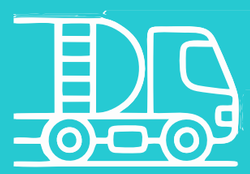
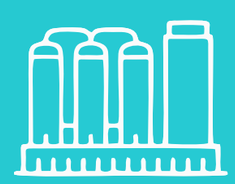
Compendium of Case Studies





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Lessons from the Indian state of Maharashtra

SCALING UP ACCESS TO OXYGEN

The state of Maharashtra in western India experienced the worst of the second wave of the COVID-19 pandemic, accounting for nearly one of every five of the 32 million cases and around one of every three of the 430,000 COVID-19 related deaths in the country by mid-August 2021. Given the unprecedented scale of the pandemic during the second wave, the state's efforts were inadequate to rapidly scale up its oxygen supplies to meet the spike in demand for medical oxygen in many of its public health facilities.Participants of the training conducted on oxygen management system

As part of its preparations for the third wave for COVID-19, the Maharashtra state government has identified that augmenting access to oxygen as one of the most effective and critical actions to improve health outcomes and save lives. The state is installing various oxygen systems – liquid medical oxygen (LMO), pressure swing adsorption (PSA) plants and oxygen concentrators – across government health facilities, in addition to improving availability of oxygen supply systems through medical gas pipeline systems (MGPS), manifold systems and oxygen cylinders.

EMERGING NEED FOR TRAINED HUMAN RESOURCES FOR MANAGING OXYGEN SYSTEMS

Although oxygen therapy is a very old treatment modality, yet various oxygen systems are fairly new to the public health systems, which, except for large teaching hospitals and tertiary healthcare facilities, had historically relied on oxygen cylinders to meet its medical oxygen demands. As a result, there are very few trained persons in the public health system, especially at district and sub-district level facilities, who understand the complexity of integration and maintenance of these newly deployed oxygen systems and know how to manage them.

Participants of the training conducted on oxygen management system

TRAINING BIOMEDICAL ENGINEERS MANAGING VACCINE COLD CHAIN TO MANAGE OXYGEN SYSTEMS

To address this gap, the state government decided to strengthen capacities of the biomedical engineers (BMEs) working with the Health Equipment Maintenance and Repair (HEMR) division of the state's health department. The BMEs and other technicians of the HEMR Division in the state have been involved in managing, operating and maintaining the Vaccine Cold Chain management systems. Engaging BMEs who manage vaccine cold chains to manage oxygen systems is an approach that had never been attempted before in the country – this was the first such initiative of its kind!

The Public Health Department in collaboration with Deputy Director, Health Services (Transport division), Pune and PATH organized a training on oxygen management system for the Biomedical Engineers and Technicians of the HEMR Division between 28 June 2021 and 06 July 2021. Thirty-three (33) BMEs were trained in three batches at the National Cold Chain Resource Centre Training Center in Pune, Maharashtra on –

- Various aspects of oxygen ecosystem and operations and maintenance of oxygen systems including MGPS.
- Trouble shooting, safety and security of various oxygen sources in the government hospitals in the state.

- Inventory management and oxygen audit for optimizing the available oxygen resources at the facility, and
- Orienting and training facility level staff on day-to-day operations and maintenance of oxygen systems in public health facilities.

The expert trainer explaining about different components of a PSA oxygen generation plant in the hospital premises to the BME trainees

PATH supported the state government in identifying subject matter expert from the public systems and the industries to facilitate the training. They shared their field experience and built technical knowledge and operational capacities through classroom learning and practical demonstration on the live systems in nearby hospitals. The training covered technical specifications, installation, commissioning, operation, maintenance, safety of the oxygen equipment and oxygen audit, related to the oxygen ecosystem components on LMO, PSA oxygen generation plants, oxygen concentrators, oxygen cylinders, MGPS and manifold systems. The BMEs also received orientation on basic fire safety guidelines and precautionary actions to avoid fire hazards.

Dr. Satish Tajne, PATH, along with Dr. Sanjay Deshmukh, Assistant Director - Medical, Pune circle, orienting the BMEs on oxygen inventory management

TRANSFERRING KNOWLEDGE AND STRENGTHENING CAPACITIES AT THE PUBLIC HEALTH FACILITIES

Following their trainings, the state allocated districts to groups of trained BMEs. The BMEs of the HEMR division are functioning as master trainers and mentors to the district staff of their allocated districts, who will further train the identified medical, paramedical and non-medical staff at the health facilities on oxygen systems.

The training design and approaches used by the state government to train the BMEs are being replicated for training the district trainers. The BMEs have also been mandated to visit all the health facilities in their allocated districts after completing the training of district trainers to provide supportive supervision to facility-specific trainings and mentor the district trainers.

As an outcome of this training at state level master trainers and district trainers visited 120 facilities within 2 months and trained a total of 1676 trainees on medical oxygen management systems at facility level.

Encouraged by the early response to this approach, the state government of Maharashtra is in process of developing a state strategy for strengthening human resources of oxygen systems, which will include developing a cadre of BMEs as trainers and building facility level capacity to maintain and repair the oxygen equipment.

SUSTAINING PSA FUNCTIONALITY BY QUICK ONSITE HANDHOLDING SUPPORT AND EFFECTIVE VENDOR COORDINATION

A case of SCB Medical College and Hospital at Cuttack in Odisha, India

Image 1. The 3000-bedded Srirama Chandra Bhanja Medical College and Hospital at Cuttack in Odisha, India

Odisha confirmed its first case of COVID-19 pandemic in mid-March 2020. Since then, the state has so far witnessed three waves of the pandemic. The second wave, which spanned five months from April to August 2021 in the state, was three times the most severe of the three, with about 11,600 new cases reported every day in the middle of May 2021. As some steel majors in the state, like the Tatas and Jindals, converted the industrial oxygen into medical grade oxygen on recommendations of the Odisha government to respond to the pandemic, the state government did not face shortage of medical oxygen.

Notwithstanding the surplus situation, the state government initiated the process of expanding and diversifying its oxygen sources. In addition to setting up LMO units and oxygen concentrators at the public health facilities, the Odisha government installed Pressure Swing Adsorption (PSA) oxygen generation plants to enable captive oxygen generation capacity in those facilities.

