Pulse Oximetry Primer

Resources to help understand the planning, policies, and technologies involved in pulse oximetry scale-up
Introduction

Accurate and timely detection and management of children and adults at high risk of morbidity and mortality is crucial. Primary (level 1) health facilities are often the first point of entry into the health system, but health workers in those facilities do not always have the necessary tools to detect all severe illness.

For health care providers to make a correct diagnosis, they must be equipped with the right tools, including access to pulse oximetry. These devices are essential for alerting health workers to hypoxemia and the need for urgent treatment, including referral to higher-level facilities and access to oxygen, which can be lifesaving.

In many countries, these critical tools are not available, not functioning properly, not suited for infants and young children who need them most, or providers lack appropriate training. In addition, there is often no comprehensive policy to help countries select the best devices for their environments, and scarce information is available on their cost-effectiveness or suitability for primary care settings.

Lacking these important devices and depending on clinical signs alone, frontline health care providers may be less likely to identify all patients who have hypoxemia and require immediate medical attention. When danger signs are overlooked or not adequately addressed, lives are at risk.

A number of global guidelines, including the World Health Organization (WHO) resolution Increasing Access to Medical Oxygen adopted at the 76th World Health Assembly and Integrated Management of Childhood Illness (IMCI), recognize the critical role of pulse oximeters as priority medical devices and routine screening tools. There is also a significant evidence base around the use of pulse oximeters in different settings, countries, and facility levels.

More is needed to ensure consistent integration of pulse oximetry into national and global guidelines as an important step toward consistent and correct use and improved care.

This primer provides information and guidance to help decision-makers, advocates, and implementers:

+ **Understand the current need** for pulse oximeters and the landscape for their availability.
+ **Consider options** for technologies, policies, and funding.
+ **Get recommendations on scaling up** pulse oximetry at the national level.
+ **Learn how country experiences** are providing evidence and lessons for incorporating and increasing use of pulse oximetry.
+ **Create advocacy messaging** to influence funding and policy change.
Who is this primer for?

**Decision-makers** are those with the authority to make improved access to oxygen delivery systems, including pulse oximetry, a reality through supportive policymaking and implementation—including funding, regulations, and laws. Decision-makers can include officials from the ministry of health, the ministry of finance, parliamentarians, regional health leaders, or district health committee members, among others.

Advocates are those who aim to increase access to oxygen delivery systems, including pulse oximetry, by influencing decision-makers to act in support of this goal. Advocates can include civil society representatives, technical experts, academia, community members, religious and community leaders, and members of the media, among others. Decision-makers are also important advocates.

Implementers are those working directly in health programs that use, or would like to use, pulse oximeters. They include health care providers, child health program directors and implementers, and technical specialists.

How to use this primer

These materials are useful for anyone who wants to learn more about the pulse oximetry landscape, technologies, and policies—and advocate and communicate about scaling up access.

- Key definitions and additional resources are noted in the sidebar, and helpful links are highlighted.
- The resources provided within the primer can be used as needed, together or separately.
- The case studies and other resources in this primer feature evidence and insights gleaned from the recent research around pulse oximetry, including PATH’s Tools for Integrated Management of Childhood Illness project.
- Pulse oximetry serves as a critical part of a country’s oxygen delivery system; as such, this resource can serve as a companion to the 2017 publication Oxygen Is Essential: A Policy and Advocacy Primer.
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Pulse Oximetry Primer was developed by PATH as part of the Tools for Integrated Management of Childhood Illness (TIMCI) project funded by Unitaid.

The primer was written by independent consultants Janie Hayes and Androulla Kyrillou and PATH staff Elena Pantjushenko, with support from PATH staff Carrie Hemminger, Janet Shauri, Michael Ruffo, Mira Emmanuel-Fabula, Olgah Odek, and Viviana Rivas.

The authors would like to thank the following individuals and organizations for their insightful feedback and support:

+ Clinton Health Access Initiative: Audrey Battu
+ JustActions: Leith Greenslade
+ PATH: Amy Dempsey, Lisa Smith, Tessa Fielding
+ Unitaid: Matthew Black, Pablo Vega Rojas
+ University of California, San Francisco: Michael Lipnick
+ University of Melbourne: Hamish Graham

PATH would like to provide special recognition to RRD Design LLC for graphic design of the primer.
Pulse oximeters allow health care providers to detect hypoxemia, which can be life-threatening and can require oxygen therapy.

Around the world, a simple technology called a pulse oximeter reliably provides health care providers with the data they need to detect hypoxemia—dangerously low levels of oxygen in the blood. Hypoxemia is a potent sign of severe illness, and early recognition enables appropriate risk stratification and management. Many clinical conditions can result in hypoxemia, including acute respiratory illnesses like pneumonia and COVID-19, newborn conditions, obstetric emergencies, asthma, and heart failure. (Pulse oximetry is also an essential device for safe surgery, and it can help chronic disease patients manage their oxygen needs at home.)

Estimates suggest that one in five sick newborns is suffering from hypoxemia upon admission to a hospital. In 2019, an estimated 7.2 million children under the age of five were admitted to hospitals in low- and middle-income countries (LMICs) needing oxygen. In children younger than five, pneumonia—which is often marked by severe hypoxemia—is the world’s leading infectious cause of death.

While being essential tools in hospital care, pulse oximeters are currently not widely or routinely used across primary health facilities in LMICs.

Oxygen therapy with pulse oximetry can be lifesaving, but access remains challenging for health care providers in many countries.

Oxygen therapy can avert morbidity and mortality from many conditions if hypoxemia is identified in time. Studies show that strengthening oxygen systems worldwide can cut hospital deaths of children under five by a quarter and hospital-based pneumonia deaths among children by half.

Pulse oximeters are the most reliable way to detect low oxygen levels in a primary care setting, yet access across facilities and countries remains a challenge. This means that fewer than 20 percent of newborns and children receive the oxygen therapy they need—in part because pulse oximetry is not widely available to health care providers.

Evidence is increasing on impact and cost-effectiveness of pulse oximetry. And new research seeks to answer questions about reliability, accuracy, and acceptability.

Pulse oximetry is the gateway to oxygen access and should be included in every country’s strategy for oxygen scale-up, in line with the recommendations outlined in the WHO Increasing Access to Medical Oxygen resolution adopted in May 2023. Global and local evidence increasingly demonstrates that making pulse oximeters widely available significantly enhances the impact of existing oxygen systems.

Recent studies have shown that pulse oximeters improved identification and treatment of children suffering from severe pneumonia by about 44 percent, when compared to relying on clinical signs alone. The pneumonia fatality rate among hospitalized children was more than double for those whose blood oxygen saturation levels were not measured by the device, as compared to those whose were. And in another study, after pulse oximetry and oxygen were provided in pediatric wards of hospitals, child deaths fell by half.

Access summary of pulse oximetry research evidence [here](#).

Whether or not health care providers are trained in pulse oximetry can significantly impact their ability to get children the treatment
they need. In a study of around 4,000 children, health care providers who had been trained under Integrated Management of Childhood Illnesses (IMCI) guidelines that did not include pulse oximeters missed approximately 88 percent of children with low oxygen levels.\footnote{7}

In specific settings and contexts, incorporating pulse oximetry may also be cost-effective. A recent study in Ethiopia found that including pulse oximetry in the standard IMCI guideline approach increased the detection of severe pneumonia in children by 12 percent and showed that one more child with severe pneumonia could be detected and treated for an additional investment of US$29.\footnote{8}

**Pulse oximetry technologies are changing and evolving.**

Pulse oximeters have been widely used for several decades, with thousands of products available in the current market of various types, features, prices, and capabilities.

