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.

Review and suggest subgroup activities here: http://bit.ly/QoCworkingdoc

The Topic for Today: QoC and Oxygen

- 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

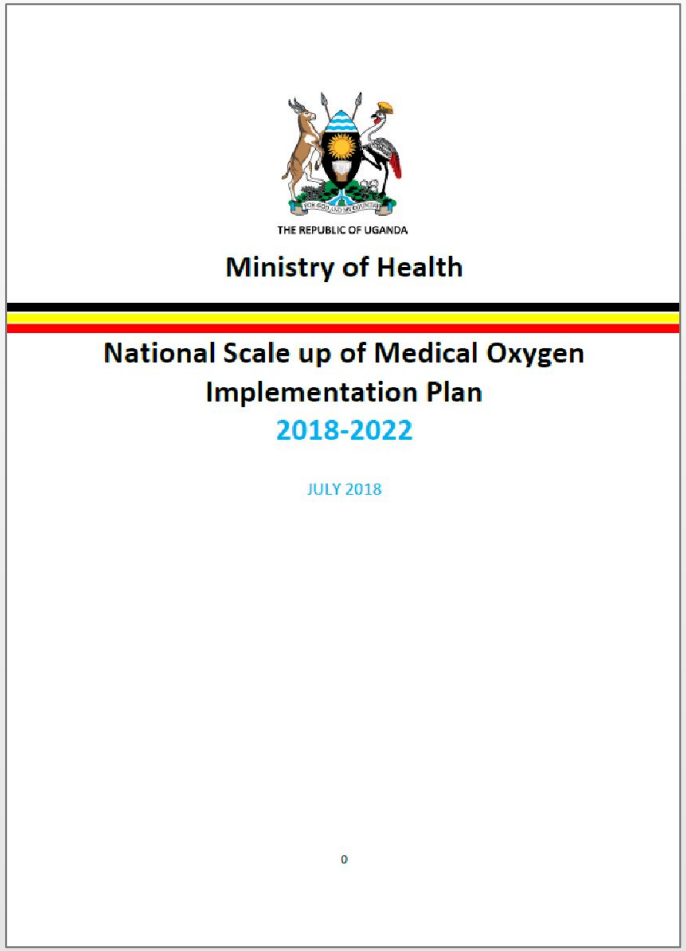
PRELIMINARY RESULTS

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

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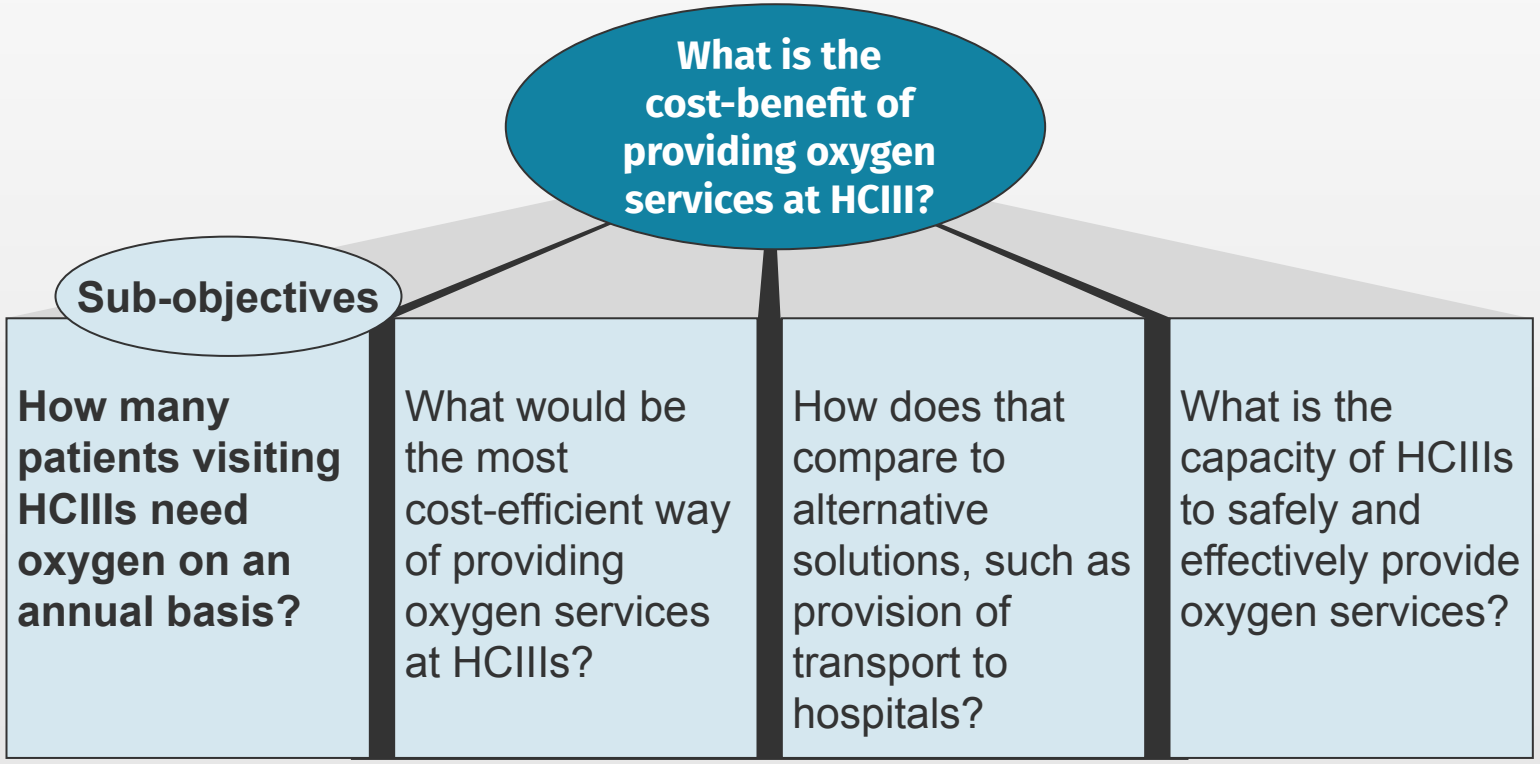
Study objectives



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)

Methodology (cont)

