Hypoxemia in primary health care settings and implications for oxygen services
Evidence from Bangladesh, Malawi, Nigeria, and Uganda

12 May 2021

Hosted by the Quality of Care Subgroup of the Child Health Task Force
Child Health Task Force Goal

To strengthen equitable and comprehensive child health programs - focused on children aged 0-19 in line with the Global Strategy for Women’s, Children's, and Adolescents’ Health (2016-2030) - through primary health care, inclusive of community health systems.

Quality of Care (QoC) Subgroup

**Goal:** To create a platform in the child health community to advocate for and provide targeted support to countries to improve QoC for children in countries where Task Force members are active.

Oxygen is an essential medicine.
Hypoxemia is an indicator for increased risk of mortality.
Modeling estimates suggest that improved pulse oximetry and oxygen access could avert 148,000 under-five child pneumonia deaths annually in the 15 countries with the highest pneumonia burden (Floyd J, Nature 2015).

- **30 million small and sick newborns** each year need special care, including safely administered oxygen.
- **4.2 million of 23 million children under five with severe pneumonia** require oxygen therapy each year.
Featuring:

**Santa Engol**  
Senior Clinical Coordinator  
Clinton Health Access Initiative

**Carina King**  
Infectious Disease Epidemiologist  
Department of Global Public Health, Karolinska Institutet

**Helena Hildenwall**  
Pediatrician & Clinical Research Fellow  
Department of Global Public Health, Karolinska Institutet

**Eric McCollum**  
Associate Professor of Pediatric Pulmonology and International Health, Johns Hopkins
Hypoxemia prevalence among patients seeking care at HCIIIs in Uganda

Presenter: Santa Engol

PRELIMINARY RESULTS
Outline

- Background
- Study Objectives & Methodology
- Results
- Conclusions & next steps
Background

• In 2018, Uganda launched its first-ever **National Scale-up of Medical Oxygen strategy** and made several key investments, including:
  • Construction of **13 oxygen plants** at Regional Referral Hospitals
  • **Leverage Global Fund and Global Financing Facility** to invest in additional pulse oximeters, oxygen plants, and cylinders
  • Launch a pilot to test **oxygen distribution models** from plants to HCIVs
• However, HCIIIs do not currently provide oxygen therapy though **HCIIIs are the most accessible point-of-care**
• What key questions that need to be answered to invest in oxygen services at HCIIIs?
Outline

- Background
- Study Objectives & Methodology
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- Conclusions & next steps
Study objectives

- What is the cost-benefit of providing oxygen services at HCIII?
- What is the capacity of HCIII's to safely and effectively provide oxygen services?
- How many patients visiting HCIII's need oxygen on an annual basis?
- What would be the most cost-efficient way of providing oxygen services at HCIII's?
- How does that compare to alternative solutions, such as provision of transport to hospitals?
- What is the capacity of HCIII's to safely and effectively provide oxygen services?
Methodology

• Sought to determine the prevalence of hypoxemia (SpO2<90%) and moderate hypoxemia (SpO2<94%) among all acutely unwell patients (children and adult)

• The study was conducted in 30 HCIIIs that were randomly selected representative of larger and smaller facilities in Jinja and Mubende regions from February – March 2021

• For patients with SpO2<90%, the study advised the clinician to refer the patient and provided money for transportation to the referral facility.

• All patients with SpO2 <93% received a follow-up survey after one week (Data not yet available)
• Data collectors were placed at each facility for one month
• Data collected were patient demographic information, presenting symptoms, blood oxygenation (SpO2), clinician diagnosis, and treatments provided
  • Spo2 was recorded using Biotech and Eden pulse oximeters
• Inclusion Criteria:
  • All acutely unwell patients visiting the facility for care at the outpatient department
• Exclusion Criteria:
  • Patients visiting the facility for vaccination, child growth monitoring, or health education/counseling
  • Women in labor
  • Patients who were under 18 unless with a parent/guardian over 18
Outline

