facilities and key respondents.

2.2.1. Survey questions

The quantitative questionnaire was adapted from the Health Facility Assessment (HFA) Infrastructure Module, NEST360 | UNICEF, version 2022.05.06. Components of the quantitative questionnaire were also drawn from:

- The Rapid EmONC Assessment Toolkit, with focus on Module 2 (Human Resources) and Module 3 (Equipment and Supplies)
- Ghana Newborn Care Assessment Tool
- Harmonized Health Facility Assessment (HFA)
- The 2011 Ghana EmONC Study, the Ghana Newborn Strategy, and the Ghana Oxygen Market Intelligence report
- Feedback from key informants throughout the national supply chain drawn from preliminary discussions on human resource capacity, equipment/devices, and protocols for managing newborn care devices

Specifically, the tool was used to collect quantitative data on the level of availability of newborn care devices in selected facilities. It included sections on the availability of oxygen equipment, categories of staff available to provide newborn care services, staffing levels, and behavior and practices in maintaining and managing newborn care devices.

The HFA CPAP and Oxygen System module that was referenced when developing the study assessment comprises these sections:

1. Facility Infrastructure (direct questions to management)
2. Neonatal Unit Infrastructure (direct questions to neonatal nurse in charge)
3. Inventory and Forecasting of Consumables (direct questions to neonatal nurse in charge)
4. Newborn Care Equipment and Supplies (direct questions to neonatal nurse in charge)
5. Biomedical Workshop (direct questions to head biomedical engineer or technician of the maintenance department)
6. Human Resources (direct questions to neonatal nurse in charge)
7. Transportation and Referrals (direct questions to transportation officer and clinical staff in charge of referrals)

2.2.2 Data collection and analysis tools

Kobo Collect was deployed to collect data. Microsoft Excel 2016 and SPSS were used to analyze data, generating descriptive outputs for key variables, such as equipment availability, and quantities/numbers of equipment and accessories (CPAPs, pulse oximeters, and oxygen concentrators/blenders).

2.2.3 Target respondents/informants

Facility level: Health staff, including midwifes/pediatricians/pediatric nurses and medical doctors/physician assistants, were interviewed on the availability and functionality of newborn devices and oxygen equipment, use, maintenance protocol, and staff capacity to perform basic maintenance procedures. Also, an administrator/clinical technologist or any other person assigned to assist with the maintenance of newborn care devices was interviewed to determine the existence of planned preventive maintenance protocols and corrective/emergency servicing arrangements for newborn care devices.

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District level: One key informant was interviewed to obtain feedback on the overall availability and management of newborn care equipment in the district.

Regional level: The regional medical stores manager/supply manager and the deputy director in charge of clinical care/regional public health nurse were interviewed to obtain information on the approach to newborn care, gaps in service quality, strategies, and access to critical equipment.

National level: Key informants from the Ministry of Health (MOH) and the Ghana Health Service (GHS) (Family Health Division, Pharmaceutical Services Department, the Clinical Care Division, Health Administration and Support Services, and the Supplies, Stores and Drug Management Division) were interviewed to provide useful data to fill data gaps.

2.3 List of Equipment for Assessment

The list of newborn care equipment and supplies whose prevalence and use were assessed can be found in Appendix 6, Table 8.

2.4 Data management and analysis

The research team used different methods to analyze quantitative and qualitative data from the field. The quantitative data analysis, carried out with Microsoft Excel, included generating charts, tables, and graphs.

The open-ended responses from interviews were transcribed and analyzed using Microsoft Excel. Each data set was transcribed verbatim to ensure all participant narratives were fully captured. To ensure accuracy in data transcription, an independent expert also transcribed and reviewed the narratives. The team used a thematic analysis approach to analyze all the interviews. Codes were systematically generated, leading to the formation of pattern and themes for interpretation of data. Two qualitative experts worked independently to preliminarily identify and agree on the themes and categories for all the narratives. Appendix 9 provides themes and participant quotes.

03.
Findings and Discussion

Findings and Discussion

The survey covered a total of 51 facilities in the Northern and Upper West Regions in Ghana. Of these, 34 are in the Northern Region and 17 are in the Upper West Region; 24 (47.1 percent) are district hospitals, 5 (9.8 percent) are polyclinics, 19 (37.3 percent) are health centers, and 3 (5.9 percent) are CHPS compounds. (Refer to Appendix 6 for a list of facilities visited.)

All 51 health facilities in this study, regardless of facility type, met the criterion of recording at least 300 deliveries in 2022. With these numbers of deliveries, the facilities are expected to be able to provide the basic essential newborn care corresponding with their respective levels of care, which is further defined in the Ghana National Newborn Health Strategy and Action Plan (Ghana MOH, 2019).

3.1 Facility infrastructure for newborn care

A facility's infrastructure is essential to its functionality and efficiency, and it requires ongoing maintenance and upgrades to ensure that it meets patient needs and remains in good condition. Health facilities must have appropriate physical areas, with adequate water, sanitation, waste management, energy supply, staffing, and equipment for routine care and management of complications in small and sick newborns.

Findings

All the 51 facilities studied had labor and delivery units. It is essential that labor and delivery units provide immediate postnatal care for monitoring and assessing maternal and newborn well-being and preventing and detecting complications (e.g., hypertension, infections, bleeding, anemia).

Not all facilities had dedicated postnatal units, implications of which are further discussed below. As shown in Figure 1, 83 percent of hospitals, 80 percent of polyclinics, 74 percent of health centers, and 67 percent of CHPS compounds had dedicated postnatal units in their facilities.

Of the facilities studied, all polyclinics had a general operating theatre. 96 percent of hospitals and 5 percent of health centers had a dedicated general operating unit; however, none of the CHPS compounds visited had one. Facilities with a pediatric ward included 96 percent of hospitals, 60 percent of polyclinics, and 11 percent of health centers.

Only 25 percent, 42 percent, and 13 percent of hospitals, respectively, had a dedicated maternity theatre, KMC unit, and special baby care unit (SCBU) for the least sick newborns, whereas none of the other facility types visited had any of these.

Among hospitals, 83 percent had a dedicated NICU, whereas these units were not present in any other facility type. Nevertheless, most facilities of other types, while lacking a dedicated NICU, provided some level of special newborn care interventions.

Context and discussion

According to the current Ghana Newborn Strategy Action Plan, facility types can be categorized into three levels of care based on signal functions, such as basic resuscitation, phototherapy, and mechanical ventilation. All facilities are expected to provide level 1 newborn care, such as care at birth, and to provide basic resuscitation for continued basic essential newborn care. District hospitals and polyclinics are expected to provide level 2 newborn care, which includes all interventions included in level 1 care together with more advanced resuscitation, which provides more comprehensive care for at-risk, SSNBs. Regional and teaching hospitals at level 3 are expected to provide all the level 1 and 2 newborn care as well as a neonatal intensive care unit.

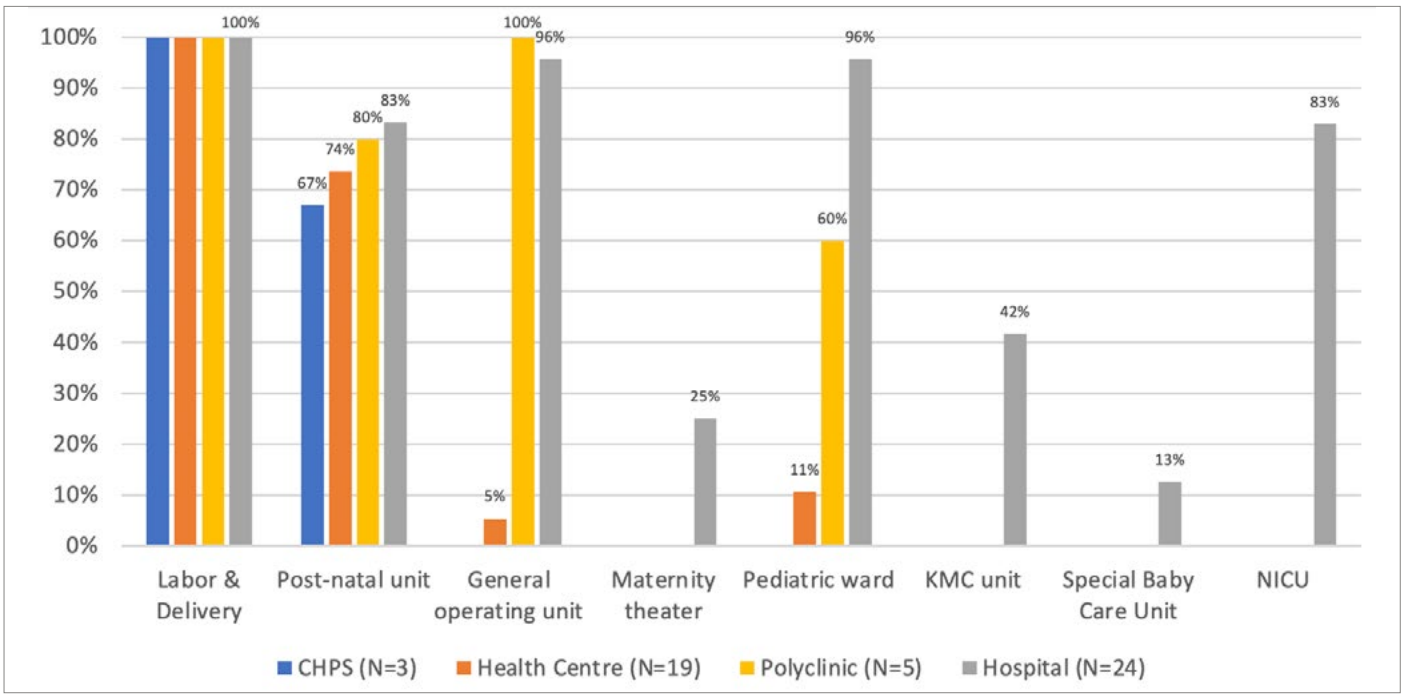

Figure 1 Availability of physical areas per facility type

To provide a **summary of infrastructure findings at higher-level facilities**: Of the hospitals surveyed, a significant number were missing a postnatal unit (17 percent), a general operating unit (4 percent), a maternity theatre (75 percent), a pediatric ward (4 percent), a KMC unit (58 percent), or a special baby care unit (87 percent). Similar trends were noted at polyclinics, which were missing postnatal units (20 percent), maternity theatres (100 percent), pediatric wards (40 percent), KMC units (100 percent), and special baby care units (100 percent). Generally, lack of specialized physical areas in the hospitals could imply inadequate intermediate and intensive care for SSNBs.

Overall, 83 percent of hospitals studied had **postnatal units**, which can be crucial to maternal well-being and therefore to newborn survival. However, 17 percent of all hospitals lacked adequate areas where mothers can receive treatment for moderate post-hemorrhagic anemia and information and counseling on home self-care, nutrition, safe sex, and family planning; breastfeeding support; and identification of newborn danger signs. Given that adequate care for mothers is linked to increased survival rates for newborns (Cochran and Soni, 2015), insufficient space for postnatal observations can affect service delivery, as mother and newborn may be discharged without adequate observation and education.

Absence of **maternal theatres** in hospitals, as in the case of most that use a general operating theatre instead, can affect service delivery in the context of emergency response to maternal conditions such as fetal distress conditions that require emergency surgery.

3.2 Equipment/devices of the newborn respiratory ecosystem

3.2.1 Availability of improvised bubble CPAP

Context

CPAP is a non-invasive type of respiratory support which works by providing a continuous level of positive pressure to

> "We need space for caring for the small and sick newborn. Space in the sense that I think UNICEF brought some generators and equipment but where we use them is very crowded. We have the service of a pediatrician, so we have a lot of referrals, and the babies get so crowded that we put so many babies into a small [area] and you are not really able to…" — Key informant, hospital

the airways to overcome lung collapse and improve ventilation. CPAP can be generated in different ways: (1) by using a variable flow of air and oxygen (variable-flow CPAP); (2) by blowing a high flow of air and oxygen (high-flow nasal cannula); or (3) by immersing the end of a respiratory circuit and making the patient exhale against a column of water, generating bubbles (bubble CPAP) (Dewez and van den Broek, 2017).

A study by Lategan et al. (2022) showed that CPAP has the greatest impact on neonatal mortality, and improving its coverage should be the primary goal for low-resourced areas, to save newborn lives. An oxygen blender, an integral part of the CPAP, helps to manage emergency-distressed babies by blending oxygen with air to avoid oxygen toxicity. The lack of it raises concerns for how distressed babies are managed in facilities.

Bubble CPAP is the form of CPAP best suited for low-resources settings. Airflow is generated by a concentrator, funneled through to the patient, and exhaled into a column of water. The level of pressure is determined by the length of the immersed pipe. This form of CPAP also relies on an oxygen blender. Bubble CPAP devices are generally cheaper than variable-flow CPAP; some use air and oxygen extracted from ambient air, unlike variable-flow CPAP which requires medical piped-gas systems or oxygen cylinders. Bubble CPAP can also provide a more stable level of pressure compared to high-flow nasal cannula. However, similarly to other forms of CPAP, many bubble CPAP devices require a constant source of electricity, which can be harder to ensure in remote facilities (Dewez and van den Broek, 2017).

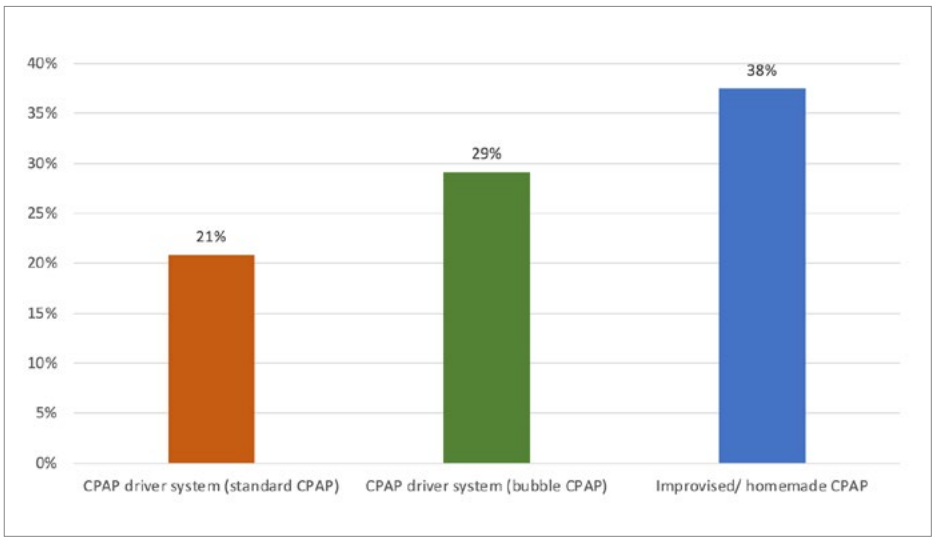

Figure 2 Availability of functioning CPAP machines in hospitals (n = 24)

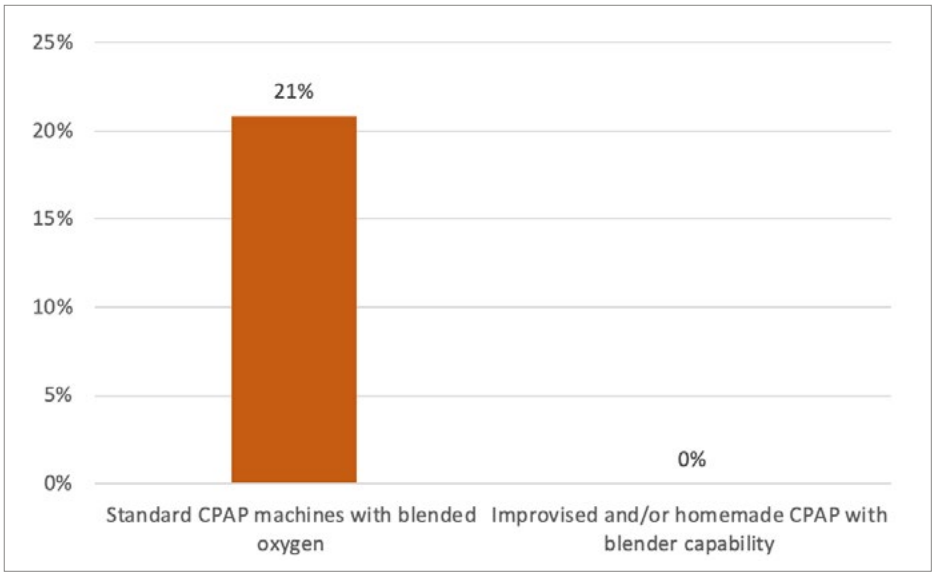

Figure 3 Availability of CPAP machines with blended oxygen in hospitals (n = 24)

Findings

At the time of the assessment survey, CPAP machines were available and functional only in hospitals. However, none of the hospitals had sufficient CPAP devices to cover all babies who require respiratory support. As shown in Figure 2, of the 24 hospitals studied, 21 percent had a standard CPAP driver system with blended oxygen, 29 percent had a bubble CPAP driver system, and 38 percent had an improvised/homemade CPAP machine. Table 3 in Appendix 2 shows a list of nine facilities with improvised/homemade CPAP.

Some hospitals reported having improvised CPAP with blending capabilities. These hospitals gave a thorough description of the devices: Staff attach the inlet of a flowmeter to the oxygen plant or oxygen concentrator and set the desired flow rate. The outlet of the flowmeter is then connected to the oxygen-delivery tube. Oxygen is provided through a three-way tap into a bottle filled with distilled water. The oxygen from the bottle then moves through the three-way tap into a nasal prong to the patient for delivery.

The study team, however, determined from this description and follow-up verification that there was no use of a blender in their improvised CPAP devices. Blending capabilities require the availability of both medical air and oxygen and a blender to mix or blend the oxygen with the medical air. Because there was no blender available,

the facilities cannot be said to have blending capabilities (see Figure 3). This highlights a knowledge gap among health facilities on the use of improvised CPAP with blending capabilities.

In the Northern Region, 27 percent of the hospitals had standard CPAP available, but the CPAP machines were nonfunctional in 50 percent of these facilities; bubble CPAP and improvised/homemade CPAP were each available in 20 percent of hospitals. In the Upper West Region, 33 percent of hospitals had available and functional standard CPAP; 67 percent had bubble CPAP, of which 33 percent were nonfunctional; and 33 percent had improvised/homemade CPAP. (See Figures 39, 47, and 48 in Appendix 2)

The above findings show that most hospitals are unable to care adequately for newborns in need of oxygen therapy/respiratory support – for instance, in cases of respiratory distress syndrome or other associated respiratory diseases. For those that provide care for such babies without CPAP, this is an essential area where significant improvement is needed.

3.2.2 Use of walled/piped oxygen

Context

The advantages of using walled/piped oxygen as an oxygen source are that it is convenient, continuous, safe, and rapid oxygen delivery. It is also cost-effective, eliminating the need for frequent cylinder refills and the need for handling and transporting heavy cylinders. Walled/piped oxygen is more environmentally friendly than oxygen cylinders, as it reduces the use of non-renewable resources and eliminates the need for cylinder disposal.

Findings

The following physical areas of the facilities were assessed for availability of walled/piped oxygen: the special baby care unit, NICU, operating theatre, labor/delivery unit, recovery room, and post-natal unit.

As shown in Figure 4, only hospitals had walled/piped oxygen. Seven of the 51 total facilities (13.7 percent) assessed indicated

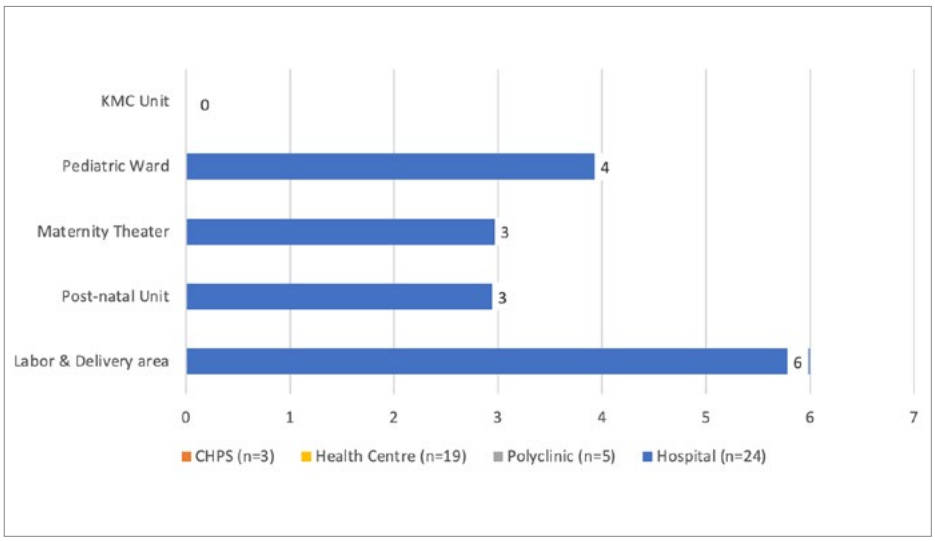

Figure 4 Availability of physical areas in facilities with walled oxygen per facility type

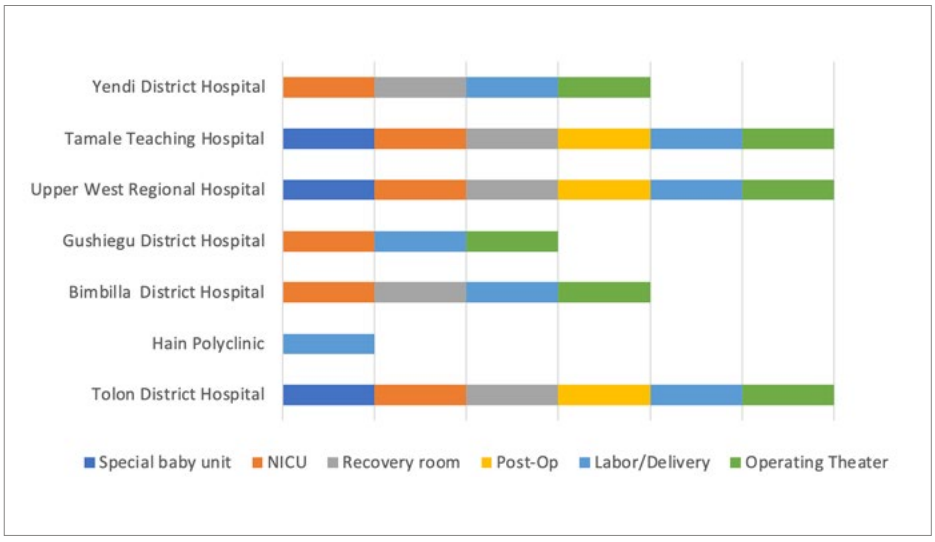

Figure 5 Availability of walled/piped oxygen in facilities and physical areas

availability of walled/piped oxygen. Six hospitals had walled/piped oxygen in the labor/delivery unit and four in the pediatric ward, followed by three in both the maternity theatre and the post-natal unit. Three hospitals had walled/piped oxygen in all the physical areas assessed. All seven facilities had walled/piped oxygen in the labor/delivery unit. Six hospitals had walled/piped oxygen in both the operating theatre and the NICU, while five out of the seven had walled/piped oxygen in the recovery room. One polyclinic had walled/piped oxygen in the labor and delivery room alone. Figure 5 identifies the seven facilities and their physical areas where walled/piped oxygen was available. Walled/piped oxygen in the neonatal units was found in Tamale Teaching Hospital, Upper West Regional Hospital, the district hospitals in Bimbila, Gushegu, Tolon, and Yendi, and Hain Polyclinic.

In the neonatal units, oxygen wall outlets/ports were found in all six hospitals with walled/piped oxygen but with varied numbers. Tamale Teaching Hospital had as many as 30 oxygen wall outlets/ports in its neonatal unit, whereas Gushegu Hospital had only two. All three special baby care units found had walled/piped oxygen.

A significant proportion of all facilities (81 percent) assessed lacked walled/piped oxygen in the neonatal unit. Few of the facilities (19 percent) had walled/piped medical air at the neonatal unit (shown in Figure 6). Among all facility types assessed, only six hospitals had walled/piped oxygen in the neonatal unit. Polyclinics, which provide services similar to those of hospitals, had only one neonatal unit with walled/piped oxygen available.

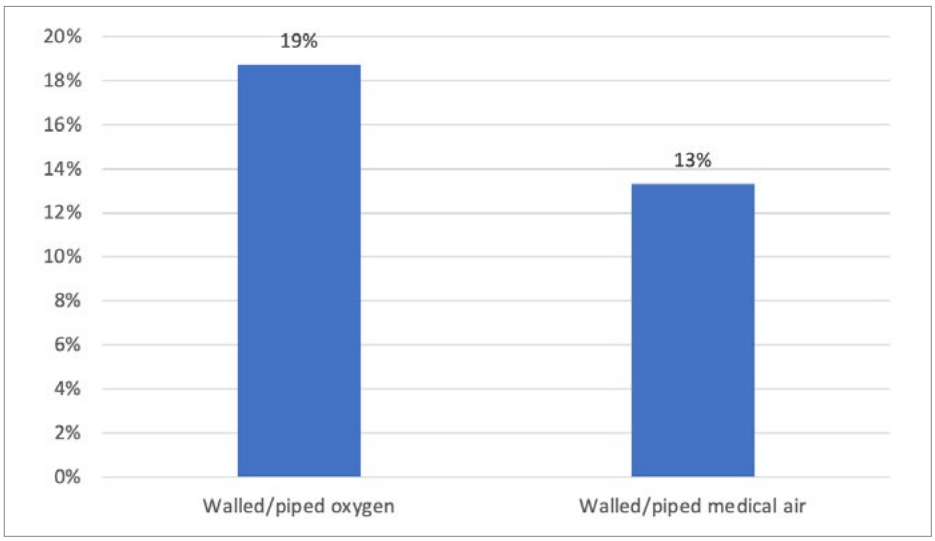

Figure 6 Availability of walled/piped oxygen/medical air in the neonatal unit

3.2.3 Sources of oxygen supply

Context

PSA, bulk liquid oxygen tank, oxygen concentrators, and oxygen cylinders are all methods for producing or storing oxygen. PSA is a technology used to separate a mixture of gases into its individual components. It is a cost-effective and energy-efficient method for producing oxygen on demand.