- 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

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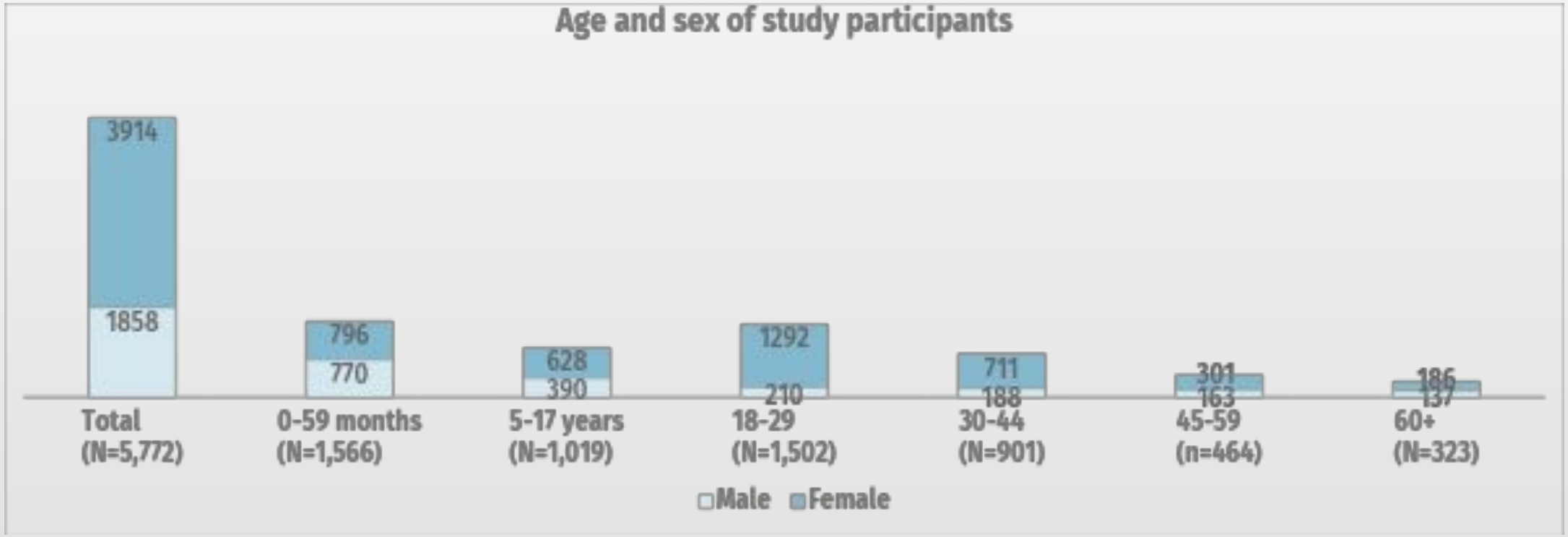
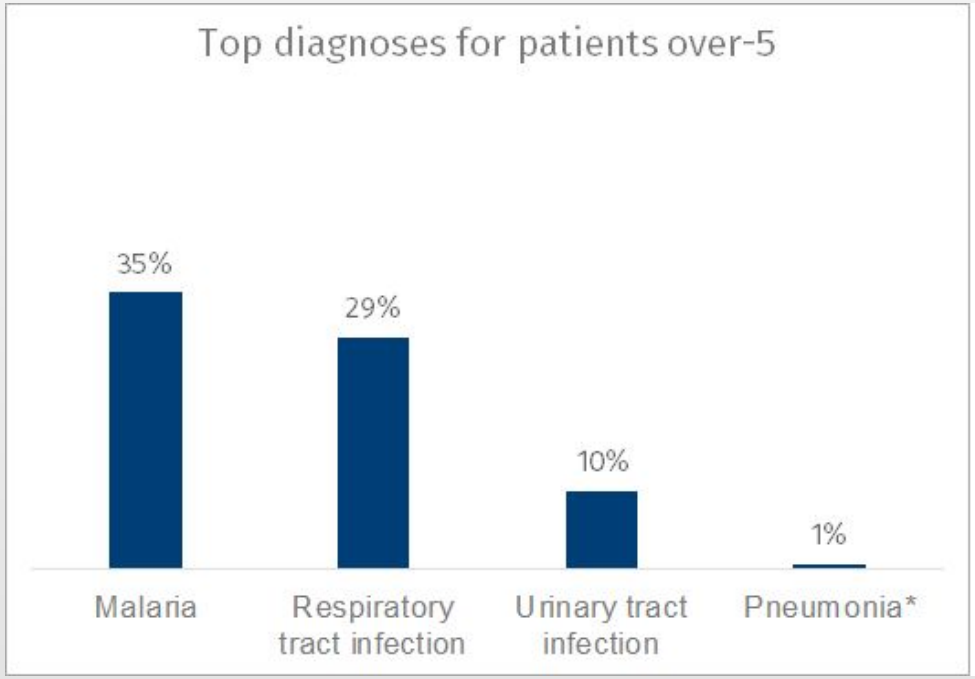
Demographics of Respondents

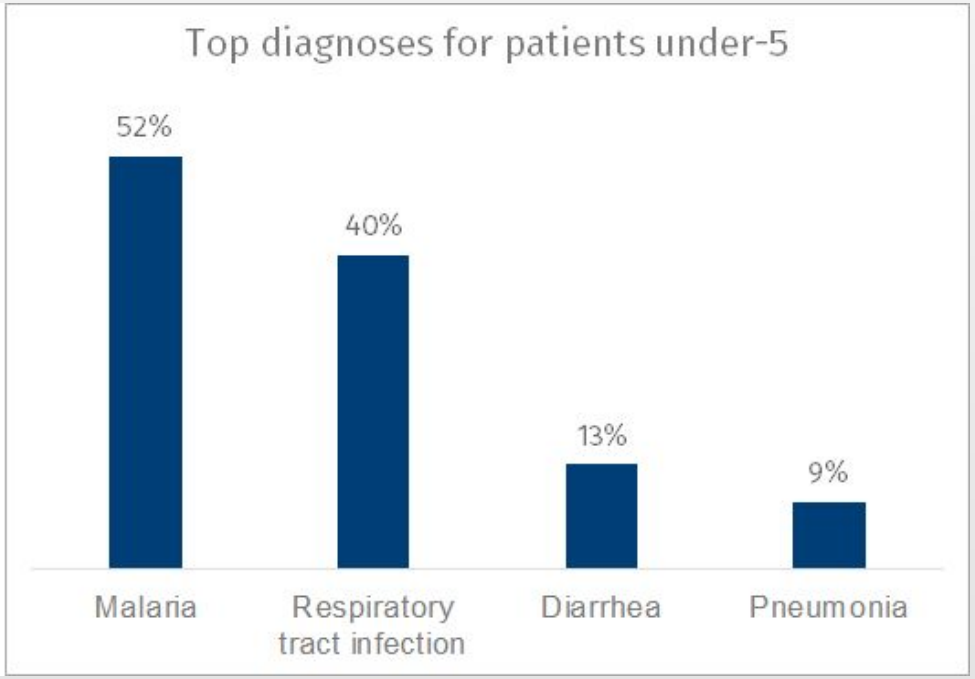
- Overall, more female than male patients visited the HCIII - 68% to 32%
- For under-five patients, a nearly equal split between female and male patients
- Children under-5 accounted for 27% of all acutely unwell patients visiting the HCIII