• Background
• Study Objectives & Methodology
• Results
• Conclusions & next steps
Demographics of Respondents

- Overall, more female than male patients visited the HCIII - 68% to 32%
- For under-five patients, a nearly equal split between female and male patients
- Children under-5 accounted for 27% of all acutely unwell patients visiting the HCIII
Malaria and respiratory infections were the most common clinician diagnoses across both age groups

- The most common diagnoses among patients over-5 were malaria, RTIs, and UTIs
- Among patients under-5, malaria, RTI, diarrhea, and pneumonia were the most common diagnoses
- Limitations: diagnoses are based on clinician reports and not standardized assessments

<table>
<thead>
<tr>
<th>Top diagnoses for patients over-5</th>
<th>Top diagnoses for patients under-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Malaria</td>
</tr>
<tr>
<td>Respiratory tract infection</td>
<td>Respiratory tract infection</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>Diarrhea</td>
</tr>
<tr>
<td>Pneumonia*</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>35%</td>
<td>52%</td>
</tr>
<tr>
<td>29%</td>
<td>40%</td>
</tr>
<tr>
<td>10%</td>
<td>13%</td>
</tr>
<tr>
<td>1%</td>
<td>9%</td>
</tr>
</tbody>
</table>

*Pneumonia was the 6th most common diagnosis among patients over-5
1% of patients under-5 had hypoxemia (SpO2<90%) while an additional 5% had moderate hypoxemia (SpO2=90-94%)

- Patients under-5 and over-60 were most likely to be hypoxemic at 1% and 0.3%, respectively
- There were nearly 4 times more patients with SpO2 between 90-94% (N=103) as there were with SpO2<90% (N=26)
Patients under-5 with pneumonia had the highest prevalence of hypoxemia (4%) and moderate hypoxemia (18%)

- Clinician-diagnosed pneumonia had the highest prevalence of hypoxemia
- Among children under-5, several diagnoses had higher levels of moderate hypoxemia
- Limitations: Potential confounding due to dual diagnoses and non-standardized diagnoses

<table>
<thead>
<tr>
<th>Hypoxemia prevalence by diagnosis among patients over-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall N=4,210</td>
</tr>
<tr>
<td>SpO2&lt;90%</td>
</tr>
<tr>
<td>SpO2&lt;94%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypoxemia prevalence by diagnosis among patients under-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall N=1,566</td>
</tr>
<tr>
<td>SpO2&lt;90%</td>
</tr>
<tr>
<td>SpO2&lt;94%</td>
</tr>
</tbody>
</table>

PRELIMINARY RESULTS
Only half (46%) of hypoxemic patients were referred to HCIVs and hospitals despite the study offering to pay for transport

- Many facilities opted to manage the hypoxemia at the HCIII through antimalarial drugs, antibiotics, and fresh air
- At least three patients/caregivers refused to be referred
- There was not a significant difference in referral practice for under-five and over-five patients

### Percent of hypoxemic patients that were referred

<table>
<thead>
<tr>
<th></th>
<th>Overall N=26</th>
<th>Under 5 N=20</th>
<th>Over 5 N=6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Referral</td>
<td>46%</td>
<td>45%</td>
<td>50%</td>
</tr>
</tbody>
</table>
Outline

- Background
- Study Objectives & Methodology
- Results
- Conclusions & next steps
Conclusions and next steps

1. **Overall low prevalence of hypoxemia among patients presenting at HCIII level facilities**
   - Next step: Forecast total hypoxemic patients seen at HCIIIs and estimate cost of oxygen provision vs. referral to hospitals

2. **Moderate hypoxemia presents a relatively large number of patients that could potentially benefit from oxygen services**
   - Next step: Analyze 1-week follow-up data to determine if moderate hypoxemia are likely to be hospitalized or die
   - Next step: Forecast potential additional hypoxemia burden that referral mechanisms and hospitals will need to manage

3. **Clinicians are often not referring patients, even when they know they're hypoxemic**
   - Next step: Use FGDs to collect more data to learn why patients are not being referred
Hypoxemia in primary health care settings and implications for oxygen services
12th May 2021