The wide variety of products creates both challenges and opportunities for decision-makers. While having multiple options is helpful to balancing needs and resources, the crowded landscape creates a challenge because not all devices are equal in terms of quality and accuracy. Reasons for the discrepancies include inadequate device testing standards, limited public access to device testing data, and misleading claims by some manufacturers.

Additionally, multiple factors can affect accuracy. These include poor circulation, skin pigmentation, movement artifacts, skin thickness, skin temperature, current tobacco use, ambient light interference, and use of fingernail polish. These limitations exist because of how the technology works. Extremities—such as finger, toe, or earlobe—are ideal probe locations because it is difficult to shine light through other body parts; however, a weak pulse and low blood pressure can lead to poor data collection at these extremities.

Generally, pulse oximeters aid with reliable and rapid screening of hypoxemia, but there is still a need for improved devices and systems that address existing challenges, which may disproportionately create barriers to quality devices for populations across LMICs. New technologies—like multimodal devices that provide additional functionality like automated respiratory rate, temperature, and/or hemoglobin measurement—are regularly entering the market. These technologies hold promise for increasing the ability of health workers to detect severe illness and prescribe treatment more affordably and efficiently.

An SpO2 reading via pulse oximetry is an important clinical parameter that primary care health workers can use to identify different levels of hypoxemia (broadly categorized as moderate 90–94%, and severe <90%) and monitor treatment response. However, interpretation of SpO2 measurements requires consideration of the patient’s broader clinical and family context (e.g., other signs of severe illness, concerned caretakers, ability to attend hospital or return for review) and the broader context of the clinical care setting (e.g., capacity of health care provider and clinic, referral distance, and feasibility). Ongoing research is looking into how to best define the role of pulse oximetry in primary care and encourage context-appropriate implementation for the most benefit to patients.

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**For advocates**

With the increasing availability of low-cost pulse oximeters on the market, prioritizing the most appropriate technology to ensure that all patients are accurately diagnosed is critical. Advocates could:

+ Encourage regulatory agencies to update their guidance to align with technical specifications.
+ Encourage international agencies and donors to explore innovative financing models to ensure that any upgraded medical devices would be available at an affordable cost for everyone who needs them; advocate that investments are made into quality devices that meet regulatory requirements and that are durable enough for clinical use.

Learn more here.
The policy landscape for pulse oximetry has been buoyed by advocacy and funding for oxygen systems—but access gaps remain.

The urgency behind funding and implementing strong oxygen delivery systems has been increasingly reflected in global guidelines and financing platforms, including the 2017 WHO decision to add a new indication for oxygen as treatment for hypoxemia to the essential medicines lists, the 2023 WHO resolution on Increasing Access to Medical Oxygen, the establishment of the Global Oxygen Alliance (GO2AL) as the driving force behind global and country coordination toward affordable and equitable oxygen access, and the Global Fund financing opportunities.

However, challenges remain, including 1) inclusion of pulse oximeters on national priority medical devices lists; 2) insufficient guidelines, regulations, and standards for pulse oximetry performance on individuals with darker skin pigmentation or children; 3) availability of performance data to help countries select the best devices for their populations; and 4) health care provider training and availability of relevant curricula.

Health decision-makers, program managers, health technology practitioners, and advocates all have a role to play in increasing widespread access to reliable, affordable pulse oximetry.

Pulse oximetry is a vital tool to detect patients who have hypoxemia and should be a critical element of every country’s oxygen delivery system planning. All stakeholders can play a role in strengthening the policies and systems that ensure that these devices are available at various facility levels and integrated into relevant health policies and clinical guidelines for pneumonia and respiratory disease.

**Health policy decision-makers** can significantly advance the use of pulse oximetry by including it in relevant health policies, regulations, and funding. To ensure sustainable introduction and adoption, health program managers and leaders can educate themselves on the local context for pulse oximetry introduction and scale, including needs, quantities, and costs. Understanding the technology landscape for pulse oximetry is critical for making value-based procurement decisions to identify quality and affordable devices that are appropriate for the specific use case.

**Health care providers** at both facility and community levels are critical to increasing uptake by ensuring devices are used. Community health care works are an important link between the community and facilities, and can help to increase demand for pulse oximeters.

**Civil society and community organizations** can serve as critical partners to governments, helping to provide accountability, community awareness, demand generation, and buy-in for pulse oximetry use at all stages of the process.

**Global advocates and multilaterals** can promote new research and guidance alignment that ensure all patients benefit from pulse oximetry equally. They can encourage needed updates to testing processes, procurement specifications, and regulations and standards to ensure device accuracy across all populations.
Global policy and funding environment

Understanding the global policies that are in place to inform national strategies—and how those in turn can provide a framework for budgeting, procurement and supply management, and program implementation—can help ensure that national and local health planning is sustainable. Being mindful of the gaps in current policies and programs offers an opportunity to generate missing evidence, focus advocacy efforts, and jump-start a regional/global dialogue on pragmatic implementation experiences to further inform policy.

This brief includes snapshots and links to:

- **Global policies**, most developed by the World Health Organization (WHO), that can guide policymakers as they incorporate pulse oximetry into national and subnational policies.
- **Global strategies** that focus on childhood illnesses and can also serve as resources for advocates to help demonstrate global momentum and support for pulse oximetry.
- **Clinical, technical, and training references** that can inform national and subnational clinical and training guidance for health workers, technicians, and maintenance staff.
- **Information on financing and funding mechanisms** that can be accessed to support pulse oximetry adoption and scale-up.

### Global policies to inform national planning

This overview of global guidance documents provides a starting point for the inclusion of pulse oximetry into national policies, plans, and frameworks—including national medicines and equipment lists.

<table>
<thead>
<tr>
<th>NAME OF POLICY</th>
<th>RELEVANCE TO PULSE OXIMETRY</th>
<th>KEY ADVOCACY ACTIONS</th>
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| Increasing Access to Medical Oxygen resolution | Several specific provisions focused on pulse oximetry, including:  
+ Acknowledgment of pulse oximeters as priority medical devices.  
+ Acknowledgment of pulse oximeters as important diagnostic tools.  
+ Use of pulse oximeters to monitor appropriate use of oxygen therapy.  
+ Need for increased awareness around the importance of pulse oximetry. | Raise awareness of the importance of pulse oximetry and ensure accountability (e.g., inclusion in core medical device lists and costed national oxygen plans). |

| WHO Model List of Essential Medicines | Pulse oximetry recommended for determining the presence of hypoxemia and guiding administration of oxygen therapy to infants and children. | Include pulse oximetry in core national medical devices lists and ensure that the pulse oximeters procured meet minimal performance requirements. |

| The Integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD) | Pulse oximetry included for use in children as part of interventions to prevent deaths in children from pneumonia and diarrhea. | Raise awareness that pulse oximetry, paired with medical oxygen access, is essential to prevent child pneumonia deaths.  
Conduct advocacy for the GAPPD deadline to be extended until 2030, to align with the Sustainable Development Goals. |
### Global policy and funding environment

<table>
<thead>
<tr>
<th>NAME OF POLICY</th>
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<tbody>
<tr>
<td>Countdown to 2030</td>
<td>No mention of oxygen or pulse oximeters.</td>
<td>Include indicators that measure the health impact and cost-effectiveness of pulse oximeters in reducing child and maternal deaths at the local and national levels.</td>
</tr>
<tr>
<td>Global Strategy for Women’s, Children’s and Adolescents’ Health (UN)</td>
<td>No mention of oxygen or pulse oximeters.</td>
<td>Conduct advocacy to ensure oxygen and pulse oximeters are part of “health system resilience” and included in the actions to “equip health workers to provide good quality care” and provide “life-saving commodities”.</td>
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<tr>
<td>WHO/Partnership for Maternal, Newborn and Child Health, 2016–2030</td>
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<tr>
<td>Child Survival Action Plan: A Renewed Call to Action to End Preventable Deaths</td>
<td>No mention of oxygen or pulse oximeters.</td>
<td>Advocate for pulse oximetry as fundamental to strengthening child health globally and ending preventable deaths.</td>
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<tr>
<td>Child Health Task Force, 2022</td>
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### Global clinical/technical/training guidelines on pulse oximetry

For health program decision-makers, these resources can provide a starting point for including clinical and training guidance into local programming.