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



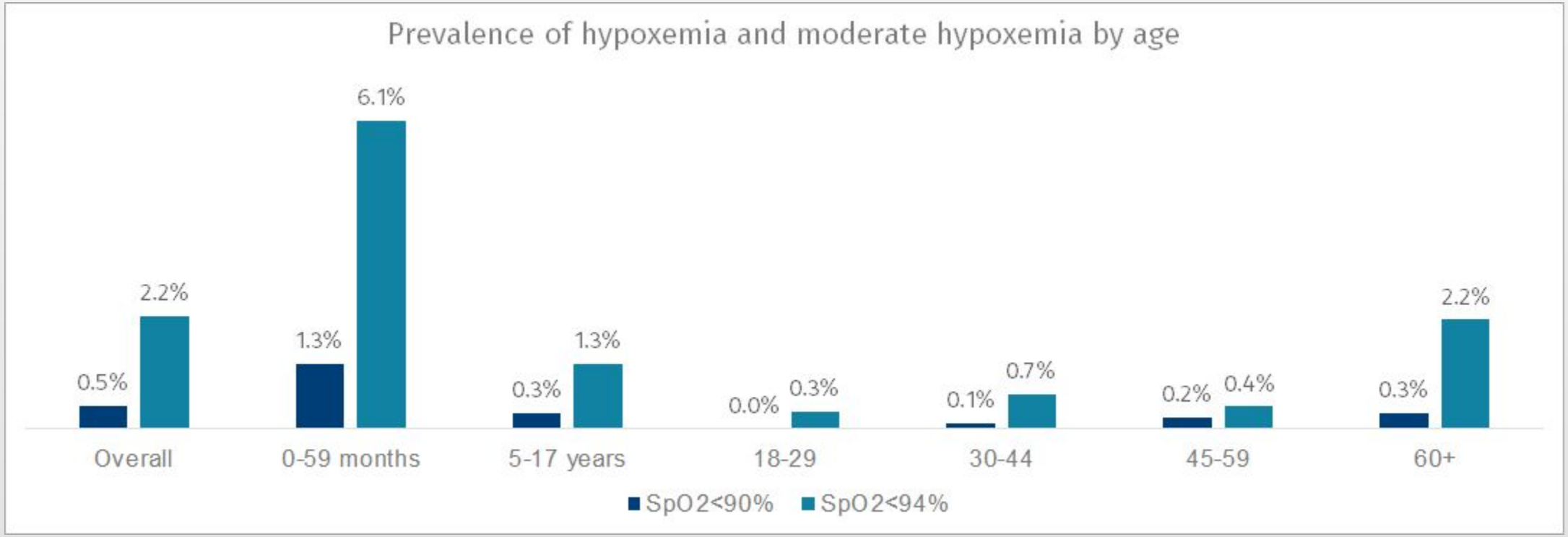


*Pneumonia was the 6th most common diagnosis among patients over-5

PRELIMINARY RESULTS

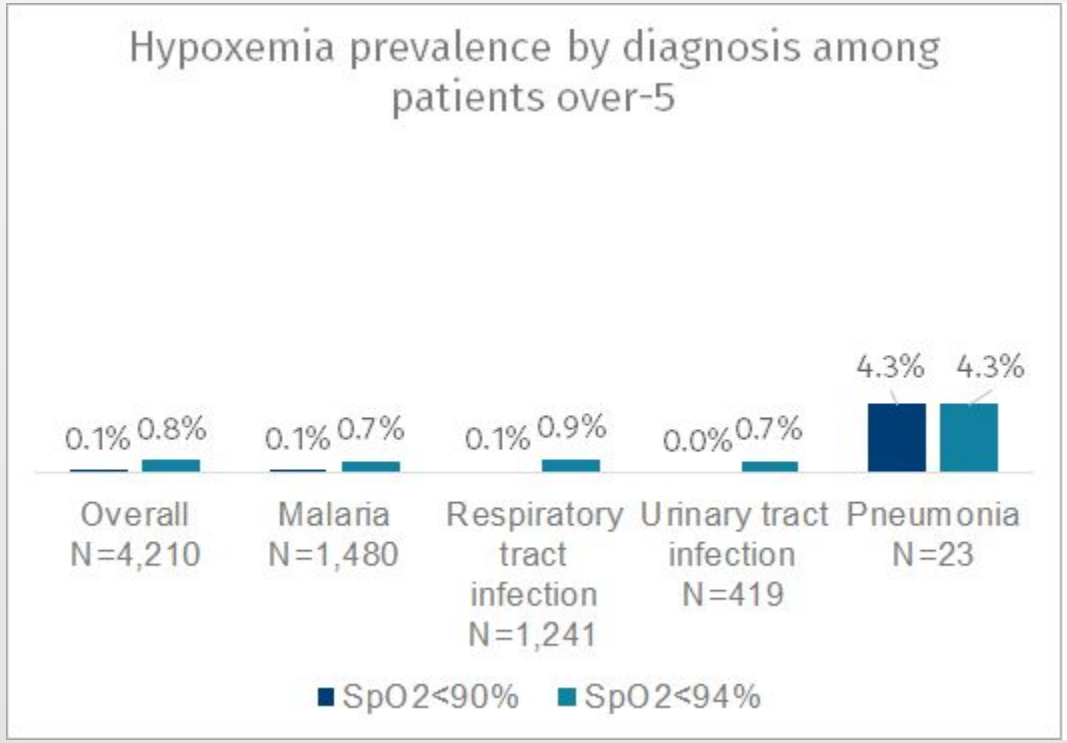
1% of patients under-5 had hypoxemia (SpO2<90%) while an additional 