The INSPIRING Project – Nigeria

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Associate Professor
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PRELIMINARY RESULTS
1. INSPIRING Project

Aims to reduce paediatric pneumonia mortality in Nigeria

Co-design project with:
• STC (implementers)
• GSK (funders)
• Local government

Situational analysis (2018/19) to determine intervention approach
2. Methods

<table>
<thead>
<tr>
<th>Jigawa</th>
<th>Lagos</th>
</tr>
</thead>
</table>
| • Cluster randomised trial  
  - **P**: communities and children <5  
  - **I**: community groups, community-facility accountability mechanism and IMCI training and essential equipment  
  - **C**: standard care, referral hospital oxygen + oximetry  
  - **O**: under-five mortality  
  - January 2020 – June 2022  
  • Clinical data collectors conducted household level pneumonia screening (+ oximetry)  | • Quasi-experimental pre-post study  
  • Pulse oximeters + oxygen + training  
  • August 2020 – June 2022.  
  • 7 government PHCs, 2 secondary facilities, 7 private facilities  
  • Study clinical data collectors screen children on arrival  
  • Oximetry in those meeting pneumonia criteria |
2. Pulse oximetry

• Lifebox pulse oximeter
  ▪ Paediatric clip probe
  ▪ Universal adult clip probe

• Clinical data collectors
  ▪ 13 Lagos
  ▪ 12 Jigawa

• Training in IMCI assessments + pulse oximetry
  ▪ Big toe as the site for measurement
  ▪ Wait for a strong and stable waveform for 3 seconds
3. Jigawa Results - Pneumonia

<table>
<thead>
<tr>
<th>Age group</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 months</td>
<td>137</td>
<td>(4.5%)</td>
</tr>
<tr>
<td>2-11 months</td>
<td>534</td>
<td>(17.7%)</td>
</tr>
<tr>
<td>12-59 months</td>
<td>2346</td>
<td>(77.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1544</td>
<td>(51.2%)</td>
</tr>
<tr>
<td>Female</td>
<td>1473</td>
<td>(48.8%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pneumonia</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2892</td>
<td>(95.9%)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>87</td>
<td>(2.9%)</td>
</tr>
<tr>
<td>Severe</td>
<td>37</td>
<td>(1.2%)</td>
</tr>
</tbody>
</table>

The prevalence of malnutrition was 12.5%
3. Jigawa Results – SpO2

- 1.9% (n=58)
  Excessive child movement & uncooperative main reasons

- 12.4% (n=375)
  Higher in younger children & agitated/crying children vs. calm/sleeping children (18.0% vs 11.7%, p-value=0.001)

- 4.7% (n=141)

- 3.7% (n=110)
3. Jigawa Results – SpO2

29% had no other measured clinical sign of illness

- 10% had a danger sign
- 10% had a fever
- 26% were moderately malnourished
- 22% were severely malnourished
- 22% had abnormal lung sounds
4. Lagos Results

- Data from August 2020 – March 2021 (8 months)

- Children presenting = 4613
  - No consent = 17 (0.4%)

- Children screened = 4596
  - No cough and/or difficulty breathing = 2312 (50.8%)
    - No fast breathing / chest indrawing = 1707 (37.1%)

- Recruited children = 577
  - Pneumonia = 232 (40.2%)
    - Severe pneumonia = 344 (59.6%)
    - Suspected COVID-19 = 1 (0.1%)
4. Lagos Results

**CFR = 0.8%**

- 6.9% had no SpO2 done
- 16.8% had suspicious measures
- 6.9% were hypoxaemic
- 8.2% moderately hypoxaemic

70% of hypoxaemic patients had a danger sign

(52% with any danger sign)

70% child non-compliant
5. Summary

• High burden of hypoxemia in both:
  • Rural, resource-poor, community setting (3.7%)
  • Primary care peri-urban setting (6.9%)

• Poor agreement between hypoxemia and IMCI defined pneumonia in Jigawa
  • Other underlying conditions? Under-ascertainment of other respiratory signs? Prevalent anaemia and malnutrition?