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<thead>
<tr>
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<tr>
<td>CLINICAL GUIDELINES</td>
<td></td>
<td>Partner with WHO on advocacy to raise country awareness around guidelines for pulse oximetry use; advocate for strengthened alignment across all relevant clinical guidelines.</td>
</tr>
<tr>
<td>Management of the Sick Young Infant Aged up to 2 Months—Chart Booklet WHO, 2019</td>
<td>When available, pulse oximeter is recommended to determine oxygen saturation and refer if &lt;90%.</td>
<td></td>
</tr>
<tr>
<td>Integrated Management of Childhood Illness—Chart Booklet WHO, 2014</td>
<td>Numerous mentions of pulse oximeters—mainly for use when children have carbon monoxide poisoning, have pneumonia, are on oxygen, or have apnea.</td>
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<tr>
<td>Pocket Book of Hospital Care for Children WHO, 2013</td>
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<td>Caring for the Sick Child in the Community UNICEF/WHO, 2011</td>
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<tr>
<td>Oxygen Therapy for Children: A Manual for Health Workers WHO, 2016</td>
<td>Pulse oximetry use recommended in hospitals for accurate hypoxemia detection; where not available, clinical signs should be used for deciding whether to provide oxygen.</td>
<td></td>
</tr>
<tr>
<td>Updated Guideline: Paediatric Emergency Triage, Assessment and Treatment: Care of Critically Ill Children WHO, 2016</td>
<td>Pulse oximetry use recommended to determine hypoxemia in all children with emergency triage, assessment, and treatment signs.</td>
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## Global policy and funding environment

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<tbody>
<tr>
<td>WHO Recommendations on Child Health: Guidelines Approved by the WHO Guidelines Review Committee WHO, 2017</td>
<td>Pulse oximetry use recommended as part of supportive care, including to determine the presence of hypoxemia and to guide administration of oxygen therapy in infants and children.</td>
<td>Advocate for recommendations to include guidance on pulse oximetry use for neonatal oxygen therapy and as a screening tool.</td>
</tr>
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<td><strong>GENERAL GUIDANCE AND PLANNING RESOURCES</strong></td>
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<tr>
<td>Oxygen System Planning Tool: Demand Estimation and Recommendations to Plan Oxygen Delivery From Source to Patient Download the tool. UNICEF, 2020</td>
<td>Customizable tool to plan demand estimation and recommendations for oxygen delivery from source to patient.</td>
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<tr>
<td>Quantification and Costing Tools for Oxygen and Pulse Oximetry PATH, 2020</td>
<td>Quantification and costing tools to understand the amount of oxygen or number of pulse oximeters needed to meet patient demand and all costs associated with owning these devices over time.</td>
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<tr>
<td><strong>DEVICE LISTS AND TECHNICAL SPECIFICATIONS</strong></td>
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<tr>
<td>WHO-UNICEF Technical Specifications and Guidance for Oxygen Therapy Devices WHO/UNICEF, 2019</td>
<td>Harmonized product specifications provided for a wide range of oxygen products including pulse oximetry, and guidance provided on their selection, procurement, use, and maintenance.</td>
<td>Update specifications in line with any updated recommendations on how to identify and procure high-quality pulse oximeters that work on children and all skin tones.</td>
</tr>
<tr>
<td>Interagency List of Priority Medical Devices for Essential Interventions for Reproductive, Maternal, Newborn and Child Health WHO, 2016</td>
<td>Pulse oximeters included in the medical equipment lists for the following categories: medical examination and diagnosis; referral; labor, delivery, and recovery; surgery and anesthesia; mother and newborn inpatient care; child inpatient care; and intensive care.</td>
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<th>KEY ADVOCACY ACTIONS</th>
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<tbody>
<tr>
<td><strong>Target Product Profile:</strong> Pulse oximeter</td>
<td>Overview of minimal and optimal performance and operational characteristics, as well as pricing for a range of newborn medical devices, including pulse oximeters (for continuous monitoring use).</td>
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<td>UNICEF, Nest360, 2020</td>
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<tr>
<td><strong>MeDevIS (Priority Medical Devices Information System)</strong></td>
<td>Open access electronic database of medical devices, including pulse oximetry, that facilitates access to guidelines, training materials, priority medical devices, and technical specifications.</td>
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<td>WHO</td>
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<td>Pan American Health Organization, 2019</td>
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### PULSE OXIMETRY TECHNICAL TRAINING RESOURCES

- WHO medical equipment how-to videos, including:
  » How to perform corrective maintenance on a pulse oximeter
  » How to decontaminate a pulse oximeter
  » How to clinically use a pulse oximeter
  » How to get a pulse oximeter ready for use
  » How to perform preventative maintenance on a pulse oximeter

- Open Oximetry FAQs and searchable site

- Nest360 Resources, videos, and job aids

- Lifebox Pulse oximetry self-learning course
Global policy and funding environment

Financing for pulse oximetry

As global momentum and local evidence for pulse oximetry grow, financing for introduction of these devices is becoming more widely available at both the national and global levels.

Domestic financing

For advocates and government decision-makers, demonstrating political and programmatic priority of pulse oximetry is critical to ensure national funding allocations. Using this checklist as a starting point for positioning pulse oximeters for national financing, decision-makers and advocates can:

- Identify key national decision-makers.
- Develop financing asks and rationale.
- Align requests with relevant budget cycles; include pulse oximeter-specific indicators in the budget performance framework.
- Ensure that scale-up plans or roadmaps exist that incorporate pulse oximeters, including evidence on their acceptability, feasibility, uptake, and impact, as well as specific contextual factors and implementation mechanisms.
- Position staff on technical working groups related to reproductive, maternal, newborn, and child health.
- Ensure inclusion of pulse oximetry as a key component of broader national health plans, strategies, and investments, including around medical oxygen, universal health coverage, and pandemic prevention, preparedness, and response.

Learn more about pulse oximetry scale-up.

Global financing platforms

Global funding for pulse oximeters is typically funneled through oxygen financing mechanisms and those that focus more broadly on maternal and child health, health systems strengthening, and broader infrastructure investments. This list highlights major funding sources for country decision-makers who are interested in seeking this type of funding to support national programs, as well as information on positioning pulse oximetry in the application process:

- **The Global Fund.** In recent years, the Global Fund has emerged as an important source of funding for respiratory care equipment, supplies, and services for low- and middle-income countries—with the COVID-19 Response Mechanism and, more recently, via the inclusion of respiratory care equipment as a new allowable resilient and sustainable system for health intervention. Countries can apply for funding for pulse oximetry technology and training under both funding routes where pulse oximetry is explicitly mentioned. For more information on the application deadlines and process, refer to the Global Fund’s website here and PATH’s guidance here.

- **Global Financing Facility (GFF).** The GFF is a country-led partnership, hosted at the World Bank, that fights poverty and inequity by advancing the health and rights of women, children, and adolescents. It does this by supporting countries to strengthen health systems and improve access to care through prioritized plans, aligned public and private financing, and policy reform. As of 2020, the GFF works in partnership with 36 countries, and an additional 31 are eligible for GFF support. See eligible countries here.

