Brief Report

Oxygen and Pulse Oximetry in Childhood Pneumonia:
A Survey of Healthcare Providers in Resource-limited Settings

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Summary

Globally, pneumonia is the leading cause of death in children <5 years of age. Hypoxemia, a frequent complication of pneumonia, is a risk factor for death. To better understand the availability of oxygen and pulse oximetry, barriers to use and provider perceptions and practices regarding their role in childhood pneumonia, we conducted a survey using a convenience sampling strategy targeting clinicians working in resource-limited countries. Most respondents were physicians from public district and provincial hospitals with access to oxygen and pulse oximetry; however, reported therapeutic use for childhood pneumonia was low. Common barriers included insufficient supply, competition for use, lack of policies, guidelines and training and perceived high cost. Despite the frequency of hypoxemia, the inaccuracy of clinical predictors, the poor outcome hypoxemia portends and the effectiveness of pulse oximetry and oxygen in childhood pneumonia, our data indicate that these tools may be underused in resource-limited settings.

Despite advances in disease prevention and healthcare delivery, pneumonia remains the leading cause of death in children <5 years of age worldwide, with an impact highest in resource-limited settings [1–3]. Hypoxemia, a frequent complication of pneumonia, is a risk factor for death [4–7]. Clinical predictors of hypoxemia are insensitive [6, 8–12]. Many children with hypoxemia are missed if pulse oximetry is not regularly utilized [13]. In resource-limited countries where oxygen is available, there is a clear improvement in mortality from childhood pneumonia [5, 14, 15]. Despite the frequency of hypoxemia, the inaccuracy of clinical predictors, the poor outcome hypoxemia signals, and the effectiveness of oxygen, many referral centers in resource-limited settings do not have access to pulse oximetry and oxygen [16, 17].

We surveyed clinicians practicing in resource-limited settings to better understand the availability of these technologies, barriers to use, and provider perceptions and practices regarding their role in the diagnosis and management of childhood pneumonia. A convenience sampling strategy was used, targeting three groups: clinicians from eight African countries in an epidemiologic research course; anesthesia clinicians from Kenyan public hospitals; and a broad e-mail distribution targeting clinicians working in resource-limited countries. Statistical analyses were prepared using the R statistical programming language (version 2.11.0). To accommodate missing data from unanswered questions, results are reported as percentages of valid responses. All data were recorded anonymously with no data linked to individuals. This study was exempt by PATH’s Research Ethics Committee.

A total of 97 surveys were completed by clinicians practicing in 19 countries throughout Africa, Asia

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and South America, with 52% from Africa. Most were physicians from public district and provincial hospitals in both urban and rural areas. A response rate for the questionnaire was unavailable because of how surveys were distributed. Response rates for individual questions ranged from 54% to 100%.

Eighty-eight percent of respondents reported that oxygen was available at their facility with 75% describing access most or all of the time (Fig. 1, dark bars). Seventy-one percent reported at least one pulse oximeter at their facility, and 59% noted having access most or all of the time (Fig. 1, light bars).

The most frequently cited mechanical or supply barriers for both tools were insufficient supply and limited access due to use by other services (Table 1). Other barriers included lack of training, policies or guidelines surrounding use, and perceived high cost. For pulse oximeters, 48% reported having non-functioning devices. The top features important in a pulse oximeter endorsed were a low saturation alarm (84%) and portability (80%).

Respondents considered oxygen to be useful for childhood pneumonia, but not universally required (Fig. 2, dark bars). Only 40% reported oxygen use most or all of the time for childhood pneumonia, and 17% a little of the time or never. In contrast to oxygen use, 44% described never using pulse oximetry in childhood pneumonia diagnosis and only 18% most or all of the time (Fig. 2, light bars). Sixty-five percent felt that pulse oximetry was extremely important for patient care, whereas only 42% found it extremely important for childhood pneumonia (Fig. 3). When compared to other tools, opinions about pulse oximetry reflected a similar pattern: only 19% strongly agreed that it was useful in pneumonia diagnosis, while 66% strongly agreed that World Health Organization (WHO) Integrated Management of Childhood Illness (IMCI) criteria were useful (Fig. 4).

The survey is a first step in examining why available technologies are inadequately implemented. Most respondents worked in hospitals where oxygen was available, had access for clinical care and used it for some, if not all, children with pneumonia. Most had some access to pulse oximetry, but in contrast to oxygen, did not use it as frequently for children with pneumonia, and found it less important for diagnosis than other tools (i.e. IMCI, chest radiography).

Barriers to use of oxygen and pulse oximetry (i.e. inadequate supply, limited access due to use by other services, broken devices, lack of policies governing use, lack of staff training and high cost) may combine to prevent providers from appreciating their utility.

### Table 1

<table>
<thead>
<tr>
<th>Reported barriers</th>
<th>Oxygen supplementation (%)</th>
<th>Pulse oximetry (%)</th>
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<tbody>
<tr>
<td>Insufficient supply</td>
<td>70</td>
<td>53</td>
</tr>
<tr>
<td>Competition for use by other services</td>
<td>46</td>
<td>53</td>
</tr>
<tr>
<td>Lack of training in use</td>
<td>63</td>
<td>46</td>
</tr>
<tr>
<td>Lack of policies or guidelines</td>
<td>59</td>
<td>54</td>
</tr>
<tr>
<td>Perceived high cost</td>
<td>31</td>
<td>35</td>
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In particular, lack of pulse oximetry may prevent recognition of the need for oxygen and its rational use, therefore undermining demand for both technologies. Typically, dissemination of new technologies can be supply side interventions (central authority pushing out technologies) or demand generation (users requesting new technologies). With pulse oximetry, it is possible that neither pressure exists, despite its cost-effectiveness and proven utility [14, 15].

This survey has important limitations, most notably, sample size and convenience sampling strategy. Based on their fields (anesthesia), academic interests (attended an international training conference on research methods) and access to technology (completion of an electronic survey), we expected respondents to have better access to technology and medical information than most in resource-limited settings where the majority of facilities do not have these tools. Responses are therefore likely to overestimate availability and access to oxygen and pulse oximetry. Whether individuals with less access would be similarly unlikely to use these tools were they available.
remains unanswered. Finally, because of the survey distribution, an accurate response rate cannot be calculated, leading to substantial non-response bias. More research is needed to better understand the degree of practice variation; follow-up surveys are underway.

Despite these limitations, further exploration is warranted. Even among our sample, we observed significant barriers to appropriate oxygen treatment in children with pneumonia, indicating the depth of the challenge. There appears to be a gap between clinician perceptions and evidence regarding the utility of oxygen and pulse oximetry in childhood pneumonia, which represents an important target for education and intervention to increase use and demand for these valuable technologies. Efforts should focus on paired implementation of both technologies, and match implementation with a stable source of technical support, staff education, supervision and monitoring and evaluation [15]. Strong evidence exists demonstrating the rational introduction of these technologies can decrease mortality for children with pneumonia at a reasonable cost. Until severe pneumonia in children can be effectively prevented, it is imperative that lives be saved through the implementation of systems that provide access to oxygen and pulse oximetry.

References