• Quality issues in pulse oximetry measurements highlight importance of on-going supervision and mentorship
EREMISS

Emergency paediatric treatment and Referral In frontline healthcare Setting

- To determine the feasibility and acceptability of implementing ETAT at health centres in Malawi
  - Estimate the prevalence of hypoxemia and danger signs amongst children presenting with an acute medical condition to health centres
  - Investigate the associations between danger signs and oxygen saturation and impact on referral decision making, referral attendance and outcomes
Setting

- Mchinji District, Malawi
- Population ~ 600,000
- ~ 90,000 children under five
- U5 mortality rate 123/1,000 (DHS 2015)
Methods

- Children aged 0-12 years
- Enrolment at 14 primary health facilities
- 1st July 2019 – 6th April 2020
- Lifebox pulse oximeter with universal and child clip probe
- Cohort study
  - Enrolling children referred from primary care
  - Data collectors assessing oxygen saturation after referral decision
  - Followed up at place referred to and 14 days after last seen
- Parallel cross sectional study assessing oxygen saturation in all children
  - One day/month/facility
Day 0

- Child presents at village clinic or health centre
- Clinical assessment by healthcare provider
  - Child not eligible for IMCI (not acutely sick)
  - Not referred
  - Care-giver refused consent
  - Referred
    - Approach by study staff for consent
    - SpO2 assessed, symptoms recorded
  - Care-giver refuses consent
    - Caregiver refuses consent or child cannot be located
      - Study staff confirm survival
    - Study staff at health centre or hospital confirm attendance
      - SpO2 re-assessed, symptoms & treatment recorded
Results – Cross Sectional

- 2943 children enrolled
- 49.2% (1447/2,943) diagnosed with malaria and 24.2% (712/2943) with non-pneumonia respiratory tract infection
- Two data collectors frequent unexpected results and excluded (n=306)
- Three refusals
- 124/2943 (4.2%) unstable curve
  - 2643 children with saturation result
    - 0.6% hypoxic (<90%). 23.5% identified by danger sign.
    - 5.4% moderate hypoxemia (90-93%). 31.7% identified by danger sign.
Results - Cohort

- 826 children included, 784/826 (94%) with complete follow up
- Overall case fatality rate of 4.1%
- 40.6% of deaths within 24 hrs from recruitment
- Saturation values
  - 65/784 (8.3%) hypoxic (<90%) with CFR 13.8%
  - 104/784 (13.3%) moderate hypoxemia (90-93%) with CFR 3.8%
  - 10/784 (1.2%) missing with CFR 20%
  - Saturation >93% CFR 2.2%
### Preliminary Results

#### Hypoxemia (<90\%)  
*N=65*

<table>
<thead>
<tr>
<th>Recruitment</th>
<th>Hospital</th>
<th>Oxygen given</th>
<th>Fatal outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>No hospital care documented</td>
<td>23 (35%)</td>
<td>4/23 (17%)</td>
<td></td>
</tr>
<tr>
<td>Missing SpO2</td>
<td>1 (2%)</td>
<td>1 (100%)</td>
<td>0/1 (0%)</td>
</tr>
<tr>
<td>Normal</td>
<td>16 (25%)</td>
<td>0/13 (0%)</td>
<td>0/3 (0%)</td>
</tr>
<tr>
<td>Moderate</td>
<td>10 (15%)</td>
<td>0/7 (0%)</td>
<td>0/3 (0%)</td>
</tr>
<tr>
<td>Severe</td>
<td>15 (23%)</td>
<td>12 (80%)</td>
<td>5/12 (42%)</td>
</tr>
</tbody>
</table>

- **Hypoxemia**: 65 patients were recruited.
- **Emergency Oxygen**: 4 out of 23 patients who did not receive hospital care received emergency oxygen, with 100% fatal outcome.
- **Missing SpO2**: 1 patient with missing SpO2 received emergency oxygen, with no fatal outcome.
- **Normal SpO2**: 13 patients with normal SpO2 did not receive emergency oxygen, with 0% fatal outcome.
- **Moderate SpO2**: 7 patients with moderate SpO2 did not receive emergency oxygen, with 0% fatal outcome.
- **Severe SpO2**: 12 patients with severe SpO2 received emergency oxygen, with 42% fatal outcome.