Bulk liquid oxygen tanks can store large quantities of oxygen, making them ideal for hospitals and other medical facilities. They are a reliable source of oxygen, as they can provide a constant supply for extended periods of time. They are also easy to refill and maintain. The only bulk oxygen tank found during the study was nonfunctional.

Despite the ease and effectiveness of PSA and bulk liquid oxygen tanks in producing or storing oxygen, only a few hospitals can afford them. Most hospitals and polyclinics rely on oxygen cylinders and oxygen concentrators as the main source of oxygen.

Oxygen concentrators work by taking in air from the surrounding environment, filtering out nitrogen and other gases, and delivering concentrated oxygen to the user through a nasal cannula or mask. Figure 7 below lists the facilities and their oxygen sources.

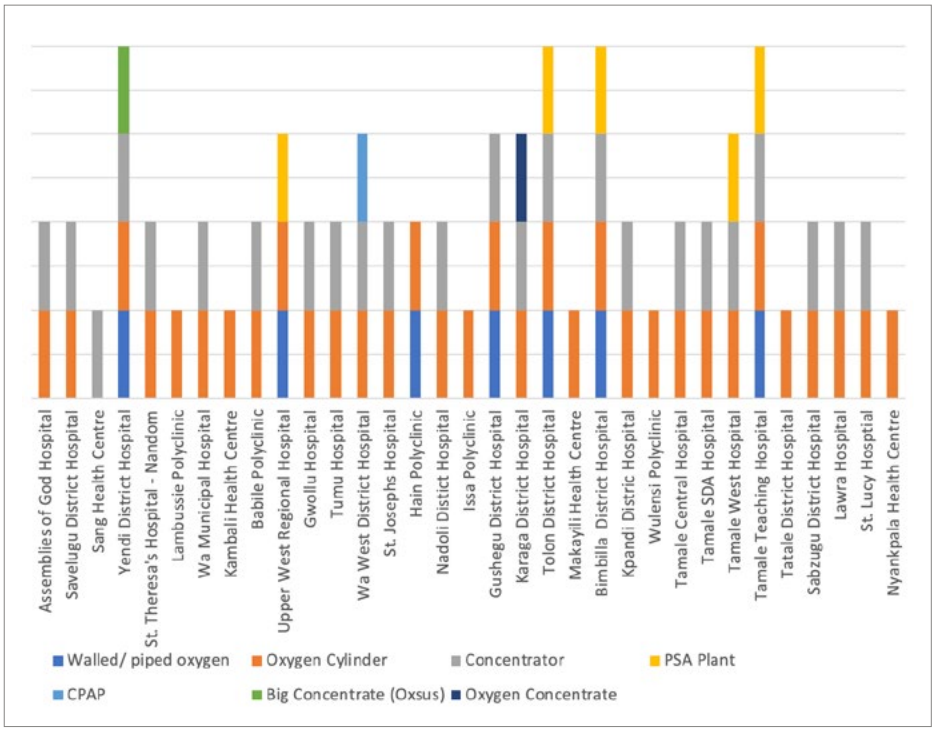

Figure 7 Names of facilities and their oxygen sources

Findings

The sources of oxygen supply for health facilities studied are as follows: All the hospitals assessed had oxygen cylinders, while 88 percent had oxygen concentrators. Nearly 20 percent had pressure swing adsorption (PSA) as an alternative source of oxygen supply, while 4 percent had bulk liquid oxygen tanks available. Of the five polyclinics assessed, all had oxygen cylinders but less than one-third had concentrators. Oxygen cylinders were the only source of oxygen in health centers, but they were found in only 16 percent of health centers overall.

As shown in Figure 8, no health centers have oxygen concentrators; therefore, it may be deduced that these babies are receiving 100 percent oxygen. None of the CHPS compounds had oxygen available at the time of the survey, also as shown in Figure 8.

The availability and functionality of oxygen concentrators were assessed across the facilities listed in Figure 9. A total of 35 oxygen concentrators were found across 19 hospitals, 27 of which were functional at the time of the visit. Tamale West Hospital had five oxygen concentrators, three of which were functional. This is followed by Tumu and Karaga District Hospital (with three concentrators each but two nonfunctional for Tumu and one nonfunctional for Karaga). Two hospitals were identified with one or two oxygen concentrators, none of which were functional at the time of visit. Nonfunctioning oxygen concentrators could be attributed to lack of replacement parts, lack of training, and poor maintenance culture, which may impact the quality of care provided for SSNBs. A number of oxygen concentrators had broken down and were taken for repair.

Oxygen cylinders were the most common source of oxygen for hospitals, polyclinics, and health centers. Portable oxygen cylinders play an important role in transporting patients during referral. They are also a reliable source of oxygen, as long as they are properly maintained and refilled. However, due to the high risk to patients, especially when blenders are not readily available, oxygen cylinders are one of the least convenient oxygen sources to use. Use of huge cylinders at the neonatal units must be discouraged, as they can easily fall and make the units unsafe for health delivery.

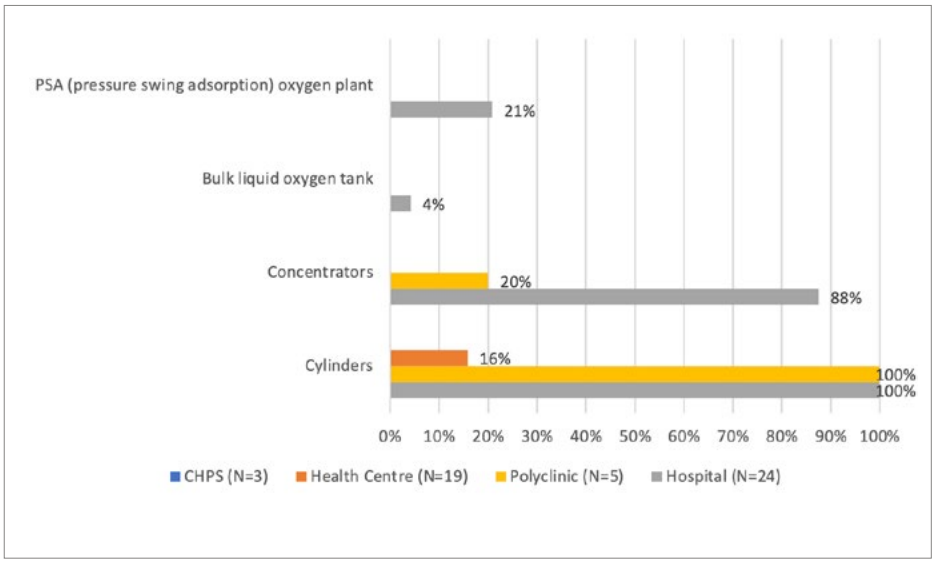

Figure 8 Availability of oxygen sources by facility type

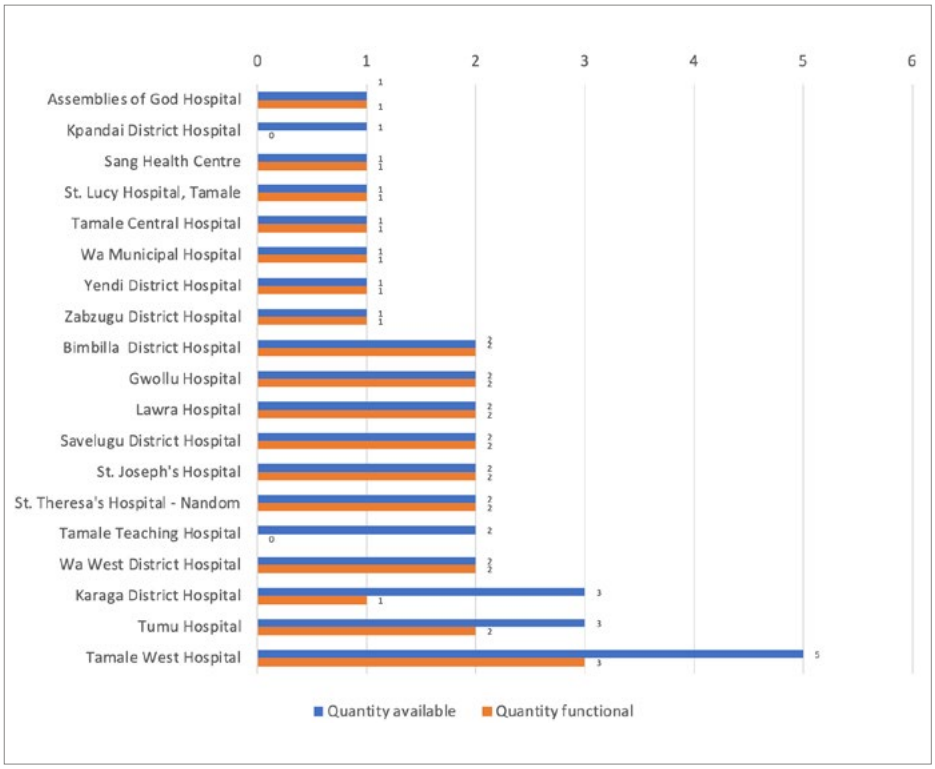

Figure 9 Number of oxygen concentrators available and functional in neonatal units

3.2.4 Oxygen purity

Oxygen concentrators are required to produce oxygen of standard purity. Oxygen purity for oxygen concentrators was assessed in 18 hospitals (see Appendix 3, Figure 49 for full findings). The median oxygen purity was 95 percent with a range from 19 percent to 97 percent. Standard purity below 88 percent may be due to improper preventive and corrective maintenance. Preventive maintenance such as routine check of oxygen purity using oxygen analyzer was absent. Other oxygen sources (cylinders and PSA) found in the Northern Region were randomly selected and measured for their oxygen purity. The

result is presented in Appendix 3, Figure 55.

3.2.5 Pulse oximeter and resuscitation equipment

Pulse oximeter is a device that noninvasively provides continuous information about the peripheral oxygen saturation (SpO2) rate. This device is used in detecting hypoxemia, due to its ability to sense changes in hemoglobin oxygen saturation. Facilities in Ghana use three common types of SpO2 devices: fingertip, handheld, and bedside SpO2. Fingertip SpO2 probes are the most common in most facilities because they are cheaper to obtain. However, they are less durable, so facilities run short of probes easily and this shortage can affect health care delivery. It is recommended that handheld and bedside SpO2 machines be the standard for maternal and pediatric health care delivery since they can last longer for facilities with a high turnover of sick babies.

Figure 10 shows the availability of pulse oximeters for neonatal care per facility type: 54 percent of hospitals, 5 percent of health centers, and 33 percent of CHPS compounds had functional pulse oximeters available at the time of visit. Pulse oximeters were not available in neonatal units in the polyclinics at the time of visit, but were observed in other physical areas of the facilities.

Resuscitation devices were found at most facilities but at levels that were inadequate and inconsistent across sites. Generally, resuscitation devices across the two regions were inadequate.

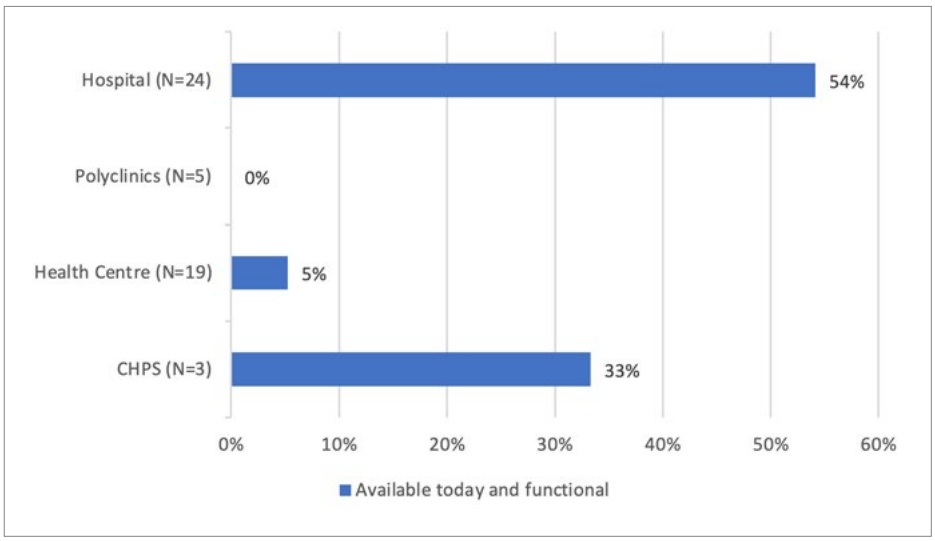

Figure 10 Availability of pulse oximeters for neonatal care per facility type

> "I know some time ago JICA [Japan International Cooperation Agency] gave us some Ambu bags but they are not sufficient for all the facilities. This is because more CHP zones have been established and other facilities have also been made functional after JICA's donations. So they are not adequate."
> — Key informant, CHPS

> "We had two...that broke down, which were donated by an individual. Since it broke down, nothing has been done about it. We are keeping it for repairs, but equipment can't easily be repaired like that. We don't have the technical know-how to do that."— Key informant, Health Center

A total of 16 pulse oximeters were available in the labor and delivery units, followed by 15 in the NICU, 12 in the pediatric ward, and 8 in the post-natal unit. Two and three pulse oximeters were seen at the maternity theatre and KMC units, respectively.

Table 1 presents data on the availability of critical equipment and devices and their numbers in specific areas within facilities surveyed. Among the areas assessed (including labor and delivery, post-natal unit, general operating theatre, pediatric ward, KMC unit, and NICU), the labor/delivery unit and the NICU had the most available equipment. This included self-inflated neonatal resuscitation bag (36), neonatal-sized mask for preterm babies (26), oxygen cylinders (26), neonatal-sized mask for term babies (25) to CPAP (1) at the labor and delivery unit. The NICU had self-inflated neonatal resuscitation bag (26), neonatal-sized mask for preterm babies (23), oxygen cylinders (19), neonatal-sized mask for term babies (23) to CPAP (12).

The pediatric unit and the post-natal unit, respectively, followed, with in terms of the most available equipment. Maternity theatre and KMC units had the least equipment. Most facilities did not have a separate maternity theatre; instead, the general operating theatre was used for maternity cases. In the same way, KMC units were part of pediatric or postnatal units, with facilities using partitions to define areas for KMC activities. Some facilities move equipment across physical areas when it is needed in other areas. Some respondents expressed frustration at the scarcity of equipment, even in newly opened facilities. Others cited problems with broken equipment.

> "The problem has been lack of equipment, for instance, recently they created and opened this place for newborn care but we do not have equipment, not even resuscitation equipment."—Key informant

Availability of equipment/devices at the labor and delivery ward	Labor and delivery	Post natal unit	Maternal theatre	Pediatric unit	KMC unit	NICU
Blender	0	0	0	0	0	2
CPAP (bubble and standard)	1	1	0	3	0	12
Humidifier	17	6	2	14	2	14
Neonatal sized masks for preterm (size 0) babies	26	8	4	12	3	23
Neonatal sized masks for term (size 1) babies	25	9	4	15	3	23
Oxygen concentrator	11	7	3	16	2	17
Oxygen cylinder	26	11	6	22	3	19
Pulse oximeter	16	8	2	12	3	15
Radiant warmer	7	2	2	5	2	0
Self-inflating neonatal resuscitation bag (Ambu bag)	36	11	5	19	4	26
Suction penguin	23	9	3	11	6	22
Suction pump	18	7	3	12	1	13
Wall oxygen	6	3	3	4	0	6

Table 1 Availability of critical equipment and their numbers per physical area

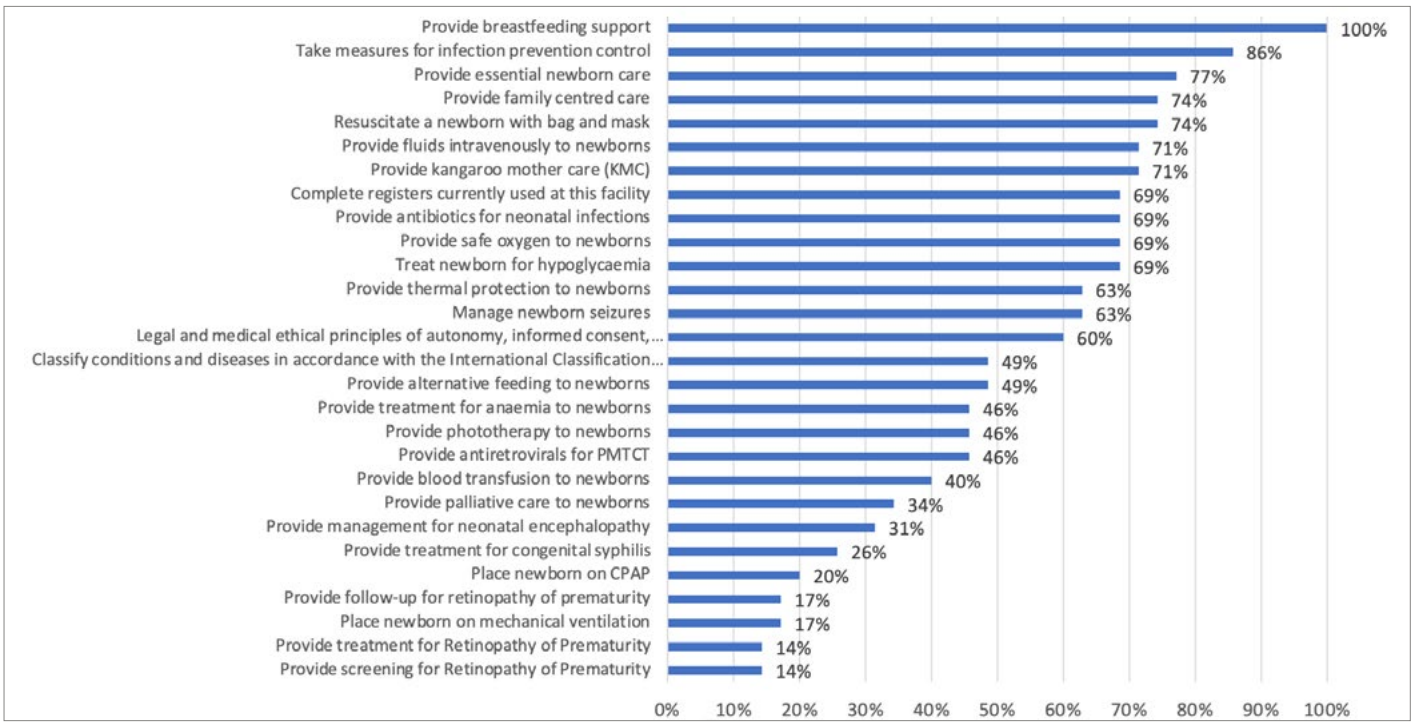

Figure 11 Neonatal care services provided in the four weeks prior to the survey

3.3 Neonatal services

To prevent infant mortality and morbidity, some facilities used a kangaroo mother intervention strategy, while some improved their referral systems and reduced services cost for caregivers to be able to afford the services provided to their small and sick newborns. On-the-job training of staff on how to properly use newborn equipment, such as the resuscitation device, increased education on personal hygiene and breastfeeding, and increased immunization were some of the strategies facilities adopted to help prevent infant child morbidity and mortality.

Figure 11 details the neonatal services provided across all facilities within the four weeks prior to the survey. All the facilities assessed provide breastfeeding support. Eighty-six percent had put in place IPC measures, while 74 percent provide some form of family-centered care and administered intravenous fluids to newborns. Overall, more than two-thirds of the facilities provide one or more neonatal service, in the following proportions: management of neonatal encephalopathy (31 percent), blood transfusion for newborns (40 percent), phototherapy (46 percent), alternative feeding for newborns (49 percent), legal and medical ethical principles of autonomy/informed consent (60 percent), thermal protection for newborns (63 percent), and safe oxygen supply to newborns (69 percent). Other services provided are listed in Figure 11.

> "CHPs, health centers, polyclinics, and hospitals all provide service for small and sick newborn babies, depending on the condition… If a child is sick or a newborn has a problem at the community level, they attend to them by referring to the next level for continuity of care if it is beyond their management."—Key informant

In terms of service provision for the care of SSNBs, the research team found that some facilities provided all levels of care. A few facilities provided some form of care while others referred to a higher level of newborn care.

Barriers to the care of SSNBs in the health facilities studied included human resource capacity and unavailability of equipment (including broken equipment), as identified by respondents at the facilities.

> "Even some of the health centers, due to capacity issues are not able to provide services for small and sick newborns."
> —Key informant

Please refer to Appendix 9 for the summary findings of key informant interviews.

3.4 Neonatal unit electricity supply

3.4.1 Availability and use of back-up electrical power

Figure 12 shows the availability of back-up electrical power supply to facilities. While 62 percent of facilities had fuel-operated generators, 8 percent and 3 percent had solar-powered and battery-powered inverters, respectively, as back-up electrical supply. The solar- or battery-powered inverters were being used to power the following equipment: incubator, radiant warmer, phototherapy light, syringe pump, suction pump, and CPAP. In one of the facilities, solar back-up power was used to power the facility's refrigerator for vaccines. This initiative will significantly ensure safety of vaccines for newborns given the lack of constant power supply.

Figure 13 shows the distribution of equipment types covered by the generator. More than two-thirds (86 percent) of facilities were using it to operate a phototherapy light; very few had it for other uses. Facilities that were using it for syringe pump and CPAPs were few (33 percent for both syringe pump and CPAPs). Overall, more than half of the facilities were using the generator for radiant warmer (81 percent), oxygen concentrator (81 percent), incubator (71 percent), or suction pump (71 percent).

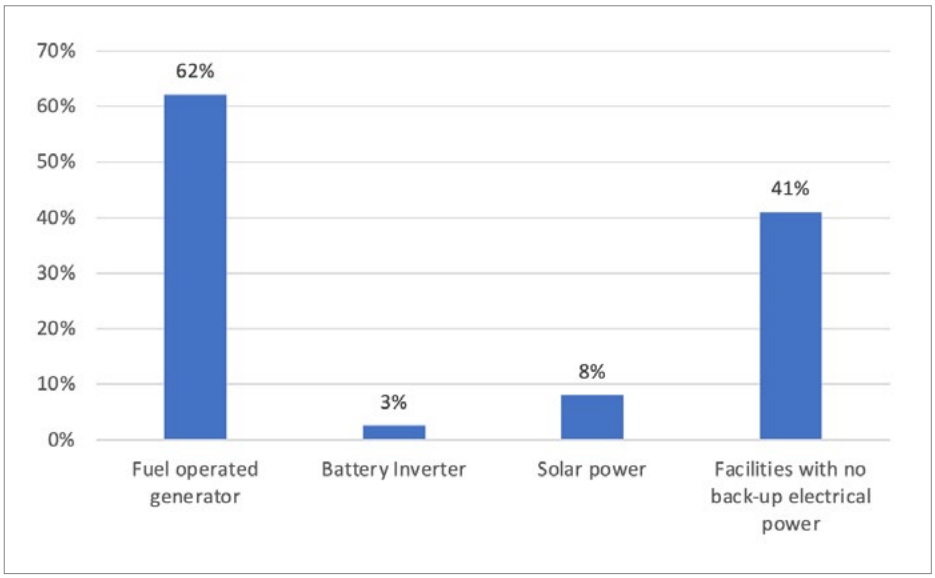

Figure 12 Availability of back-up electrical power for facilities

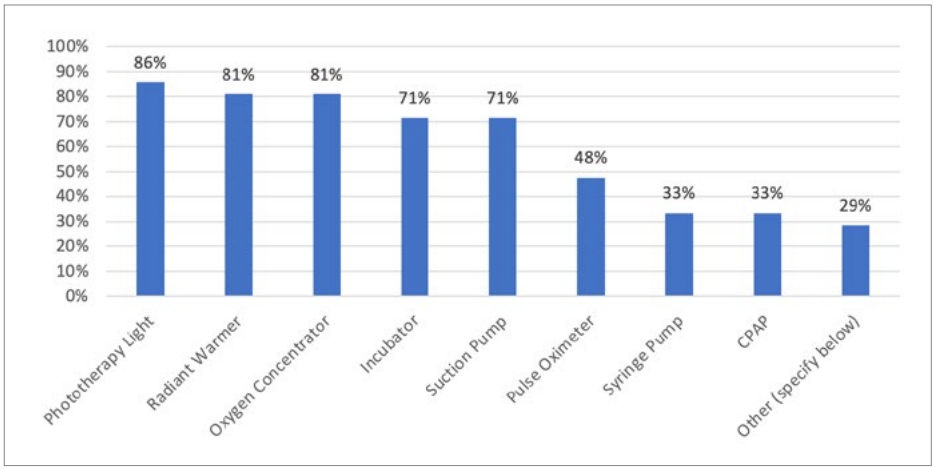

Figure 13 Types of equipment covered by fuel-operated generator

3.4.2 Mitigation plan against power surge and the impact of power outages

The research team assessed strategies to mitigate power surges in the facilities. These factors are presented in Figure 14. While a significant proportion (81 percent) of facilities did not have running cables on the floor, less than 10 percent had electrical load certification conducted within the past 12 months. Overall, about half of the facilities with appropriate power supply amperage (46 percent) also had a voltage stabilizer (43 percent).

