

© Omar al-Qattaa/AFP | Gaza's last remaining fully functional hospital, Al-Ahli, was incapacitated in the early hours of 12 April

The challenge for reliable medical oxygen

By Dominic Ellis & Anthony Wright

The Covid-19 pandemic brought the global oxygen supply challenge into sharper focus, with governments and donors investing heavily in oxygen-generation plants, concentrators, cylinders and associated infrastructure across low- and middle-income countries (LMICs).

But as the emergency response has receded, many countries are now facing a question of how to keep that infrastructure operating.

Steffi Van Uytfanghe, who works on access to medical oxygen access at the Access to Medicine Foundation, says many of the problems identified during the pandemic remain unresolved.

"There are still a lot of the same problems there," she told gasworld.

"There is still not enough capacity to do maintenance and to buy spare parts and to make sure that the spare parts arrive on time."

That can leave hospitals with oxygen plants that have been installed but cannot operate reliably because of shortages of trained personnel, replacement components or funding.

There is a particular need for biomedical engineers and technicians capable of operating, maintaining and repairing pressure swing adsorption (PSA) plants. Van Uytfanghe said many countries would like to establish national training centres, but the capital required is often unavailable.

Power supply presents another obstacle. "If the power cuts, a medical

oxygen plant will just stop generating oxygen," she said. "Someone will have to come onsite and restart the oxygen plant. If it's in the middle of the night, if someone is continuously on oxygen, that's a real problem."

Different systems, common problems

The precise challenges vary between countries, but Van Uytfanghe said power supply, maintenance and service contract management, and training and capacity building training are common issues in medical oxygen production ecosystems across LMICs.

On behalf of the Global Oxygen Alliance, the Access to Medicine Foundation has been supporting work on medical oxygen access in Uganda,

Senegal and South Africa, where differences in national oxygen markets illustrate why solutions cannot simply be transferred from one country to another.

Senegal began installing oxygen plants as early as 2007 and had therefore already prioritised oxygen before Covid-19. But that early investment has created a fresh challenge surrounding ageing infrastructure.

Some plants have now been operating for close to two decades, while lacking the monitoring systems found on newer equipment. Updating and replacing them has therefore become a priority, alongside training and strengthening post-market surveillance and regulatory oversight.

There is also a problem beyond the plant itself. A hospital may have oxygen available onsite, but without infrastructure to deliver it to the patient, that supply has limited value.

"You might have oxygen on a hospital site, but if you don't have a medical gas pipeline system, or if the piping is old or doesn't reach every ward, they can't actually get the oxygen to the bedsides of the patient," said Van Uytfanghe.

South Africa has a different oxygen ecosystem, having historically relied heavily on liquid oxygen. Its public and private healthcare systems also face different pressures, while rural facilities can be disadvantaged by their distance from liquid oxygen production sites.

Uganda, meanwhile, is heavily dependent on PSA technology and

has comparatively little liquid oxygen infrastructure. Van Uytfanghe described the country as facing a major oxygen crisis, with plants breaking down and spare parts sometimes taking months to arrive.

"Sometimes there are delays of six months," she said. "If you have a delay for six months to repair an oxygen plant, there's no oxygen in that hospital for six months."

The Foundation is now bringing manufacturers and ministries of health together in the Global Oxygen Alliance Industry Community of Practice to address those problems, including whether governments can purchase spare parts directly rather than through intermediaries.

From installation to uptime

The experience highlights a wider issue with the way medical oxygen infrastructure is procured.

Investment in new equipment can address an immediate shortage, but it does not guarantee a reliable supply several years later.

Van Uytfanghe said procurement specifications can themselves create barriers, with some tenders based on outdated requirements or copied from other markets.

This can exclude technologies designed specifically for LMIC environments, while some tenders remain focused on conventional PSA systems despite alternatives such as

VPSSA, which she said can require less energy and maintenance.

After-sales support is another area where she sees room for improvement.

"If you have very clear specifications on spare parts, maintenance kits and warranty requirements, then only companies can apply that are actually doing that after-sales maintenance," she said. "That will really increase the uptime of your plants."

It is a shift in emphasis from simply asking whether a plant can be supplied and installed, towards whether it can continue producing oxygen reliably for years afterwards.

There are signs of movement in that direction. Van Uytfanghe said engagement between the oxygen industry, governments and regulatory agencies has improved since Covid-19, while innovation is emerging around solar-powered systems and remote monitoring that could allow authorities to identify faults before they result in complete failure.