5% had moderate hypoxemia (SpO2=90-94%)

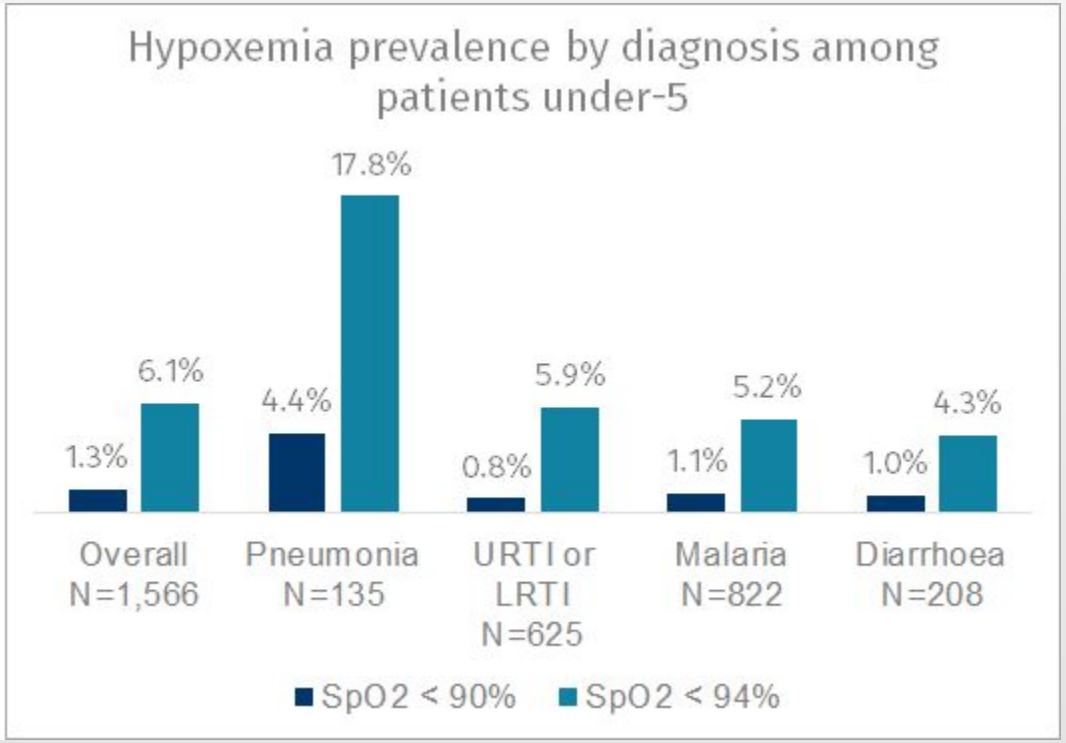
- Patients under-5 and over-60 were most likely to be hypoxemic at 1% and 0.3%, respectively
- There were nearly 4 times more patients with SpO2 between 90-94% (N=103) as there were with SpO2<90% (N=26)