The Government of India allocated 52 PSA oxygen plants to Odisha through Prime Minister's Citizen Assistance and Relief in Emergency Situations (PM CARES) Fund and 9 with support from MoPNG and 4 with support from Ministry of Railway. In addition, the state government mobilized 30 PSA oxygen plants through Corporate Social Responsibility (CSR) resources. One of the approved sites was the 3,000-bedded Srirama Chandra Bhanja (SCB) Medical College and Hospital in the Cuttack district.

USAID NISHTHA'S TECHNICAL ASSISTANCE

The United States Agency for International Development (USAID) Project NISHTHA extended a grant to PATH to provide technical assistance for faster operationalization of PSA oxygen plants in six states of India, namely, Delhi, Jharkhand, Odisha, Rajasthan, Karnataka, and Maharashtra, and for procurement and deployment of oxygen concentrators in four of those six states, i.e., Chhattisgarh, Delhi, Jharkhand, and Maharashtra.

PATH, as the Technical Support Unit (TSU) for oxygen to the Odisha government, provided technical assistance for installation and commissioning PSA plants through PM CARES in the identified health facilities and extended post-installation support.

PSA PLANT IN SCB MEDICAL COLLEGE AND HOSPITAL

The SCB Medical College and Hospital, the largest hospital in the state, handled around 1,500 out-patient department (OPD) cases and around 2,200 in-patient department (IPD) cases every day during the second wave. The teaching hospital has 182 ICU beds and 443 oxygen beds for patients.

The facility already had a 13 KL capacity of LMO plant installed in addition to 2,000 B-type cylinders, 2,800 D-type cylinders and an approximately 443 oxygen concentrators to support patients requiring oxygen support during second wave (Source: Odisha State Medical Corporation Limited). As the facility had established four COVID-19 units within its premises, the state government decided to install two PSA plants – one of 2,000 LPM capacity through PMCARES Fund and another of 600 LPM capacity with state CSR support – to cater to the need.

PATH, through the USAID NISHTHA project, assisted SCB Medical College and Hospital in getting the 2,000 LPM PSA and 600 LPM PSA oxygen plants installed. It supported the hospital management to coordinate with various stakeholders, like PSA plant vendors, district level engineers, the state nodal officers from the Health and Industry department, among others to ensure timely installation of the PSA oxygen

plant in the medical college. Once the plant was installed, PATH further supported the hospital authorities in getting a sample of oxygen generated by the plants tested for quality by providing financial assistance and coordination for the sample collection, and certification. The certification allowed the SCB Medical College and Hospital to commission of the PSA plant for use. These two PSA plants supply oxygen round-the-clock to the 173 ventilators.

Image 2. Oxygen analyzer panel of the left showing oxygen pressure at 50.7 and on the right, after troubleshooting, showing 93.4PATH also helped the hospital negotiate a one-year service warranty with the vendor. The hospital authorities placed two technical personnel from its roster, who were oriented by the vendor on daily maintenance and upkeep of the PSA plants, for post-installation management of the two plants.

Image 2. Oxygen analyzer panel of the left showing oxygen pressure at 50.7 and on the right, after troubleshooting, showing 93.4

HOSPITAL DIALS IN PATH AS OXYGEN PURITY DROPS

On 13 August 2021, the Hospital Superintendent of the SCB Medical College and Hospital called up PATH's team to inform that the 600 LPM PSA plant was not working efficiently, and its oxygen saturation level was falling rapidly, among other issues. As neither of their technicians were available around that time and the hospital administrators and the plant operators were not confident about handling the issue by themselves. PATH Odisha team sent its Technical Assistant Engineer to the SCB Medical College and Hospital to identify the problems and resolve them. PATH's engineer inspected the PSA oxygen plant and checked it for filter clogging, calibration, valves, and compressor. He also calibrated the analyzer to check whether it is showing

right concentration on display or not. PATH's engineer found that the discharge valve between the adsorption column was not working properly, due to which nitrogen, which should be released from the discharge valve, is not getting released properly. This was causing the concentration of oxygen to fall below the permissible limit to 40-50 per cent at the output.

PATH's engineer called up the vendor's service engineer for assistance. This was required because as per the terms of reference in warranty document provided by the vendor any unauthorized troubleshooting or fixes are restricted. The service engineer agreed to inspect the plant and addressed the issues.

The service engineer replaced the valves. After replacing the valves, the oxygen concentration levels were checked every few hours until the saturation level once again reached above 90 per cent levels.

> “As the PSA plant was not working properly, we were facing problems in serving the patients. It became even more difficult as our technicians were not available to check the issue. PATH's team intervened on our request and supported us in getting the issues resolved.”
>
> Soumen Sahu
> *Sub Divisional Officer (Road & Bridge Department)*

PATH's engineer also observed that there was much higher requirement of the medical oxygen in ICU than the quantity produced by the PSA plant. This increased demand reduced the oxygen pressure inside the tank, which, in turn resulted in the oxygen analyzer showing low pressure. The oxygen plant operators at the SCB Medical College and Hospital were instructed to keep additional oxygen cylinders filled as back-up. With PATH's assistance, the hospital added oxygen cylinders in the manifold unit, in addition to direct supply from the PSA oxygen plant via the medical gas pipeline system (MGPS), as a continuous source of oxygen.

> “The on-site mentoring that we received on the operational aspects of the PSA plant and the manifold unit was very crucial. We had very limited knowledge on operation and maintenance of PSA plant. We needed these forms of technical assistance!”
>
> Suraj Panda
> *PSA oxygen plant operator*
> *SCM Medical College & Hospital*

LESSONS LEARNT

- **Training is not the only approach to strengthen capacities:** It is important not to wait for training sessions after installation of a PSA plant to strengthen capacities. On-site mentoring and troubleshooting support go a long way in building confidence of the new cadre of plant technicians.
- **Establishing Standard Operating Procedures:** Along with training and mentoring support, it is important to clearly define job expectations of each staff on management of the oxygen equipment as well as clearly establishing Standard Operating Procedures on operation and maintenance of PSA plants.
- **Facility level ownership, capacity and confidence in handling the PSA plant is crucial in quick response, trouble shooting and effective vendor coordination.** These in turn can resolve any machine related issues and helps PSA plant to be functional at all times.

DELIVERING OXYGEN AT DOORSTEP: A CASE STUDY ON RAJASTHAN'S OXYGEN CONCENTRATOR (OC) BANKS

BACKGROUND

Globally, patients with mild to moderate long-term respiratory distress are primarily treated at home. These home-based patients require continuous oxygen supply for extended periods of time. In order to assist these home-based patients, two manufacturers, Union Carbide Corporation and Bendix Corporation, developed an innovative device called oxygen concentrator (OC). An OC, as the name implies, concentrates oxygen from ambient air by selectively removing nitrogen, thereby supplying oxygen to patients. Patients access the oxygen provided through the concentrator by a cannula, oxygen mask, or nasal tube.