To access funding, GFF-eligible countries must develop an investment case. In addition to national planning and forecasting, helpful tips for securing financing for pulse oximeters include:

- **Advocating to have pulse oximetry indicators in the performance framework** of the GFF project. For example, funding will be more likely if an indicator such as “90% of level 4 hospitals have at least 10 pulse oximeters” is explicitly set out in the framework. There will be set periods for civil society organization feedback on GFF projects.

- **Getting to know the World Bank country staff.** GFF projects are approximately 10 percent GFF grants and 90 percent World Bank loans or grants. Getting to know the World Bank staff in-country will be useful to stay up-to-date on when to get involved.

PATH’s Medical Oxygen Investment Case gives further insight into how pulse oximeters could be included in a GFF application—for example, by demonstrating how these devices improve the equity and efficiency in health service provision.
The Pandemic Fund. The Pandemic Fund—hosted by the World Bank—was created in September 2022 to provide a dedicated stream of additional, long-term funding for critical pandemic prevention, preparedness, and response in eligible low- and middle-income countries, through investments and technical support. It is a collaborative partnership among donor governments, co-investor countries, foundations, civil society organizations, and international agencies. Multilateral development banks, United Nations agencies, and specialized global health institutions currently serve as the Pandemic Fund’s Implementing Entities.

The Pandemic Fund approved US$338 million in its first round of funding in January 2023 (examples of the projects to be funded are listed here) and launched its second Call for Proposals on December 22, 2023, with an envelope of US$500 million.

Pulse oximeters, and the clinical and biomedical engineering workforce needed to use and maintain the devices, are relevant for priorities 1 and 3 of the second round of Pandemic Fund financing. To prepare for the next respiratory pandemic, every country should have an adequate number of pulse oximeters at different levels of the health care system, and the workforce trained and equipped to operate and maintain them.

For advocates

+ Advocate with government partners (e.g., ministries of health and finance, stakeholders) about the funding potential for respiratory care equipment as part of country grants to global financing platforms.
+ Be a thought partner for compiling application materials, including impact evidence and costed work plans.
+ Advocate to ministries of health to include pulse oximetry in their national and multi-country applications to the Pandemic Fund and to eligible regional entities to do the same, focusing on ensuring adequate supplies of quality pulse oximeters as tools for respiratory pandemic surveillance and the trained workforce needed to ensure accurate and timely diagnosis and functioning devices.
Pulse oximeter technologies

Thousands of pulse oximeters already exist in the current market, with various forms (or types), features, prices, and capabilities relating to performance and accuracy. At the same time, new technologies are regularly evolving and entering the market. Numerous resources exist to help health decision-makers evaluate and procure high-quality and appropriate devices.

The practice of value-based procurement (VBP) is one effective approach that can help decision-makers define, evaluate, and procure pulse oximetry devices that maximize overall value for money, rather than focus on the lowest purchase price. Typically, the purchase price is the only cost element budgeted and planned for by decision-makers, while pulse oximetry devices—as with most medical devices—incur indirect costs over time. In some cases, this practice can contribute to a common proliferation of underused or under-utilized medical devices. Without applying VBP practices and understanding the total cost of ownership (TCO), decision-makers may choose a device that seems more affordable, but over time is more expensive.

In the pulse oximetry context, TCO is defined as accounting for the purchase price of the device (direct cost) plus the costs of operation over its life span (indirect costs, such as batteries, probes/sensors, backup devices, spare parts, maintenance, and training).

This resource intends to:

- Provide decision-makers with key product and market information on current and new pulse oximetry devices.
- Offer guidance on how to determine the most appropriate options for their context, based on levels of funding, TCO, health system capacity, and device usage.
- Provide access to additional technologies.
Pulse oximeter technologies

PULSE OXIMETER TYPES: THE BASICS

Pulse oximeters can serve as either spot-checking or continuous-monitoring devices. A spot-check is a single SpO2 reading (to determine oxygen saturation) that detects if a patient is hypoxemic and requires oxygen therapy, whereas for continuous monitoring, the sensor (also referred to as a probe) remains fixed to the patient and a continuous reading of SpO2 is provided by the device.

A wide variety of devices exist to meet different needs, costs, and sizes and vary in terms of durability, price, and TCO. The three most common types include fingertip, handheld, and tabletop.

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<th>PORTABILITY</th>
<th>POWER</th>
<th>USE CASE</th>
<th>ACCESSORIES</th>
<th>DURABILITY</th>
<th>PRICE*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FINGERTIP</strong></td>
<td>Portable (small and lightweight)</td>
<td>Battery-operated, typically single-use; some are rechargeable</td>
<td>Replacement batteries</td>
<td>Most available models are not durable; device failure requires replacement</td>
<td>Least expensive and most common type of pulse oximeter found in all settings, Ranges from US$15 to $300 per unit, TCO (ten-year assumption) is $660 to $4,360</td>
</tr>
<tr>
<td><strong>HANDHELD</strong></td>
<td>Portable (small and lightweight)</td>
<td>Battery-operated; single-use or rechargeable and/or electrical power</td>
<td>Interchangeable probes; size specific to the patient (adult, child, infant, and neonate); single use and reusable</td>
<td>More durable compared to fingertip devices, Expected life span is approximately five years</td>
<td>If device model uses single-use probes, may be expensive and difficult to supply, More expensive than fingertip, less than tabletop, Ranges from $100 to $500 per unit, TCO (ten-year assumption) is $600 to $1,670</td>
</tr>
<tr>
<td><strong>TABLETOP</strong></td>
<td>Large, not intended to be moved regularly</td>
<td>Requires electricity</td>
<td>Interchangeable probes; size specific to the patient (adult, child, infant, and neonate)</td>
<td>More durable compared to fingertip and handheld devices</td>
<td>More expensive, Ranges from $1,730 to $2,000, TCO (ten-year assumption) is $2,034 to $2,528</td>
</tr>
</tbody>
</table>

* Price estimates from the Open Oximetry Project; TCO estimates only factor cost of device, cost of batteries and probes, and lifespan of devices and parts.
Multimodal pulse oximeters: Next-generation technology for health programs

Multimodal (or next generation) pulse oximeters—noninvasive handheld devices that expand the features of standard handheld pulse oximeters by additionally measuring respiratory rate, temperature, and/or hemoglobin levels—are a promising technology that can provide objective measurements to support clinical decision-making and improve cost efficiencies.*

Their potential benefits are numerous, including more accurate and appropriate care for children, objective measurements to support clinical decision-making, optimization of health resources by minimizing the need for costly testing, saving time spent on running multiple tests, strengthening referral decisions, reducing unnecessary hospitalization, intensive therapy, and overuse of antibiotic treatments.

As with standalone pulse oximeters, multimodal devices are non-invasive and come in different types, including fingertip, handheld, and tabletop options. Here are some examples of currently available products:

