Title
Pulse oximetry in low-resource settings during the COVID-19 pandemic

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Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Pulse oximetry in low-resource settings during the COVID-19 pandemic

Pulse oximetry is essential for assessing oxygen saturation during respiratory compromise and for monitoring patients undergoing anaesthesia, who are critically ill, or whose condition is rapidly evolving. More immediately, during the ongoing COVID-19 pandemic, silent hypoxia (ie, abnormally low oxygen saturation without symptoms of dyspnoea), is common in patients with COVID-19.[1] In low-resource settings where oxygen supplies and monitored beds are scarce, pulse oximetry is a crucial device for triaging patients and establishing the need for supplemental oxygen.[2] Early recognition of hypoxia and oxygen administration has been shown to reduce mortality,[3] and a triage tool developed in collaboration with WHO uses pulse oximetry to guide management of oxygen therapy.

In Ethiopia, pulse oximetry is not widely available.[4] The Federal Ministry of Health has developed a National Newborn and Child Survival Strategy to address these gaps, and efforts have been made between the Ministry and aid organisations to combat pneumonia and neonatal hypoxaemia and tackle shortfalls in perioperative care.[5,6]

As part of a long-term pulse oximeter training and distribution programme developed by the Lifebox Foundation, we surveyed Ethiopian hospitals for the presence and functionality of devices and capacity for oxygen saturation monitoring. In partnership with national anaesthesia professional societies, we approached anaesthesia providers in facilities capable of providing surgical care, because these providers and hospitals have been the focus of previous distribution efforts and they typically have access to a pulse oximeter if it is available. Hospitals were selected by purposive sampling, including ten hospitals each in the five most populated regions, and at least two each in the remaining six regions.

From 90 candidate public hospitals nationwide, 60 were identified and one anaesthesia provider from each was contacted for participation; 58 public hospitals and one private hospital completed the survey. All surveyed hospitals reported at least one functioning operating room. They had a median of 3 (IQR 2–5) integrated pulse oximetry monitors (IPOs) and 0 (0–2) portable pulse oximetry monitors (PPOs; appendix). Most surveyed hospitals (49 [83%]) reported additional integrated monitors in their post-anaesthesia care unit (PACU) but few portable monitors (median 0 [IQR 0–1]). Of the 41 (70%) hospitals with an intensive care unit (ICU), there were a median of 4 (4–6) integrated monitors but 0 (0–1) portable devices. 54 (91%) hospitals had an emergency room with at least one bed for critically ill patients (median 4 [IQR 2–6]), but a median of only 1 (0–2) integrated and 0 (0–1) portable pulse oximetry monitors.

We calculated the monitoring gap (designated high-acuity beds–pulse oximetry monitors) for each clinical area. In operating rooms, the mean monitoring gap was −0·6 beds (SD 2·3), meaning that on average, every operating room bed was monitored. The mean gap in PACUs was 2·9 beds (SD 3·1), in ICUs it was 1·2 (SD 2·7), and in emergency rooms it was 2·9 (SD 3·1).

Although pulse oximetry monitoring capacity is well met in most of the Ethiopian operating rooms surveyed, four referral and two general hospitals reported at least one operating room without a patient monitor. Furthermore, large gaps remain in other critical units of the hospital, including PACUs, ICUs, and emergency rooms, where on average there were 1–3 unmonitored high-acuity beds per unit. Particularly in emergency rooms, about 75% of critical beds were unmonitored in referral and general hospitals, and primary hospitals had essentially no access to pulse oximetry. Over the past 8 years, Lifebox has distributed 1108 devices in Ethiopia, typically directly to anaesthesia providers; nearly half of those surveyed had received one, and of 140 devices that were identified during the survey work, 123 were still in use up to 7 years later (nine were reported as missing and eight reported as malfunctioning). These were typically owned by the providers themselves and were thus not available for flexible clinical use. Despite its durability and usefulness in clinical care, there were very few generally available portable pulse oximeters that could move to areas of a hospital as needed, whether to recovery rooms, intensive care, emergency units, or even point-of-care screening and triage areas.

The pulse oximeter was a crucial monitoring device before the pandemic, and will be long after it subsides. Although oxygen saturation assessment and monitoring is a critical component of patient triage and clinical decision making during the COVID-19 pandemic, few pulse oximeters are available in low-resource settings. Ethiopia is no exception, and closing the monitoring gap in clinical environments, including emergency and critical care units, should be prioritised, as should availability of oxygen resources. Pulse oximeters enable clinicians to identify and rapidly treat hypoxia, monitor patients in respiratory distress or at risk of deterioration, and aid decision making and allocation of precious hospital beds and oxygen resources. Their scarcity is symptomatic of the insufficient investment in emergency and essential critical care[7] and the surgical, obstetric, and anaesthetic ecosystem.[8] Investing in these devices pays tremendous dividends because they are durable, highly valued, and can be rapidly used across clinical units.

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See **Online** for appendix

For the **Lifebox triage tool** see https://www.lifebox.org/covid-19-decision-tool/

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1 Berlin DA, Gulick RM, Martinez FJ. Severe Covid-19. *N Engl J Med* 2020; published online May 15. DOI:10.1056/NEJMcp2009575.

2 Ayebare RR, Flick R, Okware S, Bodo B, Lamorde M. Adoption of COVID-19 triage strategies for low-income settings. *Lancet Respir Med* 2020; **8:** e22.

3 Sun Q, Qiu H, Huang M, Yang Y. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Ann Intensive Care* 2020; **10:** 33.

4 The Federal Democratic Republic of Ethiopia Ministry of Health. National medical oxygen and pulse oximetry scale up road map (2016-2020/21). Feb 14, 2017. https://vdocuments.mx/national-medical-oxygen-and-pulse-oximetry-scale-up-road-map.html (accessed March 3, 2020).

5 Burssa D, Teshome A, Iverson K, et al. Safe surgery for all: early lessons from implementing a national government-driven surgical plan in Ethiopia. *World J Surg* 2017; **41:** 3038–45.

6 Warshanna-Sparklin S. Ethiopia's political will to increase access to pneumonia oxygen treatment. Aug 25, 2016. https://stoppneumonia.org/ethiopias-political-will-to-increase-access-to-pneumonia-oxygen-treatment/ (accessed June 9, 2020).

7 Baker T, Schell CO, Petersen DB, et al. Essential care of critical illness must not be forgotten in the COVID-19 pandemic. *Lancet* 2020; **395:** 1253–54.

8 Sonderman KA, Citron I, Meara JG. National surgical, obstetric, and anesthesia planning in the context of global surgery: the way forward. *JAMA Surg* 2018; **153:** 959–60.