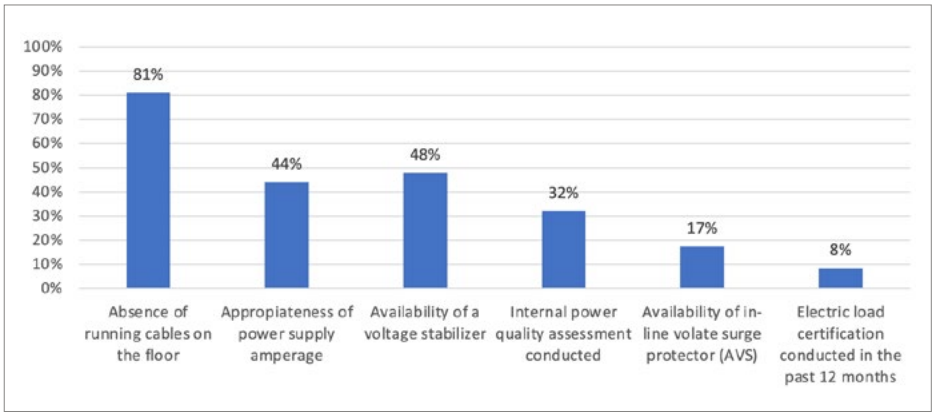

Figure 14 Mitigation against power surges

Regarding the impact of power outage on operations at neonatal units, only 12 percent (Figure 15) of facilities reported no impact of power outage on their operations, either because there was no recent outage, or because backup power prevented service disruption.

3.5 Basis for admissions, management, assessment, and discharge of newborns

Figure 16 presents data on the reason for admitting a newborn to the neonatal unit. Respiratory distress, high risk of infection, hypoglycemia, asphyxia, and low birthweight and gestational age were the main reasons for admissions. More than two-thirds of all facilities reported these factors as the basis for admitting a newborn. These were followed by jaundice, special needs, and macrosomia. Facilities also mentioned other reasons as contributory factors to newborn admissions, including bleeding post-circumcision, mothers with psychosis, congenital abnormalities and malaria, prematurity, newborn anemia, and post-operative care for intestinal obstruction.

Figure 17 presents the distribution of the cadre of staff responsible for assessing and discharging newborns. For all facilities assessed, 34 percent indicated that midwives were responsible for assessing and discharging newborns, 26 percent mentioned general nurses, and 19 percent reported that pediatric/neonatal nurses were responsible for newborn assessment and discharge. Given the specialty area of newborn care, midwives and general nurses need to be adequately trained to perform the responsibilities of assessing and discharging newborns. All cadres of staff need training in newborn care to enhance service delivery.

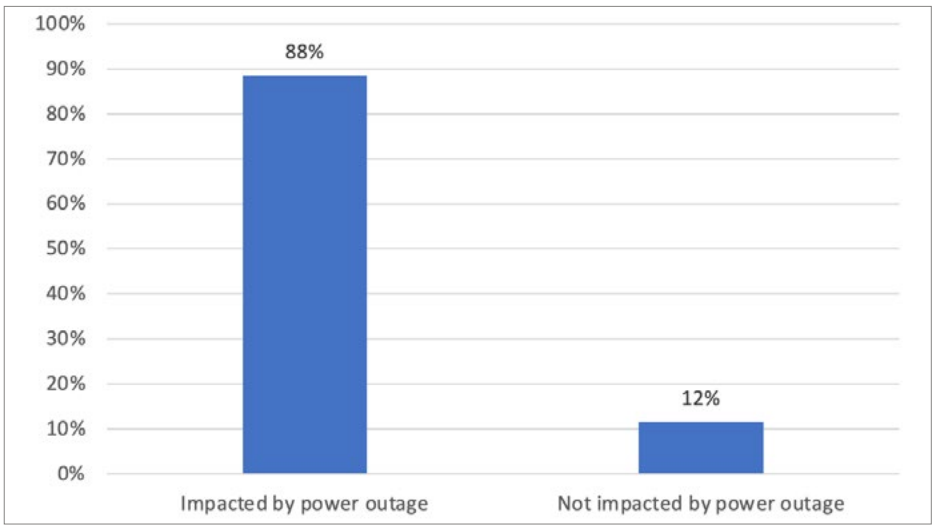

Figure 15 *Facilities with neonatal units impacted by power outage*

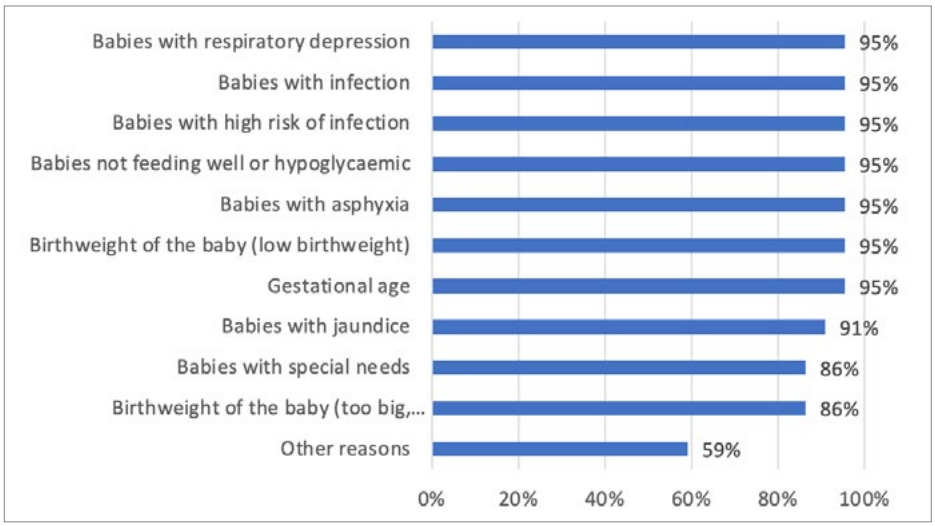

Figure 16 *Basis for admitting newborns into the neonatal care unit*

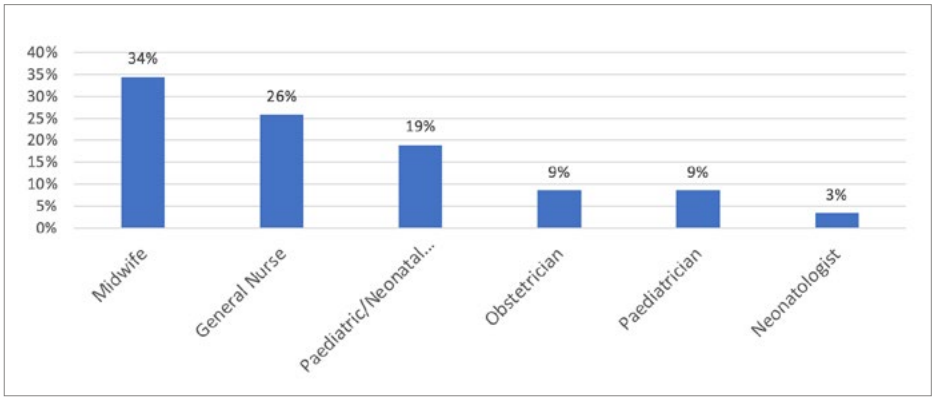

Figure 17 *Category of staff responsible for assessing and discharging newborns*

3.6 Infection prevention and control and waste management

Figure 18 presents results of IPC practices in the neonatal unit. Availability of waste containers at waste generation points, functional hand hygiene stations, hand hygiene protocols, written protocol for chlorine preparation, chorine disinfection, and appropriately maintained equipment for cleaning were the predominant practices reported by facilities for IPC. Other factors, such as appropriate segregation of waste, implementation of cleaning protocol, and existence of records on the cleaning of patients' care areas were also mentioned. Even though 66 percent of facilities had available running water on the labor and delivery ward at the time of the survey, none of the facilities reported uninterrupted supply of running water throughout the year (0 percent).

Regarding sources of water, a significant number of facilities reported obtaining their water supply from these sources: piped water from the municipality (79 percent); borehole—electric pump (69 percent); overhead storage (31 percent); and borehole—hand pump (31 percent). A few of the facilities mentioned other water supply sources, as shown in Figure 19.

Infectious waste management and disposal are a critical component for IPC. Of the facilities surveyed, 45 percent reported using an incinerator as a means of waste disposal while 40 percent used a burning pit. The remaining facilities use the municipal assembly's landfill site for infectious waste disposal (Figure 20).

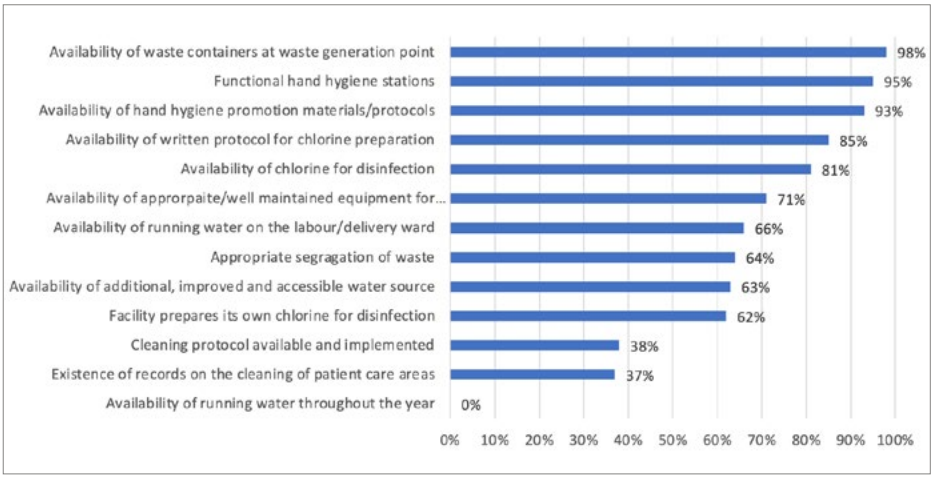

Figure 18 Infection prevention and control

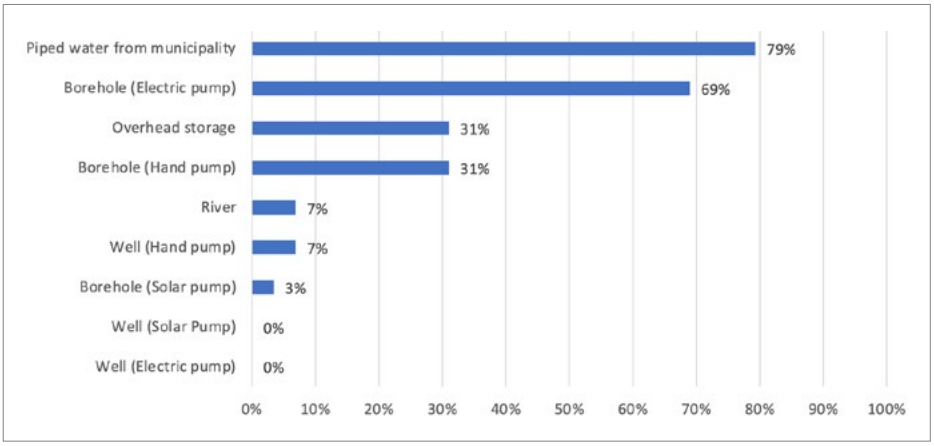

Figure 19 Sources of water available in facilities

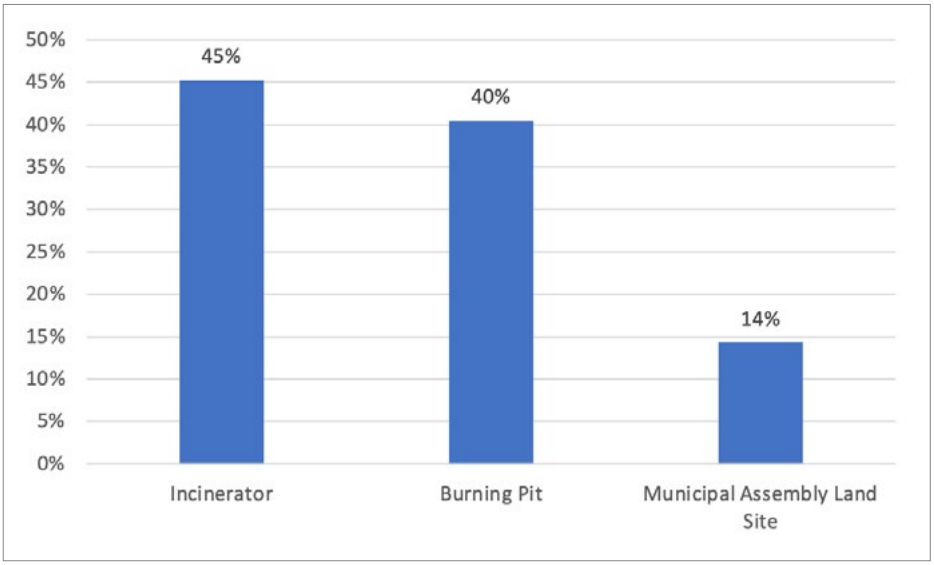

Figure 20 Method of managing and disposing infectious waste at the neonatal unit

3.7 Inventory and forecasting of consumables at the neonatal unit

Some facilities had procurement plans specific for purchasing newborn devices, consumables, and accessories; others had a procurement plan but not specific for newborn care; and some facilities did not have any procurement plan.

Figure 21 presents data on the availability of inventory registers at the neonatal unit. Across all facilities surveyed, 70 percent had a register/system in place to capture data on inventory of consumables; 50 percent conduct inventory counts for consumables at least once a week. The remaining facilities perform inventory counts either once a month (11 percent), once a day (21 percent), or on an irregular basis (18 percent), as shown in Figure 22.

Regarding the ordering frequency for consumables, almost half of facilities usually place orders at least once a week before running out of stock. A few of the facilities (3 percent) place orders once a month before running out of stock, and one-third place their orders when they completely run out of stock (Figure 23). This raises concern about the availability of consumables, and the potential impact on the quality of newborn care in the neonatal unit.

Medical devices and accessories for some facilities were procured at the national level; some support came from donors, including government, private NGOs, and individual donors. Some facilities procured some of their devices while others were obtained per request from medical stores or purchase on the open market.

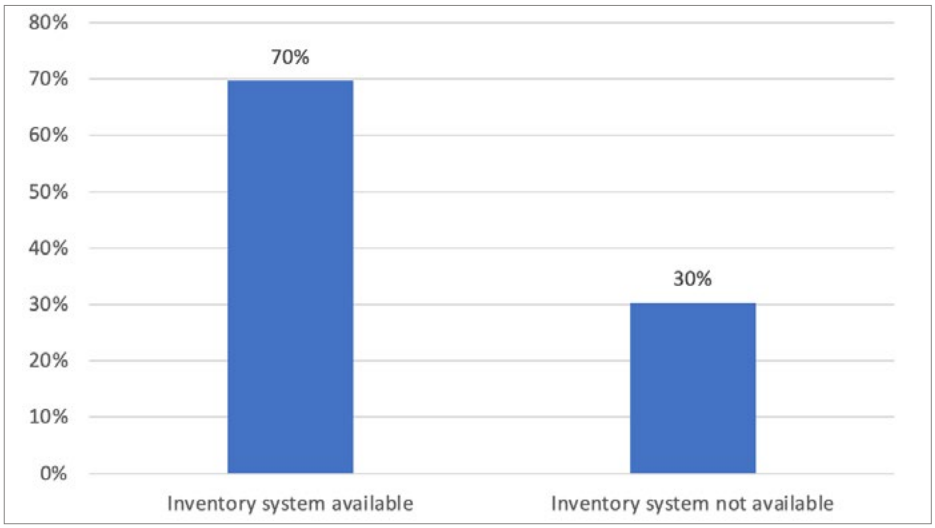

Figure 21 Availability of consumables inventory register/system at the neonatal unit

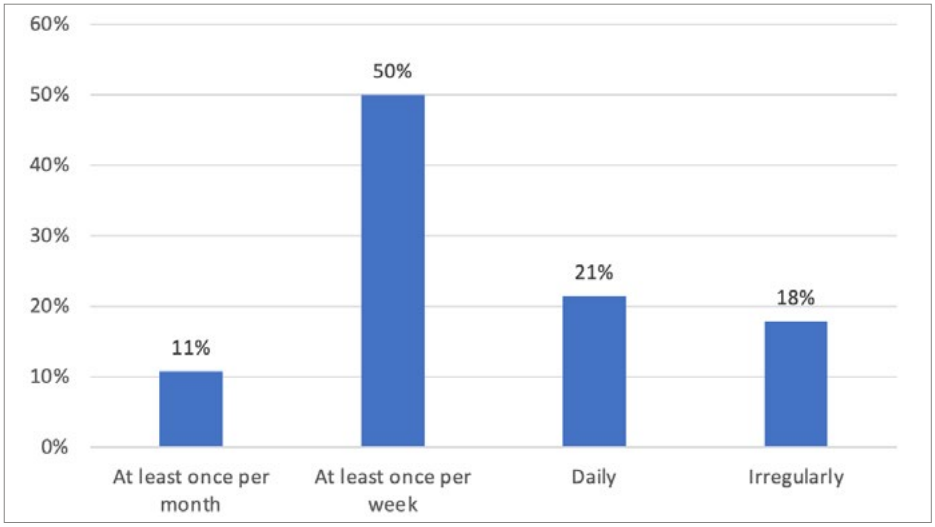

Figure 22 Frequency of inventory count for consumables at neonatal unit

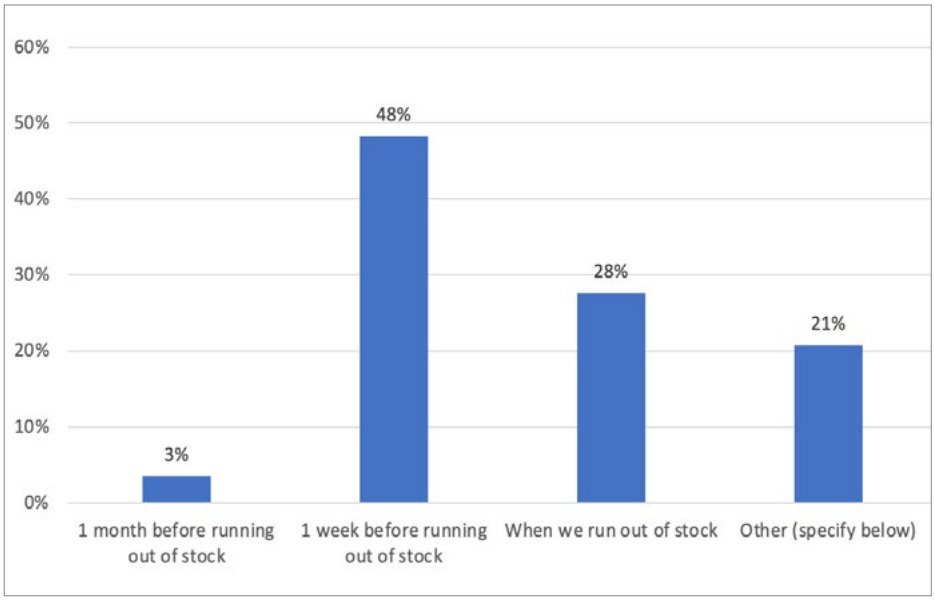

Figure 23 Ordering frequency for consumables at neonatal unit

3.8 Newborn care supplies

Medical devices and accessories for some facilities were procured at the national level, and some support came from donors, including the government, private nongovernmental organizations (NGOs), and individual donors. Some facilities procured some of their devices, and others were obtained per request from medical store or purchase from the open market.

Figure 24 presents data on the availability of devices/equipment for newborn care. Across all the devices/equipment assessed, neonatal-size face masks (size 1), neonatal-size face mask–preterm (size 0), self-inflating bag (neonatal size), and oxygen bottled/cylinder were predominantly available and functional in 50–70 percent of facilities. Nearly 60 percent of facilities did not have pulse oximeters, neonatal-size pulse oximetry probes, battery rechargers, patient monitors, oxygen humidifiers, and suction pumps, respectively. Also, only a few facilities (ranging from 3 percent to 6 percent) had indirect ophthalmoscope, oxygen blenders, respiratory rate monitors, and T piece resuscitators. None of the facilities had an apnea monitor available at the time of the visit. A few facilities reported "available" but nonfunctional equipment (including bubble CPAP, standard CPAP, oxygen humidifiers, concentrators, and bottled/cylinder, neonatal face mask (size 0,1) as well as pulse oximetry probes). The nonfunctional equipment could indicate inadequate care, lack of training, and poor maintenance, which may impair the quality of respiratory care provided for SSNBs.

Neonatal-size pulse oximetry probes were unavailable in 16 facilities in the Northern Region and 15 in the Upper West Region. In the Northern Region, 10 facilities had used pulse oximetry for neonates on respiratory support within the last four weeks; seven facilities in the Upper West Region had done the same.

Battery rechargers were available in three facilities in the Northern Region and two facilities in the Upper West Regions.

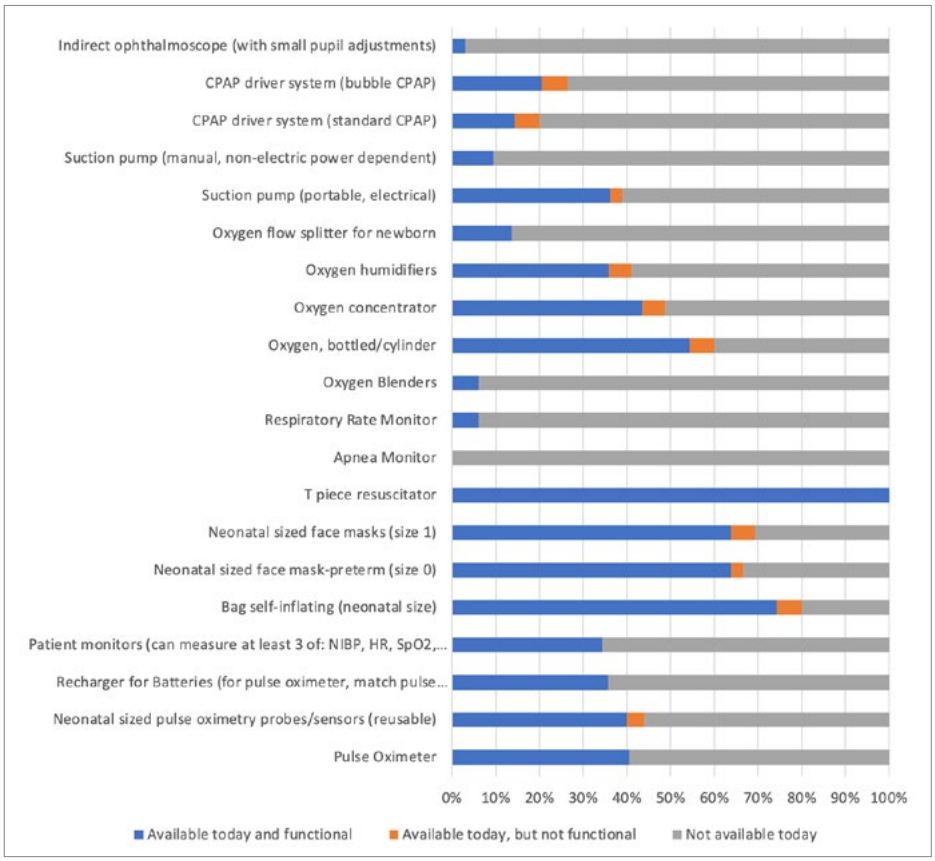

Figure 24 Availability of devices/equipment for newborn care

Pressure regulators were stocked in four facilities in the Northern Region, with one facility experiencing stockout in the last month. In the Upper West Region, only two facilities stocked pressure regulators.

The number of facilities in the Northern and Upper West Regions with stop valve was four (one facility had a recent stockout) and one, respectively.

Across both regions, four facilities each had cap and pressure gauge: three in the Northern Region and one in the Upper West Region for each device.

Oxygen devices and accessories are used to deliver good-quality oxygen to patients. Oxygen concentrators and cylinders provide a source of oxygen to be delivered through patient interfaces such as the nasal cannula, face mask, and nasal prong. The oxygen blenders mix oxygen with compressed air to reduce unrestricted oxygen delivery, which may lead to hyperoxia. Flow splitters also help to supply oxygen from one source to multiple independent outlets.

Of 34 facilities in the Northern Region, 10 facilities had 1-mm size and 9 had 2-mm size nasal prongs readily available on the day of visit. Face masks, Hudson prong, regular standard cannula, and other nasal interfaces were available in 21 percent, 18 percent, 47 percent, and 6 percent of the facilities, respectively. Oxygen blenders and cylinders were available in two and 11 facilities, respectively, with two facilities having nonfunctional cylinders. Out of the 11 facilities with oxygen cylinders, three had the 1.5, 4.5, and 7 cubic meter sizes while six had the 6 cubic meter size. Oxygen humidifiers were available in 11 facilities with two facilities having nonfunctional ones. Eighty-eight percent of the facilities had oxygen concentrators and 10 percent of these facilities had filters for them. Oxygen humidifiers were unavailable in 100 percent of the facilities in the Northern Region. Flow splitters were available in two facilities. Oxygen cannulas

were stocked by seven facilities, three of which had experienced stockout in the last month. Of the 34 facilities, 38 percent had administered oxygen therapy to neonates within the last weeks.

In the Upper West Region, eight facilities each had 1-mm and 2-mm size nasal prongs; 49 percent had face masks; 24 percent had Hudson prongs; and 29 percent had regular standard cannula. None of the facilities had oxygen blenders. Oxygen cylinders were available in 10 facilities: two facilities had the 1.5 and 3.0 cubic meter size while one, five, and three facilities had the 4.5-, 6-, and 7-cubic-meter sizes, respectively. A total 41 percent of the facilities had functional oxygen concentrators. About 29 percent of these facilities had labeled them with their maintenance schedules and 43 percent had filters for them. Only 3 percent of facilities had functional oxygen humidifiers and flow splitters. None of the seven facilities that stocked oxygen cannulas had experienced recent stockout. About 59 percent of the facilities had administered oxygen therapy to neonates within the last four weeks.

Suction pumps are used to remove fluids, mucus, etc. to keep the airways clear. Facilities in both regions had available and functional suction pumps—seven and six portable/electric and one and two manual/nonelectric dependent suction pumps in the Northern Region and Upper West Regions, respectively. Suction pump accessories were stocked in five facilities in the Northern Region and two facilities in the Upper West Region.