<table>
<thead>
<tr>
<th>PRODUCT (MANUFACTURER)</th>
<th>CLINICAL MEASUREMENTS</th>
<th>MEASUREMENT MODE</th>
<th>TARGET POPULATION</th>
<th>REGULATORY</th>
<th>CONSUMABLES</th>
<th>POWER REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rad-G (Masimo)</td>
<td>SpO2, pulse rate, respiratory rate, temperature</td>
<td>Spot-check and continuous monitoring</td>
<td>Adult, pediatric, and neonatal populations; however, neonatal probe for respiratory rate not cleared by US FDA</td>
<td>US FDA (without temperature) EU CE mark (with temperature)</td>
<td>Reusable probe for children/ adults; neonatal probe requires disposable wrap</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>Pronto (Masimo)</td>
<td>SpO2, pulse rate, Hb</td>
<td>Spot-check</td>
<td>Adult and pediatric populations</td>
<td>US FDA</td>
<td>Reusable probe for adult and pediatric populations</td>
<td>AA alkaline batteries</td>
</tr>
<tr>
<td>Radical-7 (Masimo)</td>
<td>SpO2, pulse rate, Hb</td>
<td>Continuous monitoring</td>
<td>Adult, pediatric, and neonatal populations</td>
<td>US FDA</td>
<td>Reusable probe for adult, pediatric, and neonatal populations</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>Rad-67 (Masimo)</td>
<td>SpO2, pulse rate, Hb</td>
<td>Spot-check</td>
<td>The SpO2 and pulse rate measurements are indicated for use in adult, pediatric, and infant populations, but the total Hb measurement is not intended for use on pediatric patients, pregnant patients, and patients with renal disease</td>
<td>US FDA</td>
<td>Reusable probe for adult, pediatric, and neonatal populations</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>SatLite Touch (Zug Medical Systems)</td>
<td>SpO2, pulse rate, respiratory rate, temperature, ECG</td>
<td>Spot-check and continuous monitoring</td>
<td>Device without respiratory rate, temperature, and ECG features has EU CE mark and pending US FDA approval for adult, pediatric, and neonatal populations</td>
<td>Device without respiratory rate, temperature, and ECG features has EU CE mark and pending US FDA approval for adult, pediatric, and neonatal populations Manufacturer has plans to secure EU CE mark approval for device with additional clinical measurements</td>
<td>Reusable probe for children/ adults; neonatal probe requires disposable wrap</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>Scanbo D8 (Scanbo)</td>
<td>SpO2, pulse rate, respiratory rate, temperature, glucose, blood pressure, ECG, pulse rate variability</td>
<td>Spot-check</td>
<td>Adult populations Performance validation in pediatric and neonatal populations underway</td>
<td>Japan CE mark for all measurements except respiratory rate and ECG, which are currently under review</td>
<td>Reusable blood pressure cuff and disposable blood test strips</td>
<td>Rechargeable battery with adapter</td>
</tr>
</tbody>
</table>

*Data are evolving on impact and accuracy, in addition to the device designs and costs.
### Pulse oximeter technologies

<table>
<thead>
<tr>
<th>PRODUCT (MANUFACTURER)</th>
<th>CLINICAL MEASUREMENTS</th>
<th>MEASUREMENT MODE</th>
<th>TARGET POPULATION</th>
<th>REGULATORY</th>
<th>CONSUMABLES</th>
<th>POWER REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>M800 Respiratory Rate (BioLight)</td>
<td>SpO₂, pulse rate, respiratory rate</td>
<td>Spot-check and continuous monitoring</td>
<td>M800 without respiratory rate feature for adult, pediatric, and neonatal populations</td>
<td>M800 without respiratory rate feature has US FDA approval for adult, pediatric, and neonatal populations Manufacturer has plans to secure EU CE mark approval for device with respiratory rate feature</td>
<td>Reusable probes for adult, pediatric, and neonatal populations</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>neoGuard (Neopenda)</td>
<td>SpO₂, pulse rate, respiratory rate, temperature</td>
<td>Continuous monitoring Manufacturer has plans to adapt product for spot-check measurements</td>
<td>Adult, pediatric, and neonatal populations</td>
<td>EU CE mark</td>
<td>None</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>EzeCheck (EzeRx)</td>
<td>SpO₂, Hb, creatine, glucose</td>
<td>Spot-check</td>
<td>Approved for use in patients aged four years and older Manufacturer has plans to validate product’s use in children aged 30 months and older, as well as develop a device for neonatal populations</td>
<td>Approved by India’s Central Drugs Standard Control Organization The device is also under review for US FDA approval and EU CE mark</td>
<td>None</td>
<td>Rechargeable battery with adapter</td>
</tr>
<tr>
<td>NBM 200 (OrSense)</td>
<td>SpO₂, pulse rate, Hb</td>
<td>Spot-check</td>
<td>Adults</td>
<td>Approved by US FDA, EU CE mark, Brazil Health Regulatory Agency (Anvisa), China FDA, Mexico Federal Committee for Protection From Sanitary Risks (COFEPRIS)</td>
<td>Reusable probe</td>
<td>AA alkaline batteries or rechargeable battery with adapter</td>
</tr>
<tr>
<td>Vivaray (Bosch)</td>
<td>Hb</td>
<td>Spot-check</td>
<td>Not publicly available</td>
<td>Not publicly available</td>
<td>None</td>
<td>Rechargeable</td>
</tr>
<tr>
<td>AnemoCheck Mobile app (Sanguina)</td>
<td>Hb</td>
<td>Spot-check</td>
<td>N/A</td>
<td>N/A; currently a consumer health and wellness-tracking tool</td>
<td>None</td>
<td>Rechargeable</td>
</tr>
</tbody>
</table>

Abbreviations: Anvisa, Agència Nacional de Vigilància Sanitària; COFEPRIS, Comisión Federal para la Protección contra Riesgos Sanitario; ECG, electrocardiogram; EU, European Union; FDA, Food and Drug Administration; Hb, haemoglobin; N/A, not applicable; SpO₂, blood oxygen saturation.

This is an illustrative, not an exhaustive, list. For additional information, please see the technology and market landscape report.
Factors for decision-makers in considering procurement of pulse oximeters

Strategic and holistic approach to pulse oximetry purchasing and procurement criteria could help ensure long-term benefits for health programs. The following factors could help decision-makers weigh options and balance funding:

**INTENDED USE**
- Current diagnosis and treatment procedures.
- Level of the health facility.
- Composition and infrastructure of health facility (number and types of beds or sections requiring pulse oximeters).
- Use cases:
  - Spot-check vs. continuous monitoring.
  - Patient age (adult, child, or neonate).
  - Static vs. mobile.
- Prevalence of hypoxemia-related illnesses.

**TOTAL COST OF OWNERSHIP**
- Functional and performance specifications.
- Desired product characteristics.
- Design needs and constraints.
- How the product fits in the clinical system/process.
- Direct cost (device purchase).
- Indirect costs:
  - Probes (applicable for select device types).
  - Batteries.
  - Life span of device, probes, and batteries.
  - Number of backup devices and spare parts.
- Maintenance.
- Training of health care providers and personnel responsible for maintenance and repairs.
- Shipping, customs/tariffs, and distribution.

**OPERATION**
- Human resources, skills, and training for administration and operation of pulse oximeters.
- Personnel (e.g., building maintenance employees) responsible for maintenance and repairs.

**USER PROFILE AND TRAINING**
- Facility bed capacity and structure.
- Facility staff responsible for using and/or managing pulse oximeters.
- Current capacity for installation, management, and maintenance.
- Availability and reliability of electricity.
- Availability and reliability of medical oxygen provision.
- Currently available and functioning pulse oximeters.
- Environmental factors like temperature, humidity, and elevation.

**INFRASTRUCTURE**
- Manufacturer/supplier/distributor after-sales services and terms (e.g., warranty).
- Supply chain challenges (replacement parts).
- Stringent quality standards.
- Manuals and training in local languages.
- Personnel (e.g., building maintenance employees) responsible for maintenance and repairs.

**OTHER CONSIDERATIONS**
Across the continuum of patient care, pulse oximetry is critical for identifying patients with hypoxemia, and monitoring blood oxygen saturation levels during administration of medical oxygen to patients. In both of these contexts, numerous challenges can exist, including: high-quality devices appropriate for all ages are not available or not working properly, health care providers are not fully trained to use them, devices are not available at all relevant levels of a health facility, the financing and political will to purchase and sustain the technology are inadequate, and community knowledge and understanding of the technology are lacking.

This resource, aimed at national decision-makers, focuses on:
+ Key steps for pulse oximetry scale-up that takes into consideration national and subnational contexts, including financing and policy environments.
+ Guidance for civil society advocates interested in partnering with government stakeholders to help achieve this goal.

