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Pulse oximetry in paediatric primary care in low-income and middle-income countries

Eric D McCollum, Carina King, Tim Colbourn, Hamish Graham, Mike Bernstein, Iain H Wilson, William Checkley

Johns Hopkins Global Program for Pediatric Respiratory Sciences, Eudowood Division of Pediatric Respiratory Sciences, Department of Pediatrics, Johns Hopkins School of Medicine, Baltimore, MD 21287, USA (EDM); Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA (EDM, WC); Department of Public Health Sciences, Karolinska Institutet, Stockholm, Sweden (CK); Institute for Global Health, University College London, London, UK (CK, TC); Centre for International Child Health, University of Melbourne, Murdoch Children's Research Institute, Royal Children's Hospital, Melbourne, VIC, Australia (HG); Physio Monitor, San Ramon, CA, USA (MB); Lifebox Foundation, London, UK (IHW); and Division of Pulmonary and Critical Care, School of Medicine, Johns Hopkins University, Baltimore, MD, USA (WC)

Every year, pneumonia kills more children before their fifth birthday than does any other infectious disease.¹ To end preventable deaths of neonates and children younger than 5 years by 2030 (UN Sustainable Development Goal 3.2), effective primary care interventions for child pneumonia are needed. Hypoxaemia, low blood oxygen, is a key risk factor for child pneumonia mortality.² In high-income settings, pulse oximeters, non-invasive portable devices that measure the peripheral arterial oxyhaemoglobin saturation (SpO₂), have been used in routine paediatric clinical practice for more than 30 years.³ By contrast, most paediatric primary care settings in low-income and middle-income countries (LMICs) do not routinely use pulse oximeters at all.³

While barriers to implementation have included cost and weak maintenance and supervision structures, a dearth of policy recommendations has meant pulse oximeter roll-out has not received prioritisation and investment. We argue that two knowledge gaps—in device selection and high quality evidence—underpin the low progress in pulse oximeter implementation, and that addressing these gaps could further catalyse both policy changes and the demand for pulse oximetry in paediatric primary care in LMICs.

To select the most appropriate device, increased understanding is needed concerning what clinicians and nurses need from a pulse oximeter in LMIC paediatric primary care. They need accurate devices designed to work on small, distressed children, even when they are moving or have compromised perfusion. If, as we recommend, pulse oximeters are used as screening tools among children with suspected pneumonia (ie, with observed or reported cough or difficult breathing), then devices must work quickly in overburdened facilities on

emccoll3@jhmi.edu.

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young children, who are at the greatest mortality risk but, paradoxically, are also the most challenging patients from whom to obtain timely, plausible measurements because of their small digit size and uncooperativeness. Pulse oximeter performance data on Malawian children younger than 3 years set several benchmarks, indicating that quality paediatric devices should obtain biologically plausible SpO₂ measurements in a median of about 30 s, with more than 70% within 60 s, and nearly 90% within 120 s.⁴ Devices must be robust, incorporate reusable probes, disinfect easily, work despite electricity outages and with rechargeable batteries, and have a simple and intuitive interface. To date, surprisingly few pulse oximeters meet these requirements and potential purchasers in LMICs have no access to independent device evaluation. Instead, when people in LMICs procure pulse oximeters, they are purchased solely according to price and manufacturer specifications. Evidence comparing the performance of different models is scarce, especially regarding performance in children in LMICs. Studies have confirmed that not all inexpensive pulse oximeters are accurate,⁵ which makes them unsuitable for paediatric use, and that even expensive devices perform differently under some conditions common to children in LMICs, such as motion and low perfusion.⁶

Although formal cost-effectiveness analyses are missing, basic cost projections suggest that pulse oximeters could be the best buy for LMICs. Specifically, the pulse oximeter cost per patient in LMICs would be an investment of US\$345 in one quality device (\$250/unit) with three additional paediatric probes (\$25/probe) and one spare battery (\$20/battery), which equates to less than \$0.07 per patient across 5 years in a clinic serving three to four children daily. LMICs must have the ability to transparently determine the most appropriate device for use with children in their setting, considering cost, performance, durability, and usability.

Concerning the availability of high-quality evidence, pulse oximetry and hypoxaemia data on children accessing primary care services in LMICs are scarce. Although there is evidence that hypoxaemia is common and that pulse oximeters effectively identify children with hypoxaemia in hospitals,^{7,8} similar data at the primary care level are not yet available, especially outcome data, prevalence data, and data on health-care worker device use and decision making. A WHO report⁹ published in 2019 indicates that outcome data might soon be available from both Malawi and Bangladesh. Although one large study in Malawi showed that hypoxaemia was prevalent and that government-sector health-care providers used pulse oximeters effectively during paediatric primary care,¹⁰ similar data are needed from other countries and regions. Local data are also required to understand the optimal SpO₂ threshold for hospital referral. In addition to mortality risk, the optimal threshold is likely to be driven by two factors: altitude and health system capacity. Although our understanding is incomplete, children adapted to living at higher altitudes are likely to be more tolerant of a lower SpO₂ than children at lower altitudes.¹¹ Health system capacity will also differ in LMICs, such that a one-size-fits-all SpO₂ threshold might no longer be appropriate. Areas with greater health system capacity might be able to accommodate higher SpO₂ referral thresholds, whereas areas with lower capacity might not. In addition to driving policy, such data will inform the local prioritisation of pulse oximeter distribution, training, and supervision in LMICs.

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