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# Exploring the Role of 'Outsourced Oxygen-to-the-Bedside' in Expanding Oxygen Access for Patients

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**Abstract:** Setting up sustainable oxygen systems within a health facility is complex. In this paper, we propose a conceptualisation of a particular delivery model that takes a broader approach than the traditional oxygen procurement and delivery – 'Outsourced Oxygen-to-the-Bedside' (O2B). We explore its potential strengths and limitations using early learnings from five pilot projects in India, Kenya, Tanzania, Nigeria and Uganda. O2B models involve oxygen supply services provided by external entities that provide a minimum set of oxygen supply equipment, alongside bundles of repair, maintenance and training, and are contracted to guarantee continuous medical oxygen supply to the bedside. This market-based approach may be particularly suitable for smaller rural facilities that have limited options and capacity. Envisioned benefits of this model are the reduced mental load on facilities to manage their oxygen and distribution arrangements, whilst building local skills and knowledge to increase equipment functionality, longevity, and oxygen availability. O2B providers currently offer different variations of this service, but in all cases their main value proposition is to make oxygen access easier for facilities. Potential risks include fragmentation of existing oxygen supply solutions, and difficulties in balancing business sustainability with affordable pricing - particularly to small and under-resourced facilities. Relying on financing from individual facilities is unlikely to succeed in most contexts – particularly for poorer hard-to-reach communities. Therefore, future evaluations should focus on long-term funding solutions and cost-effectiveness of different service bundles to determine best value for money in different contexts.

**Keywords:** medical oxygen; health care systems

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## Teaser Key Message

Outsourcing oxygen services has potential to improve oxygen access, but evidence on sustainability and cost-effectiveness are needed.

## Key Messages

- We propose a conceptualisation of 'Outsourced Oxygen-to-the-Bedside' (O2B), a procurement model that aims to make the provision of oxygen easier for hospital managers and healthcare workers by reducing the operational burden to an outsourced external entity.

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- This market-based approach could improve patient access to oxygen through ensuring the availability of functional equipment, strengthening oxygen production-storage-distribution systems, and complementing efforts to increase staff skills
- Key questions around sustainability, sources of financing and cost-effectiveness of these business models need to be resolved.
- Oxygen system planning needs to recognise that O2B models will not solve all the other service access and quality issues that currently prevent patients from receiving oxygen when they need it, and should be seen as one part of the broader health service strengthening.

**Key Implication**

Outsourced Oxygen-to-the-Bedside (O2B) offers potential to facilitate and improve oxygen provision for health facility managers and health care workers, however, for O2B providers to deliver results, they must be integrated into larger-scale strategic plans and financing – particularly if we want to see impact in smaller and more rural facilities that have been failed by traditional market forces.

The need for better supply solutions to ensure equitable oxygen access

Oxygen is a life-saving essential medicine and an essential clinical service required at all levels of the health system and for a wide variety of patients.[1,2] However, achieving sustainable and uninterrupted oxygen systems is complex, and equitable oxygen service coverage is still a far reality for many patients. The oxygen need-coverage gap is concentrated in low- and middle-income countries, with large rural-urban disparities.[2]

Effective and equitable oxygen service coverage requires a systems approach, considering oxygen production and distribution, equipment procurement and management, clinical capacity and guidelines, financing, and governance.[3] But for many health facilities, reliable oxygen supply is a constant challenge. Unreliable availability of oxygen is acknowledged as a complex failure due to multiple causes. Hospital managers are faced with a range of oxygen technologies and suppliers, each with different cost and risk considerations, and delivery by a variety of public and private providers. Key factors such as local biomedical engineering capacity, facility infrastructure, staff mix and skills capacity, healthcare financing, and clinical or technical normative guidance need to be considered.[4]

Hospital managers can therefore struggle to coordinate an efficient and effective system. For example, a hospital director may purchase oxygen cylinder refills from a private gas company, organise cylinder delivery using a hospital vehicle, procure pulse oximeters and oxygen concentrators from central medical stores, use district-level technicians for basic maintenance and repair but out-source complex repairs to a private engineer, pay for diesel to run the generator, and require patients to pay for oxygen – leaving little understanding of the total cost of oxygen supply. When oxygen supplies fail, this is further complicated by manufacturer warranties being difficult to redeem, and supply chains for spare parts convoluted and slow.