### Planning process

Articulating a clear plan that can lead to sustainable and coordinated introduction and uptake of pulse oximetry begins with engaging key stakeholders. This team should represent a range of disciplines and expertise: a non-exhaustive list could include programmatic, technical, clinical and maintenance, financing, policy, and civil society perspectives.

Seven topics outlined below can help lay the general foundation for building an effective scale-up plan, with adjustments made to address specific local context.

1. **Needs assessment**
   > What is the prevalence of health scenarios where pulse oximeters are desired (maternal health, newborn health, child health, surgery/critical care, other)?
   > What is the current availability of pulse oximeters in the health system? Are they appropriate for all age ranges?
   > What data/health information systems are available to answer the previous questions, and where are the key gaps?
   > What financing and human resources are available to support scale-up of pulse oximetry?
   > What are the country-specific challenges and opportunities to scale pulse oximetry?

2. **Stakeholder coordination and policy review**
   > Are pulse oximeters mentioned in critical health policies or standards? These could include health sector plans; maternal, newborn, and child health plans/policies; emergency, critical, or surgical care plans/policies; oxygen access plans/strategies; clinical guidelines; and essential device lists, among others.
   > Which critical in-country stakeholders (e.g., ministry of health departments, health facility decision-makers, manufacturers or distributors, donors) would support pulse oximetry scale-up?
   > Are there any existing mechanisms (e.g., technical working group) that could support coordination of pulse oximetry scale-up?
3. **Quantification/forecasting**
   - At which health facility level is pulse oximetry needed to be introduced?
   - Where in the facility should pulse oximetry be used?
   - For what kinds of patients and which types of conditions?
   - Does the facility have infrastructure in place to introduce and maintain these devices?

4. **Procurement, distribution, and maintenance**
   - Where can appropriate devices for the population be procured?
   - Does your country have existing guidelines or protocols for procuring, maintaining, and disposing of health devices (whether specific to pulse oximetry or not)?
   - Are there standardized ways that health devices are procured, distributed, and maintained in your country? What are the current procurement specifications for the country, and do they apply to the populations of focus?
   - Does your country have an inventory management mechanism in place to track donated, existing, or defunct health devices and their distribution?

5. **Management and training**
   - Do clinicians and other health care providers have up-to-date knowledge on how to use and manage pulse oximeters, including different use cases, pulse oximetry thresholds, use on different skin tones, maintenance, etc.?
   - Is pulse oximetry included as part of pre-service curriculum or training?
   - Is continuous training available at the facilities where you intend to introduce pulse oximeters (e.g., continuous education, on-job training, mentorship)?

6. **Financing and advocacy**
   - Who are the key global- and national-level stakeholders influencing budgetary decisions for health? How integrated is your country government into those conversations and platforms?
   - What does the donor landscape look like at both global and domestic levels?
   - Is current budget allocation available for pulse oximetry implementation package? If not, can it be feasibly identified?
   - Based on needs assessment and forecasting, what are the budget needs for scale-up?

7. **Community engagement and demand generation**
   - To what extent do families and caregivers understand and recognize the signs of hypoxemia?
   - What are the current care-seeking practices during instances of hypoxemia? How might these be improved?
   - To what extent do community health workers, families, and caregivers know about and understand how to use pulse oximeters?
   - Are sufficient and current resources available for community health care providers and other local advocates?

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**For advocates: Accelerating support for scale-up**

For civil society advocates interested in scale-up, these key principles gleaned from country experiences can help to guide work toward accountability and coordination with government and other civil society leaders:

1. Building trust with the ministry of health at national and subnational levels is key. For sustainable scale-up, health officials must lead the process, with the support of civil society.
2. Civil society advocates can accelerate scale-up by learning about—and sharing—financing mechanisms and evidence for pulse oximeters with government decision-makers.
3. Incorporating pulse oximeters, as well as technical and training guidelines, into national policy helps to ensure sustainability.
4. Community knowledge and buy-in for pulse oximeters helps to create demand from the ground up.
5. Civil society has an important role to play in monitoring financing allocated for pulse oximeters. This role can help strengthen accountability and oversight by all stakeholders.
Elements of a scale-up plan for pulse oximetry

Depending on a country’s needs, the formal process for developing, validating, and adopting a pulse oximetry scale-up plan may be part of a broader national oxygen or medical device access strategies, or a standalone resource. The latter approach can offer the granular details necessary to guide decision-makers and implementers around use cases, training, procurement and maintenance, financing, and policy integration. It can also serve as an advocacy tool to ensure that pulse oximeters receive the necessary resources and funding so that they can be fully incorporated into the broader oxygen ecosystem.

When drafting a scale-up plan, health decision-makers and program managers should consider addressing the areas set forth below. Discussion and consideration of these topics among a multidisciplinary group can help to shed light on financial and human resource needs, gaps and barriers, and strengths and opportunities that the team brings to the process.

Sample plan outline

1. Introduction:
   » Child mortality, major causes.
   » Burden of hypoxemia.
   » Timely detection and management of hypoxemia.

2. Operational readiness:
   » Inclusion of pulse oximetry devices into national procurement catalogues.
   » Procurement of appropriate devices.
   » Subnational/facility engagement and buy-in/ownership of scale-up and service integration.
   » Oxygen and pulse oximeter availability at referral facilities.

3. Programmatic readiness:
   » Training of both providers and support staff on pulse oximeter use and correct, high-quality record-keeping (traditional training, on-the-job training, and integration into pre-service and in-service training).
   » Integration into existing supportive supervision plans/checklists for accountability.
   » Inclusion of communications resources and training geared to caregivers.

4. Community engagement:
   » Ongoing engagement, not just a one-off.
   » Understanding of hypoxemia in pneumonia and other childhood illnesses.

5. Financing/budgets:
   » Consistent integration of device and spare parts procurement, maintenance, and training/supportive supervision into national and subnational budgets.

6. Monitoring and evaluation:
   » Integration of SpO2 indicators into health management information system/District Health Information System 2.
   » Integration of pulse oximetry into health registry record-keeping.
National leadership and planning are critical to scale-up pulse oximeters. However, the most effective—and sustainable—route to health care demand generation often comes through building trust and awareness directly with local communities. The Tools for Integrated Management of Childhood Illnesses (TIMCI) project in Tanzania found that community health care workers (CHWs) provide an important linchpin between the community and government health decision-makers by providing education, awareness, and encouraging visits to local health care facilities where children can be effectively treated.

The pulse oximetry challenge in Tanzania
In Tanzania, handheld pulse oximeters are not readily available to doctors and health care providers. One reason for this is because pulse oximeters are absent from key guidance and policy documents that govern public health access and procurement. For example, they are not included in the Medical Stores Department essential list of medical supplies, which means that public facilities cannot readily obtain them. Additionally, the Standard Treatment Guideline and National Essentials Medicine List for Tanzania Mainland does not specifically mention their use, nor do the Integrated Management of Childhood Illness (IMCI) chart booklet and sick child record forms.

Laying the groundwork
In 2019, the TIMCI project—funded by Unitaid and implemented by PATH, Swiss Tropical and Public Health Institute, and Ifakara Health Institute, with support from the Ministry of Health—worked across three districts to support more than 200 health care providers in 66 facilities to diagnose severe disease with pulse oximeters.

The project aimed to introduce pulse oximeters into primary health care. A key question of the project: In addition to the primary health care providers, would engaging the community through supporting, training, and resourcing CHWs improve care-seeking for young children? And could that, in turn, allow more children to receive timely diagnosis and treatment of hypoxemia?

Equipping community health care workers to save more lives
CHWs are the often-unsung heroes of primary health care. As the first point of contact for many caregivers with sick children, their role in educating families and encouraging them to seek care at primary health care facilities can save lives.