During the COVID-19 pandemic, the SARS-CoV-2 virus infected patient's respiratory systems, causing drop in blood oxygen levels and shortness of breath. As the infection level in the community soared and demand for medical oxygen increased, patients sought oxygen therapy from nearby hospitals, resulting in dwindling oxygen supplies. Hospitals revised their in-patient strategies by admitting patients with severe symptoms only, and in line with the World Health Organization's guidelines, the governments advised patients with mild to moderate symptoms to isolate at home. This led to a considerable increase in demand for OCs by COVID-19 patients who sought care at home.

The Government of Rajasthan swiftly stepped up and implemented a series of measures to support patients requiring oxygen. One of the many measures include establishing OC Banks. This case study documents various aspects of establishing OC Banks, their impact, and lessons learned from this intervention.

STRUCTURE OF OC BANKS

The Rajasthan state administration established OC Banks, or simply, "Oxygen Banks," that enabled access to oxygen to home-based patients with mild to moderate symptoms.

> This unique rental scheme of providing OCs to patients at their doorsteps has proved beneficial and cost-effective. This scheme not only benefited COVID-19 patients but also patients suffering from other respiratory disorders such as silicosis, chronic obstructive pulmonary disease (COPD), etc. Patients can be taken care of at home and family members attending to such patients need not worry about arranging medical oxygen when required.
>
> Dr Prem Singh,
> *State Nodal Officer, Rajasthan*

This initiative was aimed at providing medical oxygen equipment to patients suffering from respiratory diseases, such as COVID-19, silicosis, COPD, etc. directly at their doorstep. This concept was envisioned to reduce the spread of COVID-19, minimize the load on medical facilities, and most importantly, reduce the loss of life due to respiratory diseases.

PROCUREMENT AND QUALITY CHECKS

The Government of Rajasthan procured around 33,000 OCs through its procurement agency, Rajasthan Medical Services Corporation Limited (RMSCL), at a cost of approximately INR 50,000 – INR 60,000 per OC. The OCs were procured through the state funds. The state also received around 10,000 OCs through donations from various foundations.

Quality check of the procured OCs were conducted by issuing tenders and deploying biomedical engineers to review their quality. Facility in-charges were also directed to unbox each OC and check the devices for proper functioning.

DEPLOYMENT OF OC BANKS

The Chief Executive Officers of Zila Parishad, in coordination with District Collectors and Chief Medical and Health Officers (CMHOs), were entrusted with the task of identifying the requirement of OCs and generator sets for their respective districts. The state government equipped every health centre with two OCs and one diesel generator set. The generator sets were provided to ensure uninterrupted operation of the OCs.

Out of 33 districts in Rajasthan, seven districts namely Jaipur, Jodhpur, Udaipur, Ajmer, Bharatpur, Bikaner, and Kota were provided with more than 500 units of OCs. At least 400 OCs were stored in the Jaipur warehouse. Additionally, 200 OCs each were provided to Alwar, Bhilwara, Pali, and Ganganagar. Rest of the 22 districts were provided with 100 OCs each.

> We have an oxygen bank with 200 units of concentrators in our warehouse and provide these devices to home-based patients with respiratory distress.
> A prescription is required from the doctors and a security amount of Rs 5000/- is deposited to the bank. At the time of the delivery of the OC, the patient and family members are trained on the operation and maintenance of the device.
> We have provided seven OCs to benefactors since 2022. The scheme is beneficial to the patients as they could get oxygen therapy at home and the family members can take care of them. In future, we would like to extend this service to all the patients suffering from respiratory diseases in the community.
>
> Dr Ghanshyam Chawla,
> *Deputy CMHO, Bhilwara, Rajasthan*

CAPACITY-BUILDING ON OCS

In order to ensure that the OCs are operated and handled properly, the state government undertook series of capacity-building programs on aspects such as operations, handling filter, decontamination, among others. The trainees were primarily medical staff working from primary-level to tertiary-level health facilities. Additionally, the state has plans to conduct training on repair and maintenance of OCs through Skill Mission India so that certified repair and maintenance trainers are onboarded throughout the state.

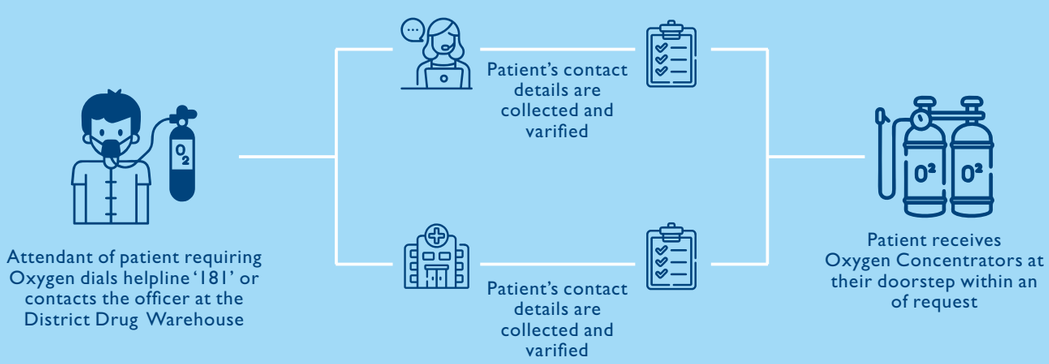
FUNCTION

On the lines of blood banks, the Government of Rajasthan facilitated seamless and decentralized supply of the OCs to the people. OCs could immediately respond to oxygen needs as they are easy to deploy and operate anywhere, thereby meeting community demands. This was also an attempt to reduce the burden on secondary- and tertiary-level hospitals.

Patients with moderate to mild symptoms of breathlessness were advised to stay at home and use OCs in case of need. Patients requiring OCs could call a helpline number or contact the officers at the District Drug Warehouse (DDW). Thereafter, the OC would be made available to them on rental basis. The helpline operator or the officer from the DDW collected the contact details of the patient and after verification. The OCs were delivered within an hour.

The staff operating the helpline number were given additional responsibility of managing the calls for OC requests. The District In-Charge of DDW and his two-member team were responsible for verifying the identity of the potential beneficiary.

