Title: Pulse oximetry in paediatric primary care: Catalyzing implementation in low-income and middle-income countries

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Each year pneumonia kills more children before their fifth birthday than any other infectious disease.[1] To end preventable deaths of newborns and children under five by 2030 (United Nations Sustainable Development Goal 3.2), effective primary care interventions for child pneumonia are needed.

Hypoxaemia, a low blood oxygen level, 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 (SpO_2), have been used in routine paediatric clinical practice for over 30 years.[3] In 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 lack of policy recommendations has meant pulse oximeter roll-out has lacked prioritization and investment. We argue, that two knowledge gaps underpin this – device selection and high quality evidence – that if addressed can further catalyze both policy and demand for pulse oximetry in paediatric primary care in LMICs.

First, what do 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 pulse oximeters are to be used as screening tools among children with suspected pneumonia (i.e., children with observed or reported cough or difficult breathing) – our recommendation – then devices must work quickly in overburdened facilities reading >90% of SpO_2 measurements within 120 seconds. Devices must be robust, incorporate reusable probes, disinfect easily, work despite electricity outages and with rechargeable batteries, and employ 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 LMICs procure pulse oximeters they are purchased solely on price and manufacturer specifications. Evidence comparing performance of different models is scarce, especially regarding LMIC performance in children. Recent studies have confirmed that not all inexpensive pulse oximeters are accurate,[4] which makes them unsuitable for paediatric use, and that even expensive devices perform differently under certain conditions common to children in LMICs, such as motion and low perfusion.[5,6]

Although formal cost effectiveness analyses are missing, basic cost projections suggest oximeters may be a best buy for LMICs. Specifically, if LMICs consider pulse oximeter costs on a per patient basis a $345 USD investment in one quality device ($250 USD/unit) with three additional paediatric probes ($25/probe) and one spare battery ($20/battery) would cost less than $0.07 USD per patient over five 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.

Next, quality pulse oximetry and hypoxaemia data on children accessing primary care services in LMICs is scarce. While there is evidence hypoxaemia is common and that pulse oximeters effectively identify children with hypoxaemia in hospitals,[7,8] similar data at the primary care level is lacking, especially outcome data, prevalence data, and healthcare worker device use and decision-making data.

A recently published World Health Organization report indicates that outcome data may soon be available from both Malawi and Bangladesh.[9] Although one large study in Malawi showed hypoxaemia was prevalent and government-sector healthcare providers effectively used pulse oximeters during paediatric primary care,[10] similar data is needed from other countries and regions. Local data is also required to understand the optimal SpO_2 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 limited, children adapted to living at higher altitudes are likely to be more tolerant of a lower SpO_2 than children at lower altitudes.[11,12] Health system capacity will also differ in LMICs such that a one-size-fits-all SpO_2 threshold may no longer be appropriate. Areas with greater health system capacity may be able to accommodate higher SpO_2 referral thresholds while areas with more limited capacity may not. In addition to driving policy, such data will inform LMICs where to locally prioritize distribution of pulse oximeters, training and supervision.

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Kingdom)/GlaxoSmithKline (INSPIRING) aim to pilot pulse oximeters during primary care in LMICs and may address some of these evidence gaps. We hope these projects and others will expand our understanding of how oximeters may improve LMIC paediatric primary care and help end preventable child deaths from pneumonia.

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