Moving beyond traditional product-based purchasing models, to outsourced service-based models may address some of these challenges. Rather than just selling equipment (e.g. an oxygen concentrator) or medication (e.g. delivering oxygen cylinders), service-based models provide integrated solutions bundling products, maintenance, training, and technical support. Health facilities pay recurring fees tied to service delivery outcomes, not capital assets or consumables. Service-based purchasing models have been implemented for a diverse range of health services in low resource settings, such as medical imaging, radiotherapy, medical waste management, and electronic health records systems. A successful example has been the transition to a service-based purchasing model for the all-in price-per-result contracts for nucleic acid testing services necessary for HIV care and treatment programmes.[5] For oxygen, different formulations of service-based models have been implemented;[6–10] however, models are diverse and there has been limited reflection and clarity about how different approaches can contribute to the broader oxygen service system.

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In this Field Action Report, we propose a conceptualization of a particular model of oxygen supply – 'Outsourced Oxygen-to-the-Bedside' (O2B). We explore its potential strengths and limitations using existing literature and learnings from five O2B providers funded by the Oxygen CoLab initiative. This paper includes authors from the Oxygen CoLab initiative (funded by the Research & Evidence Division of the UK's Foreign Commonwealth and Development Office and run by DT Global International Development UK Ltd, and Brink Innovation Limited), their O2B grantees, and academics funded to evaluate them. The content reflects our collective experiences in oxygen system strengthening and shared learnings from the inception and pilot phase of the project, using meeting notes, quarterly review and workshop reports, mapping of the service providers business models, and discussions among the authors.

**Defining Outsourced-Oxygen-to-the-Bedside**

O2B is a procurement model which aims to provide continuous reliable oxygen supply to the bedside, therefore making oxygen service provision easier for hospital managers and healthcare workers by reducing the burden of management and maintenance. Between 2021-2022, the Oxygen CoLab initiative awarded funding to five O2B providers working in India, Nigeria, Uganda, Tanzania and Kenya.[11–15] As the first step in the evaluation, we mapped O2B provider approaches to come to a common understanding of the model, through identifying similarities, differences, and clarifying intended target recipients, use-cases, and business models. The five O2B providers operate in a variety of urban and rural environments, across governmental, private, faith-based facilities of differing sizes - although all have some geographical constraint on their services due to proximity to the central filling station and/or accessibility for technical support.

For the oxygen source, two O2B providers use cylinder-based systems using a central solar-powered oxygen concentrator and compressor to refill - Leanmed's O2 Cube (10 litres-per-minute [LPM]).[16] Depending on facility needs, the O2 Cube is either set-up in the facility and distributed to the bedside using a cylinder-manifold system with high-pressure piping to regulator-flowmeters at individual beds, or off-site with cylinders delivered by the provider. Both solutions include back-up cylinders to prevent stock-out. The other three O2B providers use oxygen concentrator-based solutions, with 5 or 10 LPM concentrators. One provides tubing and flowmeters to allow a single concentrator to serve up to 6 patients, while the other two provide concentrators directly to the bedside. All three O2B providers using concentrators recognise that a back-up oxygen supply is essential but vary in the extent to which they provide this - only one provider includes automatic switch-over to a back-up cylinder they provide. A reliable supply of backup cylinders has presented challenges for providers, and none of the O2B concentrator-based providers currently offer an off-grid electricity solution to ensure a reliable electricity supply for the concentrator.

All O2B providers include preventive maintenance, and a mix of clinical and biomedical training performed by biomedical engineers who visit the facilities at set intervals. The providers also offer repairs upon request from the facility, either repairing equipment on-site or as a "swap and go" (i.e. replacing it while its repaired off-site). However, the O2B providers differ in their value-add offerings. Four include pulse oximeters at set-up, recognising their critical role in identifying patients needing oxygen and improving efficiency of oxygen use through monitoring.[17] Two provide nasal prongs at set-up, recognising the importance of appropriate delivery devices for safe, effective, and efficient oxygen use - although only one provides re-supply.

We therefore defined the core features of O2B to be:

I. The service providers are external private entities as opposed to hospital-based or government entities.
II. They include a minimum set of medical oxygen supply, delivery to the bedside, and responsibility for equipment management, maintenance, repairs, and training.
III. Procurers pay a bundled fee (either as a flat rate or linked to oxygen volume used) that includes all these elements.

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In this model, O2B providers should be more incentivised to maximise cost-efficiency over the medium- to long-term, versus the short-term goal of initial sales, by improving the longevity of oxygen equipment through proper use. They are also able to be device-agnostic, which could allow for more context-tailored solutions – especially when combined with additional value-adds to meet individual facility needs (e.g. provision of pulse oximeters). From a facility management perspective, the bundled package costs should increase cost certainty and risk smoothing, limiting the financial shocks of major repairs or ad-hoc purchasing during supply interruptions. Table 1 further elaborates the conceived benefits of this approach, as well as potential risks and mitigations, noting that empirical data on these potential risks and benefits are limited.