OXYGEN CONCENTRATOR RENTAL PROCESS



> During my hospitalization in ESI hospital, Bapu Nagar, Bhilwara, the doctors and hospital staff told us about the rental scheme of the OCs that can be used at home. This scheme was beneficial for us as I could stay at home my family could take care my care. We have talked about this scheme to everyone in the village. The scheme will benefit many people who requires oxygen at home.

Bhagwati Devi,
Gowliya Village, Sada Tehsil, Bhilwara

A refundable amount of INR 5000/- was collected from the beneficiary as security deposit before delivering the OCs, which was paid in full once the OC was returned to the bank.

REPAIR AND MAINTENANCE THROUGH E-UPKARAN

The state has developed a web-based platform to upload details of all the OCs provided through state funds. The platform includes information of OCs received through donations from various entities or as part of corporate social responsibility or procured at the state level or local level. The repair and maintenance of all the OCs in the state is managed through this platform. Apart from directly logging into the E-Upkaran website, complaints for repair of OCs can be made through other channels such as by calling a toll-free number or using the mobile app version or the e-Upkaran software.

IMPACT

- The state has ensured oxygen support to the most marginalized sections across all districts of Rajasthan by making OCs easily accessible and free of cost.
- The treatment of a majority of mild and lower moderate cases with OCs at the periphery level significantly reduced the load on secondary- and tertiary-level hospitals. This helped the medical facilities in focusing on more severe patients.

- Availability of and easy access to OCs greatly reduced the panic surrounding shortages in medical oxygen supply.
- The services of OC Banks at zero cost were an important step towards extending medical facilities to the people who otherwise could not afford them.
- OCs helped in dealing with immediate priority of treating COVID-19 patients and in improving respiratory care management of silicosis and other similar diseases in the long run.

LESSONS LEARNT

- **Simplified procurement:** The procurement was done through RMSCL, a state agency for procurement of drug and equipment. RMSCL is a reliable intermediary, with demonstrated history of quality and timely delivery. Procurement through this agency saved the state government the delays which normally come with the process of tendering.
- **Explore multiple channels:** Since oxygen is a lifesaving medicine, it is crucial that state governments explore multiple channels to make oxygen available to the marginalized population at all levels of health care. The state government linked the OC Banks to helpline number, thus, making it easily accessible to the most vulnerable population.
- **Strengthening the capacity of healthcare to respond to pandemic:** A pandemic as devastating as COVID-19 cannot be managed solely at tertiary care facilities. Training on all aspects of the oxygen ecosystem should be plugged into various upskilling plans of health care service providers and should be conducted and upgraded periodically. It is critical to prepare ourselves and the health systems not only for pandemics like these but also for the overall strengthening of the primary and critical health care needs of the country. The preparedness to such a pandemic also requires interventions at rural level and services at facility nearest to the community.
- **Use of automated system for operations and maintenance:** The use of digital platform such as E-Upkaran, ensured state-wide seamless support for repair and maintenance of OCs. It provided error-free details of all the OCs that are available and functional, thus, ensuring smooth operations and maintenance.

STRENGTHENING MEDICAL OXYGEN SYSTEM IN A HIGH-SECURITY PRISON HOSPITAL: PATH'S UNIQUE EXPERIENCE

This case study documents USAID NISHTHA partner PATH's unique experience of supporting the setting up of a pressure swing adsorption (PSA) oxygen generation plant in a hospital which is located in a prison complex in Delhi, India. This intervention is unique for PATH as an oxygen generation plant is set up in a high-security hospital that houses at least 10,000 inmates at a time, including a few high-profile inmates. This case study also mentions the heartening contribution of 8–10 inmates in the successful installation and operationalization of the plant.

INTRODUCTION

Prisons are among the most neglected living spaces in India with persistent challenges of overcrowding, lack of basic facilities, and a significant presence of inmates from marginalized and poor sections of the population. With limited medical infrastructure and resources, natural deaths of inmates are mostly related to heart and lung-related ailments, tuberculosis, etc. (National Crime Record Bureau, 2018). Hence, the COVID-19 pandemic triggered an unprecedented burden on prison authorities to not only contain transmission but also provide treatment on a much larger scale than before.

During the second wave, as the entire city of Delhi clamoured for oxygen, the Central Jail Hospital was not untouched by the oxygen crisis either. This hospital lies in Tihar Prison Complex, Delhi. It is a 100-bed hospital that was managing mild to moderate COVID-19 cases through oxygen concentrators and cylinders prior to and during the pandemic. Due to its limited capacity, the hospital was referring severe and critical cases to nearby Deen Dayal Upadhyay Hospital, which is within 2-3 kilometres of the Tihar prison complex. A COVID-19 Task Force was deployed in the Central Jail Hospital; it was responsible for timely referrals of inmates, along with providing psychosocial care to them.

The second wave of the pandemic was a wake-up call to the need for oxygen plants in all health facilities as oxygen is vital to any healthcare infrastructure and a lack of it could lead to loss of lives. Taking cognizance of the situation and in a bid to prevent oxygen crises in the future, the Government of Delhi, prison authorities, medical officers, and PATH came to a consensus of installing an 800 litre per minute (LPM) PSA

plant in the Central Jail Hospital. Moreover, this health facility was a 100-bed hospital, and as per the rules laid down by the state government, hospitals with 100 or more beds were mandated to have a PSA plant. This PSA plant provided an opportunity for overall health system strengthening as it would not only cater to the COVID-19 patients but also to patients suffering from conditions such as pneumonia or other respiratory ailments.

PATH played an active role in setting up the PSA plant in the Central Jail Hospital. PATH worked in close coordination with the Nodal Officer, Public Works Department (PWD) of the Government of Delhi, Central Jail Hospital officials, and Tihar prison authorities.

PATH'S SUPPORT IN AUGMENTING MEDICAL OXYGEN

PATH's technical support unit in Delhi was set up under the USAID NISHTHA project in response to the unprecedented surge in the demand for medical oxygen during the second wave of COVID-19. The USAID NISHTHA partner PATH's key role in Delhi was to support decision-makers on oxygen management and provide technical support to the government in installing and operationalizing PSA plants in health facilities.

The team assisted the state by installing five PSA plants with an 800 LPM capacity, donated through a grant by Google.org, the philanthropic arm of the technology giant and GiveIndia Foundation. Of these five plants, one of them was installed in the Central Jail Hospital, Tihar Jail Complex.