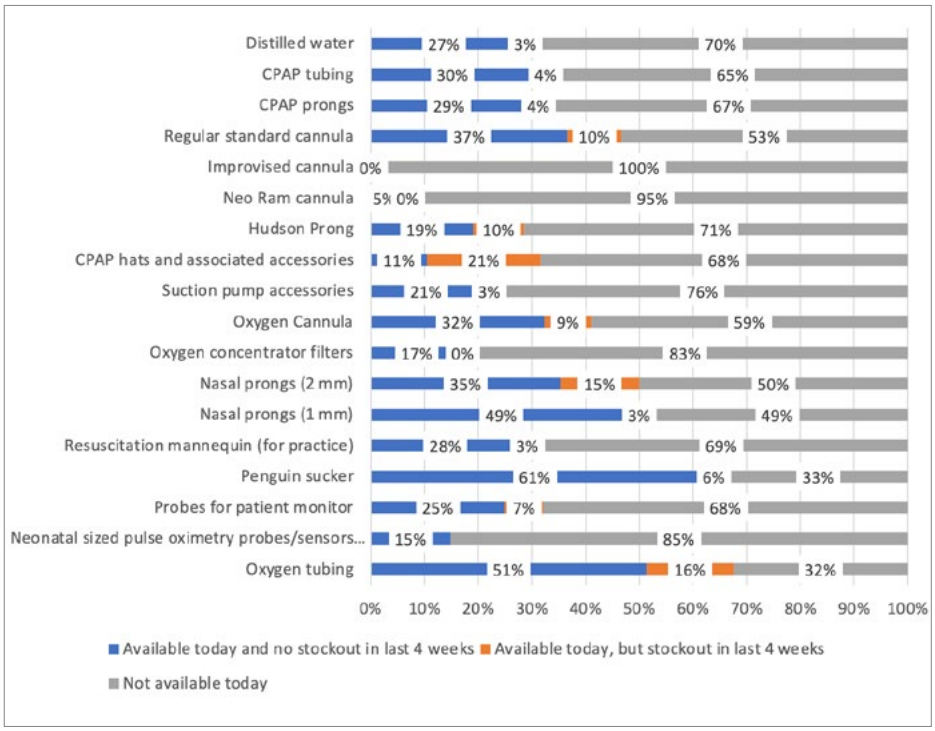

Figure 25 Availability of consumables for neonatal care

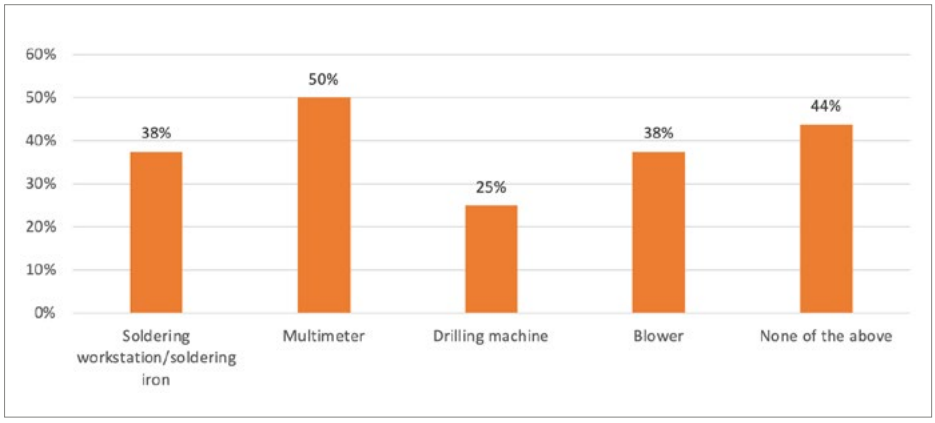

Figure 26 Availability of maintenance devices for newborn care equipment per facility type

3.9 Newborn consumables, safety analyzers, maintenance devices, basic tools, and attention to maintenance/repairs

3.9.1 Availability of consumables

Figure 25 presents information on the availability of consumables for neonatal care across all facilities. Among consumables, oxygen tubing, penguin sucker, and nasal prongs were the top available consumables that had not been stocked out for the past four weeks in the facilities (50 percent versus 61 percent versus 50 percent across all facilities).

3.9.2 Availability of maintenance devices for equipment

Maintenance devices for equipment were assessed; findings are presented in Figure 26 above. Soldering irons, drilling machines, multimeters, and blowers were the main devices whose availability was assessed. While 44 percent of facilities reported non-availability of any of these devices, 50 percent had multimeters, followed by soldering irons (38 percent), blowers (38 percent), and drilling machines (25 percent).

3.9.3 Availability of safety analyzers, and basic tools

Figure 27 presents information on the availability of safety analyzers. Oxygen analyzers were not available in any of the facilities at the time of visit. Of the facilities studied, 6 percent had phototherapy radiometers and gas flow analyzers, followed by gun thermometers (18 percent); 82 percent of facilities did not have any safety analyzers.

The study also assessed availability of basic tools, such as set of pliers, set of screwdrivers, adjustable spanner, tape measure, black tape, Allen key, and knife cutter. Findings are presented in Figures 28 and 29.

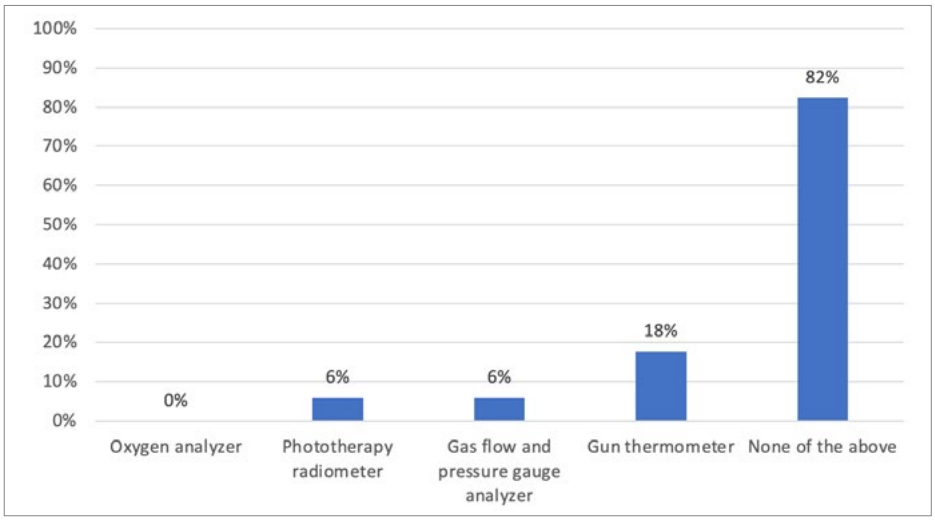

Figure 27 Availability of performance and safety analyzers

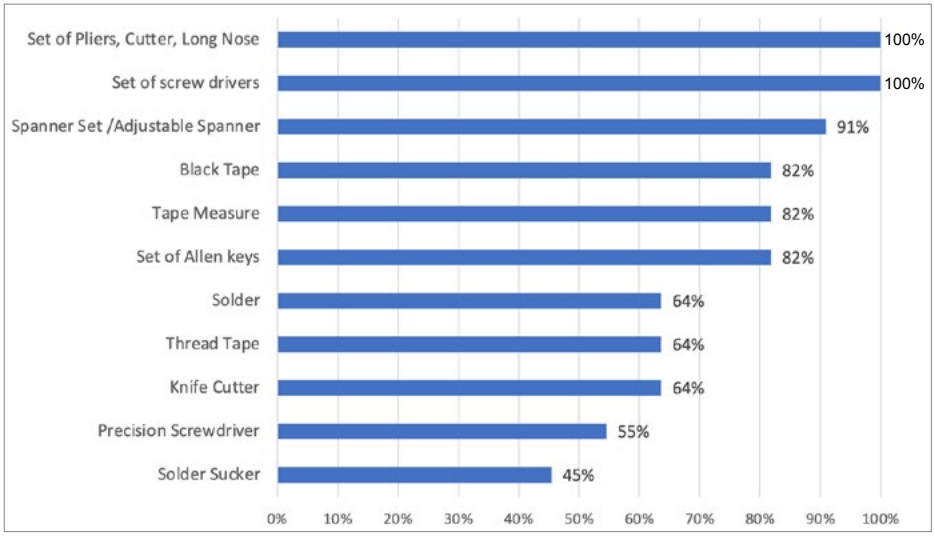

Figure 28 Availability of basic tools for maintenance per facility type

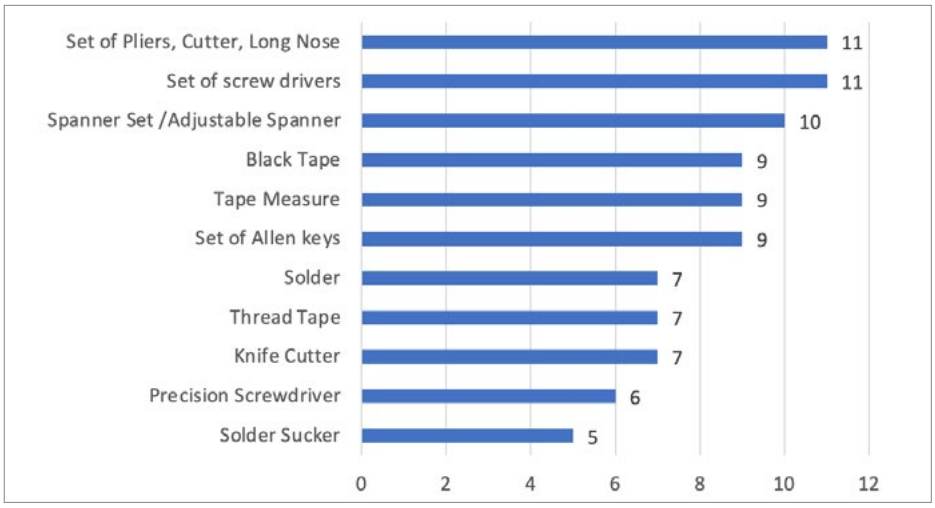

Figure 29 Availability of basic tools for maintenance by number of facilities

3.9.4 Attention to good maintenance

A good maintenance culture prolongs the lifespan of equipment, reduces the cost of repair and replacement of broken equipment, and ultimately ensures that essential equipment is always available for use in patient care. It requires relevant protocols, tools, and personnel.

Findings

In the Northern Region, 14.7 percent of facilities had dedicated workshop areas, 17.6 percent had a planned preventive maintenance system, 26.5 percent had corrective maintenance systems, 17.6 percent had a procurement plan for spare parts, and 5.9 percent had adequately equipped workshops. Assessed for the availability of maintenance tools, 5.9 percent of facilities had a soldering workshop/iron. Three facilities were each found to have multimeters, drilling machines, and blowers. Most facilities did not have performance and safety analyzers in their workshops. Only one facility had a phototherapy radiometer, gas flow and pressure gauge analyzer, and gun thermometer. Basic maintenance tools were available in the neonatal units of five facilities: five facilities had a screwdriver, two had Allen keys, five had precision screwdrivers, five had pliers/cutters/long nose, four had spanner sets, two had knife cutters, three had tape measures, four had black tape, two had thread tape, two had solder sucker, and three had solder. Of the facilities studied, 17.6 percent used a maintenance record-keeping book. Of those, 50 percent used spreadsheets, 33.3 percent used a conventional record book, and 16.7 percent used Lightwave Health Information Management System (LHIMS) record-keeping books. A total of 20.6 percent of facilities reported availability of funds for maintenance/repair of devices. A routine preventive management schedule was available in 17.6 percent of facilities, and 23.5 percent had personnel for corrective maintenance.

In the Upper West Region, no facilities had an adequately equipped workshop. However, 35.3 percent of facilities each had a dedicated workshop area, planned preventive maintenance systems, and a corrective maintenance system. A procurement plan for spare parts was available in 29.4 percent of facilities; 23.5 percent of facilities had soldering workshop iron; 35.3 percent had a multimeter; 5.9 percent had a drilling machine; and 17.6 percent had blowers. The only performance and safety analyzer available was the gun thermometer, which was found in 11.8 percent of facilities. Basic maintenance tools were present in the neonatal unit of 35.3 percent of facilities. All these facilities had screwdriver, pliers/cutters/long nose; 83.3 percent of facilities with basic tools had Allen keys, knife cutter, black tape, and thread tape. Only 16.7 percent of facilities with basic tools had precision screwdriver; 50 percent had solder sucker; and 66.7 percent had solder.

In the Upper West, 70.6 percent of facilities had some form of record-keeping book, including sections to monitor equipment maintenance: 25 percent of these facilities each used CMSS and spreadsheet, 33.3 percent used a conventional record book, and 8.3 percent used both LHIMS and other record books. Only 17.6 percent of facilities in the Upper West had available funds for maintenance/repair of devices. Only 11.8 percent of facilities in the Upper West had both personnel for corrective maintenance and routine preventive management schedule.

Discussion

Given the limited availability of maintenance tools and relevant record-keeping, it can be inferred that maintenance practices in the facilities in both study regions is not ideal. This raises questions about the quality of patient care in these facilities. In addition, shortfalls in maintenance record-keeping, which is important for preparing procurement plans, decommissioning, and tracking equipment downtime, have indirect effects on infant care, procurement, and evidence-based maintenance reporting.

3.10 Human resources

Some facilities lacked staff capable of providing specialized care and management of resuscitation devices as well as the ability to train staff to maintain these devices. There was also a lack of general training on how to maintain the equipment.

3.10.1 Capabilities by cadre: newborn care

The cadres of staff that can initiate care for newborn conditions were assessed; findings are presented in Figure 30. General nurses and general medical doctors were

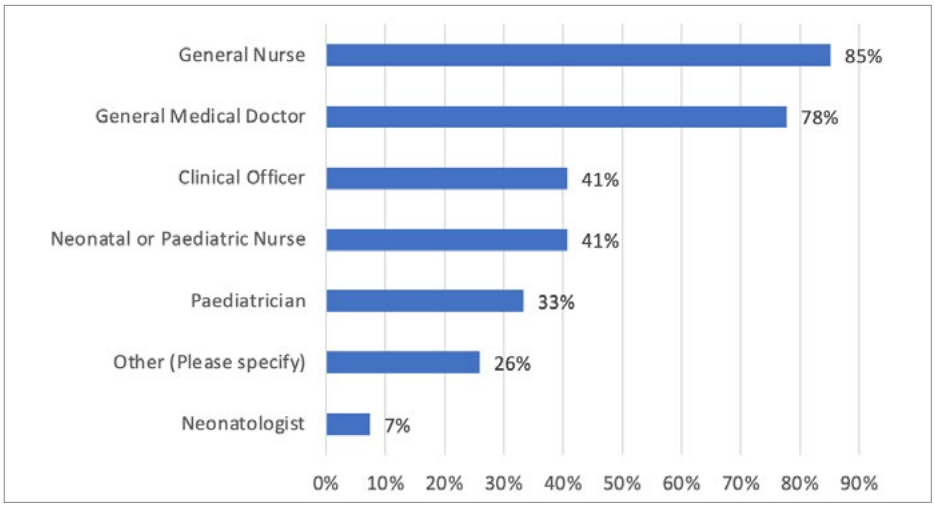

Figure 30 Cadres of staff that can initiate care for newborn conditions

found among the top two cadres of staff reported in 85 percent and 78 percent of facilities, respectively. Clinical officers and neonatal or pediatric nurse were also reported in about 40 percent of facilities. A few facilities also mentioned pediatrician (30 percent) and neonatologist (7 percent). The "other" cadre of staff was responsible for initiating newborn care in over one-quarter of the facilities.

Note that the statistics shown for the "category of staff that can initiate care for newborns" are comparable to those that are "responsible that can provide care and management of newborn conditions." The latter findings are shown in Figure 31 below.

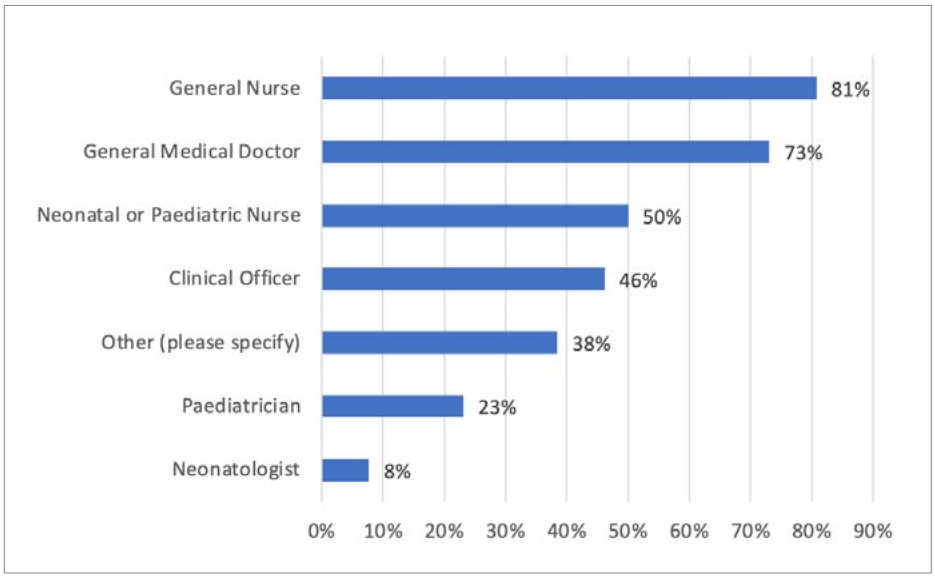

Figure 31 Cadres of staff that can provide care in the management of newborn conditions

The cadre of staff who provide care during transfer are paramedics and health care workers, as shown in Figure 32 below. About 30 percent of hospitals and polyclinics, 40 percent of health centers, and 50 percent of CHPS compounds indicated family members/ caregivers provide care during transfer. This circumstance points to the need to support the training of general nurses to effectively perform the role of pediatric nurses, to ensure adequate care for newborns during transfer. In general, the training of all health cadres is recommended for the adequate provision of care during transport of SSNBs.

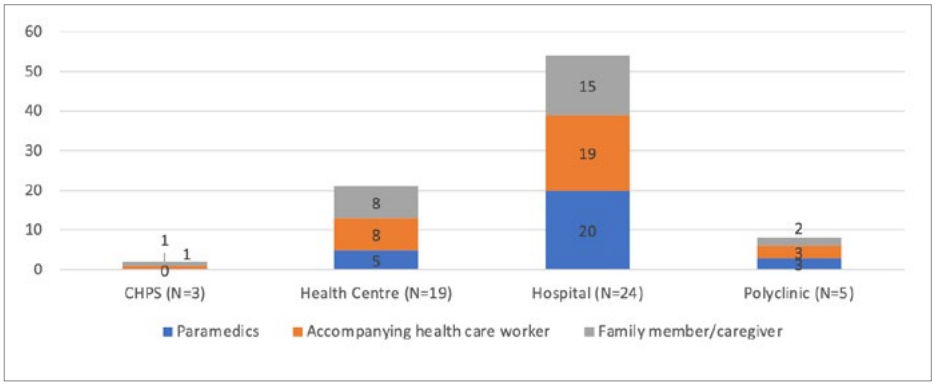

Figure 32 Cadres of personnel who provide care during transfer

3.10.2 Capacity building

Staff training overall is highly important. The ability of staff to operate devices determines the effective use of these devices and also how long they will last. Of the 34 facilities in the Northern Region, only three provided job training for staff; five of the 17 facilities in the Upper West Region provided it.

It is evident that staff training is poor in both regions; hence, poor device use and breakdowns are common in the facilities. One hospital assessed had a suction pump but none of the staff knew how to use it.

Most of the staff mentioned the need for more clinical experience and training.

Capacity building, including in-service and out-service training, was cited by key informants as a means of improving care for SSNBs.

> "One, we need to first of all build the capacity of the human resource because newborn care is a specialized area. It isn't anybody at all who can just go and start antenatal, and these are very vulnerable persons, so we need to build the capacity of these people and still provide regular in-service training, because medicine is dynamic and not static."—Key informant

3.10.3 Discipline tools to support service quality

Discipline in any work environment is key to ensuring good output. Having a system in place to report absenteeism will promote good work ethics and ensure that the ratio of staff to patient is favorable, leading to improved patient care and good outcomes.

In 20 facilities in the Northern Region, absenteeism is formally recorded: nine facilities notify senior management as well, while the other 11 facilities record only at the ward level. In the Upper West Region, absenteeism is formally recorded only at the ward level in one facility; 12 facilities formally record and notify senior staff, too.

Quality improvement teams are made up of individuals tasked with ensuring good quality of the services provided. Hospital quality improvement teams were present and functional in 18 facilities in the Northern Region and 12 facilities in the Upper West Region. Neonatal quality improvement teams were available in two facilities in the Northern Region, one of which had met, and five facilities in the Upper West Region. All teams in the Upper West Region reported having previous meetings. The lack of effective quality improvement teams for most of the facilities has consequences for the quality of neonatal care.

The role of mortality audit teams is to review all cases of mortality in the facilities, identify the underlying factors, and make recommendations to prevent similar future deaths. In the Northern Region, 15 facilities had a mortality audit team; teams had met in 11 facilities. Review meetings for maternal, stillbirth, and neonatal deaths were integrated always in seven facilities, and sometimes in eight facilities. The causes of neonatal mortality included severe pneumonia, birth asphyxia, sepsis, bleeding, late report to facility, malnutrition, malaria, stillbirth, prematurity, home accident, and neonatal jaundice.

PHOTO CREDIT: GHSC-PSM

The number of facilities in the Upper West Region with a mortality audit team was 13, and meetings were held by the teams in 12 facilities. Ten facilities always integrated review meetings for maternal, stillbirth, and neonatal death audit, while two facilities sometimes did. The leading causes of neonatal mortality were severe pneumonia, birth asphyxia, and sepsis.

04.
Conclusion

Conclusion

This section presents the overall findings and recommendations of this study, which set out to assess the prevalence of improvised bubble CPAP, 100 percent oxygen use, and pulse oximetry monitoring; identify data gaps in respiratory support and the oxygen ecosystem; assess the capability of health staff to manage and maintain equipment; and understand the maintenance protocols at facilities for the care of newborns.

Changes needed at the facilities are integrated under "Challenges," and recommended actions at the level of central government are discussed under "Recommendations."

Challenges

The study brought to light several challenges faced by health facilities that impact effective management and provision of care across the maternal, newborn, and child health life cycle, with a focus on small and sick newborns. These challenges include:

- Lack of adequate physical areas required for newborn care at all the newborn care levels
- Limited or non-availability of newborn medical equipment
- Inadequate staff capacity in terms of the number and competence of staff required to provide SSNB care and their lack of training in using the devices
- Inadequate forecasting for and procurement of medical equipment
- Lack of effective maintenance protocol for medical equipment, leading to poor maintenance

Lack of funding and the inadequate management of limited resources available for newborn care were key drivers of these challenges.

Facility infrastructure/physical areas

Facility infrastructure for most of the facilities studied was inadequate. Physical areas such as NICU, postnatal unit, maternal theatre, KMC unit, and special baby unit that are needed by all facility types for basic, intermediate, and advanced newborn care were not reliably present. All labor and delivery areas of facilities without a dedicated neonatal unit should be upgraded to provide all the basic newborn care. A dedicated postnatal area for mothers and newborns is vital for adequate observation and care for moderate maternal complications, and identification of newborns with danger signs. It is also needed for appropriate and adequate education, and counseling before discharge. Similarly, existing facilities should be upgraded, depending on their level of care, to include a dedicated NICU, maternal theatre, KMC unit, and special baby unit to provide intermediate and advanced care critical for SSNBs. The government and its leadership must put in place a plan for retooling and training to equip the facilities for efficient service delivery. Future development of new facilities should incorporate the physical

areas needed for the required level of newborn care.

Availability of improvised bubble CPAP, oxygen use, and pulse oximetry monitoring

CPAP (standard, bubble, and improvised) use in the health facilities studied is very low, as is the availability of CPAP accessories. More than half of the hospitals with improvised/homemade CPAP machines are not providing blended oxygen. CPAP use with blended oxygen in facilities should be highly supported and promoted by the government, with strict policies for proper use and education for clinicians, nurses, and midwives on the need for blended oxygen.

Despite the associated convenience, cost-effectiveness, and safety in their use, only a small proportion of the facilities had walled/piped oxygen and medical air across the physical areas and at the neonatal units. Neonatal and intensive care units should be equipped to provide walled/piped oxygen as well as walled/piped medical air that allows for the delivery of effective and safe oxygen. Where possible, existing facilities such as the labor and delivery unit, NICU, and maternal theatre should be retrofitted with walled/piped oxygen. Similarly, development of new facilities should include walled/piped oxygen delivery systems.

It was evident that oxygen cylinders were the most used source of oxygen despite being the least convenient to use and their potential to cause harm to patients. More safe sources of oxygen, such as oxygen concentrators, bulk liquid oxygen, oxygen generators, and PSA plants, are recommended for use in the NICU. Facilities should implement policies to increase the use of safer sources of oxygen in the NICU. CHP compounds that carry out deliveries must be provided with mobile and portable oxygen cylinders for transporting sick babies as well as for managing emergencies.

The purity of oxygen from oxygen concentrators and cylinders was generally within standards among a greater proportion of the devices; however, some measured very low oxygen purity, which makes the use of oxygen unsafe when the purity of oxygen is not checked regularly. For facilities that generate and use oxygen, biomedical engineers must be provided with oxygen analyzers for routine checks of oxygen purity. Neonatal care personnel should also be trained to perform regular purity checks on the oxygen generated.

Neonatal services

A significant number of neonatal services were provided by various facility types for the care of small and sick newborns. However, not all services were provided by the facilities in the last four weeks before the study. Challenges faced in providing neonatal services included limited human resource capacity and lack of equipment. There is a need to regularly monitor and examine the quality of neonatal services provided in relation to availability of protocols. Challenges in providing neonatal services should be addressed regularly.

Most of the facilities provide only basic newborn care. Proper and adequate referral and feedback systems at the various levels will ensure continuity of care and prompt interventions when referring facilities are not capable of providing the needed level of care.