**Setting up Sustainable Funding Models**

The Oxygen CoLab supported O2B providers all aimed to establish a business model where they charge facilities directly, but to date, no provider has managed to charge a full break-even or profitable price to its customer facilities. They therefore use a mix of funding sources from health authorities, donors, and private procurement. How to establish a sustainable funding model is therefore a critical question. O2B providers need to be able to demonstrate to facilities that they are a reliable medium to long-term solution for their oxygen needs, and that their offering is cost-effective. However, O2B providers also need to account for the risks of irregular payments or failure to pay, which may initially increase their service cost. To plan for a level of financial tolerance, exploring mechanisms where a guarantor (government/donor) functions as a buffer for these types of events may be needed.[18]

O2B providers can be paid by facilities directly or by third parties on behalf of those facilities, such as health authorities, private investors, or international donors. Given the challenge in becoming independently profitable to date, it is realistic that a mix of these sources will be required, until efficiencies of scale or other interventions reduce provider costs. Using progressive pricing structures and subsidization, could help support capital costs associated with provision of services to additional facilities, while tailoring their offer to facilities' ability to pay. Profitable models have the potential to incentivise O2B providers to be adaptive to facility needs, assuming that services will not be procured if they are not fit-for-purpose; however, this requires a competitive market, and for facilities to have a good understanding of what they need to have a functional oxygen system. Concentrating the different components of oxygen delivery for several facilities to one provider, as O2B does, gives the opportunity for a cost-effective solution. The macroeconomic context will play a role in the degree of subsidization required to make O2B services sustainable. However, equally important will be demonstrating the price-point at which O2B becomes a cost-effectiveness solution, and convincing facilities of this. For example, while facility managers can benchmark the price they currently pay each month for cylinder re-fills against an O2B service-bundle, quantifying the indirect costs is harder (e.g. the person time to pick up cylinders in a project vehicle, and the opportunity costs linked to this). Therefore, a key evidence priority needs to be estimating the cost-effectiveness of O2B models, for different facility types, and bundles of services..

Regardless of how O2B models are established, long-term thinking for financial sustainability should be embedded from inception - something tragically lacking from many recent investments into oxygen systems.[19] Donor models need to have a realistic time plan for when funding could be taken over by the health authorities, and reflect on whether they have the capacity and mechanisms to provide support for the period of time needed, given most funding cycles span just a few years. This should ideally be based on a clear up-front agreement with the health authorities for when and how the funding responsibility should be transferred.

**Challenges and Opportunities for O2B**

Through the implementation of the five Oxygen CoLab supported O2B models, there are common learnings and challenges that need additional attention. These pilots have all been offering relatively low oxygen volume solutions, directed at lower-level facilities with small to medium oxygen needs. These settings are currently under-served by mainstream providers, often resulting in

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high oxygen costs related to distribution. Low-volume oxygen production systems might appear less competitive for larger facilities with higher oxygen needs, but they may still find a market if they can improve oxygen supply reliability or provide tailored solutions to particular ward areas. Reliability of oxygen supply and maintenance and repair offers have been found to be attractive for these facility levels in some contexts.

The O2B providers initially entered into facilities with a specific oxygen delivery solution. However, as they have continued to implement, they have adapted their offerings to better accommodate facility needs. For example, one of the O2 Cube providers is looking to add a second device to help meet full facility demand, beyond what they can currently deliver to one ward. Another O2B provider is looking into switching from a paediatric-specific approach to a whole-facility solution. These two evolutions highlight a key concern, that introducing an additional model for oxygen supply to a facility increases complexity if the service doesn't handle ALL the oxygen requirements for the facility. So while there may be motivations to focus on a ward (e.g. prior expertise, specialised equipment for that age group, or donor priorities), O2B runs the real risk of increasing the complexity and therefore burden on facilities.

Emphasising why oxygen therapy is important has been identified as key for successful adoption no matter the delivery model.[20] The O2B providers spent considerable effort trying to demonstrate the value of external support with maintenance and provider training. Some facilities said that the 'wrap-around services' (i.e. training and maintenance) were exactly what was missing, while others were more reluctant - perceiving themselves to already have capacity, or not seeing the added value to prioritise investment. Most O2B providers are working under the assumption that 'wrap-around services' are not demanded because it is a new approach for the facilities, but success would overcome initial scepticism.

To pilot their service-package, many of the O2B providers initially offered a free trial period to enable familiarisation and gain early operational learnings (e.g. utilisation rates, maintenance needs and operational costs). This has led to challenges in later switching to a paid model. One provider has noted that some facilities are hesitant to pay a monthly fee given their oxygen demands fluctuate. This was solved through a payment system where the facility only pays after the oxygen has been used. Another provider found primary healthcare facilities in their context did not have the oxygen-demand needed to sustain reliable payments, and therefore withdrew from this service-level. Currently, O2B providers struggle with balancing competitive pricing to increase market share, with sufficiently high pricing for a sustainable model. Donor support for O2B start-ups can stimulate competition and disrupt existing markets, but this brings a risk of undermining existing oxygen suppliers and leaving facilities and patients worse off if the O2B business fails or withdraws.