> "Tihar Central Jail has been serving healthcare needs of the prisoners through all the COVID-19 surges so far. Thus, we readily agreed to support the Central Jail Hospital for strengthening respiratory care by establishing the oxygen generation plant. The hospital authorities gladly accepted this support and facilitated the entire process of installation and commission of the PSA plant, which was especially heartening."

Dr Satish Tajne,
Project Lead, Google-GiveIndia
Foundation Oxygen Project, PATH

PATH provided technical support in identifying the site for PSA plant within the prison premise and ensuring that the site was within the prescribed distance from the hospital. PATH was also involved in commissioning and imparting training to health service providers on operation, maintenance, and troubleshooting of the oxygen generation plant. Given the high-security status of the prison complex, much of PATH's role was to facilitate approvals and ensure protocols within the timelines set for the installation and operationalization of the plant.

> "It has been a wonderful and excellent experience to work with PATH for the establishment of the PSA plant in the Central Jail Hospital premises. This will prove a boon for the patients requiring oxygen therapy. All doctors along with the paramedical staff are grateful to Google grant through PATH and feel motivated to serve the catering population with full enthusiasm."

Dr. Ajay Dalal,
Resident Medical Officer (RMO),
Central Jail Hospital

Left to Right: Dr. Arun Thakran, Additional Resident Medical Officer, Mr. Mohd. Arif Khan, PHC, PATH, and Dr. Ajay Dalal, RMO

UNIQUE CHALLENGES THAT NEEDED UNIQUE SOLUTIONS

Installing an oxygen generation plant at the Central Jail Hospital complex was one of the most challenging tasks that the PATH had undertaken as the standard specifications and common procedures were not applicable at this high-security premise. It required the technical team at PATH to come up with innovative measures and practical solutions during the installation of the plant.

HIGH SECURITY PREMISE MEANT MULTIPLE APPROVALS

The Tihar Jail complex is one of the largest prison complexes in South Asia and houses many high-profile inmates. The jail is known as a model jail due to its reformatory measures and advanced security systems. As a result, the complex follows high-security protocols, and any external intervention requires multiple security checks and approvals.

The security protocols involved multilevel checks to ensure that sharp objects, mobile phones, laptops, and other gadgets were not brought inside the premises.

These security protocols became even more important as they involved screening outsiders for COVID-19 infections to prevent large-scale transmission within the heavily populated prison complex that housed staff members, healthcare workers, and prison inmates.

> “At every step, there were protocols to be followed as this was a unique setting in comparison to the other hospital settings that we have supported so far. As this is a high-security zone, several rounds of security checks were done and a proper listing of the number of people who were required for the installation was maintained at the entrance gate. Passes were also given for security reasons. Vendors were prohibited from using mobile phones and gadgets inside the premises. Our team complied with all the protocols and ensured the timely commissioning of the PSA plant.”
>
> Mr. Rohitashwa Kumar,
> *Delhi State Lead, PATH*

SITE SELECTION INVOLVED CAREFUL CONSIDERATIONS

One of the main challenges faced by the team was identifying an appropriate site within the hospital complex to install the PSA plant. The selected site had to meet the requirements of being at an appropriate distance within a high-security zone with free space of at least five meters around the plant and nearly 60-80 meters away from the manifold room.

The initial spaces that were identified could not be utilized. The first site had to be cancelled as it required uprooting several trees in the complex, and the second location had to be cancelled as it was in front of the de-addiction centre and was taking over the space meant for recreation of patients. At the end, the site was finalised near the high-risk zone at the extreme corner side of the hospital.

> “It was after a lot of deliberation that the final site where the plant has been installed was finalized based on the feasibility of the distance from the hospital and it being in vast open area which is ideal for the PSA plant setup. PATH team facilitated the process of site assessment, and the most appropriate and feasible site was selected as a result.”
>
> Mr. Arif Khan,
> *Public Health Coordinator (PHC),*
> *PATH*

MEDICAL GAS PIPELINE SYSTEM (MGPS) IS CRUCIAL TO SUPPLY OXYGEN FROM PLANT TO THE PATIENT'S BEDSIDE

The MGPS setup in Central Jail Hospital

As the hospital did not have provisions for MGPS, PATH's technical team provided support in identifying a site for the manifold room and connecting the gas pipelines to the beds in the hospital. PATH also provided the layout design and the location for the manifold room in discussion with PWD, the jail authorities and the hospital authorities.

TRANSPORTING THE PSA PLANT INSIDE THE PRISON COMPLEX NEEDED PRACTICAL SOLUTIONS

Since this health facility lies within a prison complex, moving the PSA plant inside the premise was also a challenge. For example, the PSA installation site was within the gated jail premise, and the height of the gate was about 12 feet. Given that the PSA plants were transported by trucks, the required height of the gate should be about 15 feet for the trucks to pass through. To overcome this challenge, the truck carrying the PSA plant was stationed outside the jail's wall and a crane with heavy duty levers was used to unload the PSA plant. As the height of the wall was causing hindrances in unloading and placing the plant inside the premise, a unanimous decision was taken by the hospital administration, prison authorities, and PWD to bring down parts of the wall to enable the movement of the PSA plant. This decision required a series of approvals from the highest authorities in the central government.

> "Normally cranes are used for unloading the PSA plants and placing them at the appropriate site. Here the height of the gate was less, and we couldn't cross over a wall in keeping with the security protocols. We, therefore, used a combination of a heavy lever and crane to ensure the proper unloading and placing of the plant at the site. The PATH team supported this entire exercise with the vendor and ensured a smooth site installation."
>
> Swagata Gan,
> *Monitoring and Evaluation Officer, PATH*

TRAINING FOR OPERATION AND MAINTENANCE OF PSA PLANT

After the PSA plant was deployed, PATH provided training to the healthcare service providers of the Central Jail Hospital on the operation and maintenance of the plant. The team also shared troubleshooting guides and other details for future use. For some time after training, the team regularly monitored the functioning of the plant to ensure smooth transition to the hospital staff.

A HEARTENING CONTRIBUTION FROM THE INMATES

The active participation of the inmates in setting up the plant is an example of their volunteering and contribution to fighting the pandemic. With the jail facility being an exclusive zone, some of the inmates were nominated by the hospital authorities to extend support in construction and installation activities. They were involved at all stages of installing the plant, including preparing the site for construction as well as building the required infrastructure for the PSA plant.