Neonatal unit electricity supply

Most facilities reported a negative impact of power surges on the provision of care within the neonatal unit. Also, few facilities had back power for the NICU, such as solar power, fuel-operated generators, and battery inventors. Due to the intensive nature of care provided for small and sick newborns at the NICU, it is recommended that effective measures be put in place to ensure uninterrupted power supply. Solar power and battery inverters, though having an initially high cost, are cost-effective and can provide reliable backup power for the equipment needed at the NICU.

Neonatal admission

Midwives and general nurses were the cadres mostly responsible for assessing and discharging small and sick newborns. Midwives and general nurses should receive regular in-service training on the care of SSNBs because of the specialty required. Training more pediatric nurses, pediatricians, and neonatologists is also recommended to increase their numbers at the various facility types.

IPC and waste management

Most facilities had functional hygiene stations and hygiene promotion protocols for the prevention and control of infections. However, constant supply of water throughout the year to facilitate proper hygiene was absent. It is recommended that facilities take measures to store sufficient portable water by relying on bulk storage of other sources of water such as boreholes, water reservoirs (polytank) with fitted pumps, or harvesting of rainwater to ensure continuous flow of water.

Most facilities manage their waste using a burning pit, which is not ideal, considering the environmental and soil pollution associated with this method. It is recommended that facilities invest in incinerators as a safe method of waste management.

Inventory and forecasting of consumables at the neonatal unit

Several of the facilities studied did not adequately forecast consumables needed at the NICU; most only stock consumables when they run out. Facilities should be trained in using appropriate forecasting systems for consumables needed to provide timely care for SSNBs.

Newborn care equipment and supplies

The newborn care equipment needed for the delivery of intensive care was inadequate at all facilities due to a lack

of funding and poor maintenance. It is recommended that facilities establish a system for continuous monitoring and evaluation of medical devices to ensure effectiveness for newborn care delivery. Also, facility heads need to put in place measures to source funds for equipment from donors and partners, both governmental and nongovernmental organizations.

Maintenance and repairs

To ensure medical device longevity, a strong maintenance culture is needed. Staff should be adequately trained to have a positive attitude toward assuming responsibility for maintaining the equipment used at the facilities. This goal can be reached through supportive supervision, leadership, communication, teamwork, education, planning, empowerment, and motivation.

To be effective, a strong maintenance culture requires maintenance protocols. Facilities should have dedicated workshop areas with qualified personnel and well-documented maintenance protocols. Protocols must be developed and openly displayed at vantage areas in the facilities, and their use must be enforced for standard care and quality assurance purposes. A major barrier to having a strong maintenance culture is the unavailability of basic working tools. There should be a budget allocation for maintenance and a procurement plan for basic tools and spare parts. Also, maintenance record books are important for preparing procurement plans, planning decommissioning, and tracking equipment downtime. Proper records for equipment maintenance should be kept to improve infant care, procurement, and evidence-based maintenance.

Human resources

Most health staff lacked the ability to use and maintain most of the newborn care equipment due to the absence of regular and adequate training. Newborn care is a specialized field that requires individuals who are well versed in managing newborn conditions and well equipped to handle and operate devices used for newborn care. Facilities should organize regular pre-service training, in-service training, on-the-job training, and frequent continuous development courses for staff to update their knowledge and improve their capabilities and competence in providing care for small and sick newborns. Yearly training programs, including Helping Babies Survive, Neonatal Resuscitation Program, Emergency Triage Assessment and Treatment, and Basic Life Support must be organized to equip the staff with knowledge and skills in emergency management of the sick newborn. Also, respiratory therapists must be employed and posted at the facilities.

Better staff management practices should be implemented at the facilities, such as establishing workplace standards and ethics and effective supervision, to address issues regarding human resource challenges, such as absenteeism.

Quality improvement teams should meet regularly to review performance data, identify potential areas for improvement, and implement and monitor changes. The various departments involved in service delivery should be represented on the teams to ensure effectiveness.

RECOMMENDATIONS

MOH and GHS

Expand infrastructure for maternal and newborn care (NICU, postnatal unit, maternal theatre, KMC unit, and special baby care unit) in health facilities to ensure equitable access to all levels of services critical for protecting the health of small and sick newborns as well as women seeking maternal health services. Additionally, ensure that future development of health facilities includes all the physical areas that are needed for effective maternal and newborn care.

Prioritize the training of pediatric nurses, pediatricians, and neonatologists to improve access to intermediate and advanced newborn care services in health facilities.

GHS

Support health facilities in acquiring and ensuring effective use of newborn care devices and equipment, including CPAP, pulse oximeter, and safe oxygen sources (oxygen such as oxygen concentrators, bulk liquid oxygen, oxygen generators, and PSA plants) that are recommended for use in NICU. This effort should include advocacy with development partners and stakeholders to support the provision of critical equipment for optimized treatment and management of newborns.

Provide support for acquiring oxygen analyzers to facilitate routine oxygen purity checks in facilities that generate oxygen. This will improve access to safe oxygen and ensure better treatment outcomes for SSNBs.

Review and implement a standardized referral and feedback system for SSNBs to ensure continuity of care in situations where facilities lack human resources, devices, and equipment needed for effective clinical management outcomes.

Continue to sensitize health facilities to strengthen systems for infection prevention and control as well as waste management. Efforts to achieve this goal should include funding

RECOMMENDATIONS

and technical support for installing and maintaining back-up portable water sources and incinerators, which are regarded as safe methods for managing waste.

Government of Ghana through GHS

Budget and acquire funding to procure back-up power supply for health facilities (e.g., solar power and battery inverters) to prevent disruption in newborn care and related health services that rely on uninterrupted electricity supply. Although solar power and battery inverters have an initially high cost, they can serve as a cost-effective back-up power source in the long term.

Health Administration and Support Services of GHS

Identify and build the capacity of health facilities that lack the skills and knowledge to effectively forecast and apply standard inventory management procedures for newborn medical devices. This will contribute to the management of SSNB conditions through improved availability of newborn medical devices and consumables.

Establish a strong maintenance culture for newborn care devices and oxygen equipment by bridging capacity gaps and conducting routine monitoring and supervision to promote adherence to standard protocols and planned preventive maintenance schedules.

Regional Health Directorates

Support health facilities to acquire basic tools and equipment needed for routine management of newborn medical devices and oxygen equipment. This will help deepen the culture of maintenance and improve the availability of functional devices and equipment needed for treating SSNBs and managing care.

PHOTO CREDIT: GHSC-PSM

Family Health Division

Conduct regular in-service training and supervision for relevant health staff (midwives and general nurses) as part of efforts to improve and sustain the delivery of high-quality care for small and sick newborns.

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Appendices

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APPENDIX 1: RESPIRATORY SUPPORT AND OXYGEN SYSTEM

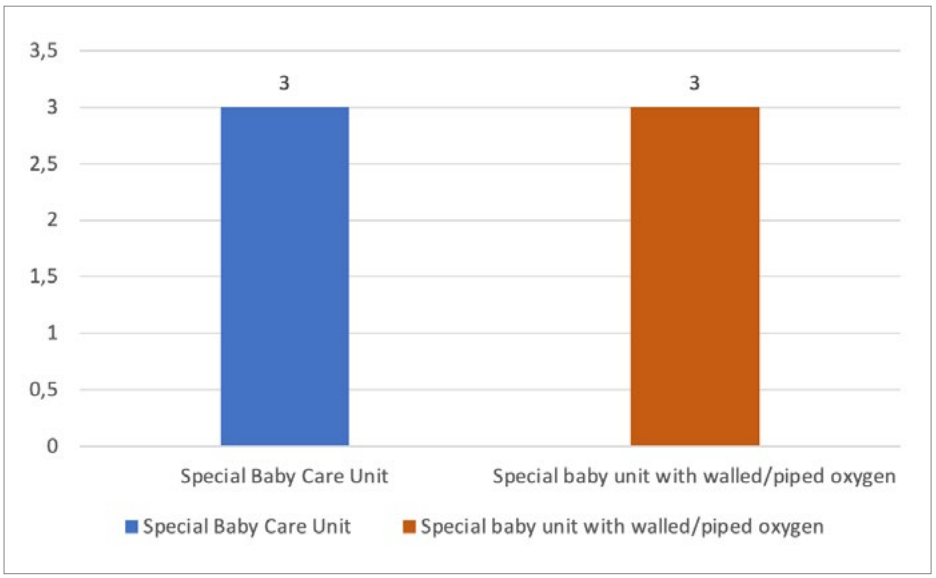

Figure 33 *Special baby care unit with walled/piped oxygen*

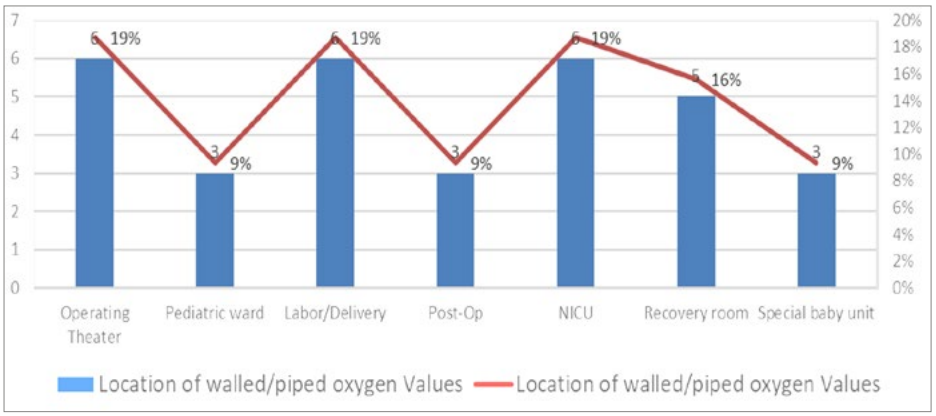

Figure 34 *Availability of walled/piped oxygen in physical areas of facilities*

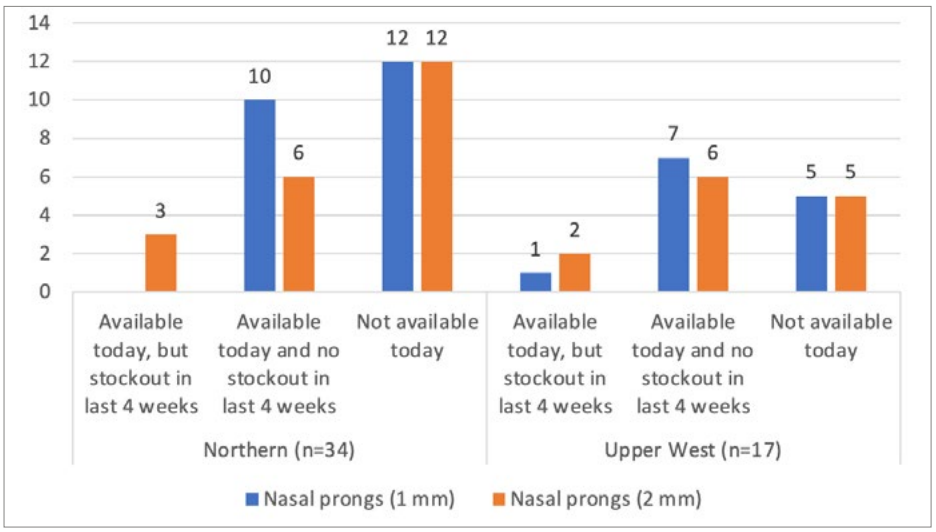

Figure 35 Availability of nasal prong in health facilities per region

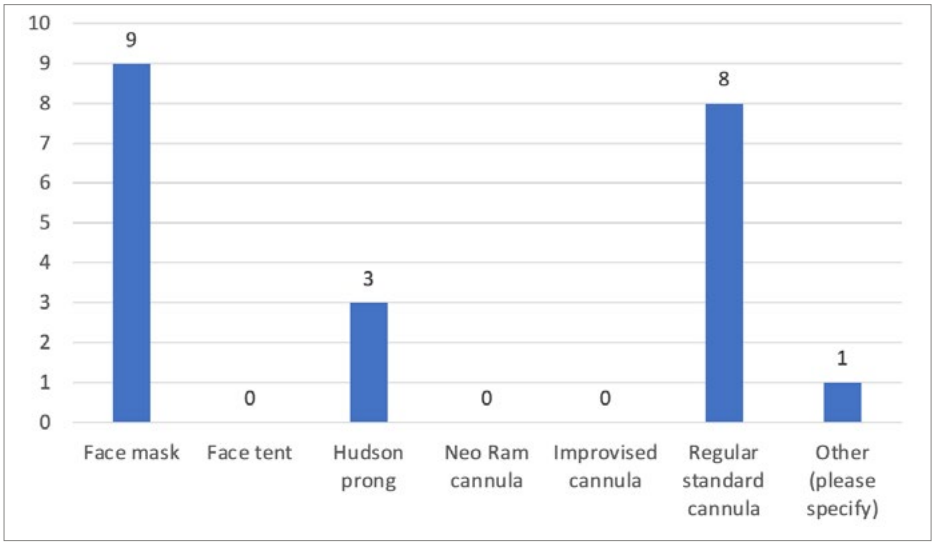

Figure 36 Number of facilities with nasal interface in the Northern Region (n = 34)

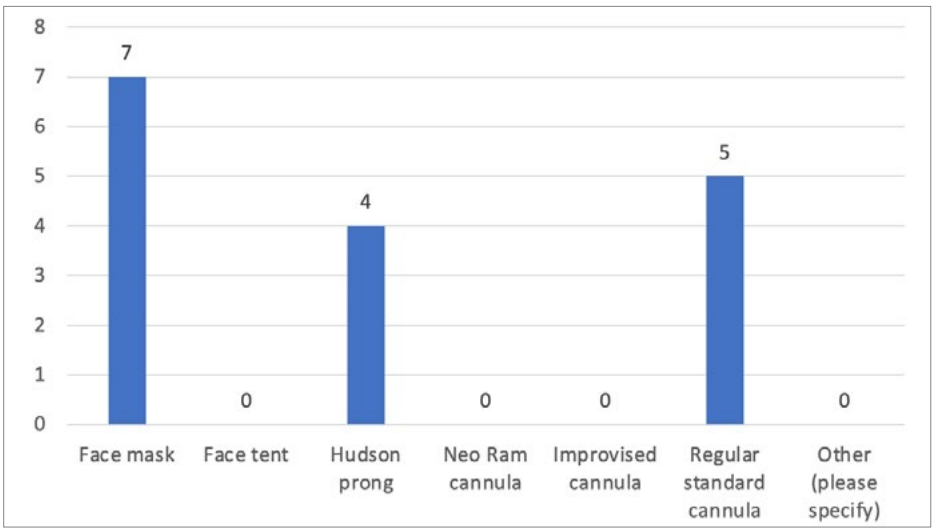

Figure 37 Number of facilities with nasal interface in the Upper West Region (n = 17)

Patient Monitor	Manufacturer	Module number
Assemblies of God Hospital	Green life	Sm80
Gwollu Hospital	Midray	UMEC 10
Lambussie Polyclinic	EDAN	M3A
Lawra Hospital	Shenzhen Mindray biomedical company	Shenzhen 518057pr China
Nadowli District Hospital	Shenzhen Mindray biomedical company	Shenzhen 518057pr China
St. Theresa's Hospital - Nandom	Midray	UMEC 10
Tamale Teaching Hospital	Midray	UMEC 10
Tamale West Hospital	EDAN	M3A
Tolon District Hospital	Drager	Vista 120s
Upper West Regional Hospital	Philips	CM10, CM150
Wa Municipal Hospital	Midray	UMEC 10
Wa West District Hospital	Midray	UMEC 10

Table 2 Facilities with patient monitors

APPENDIX 2: RESUSCITATION EQUIPMENT AND SUPPLIERS

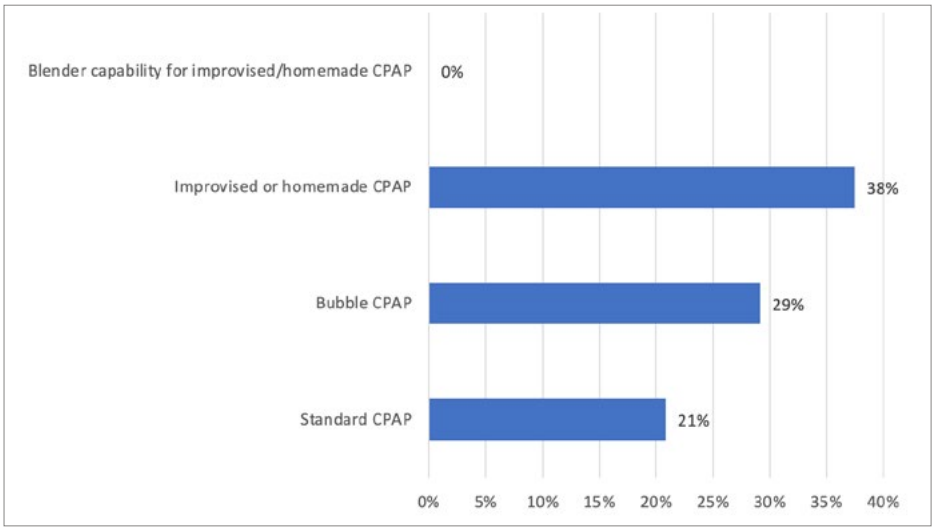

Figure 38 Availability of functional CPAP in hospitals (n = 24)

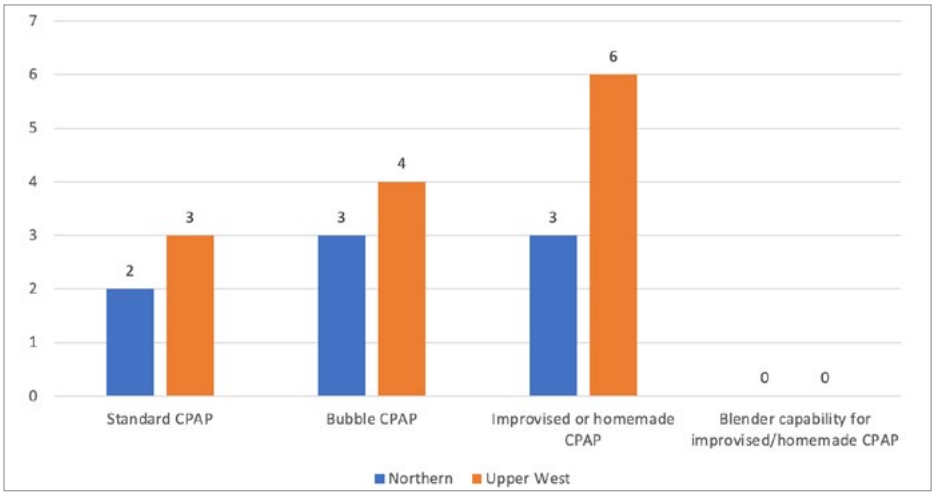

Figure 39 Percentage of facilities with functioning CPAP (standard, bubble, and improvised/homemade) (n = 51)

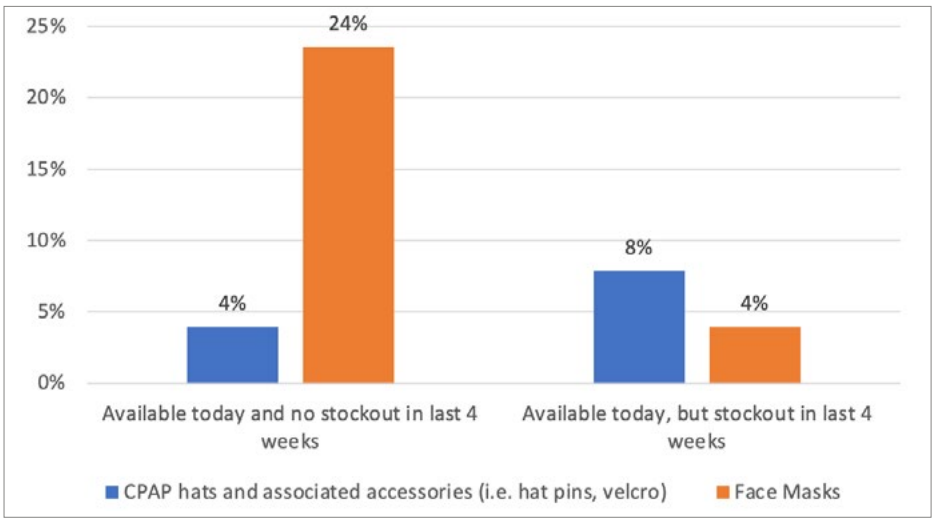

Figure 40 Availability of CPAP accessories in facilities (n = 51)

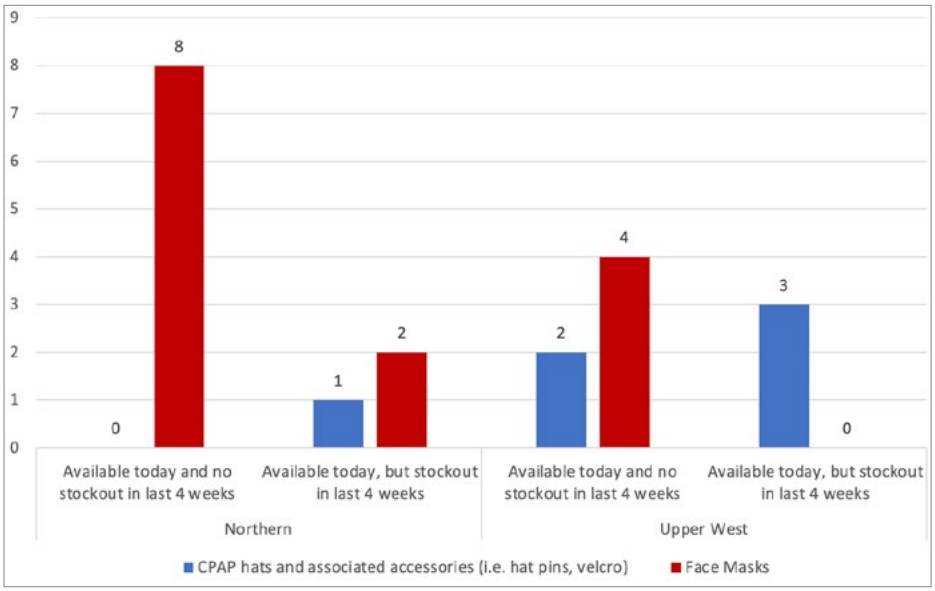

Figure 41 Number of facilities with CPAP accessories and face masks per region

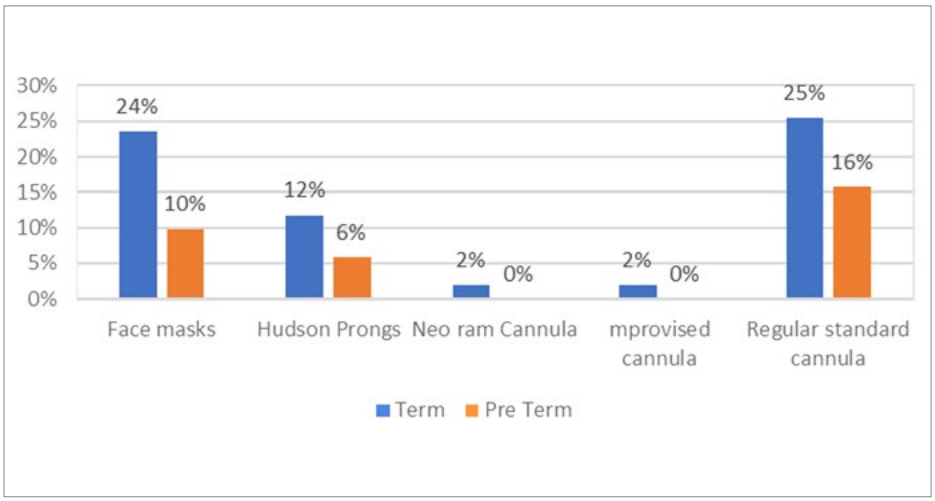

Figure 42 Availability of CPAP accessories and sizes in facilities (n = 51)

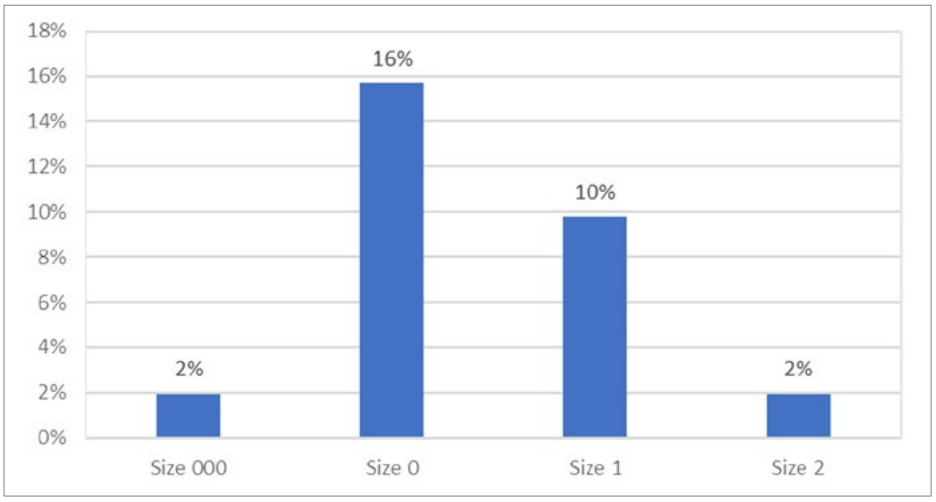

Figure 43 Availability of CPAP prong sizes stocked (n = 51)