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

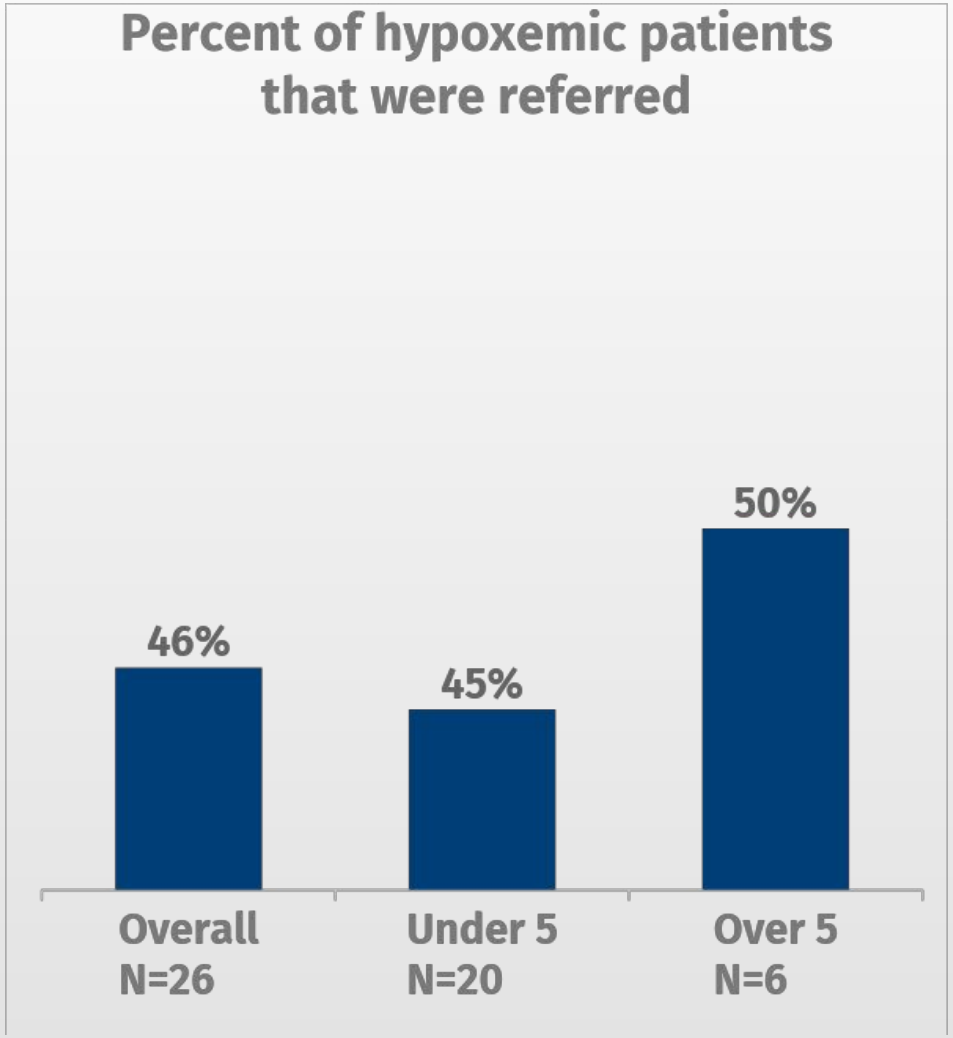




PRELIMINARY RESULTS

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



Outline

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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