Another model is "oxygen as a service" in which a local third party takes responsibility for the full oxygen supply chain for a hospital, covering installation, production, distribution, maintenance, consumable, monitoring and data management, and clinical training, and can potentially distribute surplus production to neighbouring facilities.

"It substantially increases the uptime of the plant," said Van Uytfanghe. "There's more oxygen available, not just in that

► one hospital that actually is paying the third party, but also all the hospitals around it.”

The model has demonstrated its potential, but scaling it requires upfront investment in local companies, engineers and transport infrastructure.

When infrastructure is destroyed

If maintaining an oxygen plant in a relatively stable healthcare system requires funding, skills, electricity, spare parts and logistics, the challenge becomes considerably greater when that system is operating in a conflict zone.

Van Uytanghe said humanitarian settings remove many of the conditions normally required to keep an oxygen plant running.

“You need to have the spare parts. You need to have people there that are trained,” she said. “The chance that you don’t have those things in humanitarian situations is so big.”

Maintaining stocks of replacement components can become difficult, while trained personnel may be displaced and supply routes disrupted. Even manufacturers can have limited ability to intervene when equipment is located inside an active conflict zone.

The Global Oxygen Alliance is also supporting longer-term oxygen planning in countries affected by instability, including work around an oxygen roadmap in Yemen to guide sustainable, effective medical oxygen systems. But Van Uytanghe acknowledged that keeping infrastructure operational on the ground becomes considerably harder once conflict begins.

She recalled one case in Ethiopia where an oxygen plant subsequently became located in a conflict area and part of the equipment was taken.

“It’s even already difficult in a stable LMIC,” she said. “So in conflict areas, it’s even more difficult.”

The problems facing medical oxygen systems in LMICs are often

structural. This means that equipment ages, spare parts become unavailable, electricity fails, technical staff leave and procurement systems struggle to adapt.

Conflict can take each of those vulnerabilities and compound them at once and nowhere is that more apparent than Gaza.

Gaza under heavy strain

As with most subjects in the Middle East, there isn’t a one-size-fits-all when it comes to medical oxygen, and healthcare providers continue to wrestle with a range of dynamics.

Gaza’s oxygen system faces near-total collapse, with damaged infrastructure, blockades and spare-parts shortages worsening an already severe crisis.

Lebanon’s medical oxygen supplies are under strain too, and relying heavily on emergency international aid to keep hospitals running amid the ongoing regional conflict – a challenge exacerbated by power outages.

Meanwhile GCC countries’ domestic medical oxygen supplies remain stable and resilient, but the war has severely disrupted their ability to export, distribute, and route emergency oxygen supplies to active war zones – in another illustration of its global impact.

The World Health Organization and other global agencies operate their largest global humanitarian logistics hubs out of Dubai. Much like the development of its business and tourism economy, Dubai Humanitarian has spent the best part of 23 years building its network and reputation, and it remains committed to maintaining operations despite the challenges.

In recent times, it has rapidly deployed tonnes of emergency aid shipments including 74 metric tonnes to flood-affected communities in Nepal, ongoing medical supplies to Gaza, and airlifts to Uganda in response to the Ebola crisis.

Its benign east-meet-west location, and proximity to Al Maktoum

International Airport (DWC) and Jebel Ali seaport, allows aid to reach two-thirds of the global population in hazard-prone areas within eight hours.

But as result of the active conflict and ongoing security risks around the Gulf, shipments from these hubs have faced logjams, temporarily stranding tens of millions of dollars in emergency medical aid intended for surrounding conflict zones.

Even when oxygen gas is available, the broader conflict has choked off supplies of critical petrochemical components. Scarcities in global shipping have made it harder to source the specific plastic polymers, valves, and materials needed to manufacture IV bags, tubing, and portable oxygen cylinder-filling devices.

To mitigate some of the bottlenecks from sea and air closures, GCC nations have activated the ‘Gulf land bridge’. Logistics providers are successfully utilizing cross-border overland trucking networks through safer corridors like Riyadh, Jeddah, and Oman to keep medical infrastructure flowing internally.

Only 12 of Gaza’s 34 oxygen generation stations remain operational, according to Gaza’s Ministry of Health. Medical Aid for Palestinians told gasworld the situation has deteriorated, with more oxygen plants, filling equipment and cylinders needed.