> "A very interesting thing about installing the PSA plant in Tihar prison cell premises was that about 8-10 inmates also contributed at the time of civil work construction and plant installation. This was done specially to bring a sense of ownership among them for the PSA plant."
>
> Dr. Arun Thakran,
> *ARMO, Central Jail Hospital*

LESSONS LEARNT

- **Standard procedures and innovative practices needed for complex issues:** Owing to the uniqueness of the site, located in a prison complex and meant for the benefit of prison inmates who often find themselves on the fringes of society, the installation of the oxygen plant at the Central Jail Hospital has emerged as a model for projects in similar settings. The process involved in setting up a PSA plant, including site assessment, installation, and commissioning needs to be tailor-made for the location, particularly in high-security zones.
- **Multi-stakeholder approach enables a robust oxygen ecosystem:** It is crucial to involve all stakeholders at the onset of the project to ensure smooth implementation of processes. PATH received proactive support from all stakeholders involved. These included the PSA Nodal Officer, Delhi, PWD, jail authorities, and the hospital administration. Adequate support extended by the stakeholders enabled the setting up of the PSA plant to be a smooth and timely intervention. The entire process was successfully completed within three months.

CONCLUSION

The timely installation of the PSA plant enabled provision of COVID-19 care for the inmates of the Central Jail Hospital, Delhi, who were vulnerable, especially during the second wave. The hospital is now better prepared to handle any oxygen supply-related crisis. Besides having played an active role in all the processes of the PSA plant assessment, installation and commissioning in a highly sensitive security zone, PATH went a step ahead and continued supporting the health facility by building capacity of the health staff on PSA operations and maintenance.

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TECHNICAL SUPPORT FOR OPTIMAL USE OF PRESSURE SWING ADSORPTION PLANT IN DEEP CHAND BANDHU HOSPITAL, DELHI

Deep Chand Bandhu Hospital, Delhi, Photo: PATH/Swagata Gan

This case study presents a glimpse of PATH's in-depth technical expertise in respiratory care management and ensuring self-sufficiency in health facilities through an on-site oxygen generation plant.

The COVID-19 pandemic in India led to enormous challenges for the healthcare system. Across the country, the healthcare systems were not designed to deal with a crisis of such enormous and unpredictable scale. As the country continued to reel under the impact of the second wave of the pandemic, increasing caseloads and acute shortage of medical supplies overwhelmed the hospital infrastructure. By April 2021, Delhi was among the most affected states in India with over 20,000 reported cases daily. This period revealed how Delhi, despite a relatively advanced health infrastructure as compared to other states, was under-prepared to handle a health crisis of such a magnitude.

As shortness of breath emerged to be a major concern among COVID-19 patients, there was an inordinate spurt in demand for oxygen. The crisis led many hospitals to sound an alarm and placed an emergency request to narrow the growing gap between the demand and supply of medical oxygen in the state. The government initiated several

measures to rapidly augment the oxygen supply in the state. At the same time, the national government approved installation of eight pressure swing adsorption (PSA) oxygen generation plants in different hospitals across Delhi under the Prime Minister's Citizen Assistance and Relief in Emergency Situations Fund (PM CARES Fund); a fund meant to help India battle the pandemic. PSA plants were envisaged to enhance Delhi's medical oxygen capacity and meet the peak demand of 590 metric tonnes of oxygen per day during the second wave.

DEEP CHAND BANDHU HOSPITAL - ENABLING HEALTHCARE FOR RESIDENTS OF DELHI

Deep Chand Bandhu is a state-owned hospital located in north-west Delhi and caters to nearby areas. Prior to the pandemic, the hospital had 250 oxygen beds, out of which, 130 were ICU beds, 60 were paediatric beds, 25 COVID-19 PM CARES beds, and six were neonatal ICU beds. As the infections surged during the pandemic, the number of patients seeking hospitalized care for COVID-19 increased. At one point of time, the hospital was attending to at least 80 COVID-19 patients every day. To meet the demand, the hospital had to increase the bed capacity up to 400 for the incoming patients with temporary infrastructure. Additionally, during the second wave, the hospital had to rapidly ramp up its medical oxygen supplies because a large number of patients could not respire unaided.

As the demand for medical oxygen skyrocketed, several stakeholders and communities came forward and demonstrated extraordinary collaboration to support patients of COVID-19. Deep Chand Bandhu hospital received four PSA oxygen generation plants, - three from HCL Technologies (through its corporate social responsibility initiatives) and one from Absstem Technologies (through the PM CARES Fund). The capacities of the PSA plants were 400 litres per minute (LPM) and 200 LPM respectively. All four PSA plants were connected to a manifold room which in turn supplied medical oxygen to the patient's bedsides.

After deployment of these four PSA plants in the hospital, the gas pressure in the pipelines of one of the PSA plants started to drop, although adequate amount of oxygen was being generated. The hospital authorities reported the issue to Delhi's State Nodal Officer (SNO, Oxygen). The SNO referred the issue to PATH for technical support as all the oxygen related equipment were provided by PATH to the state government.

PATH – AUGMENTING MEDICAL OXYGEN IN HEALTH FACILITIES

A technical support unit (TSU) for oxygen to the Government of Delhi was set up through support from USAID's NISHTHA project. The role of the TSU was to assist decision-makers on oxygen management and provide technical support to the government in installation and operationalization of PSA plants. The TSU provided technical support on capacity assessment, procurement and use of respiratory care products, and supplier and medical oxygen market landscaping and outreach. PATH also donated and deployed 100 oxygen concentrators (OCs) across health facilities in the city.

THE ISSUE – PRESSURE DROP IN PIPELINES AND VENDOR'S RELUCTANCE TO SHIFT

A technical team from PATH had to make multiple visits to the hospital to inspect and assess the reported issue of pressure drop in the gas pipelines and provide an appropriate solution situation. Two major issues were observed by the team -

- **Technical issues with the oxygen system:** When the team evaluated the technical specifications, attachments and layouts of the four PSA plants, manifolds, and medical gas pipeline system (MGPS), it found that the PSA plant installed by Absstem Technologies was not within the specified distance from the manifold room (60 to 80 metres as per the standard specifications). Moreover, the pipes supplying medical oxygen had numerous bends and turns that were further causing hinderance and leading to pressure drop in the pipelines.