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Hypoxemia in primary health care settings and implications for oxygen services

12th May 2021

The INSPIRING Project – Nigeria

Dr. Carina King,
Associate Professor
carina.king@ki.se @CarinaTKing

PRELIMINARY RESULTS

murdoch children's research institute

Karolinska Institutet

Johns Hopkins University

UCL

College of Medicine University of Ibadan

University College Hospital Ibadan

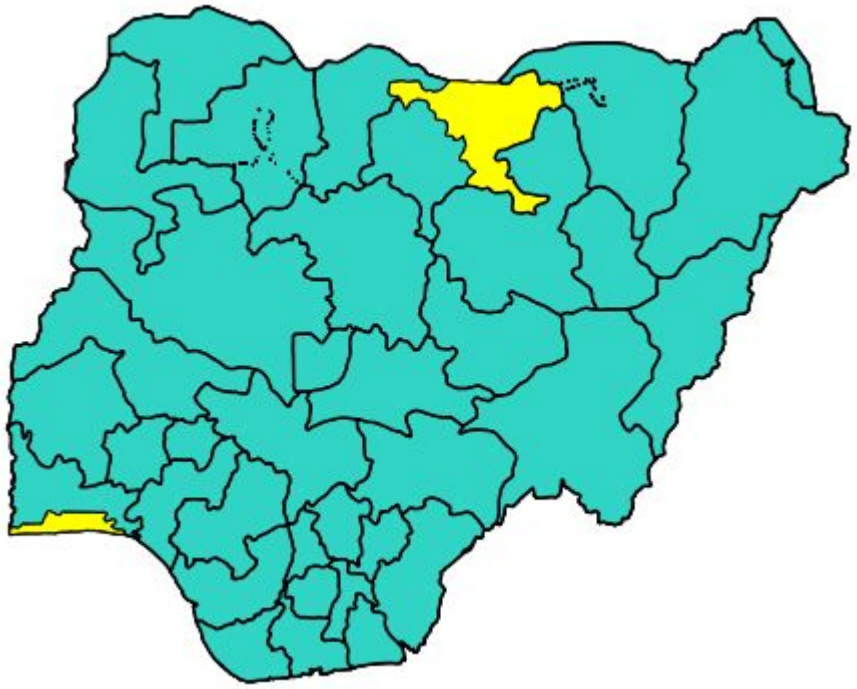
1. INSPIRING Project

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

Jigawa

- 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)