Increasing knowledge and changing practices around oxygen use have been challenging for providers. In some countries, this has been further complicated by high staff turnover, making it necessary to retrain often. Creating an enabling facility environment for oxygen therapy is cumbersome and can be difficult to achieve even if funding is available.[21] Here, the O2B model offers an advantage given the continued engagement of O2B providers, but should not be seen as a replacement for the healthcare system's responsibility to have adequately trained and competent staff. It is further important to emphasise that O2B providers are paid for delivering oxygen to the bedside, not the patient. There is therefore a risk that even if O2B successfully improves affordable and reliable oxygen access, quality of care does not follow, undermining their perceived value for money.

Several O2B providers have struggled with supply chains for equipment and spare parts. One O2B provider solved the latter by ordering enough spare parts for the lifespan at the time of procurement - but this adds considerably to up-front costs. As with any new business, start-up costs have been high, but after 18 months - 3 years of operation none of the O2B providers are independently profitable. Costs identified as particularly high are operational costs for transport and facility visits for maintenance and training – the services that make O2B stand out from other oxygen procurement systems. To become cost-efficient, providers have tried to restructure to lower operating

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costs and to increase revenue density (e.g. volume of oxygen services, target larger sections of the facilities) and diversity (oxygen adjacent offers).

## Conclusion

There are known delivery, access, and enabling environment gaps that need to be overcome for a well-functioning oxygen system.[3,22,23] O2B could be a solution that improves patient access to oxygen through ensuring the availability of functional equipment, strengthening oxygen production-storage-distribution systems, and complementing efforts to increase staff skills. However, the success will be dependent on several factors. O2B providers need to be fairly paid for achieving a reliable and high quality service, that ensure an interrupted supply of oxygen that meets the facilities demands. This means that O2B providers should be encouraged to offer solutions that are tailored to the facilities' needs and not simply sell oxygen to the consumer. But, also that funds to support O2B providers must be integrated into larger-scale strategic plans and financing – particularly if we want to see impact in smaller and more rural facilities that have been failed by traditional market forces. This may involve additional subsidisation or incentives for providers to service particular regions or facilities. Oxygen system planners should recognise that O2B models will not solve all the other service access and quality issues that currently prevent patients from receiving oxygen when they need it, and is just one part of the broader health service strengthening that is needed.

**Table 1.** A summary of key potential benefits, risks, and suggested mitigation practices that should be kept in mind when considering investing in Outsourced-Oxygen-to-the-Bedside.

| Potential benefits | Potential risks | Potential mitigation practices |
|---|---|---|
| Reliability: Improved equipment functionality, longevity, and oxygen availability, with the responsibility for maintenance falling on the provider and payments tied to functionality. | Efficiency/profitability driven so hard that quality of oxygen availability at the bedside becomes compromised.<br>Clinical providers lack the skills and/or motivation to make use of available oxygen. | Minimum requirements established by health authorities/donors.<br>Further inclusion of payment-per-volume-provided and payment-per-usage components. |
| Streamlined implementation in one single package / reduced supply chain complexity by taking care of all the oxygen supply and distribution arrangements. | Oxygen provider does not assume full responsibility but only provides parts of a full oxygen solution.<br>Import barriers hamper the availability of spare parts, which results in breakdown of provider equipment. | Same as above, plus facilitate the import of oxygen equipment and spare parts and in-country manufacturing. |
| Increased oxygen cost certainty, and risk smoothing, by aggregating all capital and operational expenditure into a single cost package. | Insufficient revenue to cover costs, including scale-up and life-long maintenance of equipment. | Sufficient long-term funding to cover all types of costs. |
| Greater responsiveness to individual hospital needs and variation in needs (including seasonal and pandemic response), as well as pre-existing infrastructural constraints. | The oxygen provider does not sufficiently adapt services to facility needs. | Further inclusion of payment-per-volume-provided and payment-per-usage components. |
| Lower achievable cost structure for reliable oxygen supply than is currently possible in many oxygen contexts. | Unspoken disagreement on how to achieve long-term financial sustainability (i.e. assumption that government to eventually take over financial responsibly from donor without this being agreed upon). | Long-term responsibilities are clearly outlined in funding agreement. Context specific evidence on successes for take over of funding responsibility is used to set up a plan that is likely to be kept. |

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