To improve their ability to identify oxygen-related issues, TIMCI trained and supported more than 200 CHWs affiliated with 66 health facilities across three districts (Sengerema, Mwanza; Kaliua, Tabora; and Tanga City, and Tanga). The CHWs reached out into the community, built trust with families, encouraged care-seeking behavior, and provided follow-up to children after they received treatment.

The TIMCI project learned quickly that the CHWs played a critical role in encouraging caregivers to bring their children to local primary health care facilities. More sick children found their way to the clinic and received timely treatment for hypoxemia and other illnesses with increased engagement by CHWs. The opposite was also true: fewer children arrived at clinics when CHWs were not engaged.

CASE STUDY
Creating community demand for pulse oximeters in Tanzania

“CHWs help to create the community investment and buy-in. They help identify what the community wants. They live in the communities and are trusted by them. We have all the confidence of advocating for scale-up because we have backup from the community.”
—Deusdedit Mjungu, PATH

Sengerema
MWANZA
Kaliua
Tabora
Tanga City
TANGA

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To ensure that the CHW approach was sustainable, TIMCI partnered closely with government officials, with an eye toward both the project outcomes as well as a longer-term scale-up effort. Staff partnered closely with the Ministry of Health and Ministry of Presidents Office Regional Administration and Local Government Authority.

TIMCI found that the most effective supervisory structure was to connect CHWs with local government coordinators. This connected the CHWs directly to their reporting facilities and increased communication and trust between the communities and local government.

Engaging the communities where community health care providers live and work

CHWs reached more than 16,500 people through house visits. CHWs providing community education and engagement in the communities where they live and work helped to reinforce their ability to care better for local children, while increasing the broader demand for pulse oximetry.

Messages to parents, caregivers, and other members of the community focused on identifying danger signs in children, what to do when they became sick, and when and where to refer children for further management.

“I look forward to visits from my CHW. Before, I never saw the importance of taking my child to the facility when he felt sick. But once my child fell sick and almost lost his life—he would have died if it were not for the intervention of the CHW who happened to visit my home and rushed us to the facility where we got immediate medical attention. We had to be referred to a higher-level facility because the pulse oximeter measurement showed my child was out of oxygen.”

—Shida Mahendeka, Sengerema district

Community health care provider from Nguvumali dispensary in Tanga district, Tanzania, conducting home visits.
From 2019 to 2023, the AIRE (Improving the Diagnosis of Respiratory Distress in Children) project, led by the Alliance for International Medical Action (ALIMA) with funding from Unitaid, introduced and evaluated the routine use of pulse oximeters as part of the Integrated Management of Childhood Illness (IMCI) consultations at 200+ primary health care centers in Burkina Faso, Guinea, Mali, and Niger. The project examined whether, and how, pulse oximeters helped children under the age of five and the health care workers who were treating them. Over the course of the project, it followed the health evolution of nearly 2,000 children suffering from a severe illness. Among key findings:

**Hypoxemia was common among children with severe disease attending primary health care facilities and represented a significant mortality risk.**

- Across the four countries, nearly one in ten children under five with severe disease had hypoxemia.
- There was correlation between hypoxemia prevalence and severe outcomes—between 37.5% and 64.2% of children identified as severe cases resulting in death had hypoxemia.

**After four to six months of the project, pulse oximeters were used in over 90% of the IMCI consultations at the participating primary health care facilities.**

- Children diagnosed with severe hypoxemia, as measured by pulse oximetry, were referred more often than severe cases without hypoxemia.
- More than half of children with severe hypoxemia were referred effectively.

**Pulse oximetry reassures health care providers in their diagnosis and referral decisions and increases caregivers’ trust in health workers.**

- More than three-quarters of health workers adopted pulse oximetry after several months of use.

**Early case management and quality care at primary health care level and hospitals is critical to reducing child mortality.**

- Across the four countries, hospital referrals were a challenge with a significant proportion of severe cases not reaching the hospital. Among severe cases, a significant proportion of deaths occurred before arrival at the hospital.

Learn more here.
The success of pulse oximetry scale-up depends in part on a growing demand for pulse oximeters by health experts, civil society, and government stakeholders. This messaging map is designed primarily for advocates who are delivering messages about the importance of pulse oximeters to health decision-makers, policymakers, and political stakeholders.

**THE PROBLEM**

Many patients—including children and pregnant women—lose their lives to hypoxemia because it is not diagnosed accurately or in time for patients to receive oxygen therapy.

- Hypoxemia is a dangerously low level of oxygen in the blood. Many common conditions can cause hypoxemia, including pneumonia, neonatal sepsis, asthma, and COVID-19.
- Globally, the most vulnerable patients—children, mothers, and the very sick—bear the greatest burden of hypoxemia.
  - In children younger than five years of age, pneumonia, which is often marked by severe hypoxemia, is the world’s leading infectious cause of death.
  - One in five sick newborns is suffering from hypoxemia upon admission to a hospital. In 2019, an estimated 7.2 million children under the age of five were admitted to hospitals in lower-income countries needing oxygen.

**THE SOLUTION**

Pulse oximeters can quickly and accurately give health care providers the information they need to save lives.

- A simple technology called a pulse oximeter allows health care providers to diagnose conditions that require lifesaving oxygen therapy for newborns, children, and mothers.
- Pulse oximeters are the most reliable way to detect low oxygen levels in a primary care setting. Measurement of oxygen saturation with pulse oximetry should be regarded as an essential vital sign—in children this should be the fifth vital sign.
- Fewer than 20 percent of newborns and children receive the oxygen therapy they need, in part because of a lack of access to pulse oximeters.
- But across many LMICs, health care providers at PHC facilities continue to lack access to these helpful tools.
THE EVIDENCE
Scaled-up access to pulse oximeters can—and should—be a critical part of every country’s oxygen strategy.

+ Pulse oximetry is the gateway to oxygen access and should be included in every country’s strategy for oxygen scale-up, relevant health policies, and clinical guidelines for pneumonia and other respiratory disease.
+ Global and local evidence increasingly demonstrates that making pulse oximeters widely available considerably enhances the impact of existing oxygen systems.
  » In one study, after pulse oximetry and oxygen were provided in hospital pediatric wards, child deaths fell by half.³
  » Research has shown that pulse oximeters can improve the identification and treatment of children suffering from severe pneumonia by about 44 percent.⁵ In another study, the pneumonia fatality rate among hospitalized children was more than double for those whose blood oxygen levels were not measured compared with those whose levels were assessed.⁶
  » Pulse oximetry may also be cost-effective. A recent study in Ethiopia found that including pulse oximetry in WHO IMCI guidelines increased the detection of severe pneumonia in children by 12 percent; further, for each investment of US$29, an additional child with severe pneumonia could be detected and treated.⁸
+ Pulse oximetry scale-up can be effective both as part of a country’s overall oxygen strategy and as an element of other maternal and child health plans and policies, and as part of National Surgery, Obstetric and Anesthesia Plans (NSOAPs), depending on local context and needs.

CALL TO ACTION
Advocates, health decision-makers, and health care providers can make pulse oximeters more widely available by taking steps to prioritize and finance pulse oximetry.

Health decision-makers can include pulse oximetry in relevant health policies, regulations, and funding. To ensure sustainable introduction and adoption, leaders can educate themselves on the local context for pulse oximetry introduction and scale, including needs, quantities, and costs.

Health care providers can save lives by using pulse oximeters where available and encouraging increased demand for pulse oximeters by serving as a link between the community and the health system.

Civil society and community organizations can partner with governments to share knowledge, create community awareness and buy-in, and establish accountability for pulse oximetry scale-up.