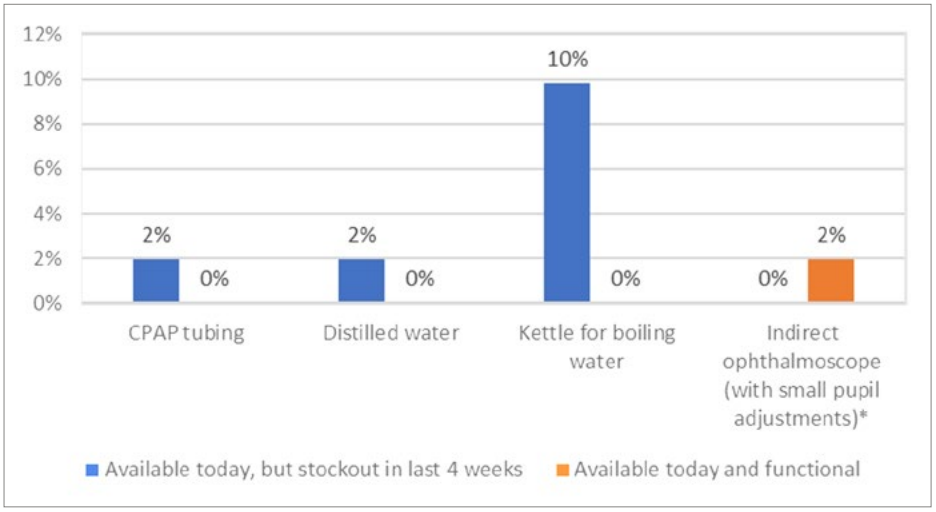

Figure 44 Availability of CPAP accessories and indirect ophthalmoscope in facilities (n = 51)

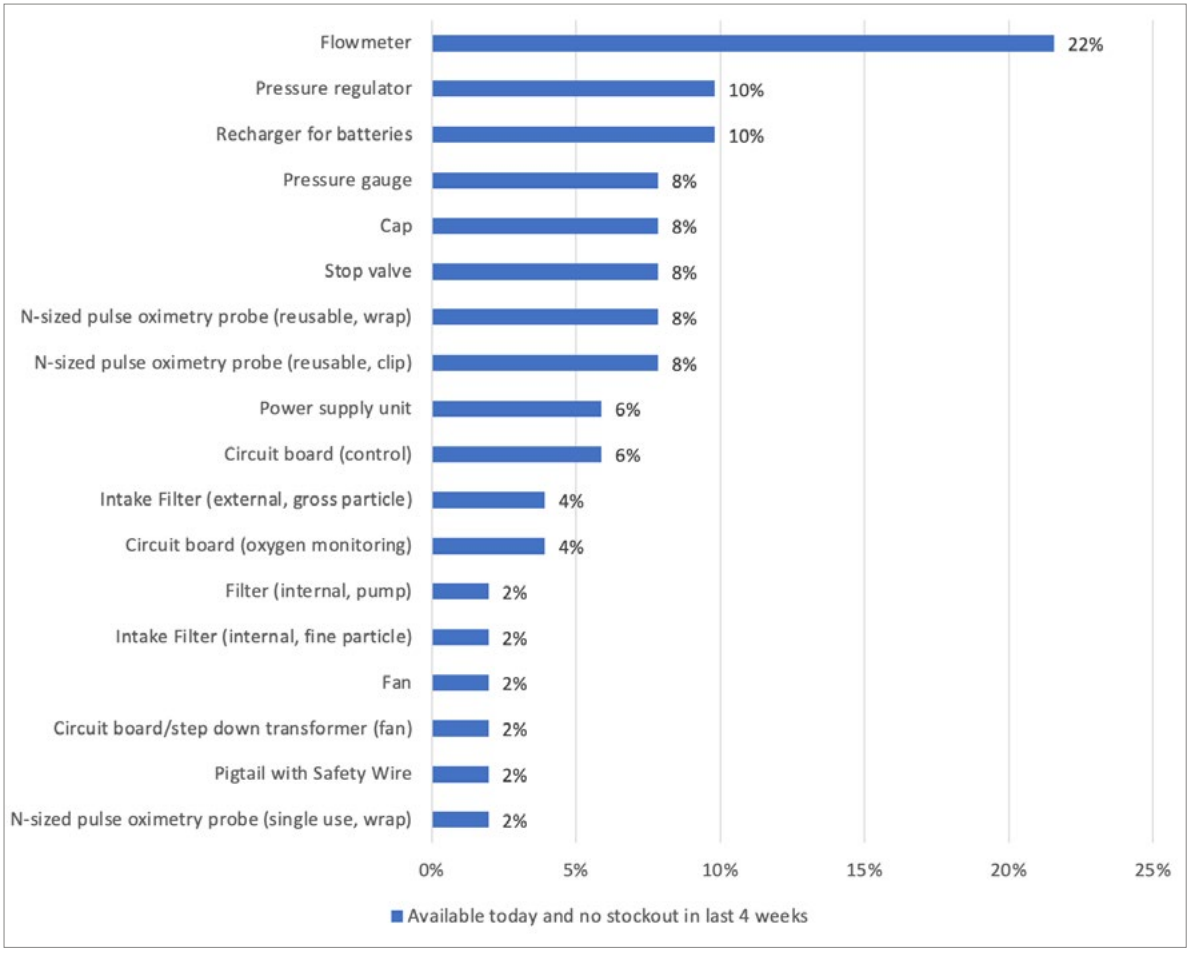

Figure 45 Availability of neonatal equipment and accessories in facilities (n = 51)

A	Facilities using improvised or homemade CPAP?
1	Gwollu Hospital
2	Tumu Hospital
3	Tamale Teaching Hospital
4	St. Theresa's Hospital – Nandom
5	Wa Municipal Hospital
6	Upper West Regional Hospital
7	Tamale Central Hospital
8	Assemblies of God Hospital
9	Lawra Hospital

B	Facilities having blender capability for improvised and/or homemade CPAP
1	Gwollu Hospital
2	Tumu Hospital
3	Tamale Teaching Hospital
4	Upper West Regional Hospital

Table 3 Hospitals with improvised or homemade CPAP and having blender capabilities

Facility	*NICU CPAP driver system (standard CPAP)* Quantity available	Quantity functional	*NICU CPAP driver system (bubble CPAP)* Quantity available	Quantity functional
Assemblies of God Hospital	2	2		
St. Theresa's Hospital - Nandom			1	0
Wa Municipal Hospital			1	1
Gwollu Hospital	1	1	1	1
Tumu Hospital	1	1	1	1
Tolon District Hospital	1	0		
Tamale West Hospital	2	0	2	0
Tamale Teaching Hospital	1	1	6	6
Lawra Hospital	1	1	1	1
TOTAL	9	6	14	11

Table 4 Facilities and number of CPAP (standard and bubble) driver system in the NICU units and functional

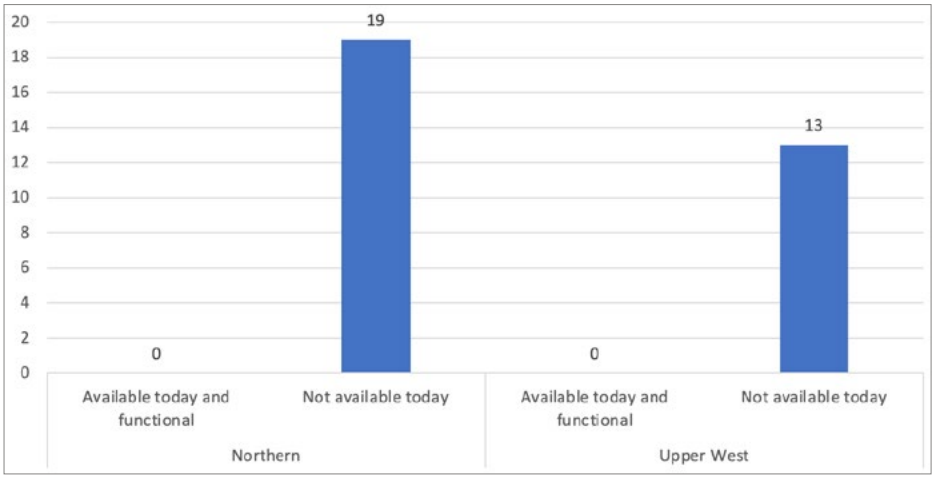

Figure 46 Number of facilities with oxygen blenders per region (n = 51)

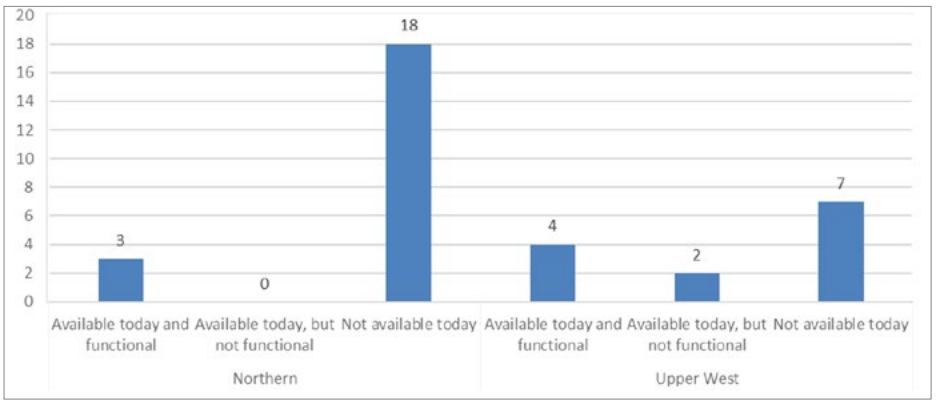

Figure 47 Number of facilities with bubble CPAP per region (n = 51)

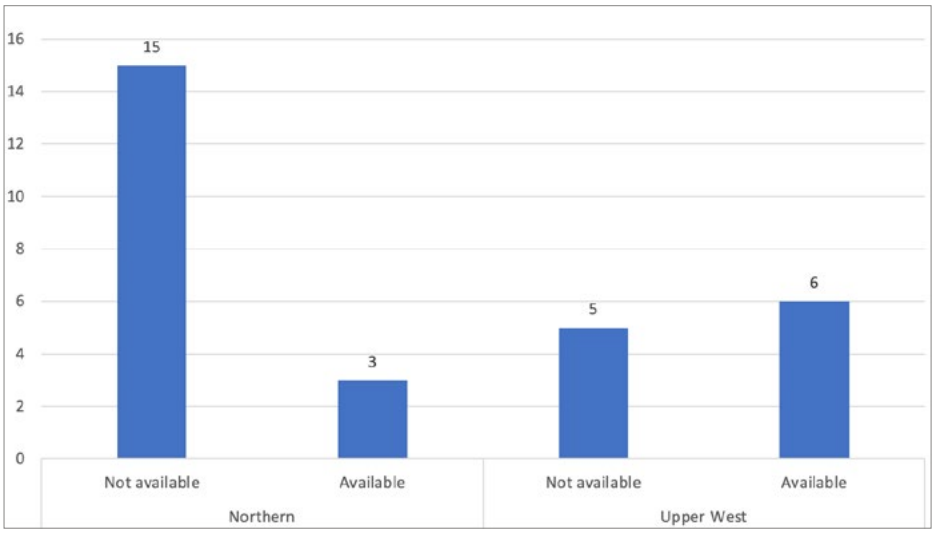

Figure 48 Number of facilities with improvised/homemade CPAP in Northern and Upper West Regions (n = 51)

APPENDIX 3: SAFE OXYGEN DELIVERY EQUIPMENT AND SUPPLIES

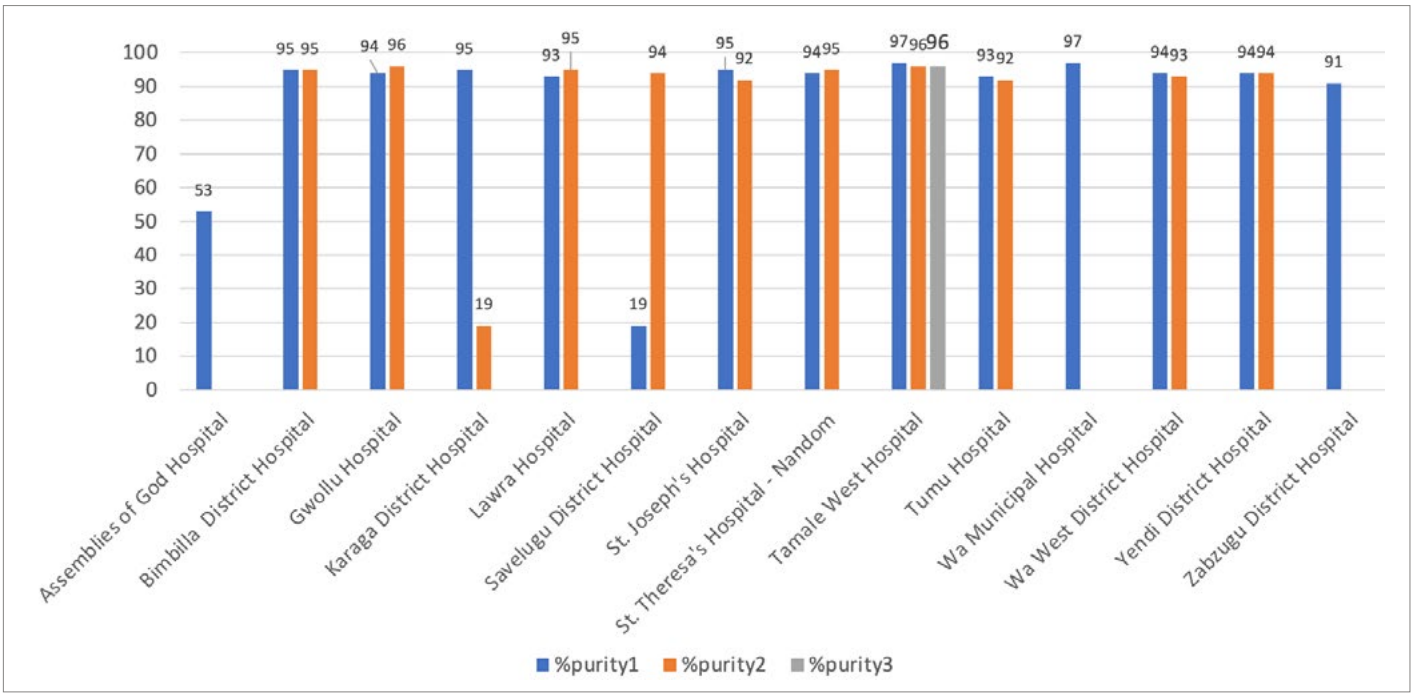

Figure 49 Purity of oxygen concentrators found in facilities

*Note: The oxygen purity for concentrators was determined for the number of concentrators available and functioning in each facility reported. For example, facilities with three oxygen concentrators available and functioning will have a measured oxygen purity for each concentrator, giving a total of three measured oxygen purity.

NICU oxygen cylinder

Facility	Quantity available	Quantity functional
Assemblies of God Hospital	1	1
Gwollu Hospital	1	1
Hain Polyclinic	1	1
Karaga District Hospital	1	1
Nadowli District Hospital	1	1
Nyankpala Health Centre	1	0
Savelugu District Hospital	1	1
St. Joseph's Hospital	1	1
St. Theresa's Hospital – Nandom	1	1
Bimbilla District Hospital	1	1
Tolon District Hospital	1	1
Tumu Hospital	1	1
Wa West District Hospital	1	1
Zabzugu District Hospital	1	1
Gushiegu District Hospital	2	2
Tamale West Hospital	2	2
Upper West Regional Hospital	3	3
Wa Municipal Hospital	3	3
Lambussie Polyclinic	4	4
St. Lucy Hospital, Tamale	5	5
Tamale Teaching Hospital	6	6
Total	**39**	**38**

Table 5 Facilities and number of NICU oxygen cylinders available and functional

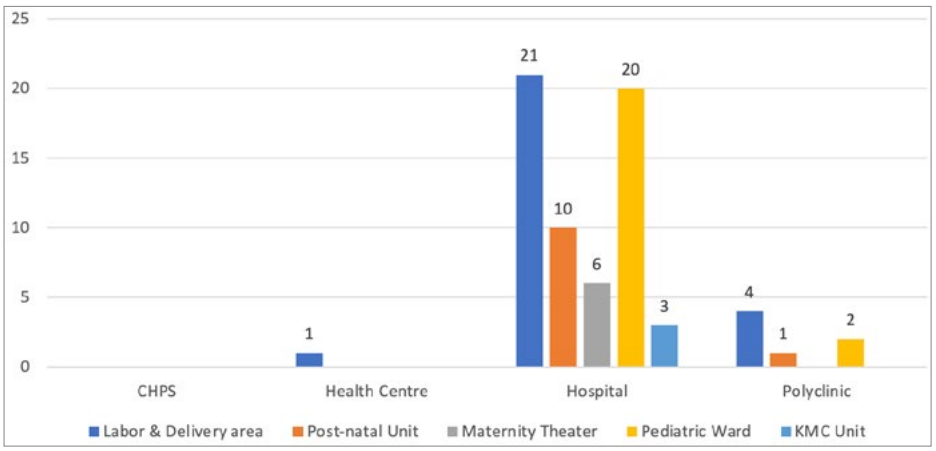

Figure 50 Availability of oxygen cylinders per facility type

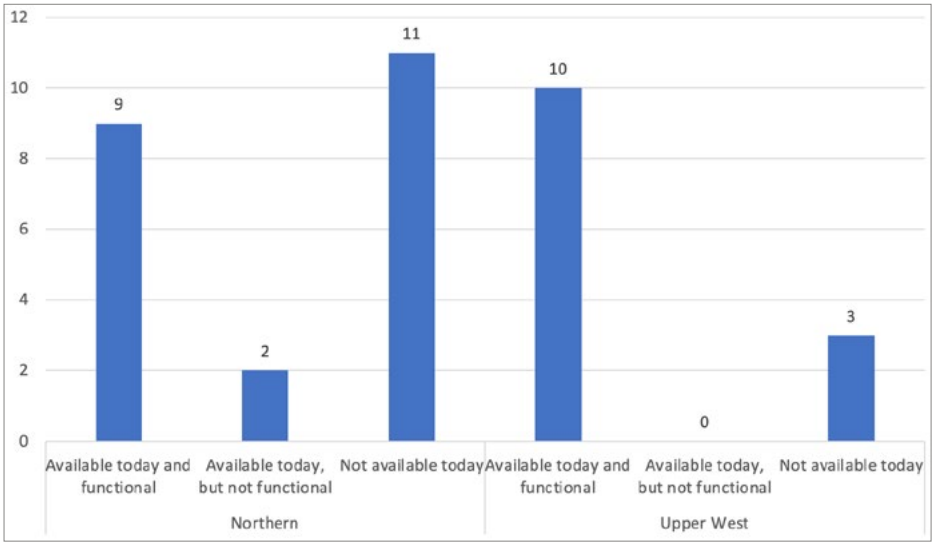

Figure 51 Number of facilities with bottled oxygen cylinders (n = 51)

	Name of Facility	Name of Unit	No. Available	No. Functioning	Manufacturer	Model Number	Oxygen Concentration (purity)
1	Tamale Central Hospital	Neborn Care	1	1	Nidek	Max 30	86.5
		Labour and Delivery	1	1	NA	V5-WN	…
		Child Health	2	0	Hospitex	K5BW-3L	21.1
					Canta	V8-WN-NS	0
2	Tamale West Hospital	Neborn Care	5	3	Airsep	New life intensity 10	97
					Airsep	New life intensity 10	96.5
					Airsep	New life intensity 10	96.9
		Post Natal	1	1	Konsung	KSOC-5 (8 liter)	93
		Child Health	1	1	NA	Tf-5	18.8
3	St. Lucy Hospital	Neborn Care	0	1	-	-	-
		Labour and Delivery	1	1	Konsung	KSOC-5(8Liter)	92.3
4	Tolon District Hospital	Child Health	1	2	Canta	V8-WN-NS	93.2
5	Savelugu District Hospital	Neborn Care	2	1	Canta	V8-WN-NS	19.9
					NA	NA	94.7
6	Karaga District Hospital	Neborn Care	3	1	Airsep	New life elite	95
					Airsep	New life elite	…
					Canta	V8-WN-NS	19.7
		Child Health	1	0	Airsep	New life elite	94.1
7	Gushegu District Hospital	Labour and Delivery	1	1	…	…	…
		Child Health	1	1	Yuwell	7F-5	94.2
8	Yendi Municipal Hospital	Neborn Care	1	1	Canta	V8-WN-NS	94.2
		Post Natal	1	2	Canta	V8-WN-NS	93.5
		Child Health	2	1	Canta	V8-WN-NS	93.5
					Canta	V8-WN-NS	93

9	Assemblies of God Hospital	Neborn Care	1	1	Greenlife	Hemocare	53.6
		Child Health	1	1	Greenlife	Hemocare	53.6
10	Zabzugu District Hospital	Neborn Care	1	0	Yuwell	7F-5	91.8
11	Tatale District Hospital	Labour and Delivery	1	2	-	-	-
12	Bimbila Municipal Hospital	Neborn Care	2	1	Canta	V8-WN-NS	95.2
					Konsung	KSOC-5(8 liters)	95.6
		Labour and Delivery	1	0	Yuwell	7F-3	88
		Child Health	1	0	Canta	V8-WN-NS	19.9
13	Kpandai Municipal Hospital	Neborn Care	1	0	Micromed	7F-5	…
		Labour and Delivery	1	0	NA	NA	19.9
14	SDA Hospital	Child Health	1	1	Longfian	JAY-10W	94.7
15	Tamale Teaching Hospital	Neborn Care	2	0	Airsep	Newlife Intensity	…
					Airsep	Newlife Intensity	…
		Maternal theatre	1	1	Canta	V8-WN-NS	95.3
		Child Health	5	5	Devilbiss	NA	94.6
					OXTM	OX-10A	91.6
					Devilbiss	NA	95.7
					Canta	V8-WN-NS	93.8
					NA	OZ-5-01GW0	94.9

Table 6 Availability of oxygen concentrators in the Northern Region

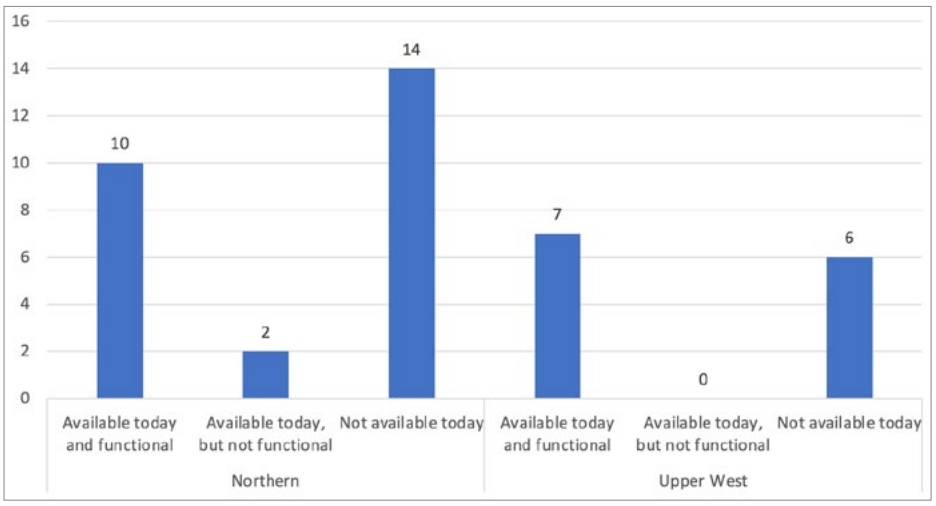

Figure 52 Number of facilitators with oxygen concentrators per region (n = 51)

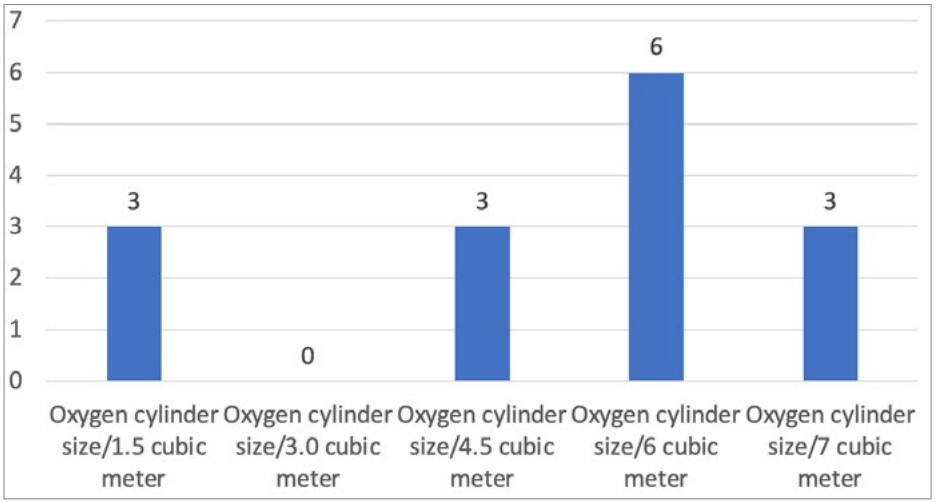

Figure 53 Availability of various sizes of oxygen cylinders in facilities in the Northern Region (n = 34)

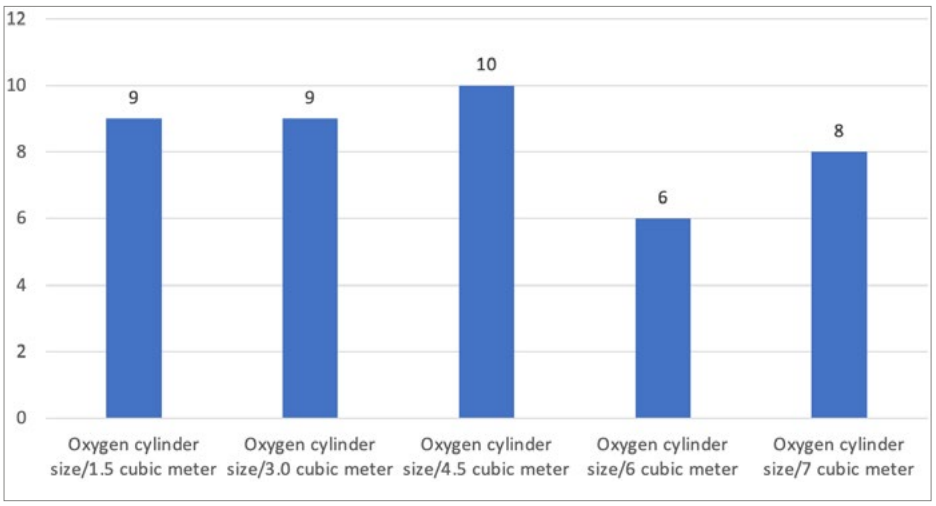

Figure 54 Availability of various sizes of oxygen cylinders in facilities in the Upper West Region (n = 17)

*Note: Although Northern region has over twice population size of Upper West regions, the research found out that Northern region has less oxygen cylinders compared to Upper West region. This may probably be due to the availability of more concentrators in Northern region than Upper West region.