- **Fatal Outcome**: 5 out of 12 patients with severe hypoxemia died.
- **Emergency Oxygen**: 4 out of 23 patients who did not receive hospital care received emergency oxygen.

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**Karolinska Institutet**

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## PRELIMINARY RESULTS

<table>
<thead>
<tr>
<th>Recruitment</th>
<th>Hospital</th>
<th>Oxygen given</th>
<th>Fatal outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate hypoxemia (90-93%)</td>
<td>Severe 11 (11%)</td>
<td>10 (91%)</td>
<td>0/10 (0%)</td>
</tr>
<tr>
<td></td>
<td>Moderate 6 (6%)</td>
<td>2 (33%)</td>
<td>1/1 (50%)</td>
</tr>
<tr>
<td></td>
<td>Normal 29 (28%)</td>
<td>4 (14%)</td>
<td>0/4 (0%)</td>
</tr>
<tr>
<td></td>
<td>Missing SpO2 3 (3%)</td>
<td>1 (33%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td></td>
<td>No hospital care documented 55 (53%)</td>
<td>2/55 (4%)</td>
<td></td>
</tr>
</tbody>
</table>

*Fatal outcome: N=104*
Study limitations

- Only recruitment during office hours – some cases may have been missed
- Incomplete verbal autopsy data of deaths due to pandemic
- Not health workers performing saturation assessment
- No outcome data for those who were not referred
- Quality of oxygen provided at hospital not known
Outpatient pulse oximetry for children with suspected pneumonia in rural Bangladesh: prospective observational study

Dr. Eric D. McCollum, MD, MPH
Associate Professor of Pediatrics
Eudowood Division of Pediatric Respiratory Sciences
Director, Global Program in Respiratory Sciences
Johns Hopkins University
@tinylungsglobal
Background

• Hypoxemia means low oxyhemoglobin saturation in the blood stream

• Hypoxemia is a key indicator of **mortality risk** among children hospitalized with pneumonia in low-income and middle-income countries (LMICs)

• Pulse oximeters estimate peripheral oxyhemoglobin saturation (SpO$_2$) non-invasively

• SpO$_2$ measurement <90% defined as hypoxemia per WHO
Background

• Pulse oximetry implementation is limited in LMICs overall & in Bangladesh

• Limited to no role of pulse oximetry at outpatient clinics for children, although recommended by the WHO

• Limited data on prevalence and outcomes of children with hypoxemia identified during outpatient care

https://www.britannica.com/place/Bangladesh
Study design & objectives

- **Design** – prospective observational substudy of children with suspected pneumonia nested within a pneumococcal conjugate vaccine effectiveness study in rural Bangladesh

- **Objectives** –
  1. Determine the predictive value of outpatient pulse oximetry for mortality
  2. Evaluate the added value of outpatient pulse oximetry for identifying mortality
Study setting

Projahnmo study site
Study eligibility & Data collection

• September 2015 to September 2017
• Upazila Health Complex Outpatient clinics
  • 3-35 months of age
  • Lived in surveillance area
  • Cough and/or difficult breathing
• Outcome: Vital status two weeks after outpatient clinic visits
Statistical Analysis

• Standard descriptive statistics

• Predictive value of outpatient pulse oximetry for mortality
  • Binary logistic regression for unadjusted odds ratios (ORs) and 95% confidence intervals (CIs)
  • To identify whether SpO₂ was an independent predictor of two week mortality, covariates with p < 0.10 in bivariate analysis were fitted to a random effects logistic regression model with clinic as the group variable

• Stata version 16.1 (College Station, TX)