Global and local advocates can help to promote inclusion of pulse oximetry in a country’s oxygen strategies, in line with recommendations outlined in the WHO resolution, Increasing access to medical oxygen. This guidance includes:
  » Assessing the scale of the gaps in access to medical oxygen in health systems, including at subnational- and local-level health facilities, to provide patients with the required amounts of oxygen and related diagnostic tools, including pulse oximeters.
  » Raising awareness among key stakeholders and broader public about the critical role of pulse oximetry as a routine screening tool and part of oxygen ecosystem, and the need to prioritize both in national / global budgets and policies.
  » Preventing toxic levels of medical oxygen among preterm newborns and providing safe medical oxygen by using pulse oximeters that meet global standards for technical specifications.
  » Understanding that pulse oximeters have been recognized as priority medical devices in key global policies.
Pulse oximetry is an essential tool for detecting hypoxaemia that should be available at all facility levels and should be integrated into clinical guidelines for pneumonia and other respiratory disease. Measurement of oxygen saturation with pulse oximetry should be regarded as an essential vital sign— in children this should be the 5th vital sign. Widespread availability of pulse oximetry to inform use of oxygen is key to reduce deaths and reduce global inequity in child health.

### Health Outcomes

**Study**

- Zar, HJ, McCollum, ED. *Pulse oximetry to detect paediatric hypoxaemia—the fifth vital sign*. The Lancet Global Health. 2023;11.

**Country**

- Malawi and Bangladesh
- Papua New Guinea
- Bangladesh
- Multiple LMICs

**Population**

- Children aged 3–11 months in Bangladesh; children under 5 in other countries
- Two prospective observational studies enrolled children 0–4 years presenting with pneumonia to health-care facilities in Goroka Town, Eastern Highlands Province.
- Children aged 3–35 months, participating in a community surveillance program; primary study population, children aged 3–11 months.
- Secondary analysis of 41 studies conducted in 31 countries, including 29 LMICs

**Level of Care**

- Primary health care and hospitals
- Primary health care
- Primary health care
- Hospitals

**Summary of Findings**

- Pulse oximetry is an essential tool for detecting hypoxaemia that should be available at all facility levels and should be integrated into clinical guidelines for pneumonia and other respiratory disease.
- Measurement of oxygen saturation with pulse oximetry should be regarded as an essential vital sign— in children this should be the 5th vital sign.
- Widespread availability of pulse oximetry to inform use of oxygen is key to reduce deaths and reduce global inequity in child health.
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<th>STUDY</th>
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<tr>
<td>Colbourn, T, et al. Predictive value of pulse oximetry for mortality in infants and children presenting to primary care with clinical pneumonia in rural Malawi: a data linkage study. PLOS Medicine. 2020;17(10):e1003300.</td>
<td>Malawi</td>
<td>Children, aged 0–59 months, with clinical pneumonia diagnosis</td>
<td>Primary health care centers</td>
<td>Pulse oximetry identified fatal pneumonia episodes at health centers that would otherwise have been missed by WHO referral guidelines alone.</td>
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<td>McCollum et al. Pulse oximetry for children with pneumonia treated as outpatients in rural Malawi. Bulletin of the World Health Organization. 2016;94(12):893–902.</td>
<td>Malawi</td>
<td>Children, aged 2–59 months, with clinically diagnosed pneumonia.</td>
<td>Primary health care and rural health centers</td>
<td>A study of more than 13,000 children in rural health centers found that approximately 69% of children with an SpO2 less than 90% would not have been referred without pulse oximeters.</td>
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**FEASIBILITY/HEALTH CARE PROVIDER ACCEPTANCE**

The pulse oximeter—a tool to introduce in the Integrated Management of Childhood Illness (IMCI) in West Africa, the AIRE project (Improving the Diagnosis of Respiratory Distress in Children). 2023.

Since its launch in 2019, the AIRE project has introduced and evaluated the routine use of pulse oximeters in more than 90% of IMCI consultations in primary health centers.

Burkina Faso, Guinea, Mali, Niger Children under 5 years attending IMCI clinics, eligible for pulse oximetry use. | Health care providers at primary health care level | The routine use of pulse oximeters facilitated the referral of 70% to 100% of children with severe hypoxemia. More than three-quarters of health workers have adopted pulse oximeters, reporting ease of use and increased confidence in their diagnosis and referral decisions. However, hospital referrals and oxygen access remain a challenge. Except for Burkina Faso, 8.3% to 20% of children with severe hypoxemia were cared for in primary health centers, while a significant proportion died before they reached the hospital. |

Kumar, H, et al. Experiences from an implementation model of ART diagnostic device in pneumonia case management among under-5 children in peripheral healthcare centers in India. Clinical medicine insights. Pediatrics. 2021;15:11795565211056649. Multimodal pulse oximeter (Masimo Rad-G) was tested in the study. | India | Children under 5 presenting with acute respiratory infection symptoms. | Primary health care | The study found that pulse oximeters in primary care settings—together with IMNCI training—is a feasible approach to provide equitable care to children under five.

Correct referrals were made in 77.6% of cases of severe pneumonia. Pulse oximeters were highly accepted among health workers who reported that it helped in the timely diagnosis and treatment of pneumonia. |

Baker, K, et al. Usability and acceptability of a multimodal respiratory rate and pulse oximeter device in case management of children with symptoms of pneumonia: a cross-sectional study in Ethiopia. Acta paediatrica. 2021;110(5):1620–1632. | Ethiopia | Children under 5 with cough or difficulty breathing, and health workers. | First-level health facilities and health posts | There was high acceptance of the device among caregivers and providers. Providers found it helpful to refer cases based on SpO2 levels and some reported it improved their prescribing behavior. |

Graham, HR, et al. Adoption of paediatric and neonatal pulse oximetry by 12 hospitals in Nigeria: a mixed-methods realist evaluation. BMJ Global Health. 2018;3:e000812. | Nigeria | Children admitted to hospitals, and project nurses and hospital staff. | Secondary level hospitals | The study found pulse oximeters can be successfully introduced into routine pediatric and neonatal care, but it requires organizational and individual behavior change. Strategies included communicating the “why”; connecting new knowledge and practices with existing ones; using hands-on training; ongoing support, supervision, and leadership; and ongoing reminders in the workplace. |
### STUDY


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<td>Uganda</td>
<td>Primary: proportion of children under 5 with severe hypoxemia (SpO2 &lt;90%); Secondary: severe (SpO2 &lt;90%) and moderate hypoxemia (SpO2 90%–93%) prevalence by age/sex/complaint; number of children with hypoxemia referred, admitted, and recovered.</td>
<td>Primary health care</td>
<td>The findings suggest that young children (under-5) are a key risk group for whom routine pulse oximetry assessment may improve identification and management of hypoxemia. Current referral practices are missing a significant number of severely unwell children with hypoxemia. Performing pulse oximetry according to WHO guidelines would have missed 14% of severe hypoxemia and 11% of moderate hypoxemia. Routine pulse oximetry has potential to improve referral, management, and clinical outcomes.</td>
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### COST EFFECTIVENESS


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<td>Thailand</td>
<td>Patients of any age with acute respiratory infections.</td>
<td>Primary health care</td>
<td>The program reduced the deaths from respiratory infections in children under 5 years by 0.19 per 100,000 patients annually, translating to 2.0 DALYs (disability-adjusted life years) averted per year in the study population. The program saved an estimated US$12,757 annually.</td>
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<td>Ethiopia</td>
<td>Children, aged 2–59 months.</td>
<td>Primary health centers</td>
<td>Including pulse oximetry in the standard IMCI guidelines increased the detection of severe pneumonia in children by 12% and showed that one more child with severe pneumonia could be detected and treated for an additional investment of US$29.</td>
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For additional research evidence: openoximetry.org/publications
Endnotes