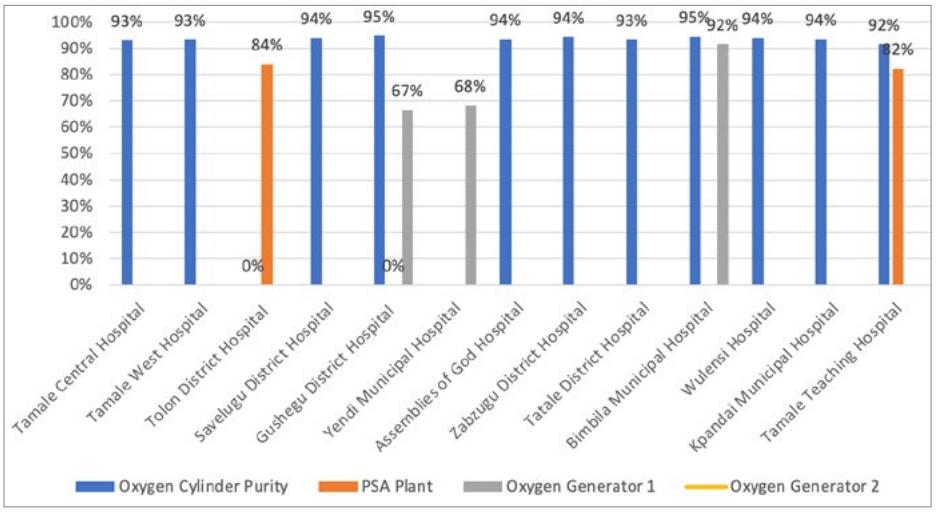

Figure 55 Purity of oxygen in oxygen cylinders, PSA plant, and oxygen generators in health facilities in the Northern Region

APPENDIX 4: MAINTENANCE

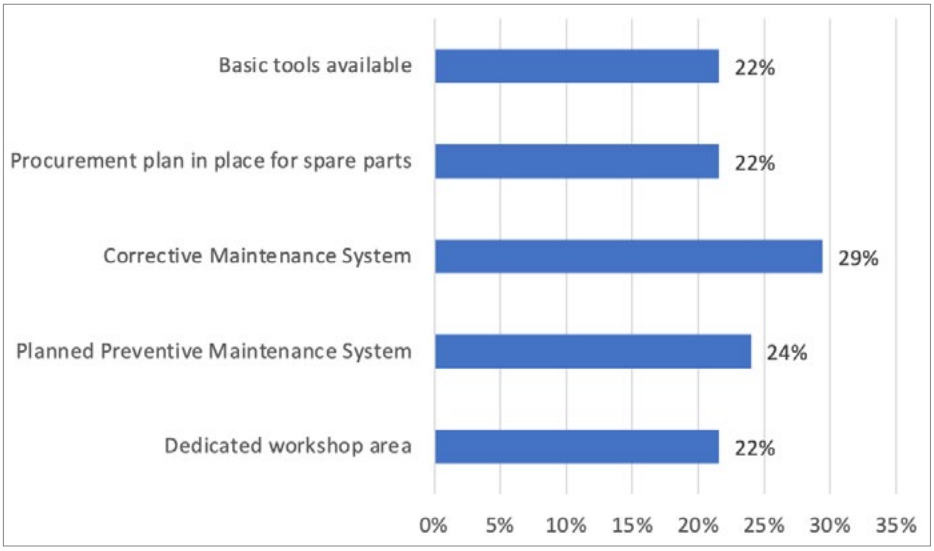

Figure 56 Percentage of facilities with key maintenance practices (n = 51)

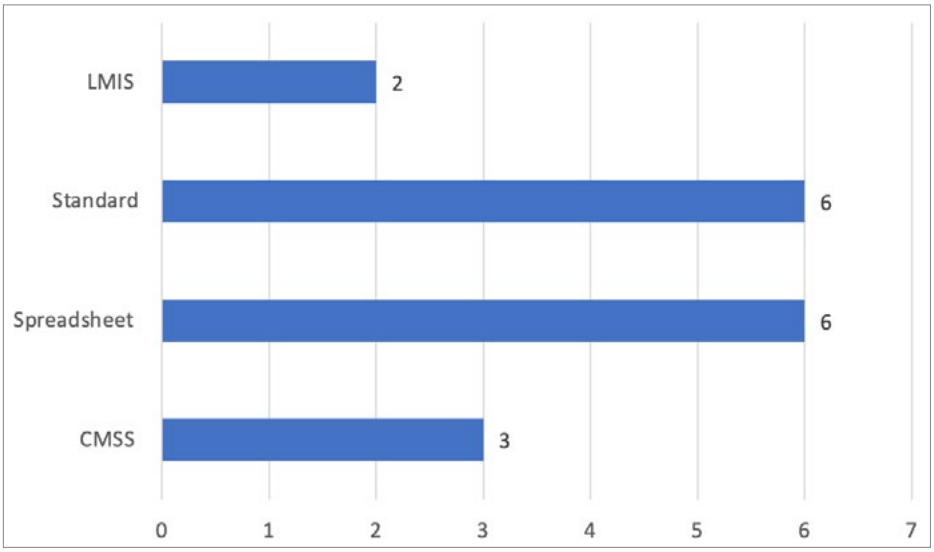

Figure 57 Number of facilities with maintenance record keeping (n = 51)

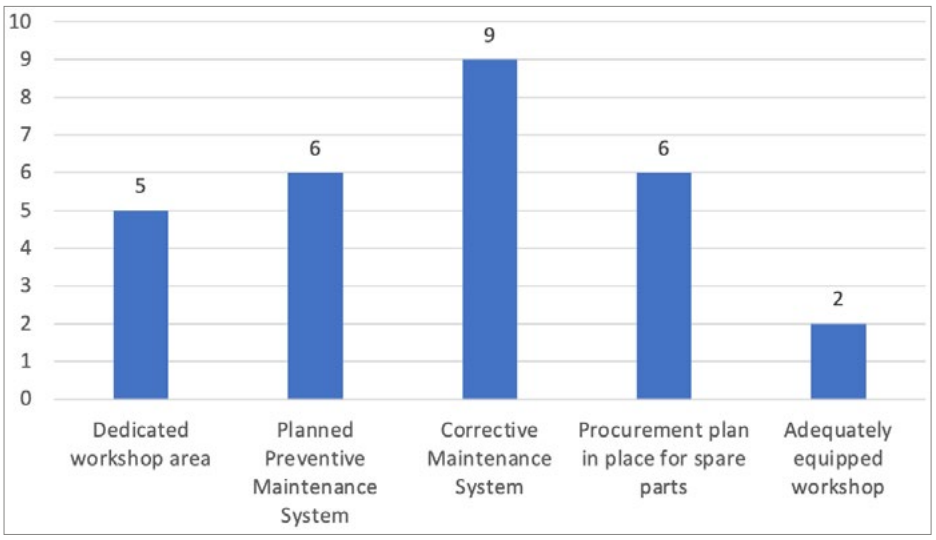

Figure 58 *Number of facilities with key maintenance practices in the Northern Region (n =34)*

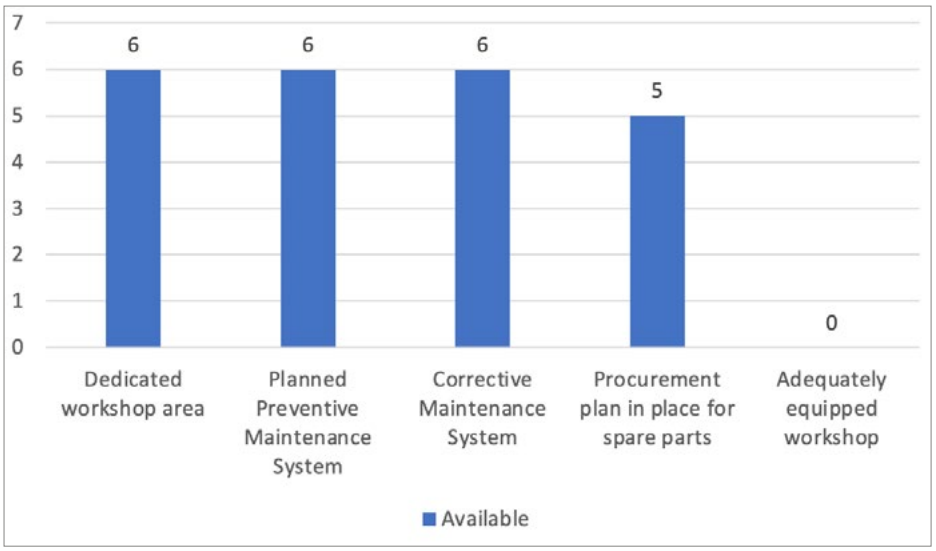

Figure 59 *Number of facilities with key maintenance practices in the Upper West Region (n = 17)*

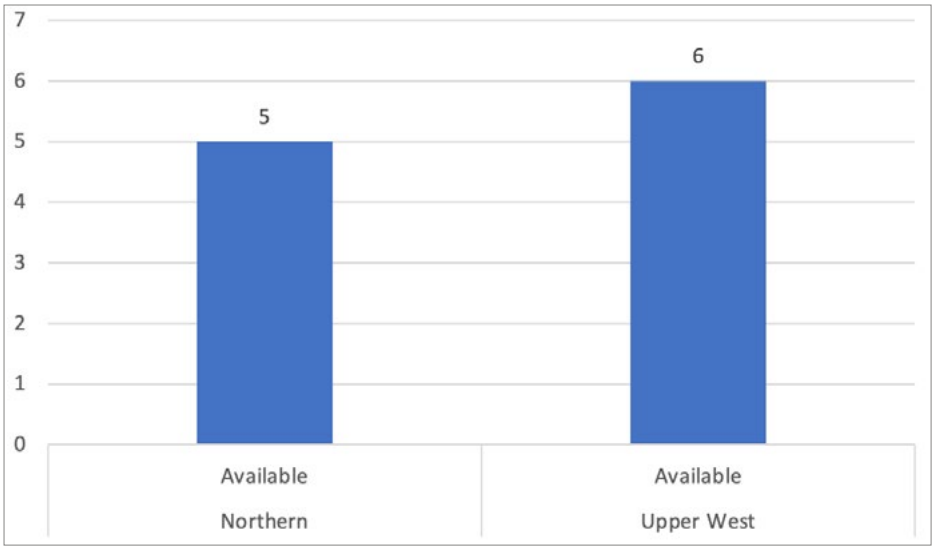

Figure 60 *Number of facilities with basic tools for maintenance at their neonatal units per region (n = 51)*

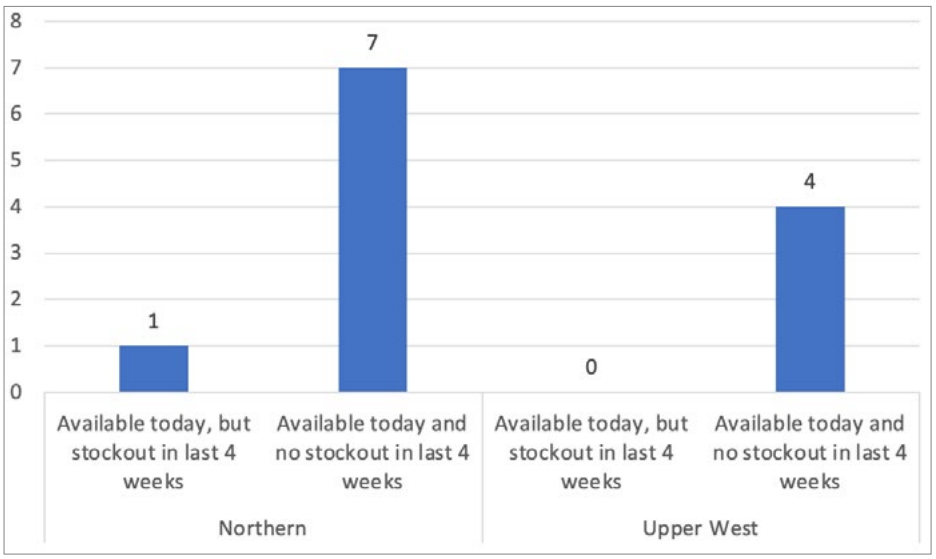

Figure 61 Number of facilities with flowmeter per region (n = 51)

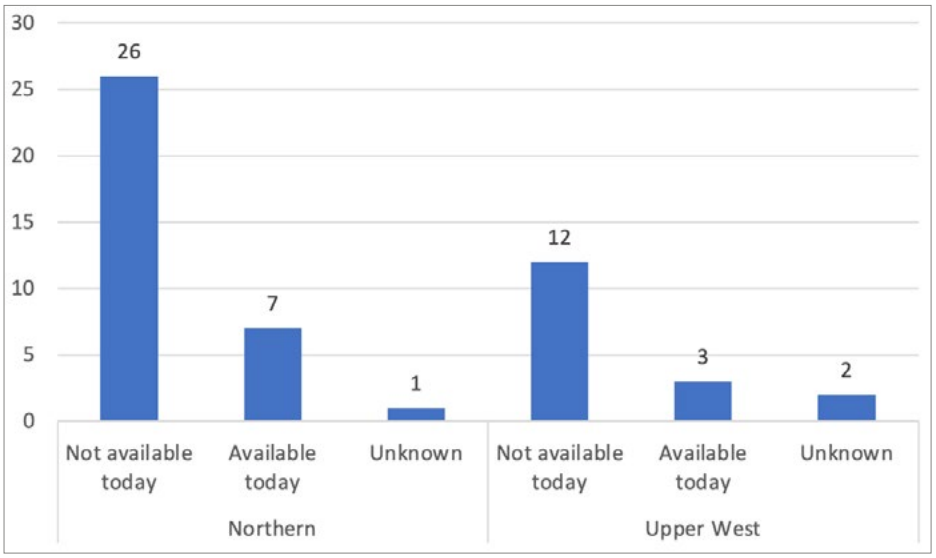

Figure 62 Availability of funds for maintenance or repair in facilities per region (n = 51)

APPENDIX 5: SERVICES AND HUMAN RESOURCES

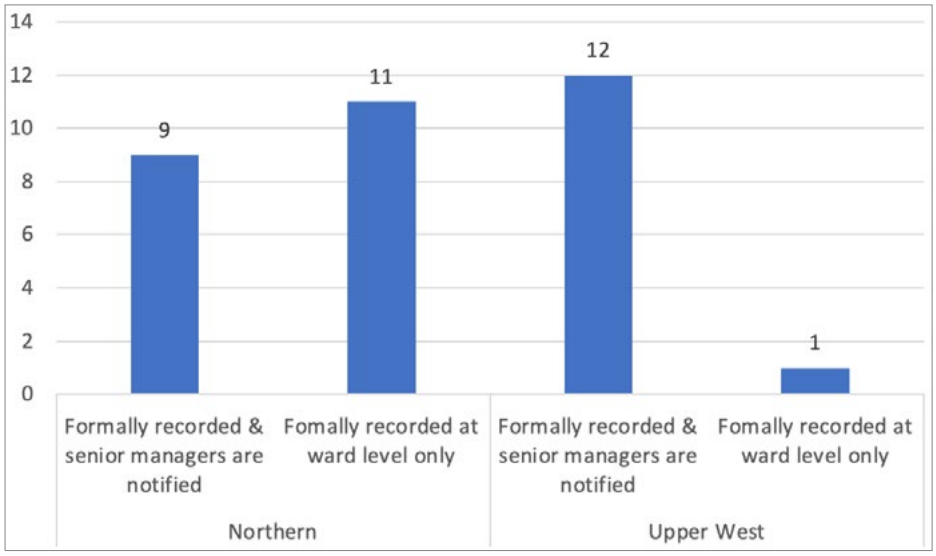

Figure 63 Number of facilities with a record of absenteeism (n = 51)

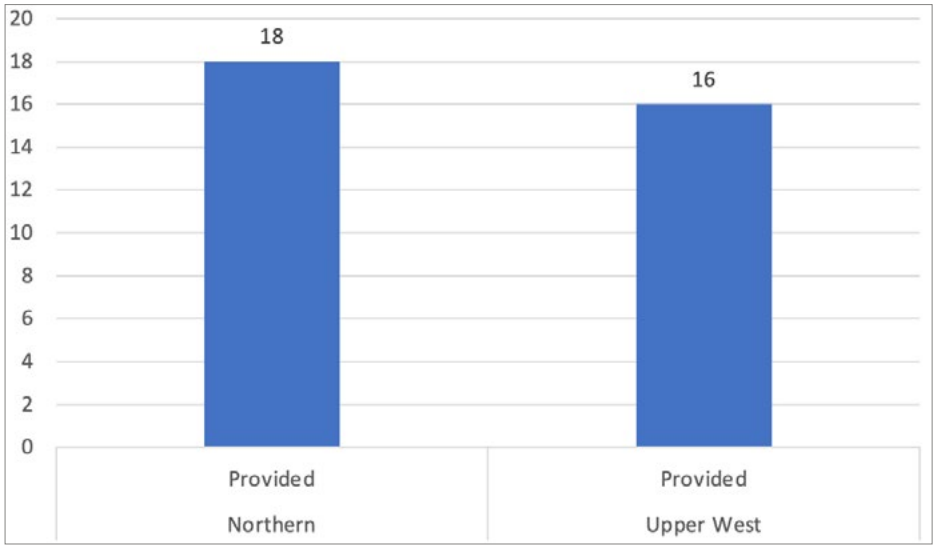

Figure 64 Number of facilities that provide feedback to referring facilities on patient outcomes per region (n = 51)

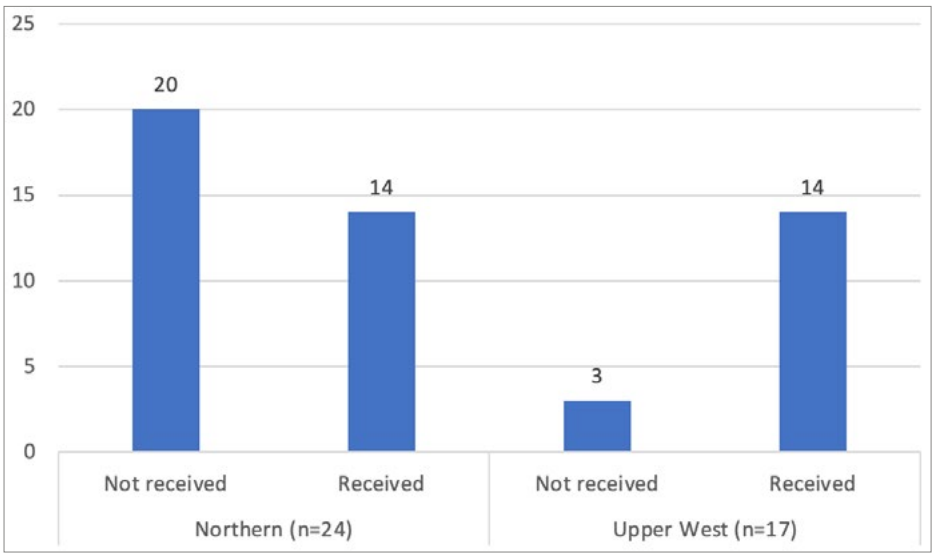

Figure 65 Number of facilities that receive feedback on patient outcomes from referral facilities per region (n = 51)

APPENDIX 6: LIST OF STUDY FACILITIES

Table 7 List of facilities selected per region for the study

No.	Region	District	Facility Name	Facility Type
1	Northern	Gushiegu	Katani CHPS	CHPS
2	Northern	Gushiegu	Nawuhugu CHPS	CHPS
3	Northern	Gushiegu	Kpatinga Health Centre	Health Centre
4	Northern	Gushiegu	Nabuli Health Centre	Health Centre
5	Northern	Gushiegu	Gushiegu District Hospital	Hospital
6	Northern	Karaga	Karaga District Hospital	Hospital
7	Northern	Kpandai	Kpandai District Hospital	Hospital
8	Northern	Mion	Sang Health Centre	Health Centre
9	Northern	Nanton	Nanton Health Centre	Health Centre
10	Northern	Nanumba North	St. Joseph Clinic & Mat Home – Chamba	Clinic
11	Northern	Nanumba North	Bincheratanga Health Centre	Health Centre
12	Northern	Nanumba North	Makayili Health Centre	Health Centre
13	Northern	Nanumba North	Bimbilla District Hospital	Hospital
14	Northern	Nanumba South	Lungni Health Centre	Health Centre
15	Northern	Nanumba South	Wulensi Polyclinic	Polyclinic
16	Northern	Saboba	Assemblies of God Hospital	Hospital
17	Northern	Sagnarigu	St. Lucy Hospital, Tamale	Hospital
18	Northern	Savelugu	Diare Health Centre	Health Centre
19	Northern	Savelugu	Savelugu District Hospital	Hospital
20	Northern	Tamale	Fooshegu CHPS (Presbyterian Clinic – Fooshegu)	Health Centre
21	Northern	Tamale	Tamale Central Health Centre	Health Centre
22	Northern	Tamale	Tamale Central Hospital	Hospital
23	Northern	Tamale	Tamale SDA Hospital	Hospital
24	Northern	Tamale	Tamale Teaching Hospital	Hospital
25	Northern	Tamale	Tamale West Hospital	Hospital
26	Northern	Tatale-Sangule	Sangbaa CHPS	CHPS

27	Northern	Tatale-Sangule	Tatale District Hospital – Tatale	Hospital
28	Northern	Tolon	Nyankpala Health Centre	Health Centre
29	Northern	Tolon	Tolon Health Centre	Health Centre
30	Northern	Tolon	Tolon District Hospital	Hospital
31	Northern	Yendi	Yendi District Hospital	Hospital
32	Northern	Zabzugu	Kukpaligu Health Centre	Health Centre
33	Northern	Zabzugu	Nakpale Health Centre	Health Centre
34	Northern	Zabzugu	Zabzugu District Hospital	Hospital
35	Upper West	Daffiama Bussie Issa	Issa Polyclinic	Polyclinic
36	Upper West	Jirapa	St. Joseph's Hospital	Hospital
37	Upper West	Jirapa	Hain Polyclinic	Polyclinic
38	Upper West	Lambussie Karin	Lambussie Polyclinic	Polyclinic
39	Upper West	Lawra Municipal	Lawra Hospital	Hospital
40	Upper West	Lawra Municipal	Babile Polyclinic	Polyclinic
41	Upper West	Nadowli-kaleo	Nadowli District Hospital	Hospital
42	Upper West	Nandom	St. Theresa's Hospital – Nandom	Hospital
43	Upper West	Sissala West	Gwollu Hospital	Hospital
44	Upper West	Tumu	Tumu Hospital	Hospital
45	Upper West	Wa East	Bulenga Health Centre	Health Centre
46	Upper West	Wa East	Loggu Health Centre	Health Centre
47	Upper West	Wa Municipal	Kambali Health Centre	Health Centre
48	Upper West	Wa Municipal	Upper West Regional Hospital	Hospital
49	Upper West	Wa Municipal	Wa Municipal Hospital	Hospital
50	Upper West	Wa West	Dorimon Health Centre	Health Centre
51	Upper West	Wa West	Wa West District Hospital	Hospital

Table 8 List of devices assessed

Device class/type	List	
Respiratory support and oxygen systems	• Oxygen tubing • Pulse oximeter • Neonatal-size pulse oximetry probes/sensors (reusable • Neonatal-size pulse oximetry probes/sensors (consumable) • Recharger for batteries (for pulse oximeter, match pulse oximeter batteries) • Patient monitors (can measure at least three of NIBP, HR, SpO2, ECG, RR, Temp) • Probes for patient monitor	
Oxygen cylinders	• Bag self-inflating (neonatal size) • Neonatal-size face masks (size 0) • Neonatal-size face masks (size 1) • Penguin sucker • Resuscitation mannequin (for practice) • T piece resuscitator	
Safe Oxygen Delivery Equipment and Supplies	• Apnea monitor • Respiratory rate monitor • Nasal prongs (1 mm) • Nasal prongs (2 mm) • Oxygen blenders • Oxygen, bottled/cylinder • Oxygen concentrator • Oxygen concentrator filters • Oxygen humidifiers • Oxygen flow splitter for newborn • Oxygen cannula • Suction pump (portable, electrical) • Suction pump accessories • Suction pump (manual, non-electric power dependent)	
CPAP Equipment and Supplies	• CPAP driver system (standard CPAP) • CPAP driver system (bubble CPAP) • CPAP hats • Face mask • Hudson prong • Neo Ram cannula • Improvised cannula • Regular standard cannula • CPAP prongs • CPAP tubing • Distilled water • Kettle for boiling water	
Retinopathy of Prematurity Equipment and Supplies	• Indirect ophthalmoscope (with small pupil adjustments)	
Spare parts	Pulse oximeters	• Neonatal-size pulse oximetry probe (reusable, clip) • Neonatal-size pulse oximetry probe (reusable, wrap) • Neonatal-size pulse oximetry probe (single use, wrap) • Recharger for batteries

Spare parts	Oxygen cylinders	• Pressure regulator • Stop valve • Cap • Pressure gauge • Flowmeter • Pigtail with safety wire
	Oxygen concentrators	• Flowmeter • Circuit board (control) • Circuit board (oxygen monitoring) • Circuit board/step down transformer (fan) • Fan • Solenoid valves (equalization) • Molecular sieve beds • Power supply unit • Intake filter (internal, fine particle) • Intake filter (external, gross particle) • Reservoir tank • Muffler with exhaust filter • Compressor • Compressor rebuild component • Starting capacitor
	Oxygen Flow Splitters	• Flowmeter
	Suction pumps (portable, electrical with accessories)	• Pump assembly • Vacuum gauge • Filter (bacterial) • Collection reservoir • Collection reservoir lid • Power supply unit
	Suction pumps (manual, non-electric power dependent)	• Piston assembly • Vacuum gauge • Filter (bacterial) • Collection reservoir and lid
	CPAP driver system (standard or bubble CPAP) with accessories	• Pump assembly • Filter (internal, pump) • Flowmeter • O-ring • Power supply unit
	Maternal and child care (additional) equipment and supplies	• Foetal doppler • Anaesthesia machine • Adult SPO2 • Non-rebreather mask for adult

APPENDIX 7: KEY TASKS AND DELIVERABLES

1.2 Key Tasks

To meet the objectives of the study, the following key tasks were undertaken:

– A desk review of relevant project documents (Ghana EmNOC report, Newborn Strategy Action Plan 2019–2023, Ghana Standard for Improving the Quality of Care for Small and Sick Newborns, Child Health Policy, Ghana Productive, Maternal, Newborn, Child and Adolescent Health and Nutrition (RMNCAH&N) 2020–2025, among other past assessment reports).