• Ethics approvals obtained
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No pneumonia N=1,250</th>
<th>Non-severe pneumonia N=7,347</th>
<th>Severe pneumonia N=1,022</th>
<th>Total N=9,619</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, in months</td>
<td>Median (IQR)</td>
<td>10 (6, 17)</td>
<td>11 (6, 19)</td>
<td>15 (8, 23)</td>
</tr>
<tr>
<td>Sex</td>
<td>Females, n (%)</td>
<td>523 (42%)</td>
<td>3,120 (42%)</td>
<td>375 (37%)</td>
</tr>
<tr>
<td>Fast breathing for age, n (%)</td>
<td>0</td>
<td>6,897 (94%)</td>
<td>896 (88%)</td>
<td>7,793 (81%)</td>
</tr>
<tr>
<td>Lower chest wall indrawing</td>
<td>0</td>
<td>2,523 (34%)</td>
<td>385 (38%)</td>
<td>2,908 (30%)</td>
</tr>
<tr>
<td>WHO general danger signs</td>
<td>0</td>
<td>0</td>
<td>1,022 (100%)</td>
<td>1,022 (11%)</td>
</tr>
<tr>
<td>SpO₂ in room air</td>
<td>Median (IQR)</td>
<td>97 (96, 98)</td>
<td>97 (96, 98)</td>
<td>97 (95, 98)</td>
</tr>
<tr>
<td>94% – 100%</td>
<td>1,164 (93%)</td>
<td>6,607 (90%)</td>
<td>871 (85%)</td>
<td>8,642 (90%)</td>
</tr>
<tr>
<td>90% – 93%</td>
<td>65 (5%)</td>
<td>482 (7%)</td>
<td>90 (9%)</td>
<td>637 (7%)</td>
</tr>
<tr>
<td>&lt; 90%</td>
<td>5 (0%)</td>
<td>138 (2%)</td>
<td>28 (3%)</td>
<td>171 (2%)</td>
</tr>
<tr>
<td>Failed measurement</td>
<td>16 (1%)</td>
<td>120 (2%)</td>
<td>33 (3%)</td>
<td>169 (2%)</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>26 (2%)</td>
<td>517 (7%)</td>
<td>127 (12%)</td>
<td>670 (7%)</td>
</tr>
<tr>
<td>Mortality</td>
<td>3 (0.2%)</td>
<td>20 (0.3%)</td>
<td>8 (0.8%)</td>
<td>31 (0.3%)</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of 3-35 month old children with cough and/or difficult breathing at outpatient clinics in rural Bangladesh
### Table 2. Mortality among 3-35 month old children with cough and/or difficult breathing at outpatient clinics in rural Bangladesh

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Alive (%) N=9,588</th>
<th>Dead (%) N=31</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SpO₂</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94% – 100%</td>
<td>8,627 (99.8%)</td>
<td>15 (0.2%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>90% – 93%</td>
<td>630 (98.9%)</td>
<td>7 (1.1%)</td>
<td></td>
</tr>
<tr>
<td>&lt; 90%</td>
<td>167 (97.7%)</td>
<td>4 (2.3%)</td>
<td></td>
</tr>
<tr>
<td>Failed SpO₂ measurement</td>
<td>164 (97.0%)</td>
<td>5 (3.0%)</td>
<td></td>
</tr>
<tr>
<td><strong>Outpatient clinic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beanibazar</td>
<td>3,031 (99.5%)</td>
<td>14 (0.5%)</td>
<td>0.007</td>
</tr>
<tr>
<td>Zakiganj</td>
<td>2,316 (99.5%)</td>
<td>12 (0.5%)</td>
<td></td>
</tr>
<tr>
<td>Kanaighat</td>
<td>4,241 (99.9%)</td>
<td>5 (0.1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Age, in months</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>11 (6, 19)</td>
<td>6 (4, 9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>WHO general danger signs¹</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>8,568 (99.7%)</td>
<td>23 (0.3%)</td>
<td>0.006</td>
</tr>
<tr>
<td>At least one present</td>
<td>1,014 (99.2%)</td>
<td>8 (0.8%)</td>
<td></td>
</tr>
<tr>
<td><strong>Hospitalization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>657 (98.1%)</td>
<td>13 (1.9%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Oxygen treatment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>277 (96.2%)</td>
<td>11 (3.8%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 3. Odds of mortality among 3-35 month old children with cough and/or difficult breathing at outpatient clinics in rural Bangladesh according to SpO₂