Omkar Patil, Technical Assistance Engineer, PATH, reviewed the situation and said, "The challenge for the PM CARES donated plant was that technically connecting the PSA plant outlet with liquid medical oxygen is possible but it needed a separate manifold. Ideally, the desired distance of a PSA plant from the manifold should be within 80 meters to avoid pressure drop. But in the case of PM CARES plant in DCB Hospital, the distance of the PM CARES plant from the gas manifold room was more than 120 meters. Due to this huge distance between the PSA plant and the manifold room, pressure drop was observed for the respective plant."

- **Stakeholders' disagreement to shift the PSA plant closer to the manifold room:** To resolve this issue, PATH's technical team proposed relocation of the Absstem Technologies installed PSA plant closer to the manifold room. However, the proposal was rejected by the technical team of Absstem Technologies. They mentioned that the warranty on the PSA plant will stand invalid if the current structure is altered in any way.

A SOLUTION FOR BENEFIT OF THE PATIENTS

In order to provide a solution to the technical issues and address stakeholder disagreements, PATH facilitated various initiatives -

- **Series of discussions and consultations to reach a common ground:** PATH organized several rounds of discussions with the hospital authorities and technical experts of Absstem Technologies. As the parties could not reach a consensus even after many meetings, a high-level meeting with Central Medical Services Society (CMSS) officials, Central Government consultant, Public Works Department (PWD) officials, PSA plant vendor, and hospital administration was facilitated by PATH. Following this meeting, the vendors agreed to the solution of relocating the PSA plant near the manifold room, close to the other three PSA plants, and the warranty on the PSA plants remained valid.

Omkar Patil, PATH said, "This particular work was one of the most unique in my professional career. During my interaction with the various stakeholders in this meeting, I emphasized the importance of relocation of plant for effective working and suggested collaboration with vendor also taking reference of the order from the State Nodal Officer, PSA. The issue was also escalated at the level of Ministry of Health & Family Welfare. Later after a long discussion between the various key stakeholders the issue was resolved, and the vendor accepted the relocation order from the high authority."

- **Sharing technical expertise to relocate the PSA plant near the manifold room:** PATH supported the relocation and re-commissioning of the PSA plant to ensure that the plant is placed at an appropriate location. The PWD extended the shed of the three existing PSA plants near the manifold room to accommodate the relocated PSA plant.

Dr. Suman Kumari, Medical Superintendent, Deep Chand Bandhu Hopsital, said, "We were in a dilemma as our team did not have the adequate technical understanding on what to do regarding the issue. It was only due to the PATH team who guided us that CMSS officials and the Absstem plant vendor were convinced of the need of relocating the plant without hampering the warranty contracts. We are extremely grateful for the timely technical support of the PATH team through the USAID-NISHTHA grant."

- **Capacity strengthening for effective operation and maintenance of oxygen equipment:** Besides the technical support, PATH realized that capacity strengthening of the health service providers in the hospital is required for effective operation and maintenance of the oxygen equipment. A virtual training session was organized to enhance the technical capacity of the staff to handle such crisis and to make informed decisions related to the PSA plant.

Nodal Officer, Deep Chand Bandhu Hospital said, "Training held at Deep Chand Bandhu Hospital in November 2021 was very informative and helpful for imparting operative and troubleshooting of PSA plants. The session also solved many issues related to LMO and gas manifold. We are thankful to PATH and Delhi Secretariat."

LESSONS LEARNT

- **A consultative conflict resolution system is necessary in a multi-stakeholder initiative:** When there are multiple stakeholders involved, it is important to have inclusive and collaborative decision-making. Stakeholder coordination is an important step in such cases. PATH, through meetings and discussions involving all stakeholders, facilitated in reaching a common ground on the technical issue and resolved it.
- **It is important to involve experts in the field, especially in cases of oxygen equipment:** Involvement of a technical agency, such as PATH in this case, is crucial as the organization has immense experience in installing and deploying oxygen generation plants in the country. It uses a combination of public health, medical and engineering expertise at all stages of engagement.
- Capacity strengthening of healthcare professional and periodic joint review with all stakeholders is important to keep the PSA plants functional.

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Project NISHTHA is United States Agency for International Development (USAID)'s flagship health system strengthening project implemented by Jhpiego which aims to transform primary healthcare to ensure provision of equitable, comprehensive, and client-cantered healthcare, and to improve health outcomes for India's marginalized and vulnerable populations, including women and girls. In April 2020, USAID provided supplemental COVID-19 Emergency Response Funding to NISHTHA for the provision of need-based responsive technical assistance at the national level and in 13 intervention states to strengthen the response toward the COVID-19 emergency.

STRENGTHENING OXYGEN INFRASTRUCTURE IN A PRIVATE HOSPITAL: A CASE STUDY OF PUBLIC-PUBLIC-PRIVATE PARTNERSHIP AT VIKAS MULTI-SPECIALTY HOSPITAL IN BARGARH, ODISHA

INTRODUCTION

As medical oxygen proved to be a life-saving drug for the treatment of COVID-19 patients in absence of proven therapeutic solution to patients suffering with the infection, the country's toughest challenge was the skyrocketing demand for medical oxygen for the patients, who were unable to breathe unaided. As the Government of India responded by scaling up oxygen production, repurposing the industrial grade oxygen to medical grade liquid oxygen, converting cryogenic tankers to liquid oxygen tankers to increase the fleet of oxygen carriers to transport liquid medical oxygen (LMO), installing pressure swing adsorption (PSA) plants and deploying oxygen concentrators, among other initiatives, many non-government stakeholders, corporate and business houses, private philanthropic foundations, high net worth individuals (HNIs), among others also stepped up to strengthen oxygen generation and distribution capacity in the country.

To tackle the COVID-19 crisis, the Government of Odisha set up a dedicated Oxygen Task Force in April 2021 under the aegis of Principal Advisor to the Chief Minister to manage the production, storage, filling, transportation, and overall management of oxygen. It constituted a State Technical Support Unit (State oxygen TSU) for ensuring fast tracking of PSA plants and LMO installation along with ensuring rational use of oxygen at facility level by taking up capacity building related to oxygen management. This TSU has been established by PATH with support from USAID NISHTHA. The state, already with surplus of oxygen owing to the presence of multiple industrial oxygen plants, took the corporate partnership route as an integral part of its response to the calamitous oxygen crisis. The oxygen task force included the major industry representatives, including many public sector majors like Odisha Hydro Power Corporation Limited, Odisha Mining Corporation Limited, Indian Oil Corporation Limited (IOCL), and Mahanadi Coal Field, among others to support the hospitals as part of their CSR initiative.