– Detailed briefing sessions with GHSC-PSM technical staff to secure the inputs of the technical team into the proposed implementation approach.

– Development of an inception report, detailing the study design, methodology, indicators, tools, work plan schedule, and budget to carry out the assignment in the study areas. This was developed and finalized in consultation with the GHSC-PSM team and other relevant stakeholders within the GHS set-up.

– Development of sampling plan, sampling design, and data collection and management protocol that included key indicators. The data collection tools adequately addressed key research areas.

– Training of field staff (supervisors, interviewers, observers/record reviewers)

– Field data collection at all sampled sites (51 facilities), data cleaning, data analysis, and results synthesis.

– Development and submission of the first draft of the study report and debriefing of GHSC-PSM, GHS, and other partners.

– Provision of data resources including raw data, cleaned data, and data collection tools.

1.3 Study deliverables

Expected deliverables of the study were as follows:

– A health facility assessment report that answers the objectives of the study and covers the relevant areas required. This includes information on data gaps regarding the availability of resuscitation devices for the care of SSNBs, level of health staff capacity to manage and maintain devices critical to ensure adequate care for SSNBs, maintenance protocols for medical devices for newborn care, and understanding of the oxygen ecosystem for SSNBs at facilities.

– A PowerPoint presentation summarizing key findings of the report.

– A technical brief including findings from the assessment.

– A research poster with preliminary data for the 2023 International Maternal Newborn Health Conference.

APPENDIX 8: QUALITATIVE TOOL

Demographic information (to be completed by the interviewer):

Name of Region

Facility Name	
Interviewee Role	
Interviewer Name	
Notetaker Name	
Date of Interview	

Introduction and background (to be read aloud by interviewer):

Thank you for taking the time to speak with us about medical devices for newborn care in health facilities in the public health sector in Ghana!

My name is_____ and assisting me today is _____.

We will be conducting this interview with you on behalf of USAID's Global Health Supply Chain Program-Procurement and Supply Management project, which is a United States government-funded project that focuses on improving the availability of and access to life-saving medical devices, medicines, and medical supplies.

Kindly note that the information provided will be confidential. Your participation in this interview is very important. as it will inform measures for improving the availability and management of medical devices for small and sick newborns (SSNBs).

Your insight will be highly valuable for our assessment. This interview will last approximately 20 to 30 minutes, during which I will ask you a few questions of interest. Please keep in mind that there are no wrong answers; therefore, please feel free to share your views. My colleague will be taking notes during the interview process to ensure that we have collected accurate information. In addition, we are planning to record this interview with your permission as it helps us keep track of any information we may have missed during notetaking.

We ensure that the recording will not be shared outside of the research team. You will remain anonymous, and your responses will remain confidential. During our analysis and reporting process, we will not use any identifiable traits that could be attributed to you. At any point during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question.

You may also stop the interview at any time for any reason. Is it okay if I start to record now (wait for response and if interviewee is not ok with recording, please put the recorder away and proceed with the interview and take detailed notes as you go).

Before we get started, do you have any questions?

Interview Questions (probes are italicized but remember to probe based on the responses):

Questions	Notes
1	
a. Does your facility provide services for the care of small and sick newborns (SSNBs)? b. If no, why is your facility not providing services for the care of SSNBs? c. If yes, how can we improve the service for the care of SSNBs in your facility? d. How does this facility obtain medical devices and accessories? e. Is there a plan for procuring newborn devices? f. If yes, please describe the process. g. What successes have been recorded or achieved in your facility with the management of SSNBs?	
2	
a. Does your facility have resuscitation devices for the care of SSNB? b. If not, please provide reasons why this facility does not have resuscitation devices? c. If yes, what type of resuscitation devices do you have? d. What are the challenges associated with resuscitation devices for the care of SSNBs in your facility? e. How will these challenges associated with resuscitation devices be addressed or solved?	
3	
a. What can you say about the health staff capacity to manage and maintain resuscitation devices critical to ensure adequate care for small and sick newborns? (Probe further in terms of their knowledge, skill, training, and re-training) b. How can staff capacity be improved to manage and maintain resuscitation devices?	
4	
a. What are the challenges associated with the availability of the following for the care of SSNBs within your health facilities? - Improvised bubble CPAP - 100% (or optimum) oxygen supply - Pulse oximetry and other monitoring system - Oxygen concentrators/blenders b. How would these challenges be addressed or solved?	
5	

a. How are the medical devices for newborn care in health facilities maintained? b. What can you say about the maintenance culture in your health facilities in terms of - Frequency of maintenance - Material availability - Human resources capacity - Operating process c. How would the facilities help improve the maintenance culture for these devices? d. What are the challenges associated with maintenance of medical devices? e. How can these maintenance challenges be rectified? f. How is your facility able to cover for expenses for maintenance of these devices (if not mentioned already)	
6	
a. Does the facility have a maintenance protocol for medical devices for newborn care? b. If no, what are the reasons why your facility does not have maintenance protocol for medical devices for newborn care. c. If yes, how are maintenance protocols for medical devices for newborn care in health facilities developed and reviewed? d. How can the challenges associated with maintenance protocol be addressed?	
7	
a. Is there any policy on the availability of medical devices for newborn care in health facilities? b. If yes, what is the policy? What can be done to enhance or improve the policy? c. What recommendations would you give to improve the availability and maintenance of newborn medical devices in health facilities?	
8	
a. What challenges do you face in the referral and transport to your facility from another facility of - Newborns? - Sick mothers? - Sick children? b. What challenges do you face with referral and transport out of this facility to another facility of - Newborns? - Sick mothers? - Sick children??	

APPENDIX 9: SUMMARY FINDINGS—KEY INFORMANT INTERVIEWS

1.0 Introduction

A semi-structured interview guide was used to collect qualitative data on oxygen ecosystem, capacity of staff to manage and maintain equipment, as well as the newborn device maintenance protocols to identify gaps in service quality and access to critical equipment. Target key informants and respondents from facilities, districts, and regional and national levels were interviewed.

The report highlights the challenges faced by the facilities in providing quality newborn care with regards to the availability of the following: resuscitation devices; bubble CPAP; 100% optimum oxygen supply; pulse oximeters; oxygen concentrators/ blenders; maintenance practices for medical devices; services for small and sick newborns provided and staff capacity. It also provides some recommendations by respondents on how to address these challenges.

2.0 Challenges faced by facilities in the provision of care for small and sick newborns

2.1 Neonatal services

In relation to providing service for the care of small and sick newborns, respondents mentioned that some facilities provided all forms of care; a few facilities provided some form of care while others would refer to a higher level of newborn care.

> "The CHPS, health centers, polyclinics, and hospitals all provide service for small and sick newborn babies depending on the condition. As I said, if a child is sick or a newborn has a problem at the community level, they attend to them by referring to the next level for continuity of care if it is beyond their management."

Key informants indicated that health care workers faced certain barriers when providing care for small and sick newborns. The barriers included human resource capacity, unavailability of equipment, and nonfunctional equipment.

> "Even some of the health centers due to capacity issues are not able to provide services for small and sick newborns."

> "The problem has been lack of equipment. For instance, recently they created and opened this place for newborn care but we do not have equipment, not even resuscitation equipment,"

> "We had two ... that broke down, which were donated by an individual. Since it broke down, nothing has been done about it. We are keeping it for repairs but equipment can't easily be repaired like that. We don't have the technical know how to do that."

2.2 Funds and resources for neonatal services

Of the 24 respondents, 18 mentioned at least one of the following funding issues in various forms: lack of funds, inadequate funds, nonavailability and scarcity of resources as one of the dominant challenges faced by facilities in providing newborn care.

Respondents mentioned inadequate funds as a major contributor to the nonavailability of resuscitation devices and spare parts.

"[Hmm], it is a matter of funding [laughs]. It is the funding that is our problem because when you look at what they generate, it is just to buy some of these things [ahaa]. So, some of these, the equipment, though they are very important you look at what they are generating, because we mainly use the internally generated funds to do some of these things but if a facility is not generating it is very difficult to buy some of these things for them. So, we turn to fold our arms and then to depend on donors for some of these things but if the generation were to be [err mm] much. We would have used the internally generated funds to buy some of this equipment for them."

"… even if you get the spare parts, financing, and purchase of the spare part is usually a challenge. Now, if you make an effort to get them purchased, the payment becomes a problem (they chuckle), yes, the facilities couldn't pay. So, it makes it difficult sometimes, you place an order, the order comes or the parts come, and they will now be calling you but the facility will not be able to pay. So now, it is making it more difficult to talk to the people to get you parts these days, it is really difficult."

"Inadequate funds to be able to procure spare parts."

"Yes, that one, that is why I said it is very erratic and because of inadequate funds we are unable to provide most of the materials that would be needed to replace and maintain them."

Respondents mentioned inadequate funds as major contributor to poor device maintenance and servicing

"… regular servicing of the machine is something we should improve that boils down to availability of funds. We need to service them regularly so that we can maintain them. And so inadequate funds, irregular servicing and then the improper use of some of the equipment by staff are some of the challenges we... that confront us in the district."

"… I carry them to the regional equipment unit for them to work on them and send them back because I ... but it's just that the servicing is not frequent. Sometimes quarterly, we do it quarterly."

2.2 Staff capacity for newborn care

All the twenty-four (24) respondents mentioned either low or no staff capacity building and training to operate and maintain newborn equipment and provide newborn services as a major limitation in the care of small and sick newborns.

Some facilities lacked the expertise to operate the devices for SSNBs.

"The challenges I think the, the challenges like for instance, it boils down to capacity issues. [Err] hmm oxygen is one of the issues, the use of oxygen. I remember in the health centers like this, when we went to introduce one of the doctors to the facility, the midwife boldly opened up that… we asked whether there was oxygen at the facility and she said yes but she doesn't know how to use it. So, it boils down to capacity issues. that is the problem. so sometimes …… and the capacity to use those devices available".

"And let me also say that even if some have resuscitation devices for SSNBs, probably they don't have the knowledge as to how to use them. They may try, maybe per what they've learnt in school or elsewhere".

"How to operate this equipment….. with that one too because many a time, there are a lot of equipment that come in service without people being told how to use them..."

"You see that the challenge is how inadequate knowledge of the use is. For instance, if it's a new person, that person needs to be orientated on how to use that device."

"Currently, almost all the health centers have oxygen supply in the district, it's just the ability to use. … some midwives cannot even use the oxygen, you understand. The ability to use… The day we went there, she actually expressed fear that, she cannot use that oxygen equipment."

"If you are going to give us bubble CPAP, it means that we have to train."

Other facilities had inadequate requisite skilled staff to provide neonatal services.

"We do not have the requisite skilled staff--pediatricians, medical officers and so forth and we don't have newborn neonatal intensive care unit in the district."

"Yeah, for the health centers and the polyclinics we have. For the CHPS you know they don't even have midwives, community health nurses- capacity issues."

2.3 Neonatal devices, equipment, and spare partsrequisite skilled staff to provide neonatal services.

All 24 respondents reported a limitation in the availability of neonatal devices, equipment, and spare parts and their negative impact on service delivery

"We are providing the services but due to limited devices we do our pre-referral medication or care and early referral. So, what we can do with the little resources we have, we do that and refer them to the appropriate quarters for further management."

"… We provide maternal and newborn care services but we do not have adequate resuscitation devices. I mean if I say adequate resuscitation devices, I am referring to Ambu bag, I am referring to oxygen cylinders, I am referring to essential medications for the resuscitation of babies. So, basically logistics and equipment are the issues."

"The only thing available is the Ambu bag and that's all the [equipment]. And with the Ambu bag, for now, most [of the ones in the facilities] are not functioning, especially for this particular facility. The Ambu bag for now is not functioning."

"So even though we have, they are not adequate. The facilities that are directly under the district health Directorate, sometimes there are some that are also very big especially the health centers, that I think we should have oxygen cylinders, oxygen concentrators and what have you."

"An individual donated four to us, just recently, just that they are not adequate. We would be able to use them."

"So, oxygen is a problem. Consistent and reliable supply of oxygen is a problem in our facilities."

"… The whole of the Northern it is just recently that they sent some oxygen generators to some of the hospitals otherwise some of them use concentrators but the supply of oxygen is a challenge."

"Concentrators, quite a number of them don't have them, a lot of them. Mostly, you can see them in some of the district hospitals. Even those ones that are there, there are problems."

"… even if you get the spare parts, financing, and purchase of the spare part is usually a challenge…"

"Okay, one of the challenges is that there are certain times where some children who are not supposed to lose their lives but because of lack of this equipment at the service delivery points at the end of the day, that child can just go [die]."

2.4 Procurement of medical devices and accessories

Some facilities procure medical devices and accessories at the national level and some get them through support from donors. Respondents also mentioned government, private non-governmental organizations (NGOs), and individual donors assist them with the devices. On the other hand, others obtain their devices from medical stores or purchase them from the open market. Respondents indicated that the facilities do not have the means to procure most devices needed. Delays in NHIS reimbursement were also cited to compound the problem of lack of funds.

> "Most of the time, it is the basic devices that we procure. Majority of the devices are either procured at the national level or donated by our partners."

> "And some of this equipment, we as a directorate cannot procure. We have to probably partition or request through partners. Yeah. When it comes to the procurement of some equipment, it's beyond us. Yeah, yes, we have to go to the next level because we have a cut-off point as to the amount and what we can procure for events."

> "Most of the time, it is the basic devices that we procure. Majority of the devices are either procured at the national level or donated by our partners."

Lack of funding was a major cause of the inability to procure medical devices and accessories

> "We have a plan, just that we don't have the money. There is always a plan because ideally for me every health center you know or should have some basics equipment for resuscitation and you know some of these breakdowns once in a while so we need them."

> "Yes, there is. There is a plan. However, the challenges are always [errhh erhhh] the challenges of funding and then [err] which is always the biggest headache. So though the plan is there, executing the plan is a challenge."

NHIS reimbursement delays were also a cause of the inability to procure devices and accessories.

> "The challenge is that resuscitation devices for SSNBs are not adequate and we are not able to provide them because most of the time we depend on our NHIS to be able to procure some of those things and if NHIS is not paying regularly as possible, then it becomes a challenge for us to procure."

2.5 Inferior devices

Some facilities reported that the purchase of inferior devices was a major challenge.

"The challenge is also that, the donors sometimes just give the facilities the money to purchase, and in that case too they bypass the 'window' and just buy anything."

"… some of [the devices] don't even have manuals and when there is fault on the equipment you don't even know what it is…."

"Yes, pulse oximetry, the type that was in the system wasn't very good. They are small, small ones. I mean, you procure them and within a very short time they have broken down…"

2.6 High cost of devices

Some facilities reported the high cost of devices and limited insurance coverage as major challenge to devices availability.

"I think we wanted to buy some [CPAP], but the cost was quite exorbitant. I remember we discussed it, and we saw one of our suppliers- 'ASGA'. They had but the price was quite exorbitant so we didn't buy."

"….. beyond extended use of oxygen, the health insurance doesn't cover it so it is another stumbling block. Maybe the child needs it for 24 hours, 72 hours, one week. Given the cost, they are not able to pay."

2.7 Maintenance practices

Of the 24 respondents, 21 mentioned poor maintenance and/or undocumented protocols as an impedance to neonatal service delivery. Reasons cited for poor maintenance and servicing were inadequate funding, inadequate training of staff, unavailability of standard operating procedures for devices, and delayed response to maintenance directives.

"The only challenge is because of poor maintenance. I mean, they will use it until it breaks down, and people don't even know how to remove the filter and clean it…"

"There is no maintenance culture with regard to Oxygen concentrators or blenders. Ideally, biomedical engineers should be deployed and tasked to quarterly or monthly, or yearly service the equipment. But that is not done so why won't the machines break down?"

"Pulse oximeters too, are also a challenge……. and even when you go, you will see some of them have been mended with plasters…."

Inadequate funding was a reason for poor maintenance

"… regular servicing of the machine, is something we should improve that boils down to availability of funds. We need to service them regularly so that we can maintain them. And so inadequate funds, irregular servicing and then the improper use of some of the equipment by staffs are some of the challenges we... that confront us in the district."

Some facilities lacked maintenance experts or trained staff to maintain these medical devices

"But you see simple cleaning of the equipment is important. Sometimes they leave it for people who are not trained to handle them to do and that's where sometimes the destruction comes."

"Maintenance culture, in terms of human resources for estates and equipment are areas that we need to build the capacity of staff. If you look at the whole district, you don't even have any official…. errrr let me say a well-trained estate and equipment officer."

"In case they are faulty, many a time, we don't have the people in the district… I do collect them, send them to the maintenance unit at the TTH and that is where they will maintain some of them for us if only, they are able to do it. If they are not, it means we have to look for money and buy new ones for them."

Other facilities also had no written maintenance protocol or guidelines

"That is something that is lacking, in our case, the hospital. It is done haphazardly… we do not have those plans."

"We do not have some for the facility. I am not sure if there is one for the service in general but we haven't developed one for the facility."

"There is no maintenance culture with regard to the use of equipment. … It's just like a car, you use it, no maintenance--you don't change oils, you don't do anything it's going to break down and you can't even repair. So, for the maintenance it's zero."

"… [err] unavailable standard operating procedures."

Some facilities experienced a delay in response to maintenance directives.

"Okay, thank you. [Um], when it comes to the challenges, you know, in the Ghana Health Service, everything deals with hierarchy. So sometimes, maybe you see that this equipment, there's something wrong with it, you need to report to the next facility or the next person ahead of you. And now you do the reports, and maybe due to a busy schedule, you may not get a response from the person… And I report to the next facility, this is it and then the answers are not coming the responses are not coming on time."

3.0 Recommendations to improve the quality of care for small and sick newborns in facilities

3.1 Build staff capacity

All respondents mentioned the need for training of staff on how to operate and maintain devices. Workshops, on-the-job training or coaching, and specialized training were some of the recommendations to build staff capacity to operate and maintain newborn devices.

Respondents mentioned the following about the need to build staff capacity.

"The next thing I'll also propose is that if the machines are there or the equipment are there, and then the technical know-how is not there, they want to use it but you don't have that knowledge. At the end of the day, the machine will be there, and the child will still pass on. So, I plead that if these machines are able to be provided to the various facilities, then the staff who manage those sections or units should equally be given training as to how to use them in other to save the lives of our children."

"…… We have a good number of staffs, midwives, PAs in the district that use those devices to resuscitate. We need to build their capacity…"

Respondents mentioned workshops as a means of building staff capacity.

"Yeah, in my opinion maybe they need capacity building. Yes, if we build their capacity. Like helping baby breathe, that, was one of the workshops that was done. It was organized by UNICEF or so some time ago which was very helpful because they will teach you how to resuscitate or in delivering a baby how to go through the process. So, with this kind of training, I think it will help a lot if they build their capacity towards that."

Specialized training was also mentioned by respondents to improve staff capacity.

"Pediatrician, for instance, we are even looking for people to go and [train] but it's just that people are ... Ghana college of nurses don't pick them to go and specialize in those areas, we can ... and if our doctor is also not interested in that area, that is another issue. But we are actually encouraging staff to see how we can build their capacity in those areas."

On-the-job training or coaching and structured in-service training were among the methods of building staff capacity recommended by the respondents.

"On-the-job coaching, the structured in-service training and then allowing staff to go to school to also build their capacity in that area. It will address that gap. Then we could... I mean posting in too can also… staff need to be posted into the district; specialized staff to help…"

"… the staff can be trained on how to maintain them. They are trained to maintain them and then periodically, they can maintain them themselves. Those that are beyond them and need technical assistance, we arrange with the engineering department, and clinical engineering department to come in and help with the maintenance."

Respondents mentioned staff training on how to maintain devices in the facility

"Maintenance culture can be improved in our facilities by: One, getting people who are committed to take up activities about maintenance issues …"

"…once it is planned maintenance and of course ensuring the regular training of staff, especially new staff into this unit so that they know how to better care for these. And then of course making sure that standard operating procedures are available and staff are trained adequately on them."

"We also have to look at the personnel that will manage that equipment. So that we can get the personnel available and then also equip them with the necessary knowledge that they need in order to operate those machines."

3.2 Establishment of neonatal units

Respondents recommended that neonatal units should be established in the district hospitals to facilitate the provision of more advanced newborn care

"….. and also, at least we should be able to have well established and furnished NICU at the district hospital. We are privileged to be given one of those under agenda 111 hospitals. I don't actually know whether it comes with a NICU. If it comes with NICU, fine but if it doesn't it means we need to establish one."

3.3 Purchase of equipment with support from government and stakeholders

It was recommended that facilities solicit support from government and partners to fund the purchase of newborn devices and equipment.

"So, we keep talking to our partners. We have a number of NGOs who are supporting that plan and are here to support us with some of those equipment. So, we begin engaging them, and they are supporting in that area."

"So, government should intervene, we are looking at central governments or partners. Partners can come in to support us. Once a while we have partners who can support but not that particular equipment. But what they support us with like the oxygen, the cylinders and then I believe if we are able to get those things…"

3.4 Comprehensive stakeholder consultation on device procurement

It was recommended that effective consultation should take place to ensure the right specification of devices are purchased.

"One of them is [erm] mostly when it comes to the procurement, there is a problem. Sometimes our unit does not consult the procurement processes sometimes with the hospitals especially when the hospitals are buying. And in some cases, the donors also do not consult because we need to know some specifications so usually this is what they do."

3.5 Development, dissemination, and proper implementation of policies on newborn care

Respondents recommended that newborn care policies be developed, disseminated, and well implemented by policy makers at all levels of care.

> "So, if there are policies, they should be well disseminated so that people are well aware and we would ensure that they are implemented."

> "Okay, thank you. In my opinion, I think some of these policymakers have to take it up, to see how best they can help. I will say, as you've come, you have introduced yourself and you are taking this data, it is our hope that it will get to our policymakers so that they can also hear our cry and make an impact. Sometimes they come and then we say these things are not there, these things are not there, and then when they go, you don't hear anything from them. And as we are all here, I cannot use my personal money to buy the equipment for the facility. If I do, how many of them can I buy? So, it's up to our policymakers to come to our aid, and then provide these things for us. So that we'll be able to use."

3.6 Inventory assessment of the device and equipment

Inventory assessment of devices and equipment was recommended by respondents as a means to regularly identify gaps in equipment needs and meet those needs.

> "I think what we can do is to, first of all, take stock of those critical devices per the levels of service delivery, then we need to take stock of those facilities and those devices. And where there are gaps, we have to find a way of filling those gaps and also put in measures to track the utilization of those devices."

> "Ghana health service should try as much as possible to assess the availability of equipment at the facilities. And the district should also have comprehensive plan and then put down the equipment we need at all level and be able to find out those that are not available and see how we can make them available for service delivery to go on. Then we will encourage them and train the staff at the facility level."

3.7 Encouragement of staff to follow standard operating procedures for devices

Respondents recommended that adherence to standard operating procedures should be encouraged among staff at the various facilities.

> "… we should try as much as possible to always adhere to the precautions of using the devices. Almost all our devices have a specific way of how are supposed to be used. Most of them… they are always spelled out in the manual. You know by nature of… we don't like using manuals, we feel like everything we should be doing it the crooked way."

"It should be properly placed after it is used. It should be properly maintained, cleaned, and put it where it is supposed to be. That way we will be able to extend their lifespan…"

3.8 Provision of funds

Respondents recommended special funds should be dedicated for purchasing, servicing, and maintaining devices and also called for donor support from USAID and UNICEF, among others.

"The devices are expensive and if it is left with management of facilities to procure in adequate quantities, I can tell you they will run bankrupt for the next decade. So, if we have donors coming in to support, higher-level organizations like the USAID, you know procuring and distributing them to facilities and regions based on DHD I'm sure it will go a long way to support the regions too you know…I mean in the past, UNICEF has done so much in terms of newborn care and I have always praised them anywhere I go with regards to that. They've been a really important stakeholder in that area."

3.9 Establishment of a strong maintenance culture

Respondents mentioned the need to strengthen the system for maintenance of equipment and also collaborate with the clinical engineering unit and district health directorates (DHDs) to be able to provide maintenance support.

"Then another to recommend is that even though there is maintenance, it should be strengthened in order to take their maintenance rate serious when that equipment is being provided. From time to time, you make sure that they are being maintained in order to keep long."

"Yeah, what can be done is last year… for us to collaborate with the clinical engineering unit so that quarterly they can come and monitor some of the equipment. Possibly those that will be needing calibration, they can calibrate for us. Not necessarily these two things that we have mentioned, but I think if we have the sophisticated ones and the clinical engineering can come in as and when necessary, we can work together."

"Also recommend that at the district level they can also have maybe someone who goes to the facility from time to time to check on that equipment so that the person can report early."

"In addition to those, as I've mentioned, you know some of these machines need technical things. So, having an engineer within the health facilities in order to check on them will also help to keep the machines long for all of us. Thank you."