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>p value</th>
<th>Adjusted odds ratio¹</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpO₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94% – 100%</td>
<td>Ref</td>
<td></td>
<td></td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% – 93%</td>
<td>6.39</td>
<td>2.60, 15.73</td>
<td>&lt;0.001</td>
<td>3.04</td>
<td>1.16, 7.99</td>
<td>0.024</td>
</tr>
<tr>
<td>&lt; 90%</td>
<td>13.77</td>
<td>4.52, 41.94</td>
<td>&lt;0.001</td>
<td>4.95</td>
<td>1.46, 16.76</td>
<td>0.010</td>
</tr>
<tr>
<td>Failed SpO₂ measurement</td>
<td>17.53</td>
<td>6.29, 48.81</td>
<td>&lt;0.001</td>
<td>8.00</td>
<td>2.53, 25.26</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

¹Random-effects logistic regression with clinic as the group variable, adjusted for age in months, WHO general danger signs, hospitalization, oxygen treatment
Results – Added value of SpO$_2$ for identifying deaths

- 61.3% (19/31) deaths referral eligible with SpO$_2$ <94% or failed SpO$_2$ vs 25.8% (8/31) without pulse oximeters (p=0.004) (current standard)
  - vs 38.7% (12/31) with SpO2 <90% (current WHO recommendations) (p=0.075)
Conclusions

• Children in rural Bangladesh identified as hypoxemic during outpatient care have a higher odds of mortality than those without hypoxemia.

• Compared to application of clinical guidelines alone, including pulse oximetry using a <94% threshold identifies more fatalities as hospitalization eligible.

• These findings strongly support wider implementation of pulse oximeters for the outpatient care of children with cough and/or difficult breathing in Bangladesh.
Acknowledgements

• Projahnmo Research Foundation team in Sylhet, Bangladesh, with special thanks to Dr. Salahuddin Ahmed, Dr. Arun D Roy, Dr. Nabidul H Chowdhury, and Dr. Abu AM Hanif

• Children and caregivers for participating in this study

• National Institutes of Health, GlaxoSmithKline, and the Bill and Melinda Gates Foundation their support of this study
### Summary of hypoxemia and moderate hypoxemia prevalences across studies

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>Setting</th>
<th>SpO2&lt;90%</th>
<th>SpO2&lt;94%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>3-35 months w/ cough and/or difficult breathing</td>
<td>Upazila Health Complex Outpatient clinics</td>
<td>1.7%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Malawi</td>
<td>0-12 years w/ any acute illness</td>
<td>Mchinji District; 14 primary health facilities</td>
<td>0.6%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Under-5</td>
<td>Jigawa: Community/ Household</td>
<td>3.7%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>Under-5 with fast breathing or chest in-drawing pneumonia</td>
<td>Lagos: 7 government PHCs, 2 secondary facilities, 7 private facilities</td>
<td>6.9%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Uganda</td>
<td>Under-5 w/ any acute illness</td>
<td>Jinja and Mubende Regions; 30 HCIIIs</td>
<td>1.3%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>
Resources

Engage with the **co-chairs:**

- Anne: adetjen@unicef.org
- Patty: pjodrey@usaid.gov

Subgroup information, recordings and presentations from previous meetings and webinars
www.childhealthtaskforce.org/subgroups/qoc

*The recording and presentations from this webinar will be available on this page later today*


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Become a member of the Child Health Task Force: [www.childhealthtaskforce.org/subscribe](http://www.childhealthtaskforce.org/subscribe)
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