This case study documents one such public-private partnership in the state where IOCL, a Public Sector Undertaking (PSU), and Vikas Multi-Specialty Hospital, a private tertiary hospital, with collaboration with the Department of Health Services, Odisha to make the health facility more self-sufficient in oxygen management. PATH, as the TSU for oxygen to the government of Odisha, provided technical assistance for the installation and commissioning PSA plant at Vikas Multi-Specialty Hospital and extended post-installation support.

VIKAS MULTI-SPECIALTY HOSPITAL, BARGARH GETS DECLARED AS THE DISTRICT COVID HOSPITAL

Vikash Multi-Specialty Hospital is a private hospital established in 2018 and located in Bargarh district in the eastern Indian state of Odisha. The 150-bedded hospital provides clinical, diagnostic and laboratory services, in addition to transfusion services, pharmacy and professions allied to medicine and support services. The hospital, also accredited by National Accreditation Board for Hospitals and Healthcare Providers (NABH), has average monthly out-patient footfall of around 5,500 cases and more than 150 admissions new in-patient admissions every month. Equipped with four state-of-the art operation theatres, 64 ICU Beds, eight emergency beds, seven neonatal ICU beds, four Paediatric beds and 14 High Dependency Unit (HDU) beds and 64 ventilators for severe or critical cases, this hospital provides round-the-clock support for trauma and emergency cases.

As the number of COVID-19 cases rose sharply between April and June 2021 in Bargarh and other districts in western Odisha and the neighbouring state of Chhattisgarh, lack of medical facilities with capabilities to manage cases in the region saw Vikas Multi-Speciality Hospital receiving a huge caseload of severe COVID-19 cases. At the peak of the second wave, the hospital was treating around 150-200 COVID-19 cases daily, out of which around 20 percent or more required oxygen. These patients were not only coming directly to the hospital but were also getting referred by the public health facilities in western Odisha and Chhattisgarh.

Taking cognizance of the COVID-19 caseload being managed at the Vikas Multi-Specialty Hospital, the Government of Odisha entered into an agreement with the hospital management for providing free treatment to the COVD-19 cases. The cost of treatment was reimbursed by the Government of Odisha through Chief Minister Relief Fund (CMRF). The government extended human resources support to the hospital in running designated COVID-19 facilities and declared Vikas Multi-Specialty Hospital as

District Covid Hospital in Bargarh district. As part of this agreement with the state government, patients with moderate and mild symptoms were treated in the District Headquarter Hospital (DHH), Bargarh with support from the trained staff from Vikas Multi-Speciality Hospital, while the severe and critical COVID-19 patients began getting referred from the District Headquarter Hospital (DHH), Bargarh to Vikas Multi-Speciality Hospital for intensive care or ventilator support.

MINISTRY OF PETROLEUM AND NATURAL GAS STEPS IN TO STRENGTHEN INFRASTRUCTURE AT VIKAS MULTI-SPECIALTY HOSPITAL'S TO MANAGE COVID-19 CASES

Around the same time, the Indian Oil Corporation Limited (IOCL) under the Ministry of Petroleum and Natural Gas (MoPNG), Government of India, as part of its Indian Oil Arogyam initiative, declared for providing financial support for a 100-bedded ICU with all the advanced equipment to Vikas Multi-Specialty Hospital. Through this initiative IOCL which have a great track record in providing quality medical services and gained trust of people of this region. Indian Oil Arogyam the flagship CSR scheme was launched in 2018-19 that seeks to strengthen primary healthcare in the country. The initiative, during the COVID-19 crisis, was repurposed to enhance strengthening of response to the pandemic.

Although the hospital already had both B and D type oxygen cylinders and a liquid medical oxygen (LMO) storage tank of 6KL capacity, both which are being maintained and refilled through external vendor. The hospital had also made arrangements with Linde to ensure availability of an LMO tanker round-the-clock to refill the empty LMO tank during the second wave, there was a need for the hospital to have captive oxygen generation capacity.

Furthermore, the MoPNG identified this hospital for supporting it with two PSA oxygen generation plants of 960 litres per minute (LPM) capacity with direct funding support from Indian Oil Corporation Limited (IOCL). The two oxygen generation plants were installed in the hospital in June 2021. Both the oxygen generation plants, which were installed in one shed, further increased the oxygen capacity of the hospital and strengthened the available oxygen supply. The hospital has deployed a Bio Medical Engineer for its maintenance of medical equipment along with 15 dedicated operators on its payroll. With staff available to monitor and maintain the plants round-the-clock and the plants maintenance covered under the Comprehensive Annual Maintenance Contract (CAMC), the oxygen produced by the plants are being utilized in the cardiac care unit (CCU), ICU, and all operation theatres and HDUs with oxygen beds.

THE TECHNICAL SUPPORT UNIT ENHANCES HOSPITAL'S CAPACITY TO MANAGE OXYGEN SYSTEMS

USAID NISHTHA as the Oxygen TSU for the state supported Vikas Multi-Specialty Hospital in fast-tracking the PSA installation, and also strengthened capacity of the operators and technicians in the operation and maintenance of the PSA plants, manifolds, LMO storage system, oxygen cylinders and oxygen concentrators. The capacities were enhanced through classroom training, as well as demonstration visits and mentoring. The TSU team provided supportive supervision during field visit and guided the hospital management on strengthening institutional capacity, like formation of a facility level oxygen committee among others, for sustainable and smooth management of medical oxygen. The Vikas Multi-Specialty Hospital formed a Hospital Oxygen Committee with clear role and responsibilities of various committee members. This committee meets regularly to take stock of oxygen production and use, and also conducts periodic oxygen audits for reducing wastage and rationalizing oxygen use.

WAY FORWARD

Being a NABH accredited hospital, Vikas Multi-Specialty Hospital is working with oxygen TSU for creating standardized policies, which include Safe Handling of Medical Gases Policy, and Standard Operating Procedure (SOP) for management of oxygen, to maintain quality of service and ensure safety of operation.

The support from MoPNG through IOCL and Government of Odisha through the oxygen TSU is helping people of from six districts - Jharsuguda, Sambalpur, Balangir and Nuapada in Odisha as well as the border districts of Chhattisgarh - Mahasamund and Raigarh – get benefitted with round-the-clock availability of medical oxygen in the Vikas Multi-Specialty Hospital.