Reports that only 12 of 34 oxygen-generation stations and four of 30 cylinder-filling devices remain operational were confirmed by MAP, which warned of further deterioration given the ongoing emergency situation and continuous injuries that happen daily, in addition to chronic diseases and respiratory patients who are in dire need for such health care.

“If another generation stations stops, and there is a high likelihood to happen at any time, this would increase the demand and pressure on other stations, in which it will increase its working ours and would negatively-affect the efficiency, and accordingly this will lead to another generation station failure,” according to a

MAP statement.

“From other perspective, patients who require continuous oxygen supply will be referred to other hospitals that have continuous oxygen generation, this will increase the pressure and burden the other stations and healthcare workers.”

Repairing equipment is another challenge as there are no spare parts in the local market and products are prohibited from entering Gaza.

“There are many critical parts that are vital to keep the oxygen generation stations operational, such as air compressors, oil compressors, exhaust mufflers, medical oxygen analysers, valves, filters, pressure gauges, pistons and many other mechanical parts. The local market is scarce for such items, and many efforts are spent in order to keep stations functional by using second hand and repaired collected spare parts from damaged equipment,” it said.

Since the onset of Israel’s military offensive in October 2023, The Palestinian Centre for Human Rights (PCHR) says the entry of new oxygen stations, as well as spare parts required for preventive maintenance and emergency repairs, has been restricted.

PCHR warned that the situation has left Gaza’s capacity to produce, fill and distribute medical oxygen at risk of collapse. Oxygen is relied upon across intensive care units, paediatric and neonatal units, operating rooms and emergency departments, while some patients receiving treatment at home also depend on a continuous supply.

The warning follows an alert in April, when Gaza’s health ministry said the only oxygen generation plant serving Gaza City and the north was at risk of shutting down because of repeated malfunctions and restrictions on equipment entering the territory.

Gulf shielded by investment

While conflict-affected pockets face imminent shortages, wealthier nations

Monitoring MERS

Middle East respiratory syndrome (MERS) is a viral respiratory disease caused by a coronavirus (MERS-CoV) that was first identified in Saudi Arabia and Jordan in 2012.

Coronaviruses are a large family of viruses that can cause diseases ranging from the common cold to Severe acute respiratory syndrome (SARS) and Coronavirus disease-2019 (Covid-19).

Typical MERS symptoms include fever, cough and shortness of breath, commonly leading to pneumonia.

About 70% of new or emerging pathogens are of animal origin, including MERS-CoV which can be transmitted between dromedary

camels and people; onwards person-to-person transmission can lead to outbreaks in hospitals and households.

Over 2,600 laboratory-confirmed cases of human infection with MERS-CoV have been reported to WHO; the majority (84%) were reported from the Arabian Peninsula.

Approximately 37% of MERS cases reported to WHO have died, but this likely is an overestimation as surveillance systems may miss mild or asymptomatic MERS cases. There is currently no specific treatment or vaccine licensed for MERS.

in the region such as Saudi Arabia and the UAE maintain stable medical oxygen markets supported by growing domestic healthcare investments and commercial production.

The Saudi oxygen market is projected to reach \$646.6m by 2030, supported by government healthcare goals under Vision 2030.

Qatar has stable and well-maintained domestic medical oxygen supplies, supported by local industrial gas producers like Gasal and a robust healthcare infrastructure.

In Egypt, where explicit critical shortages of medical oxygen are tightly managed, the wider medical and pharmaceutical supply sector has experienced major disruptions due to severe debt accumulations and liquidity crunches involving the Authority for Unified Procurement.

Concerns over oxygen availability largely hark back to severe localised pressure points and tragic incidents during peak Covid-19 waves, prompting the state to scale up national production capacity, implement

strict electronic tracking systems, and outlaw hoarding.

In Iraq, WHO-backed national workshops have introduced digital tools such as the Live Oxygen Platform to map facility needs, streamline logistics and train biomedical engineers in oxygen management.

PSA tech take up

Across wider Middle Eastern healthcare markets, providers are shifting toward PSA technology and containerised, weather-resistant oxygen generation plants engineered to withstand extreme desert heat and reduce reliance on external supply chains.

Commercial demand for home-based and portable medical oxygen concentrators continues to expand rapidly, supported by regional awareness campaigns targeting chronic respiratory diseases like COPD.

Portable oxygen concentrators and advanced delivery devices are seeing the fastest growth as home-based oxygen therapy becomes more common. **SW**