Lagos

- 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

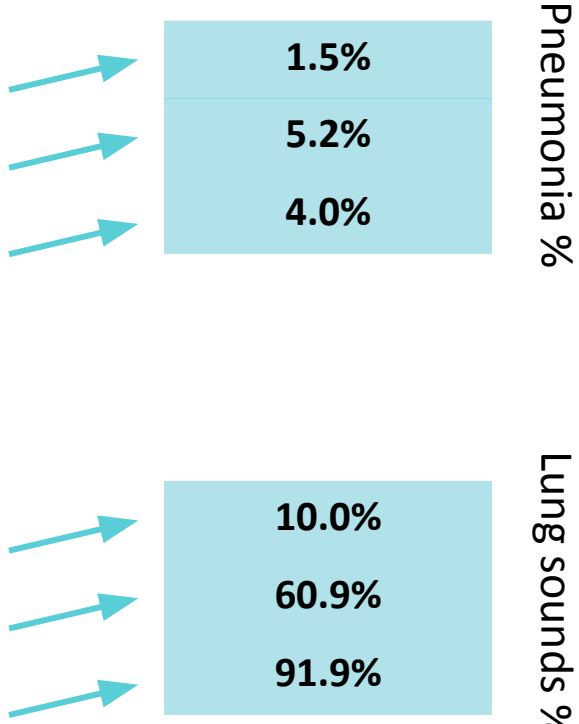
2. Pulse oximetry

- 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*

PRELIMINARY RESULTS

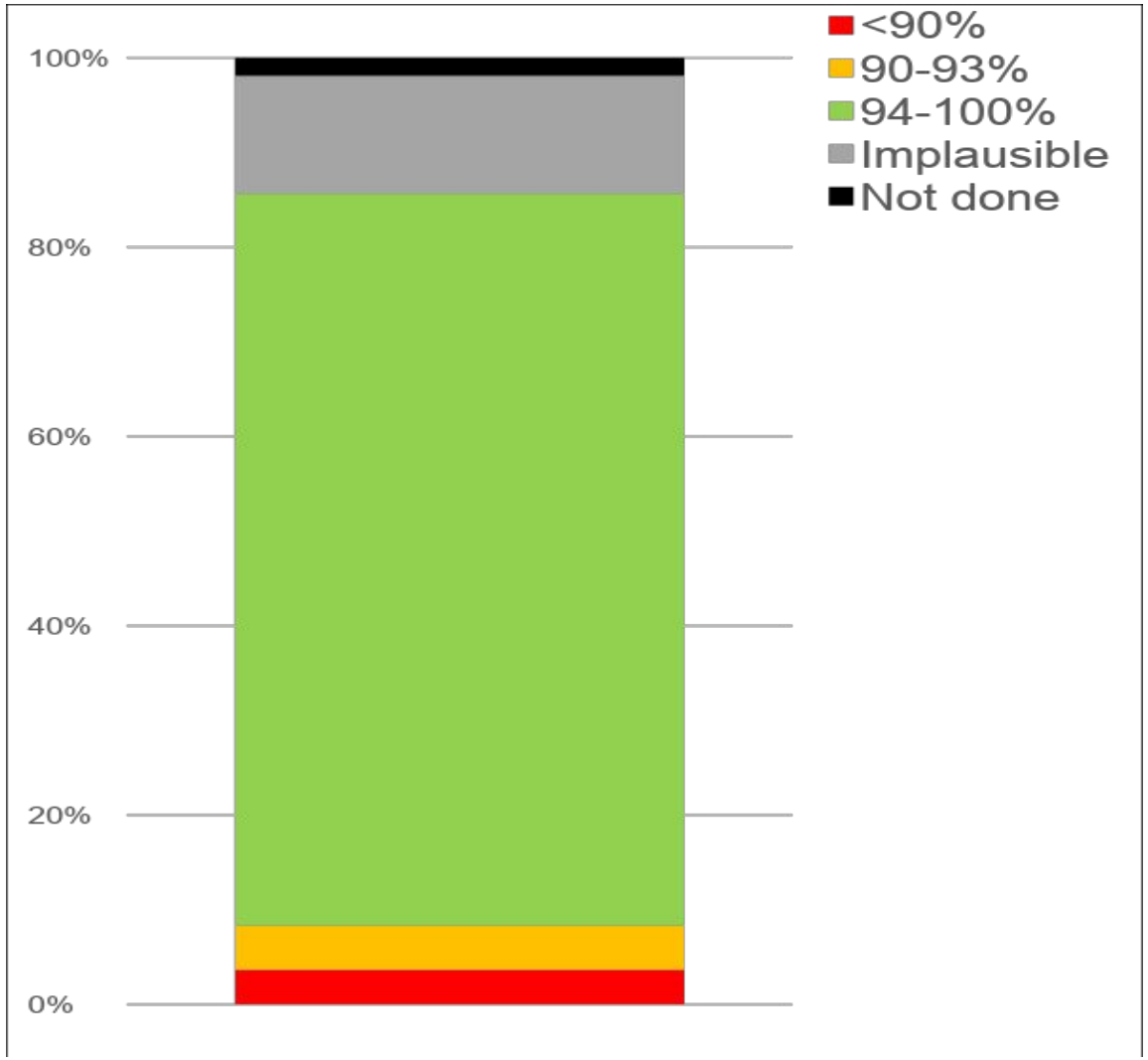
3. Jigawa Results - Pneumonia

Total = 3017			
Age group	<2 months	137	(4.5%)
	2-11 months	534	(17.7%)
	12-59 months	2346	(77.8%)
Sex	Male	1544	(51.2%)
	Female	1473	(48.8%)
Pneumonia	None	2892	(95.9%)
	Pneumonia	87	(2.9%)
	Severe	37	(1.2%)



The prevalence of malnutrition was 12.5%

3. Jigawa Results – SpO2



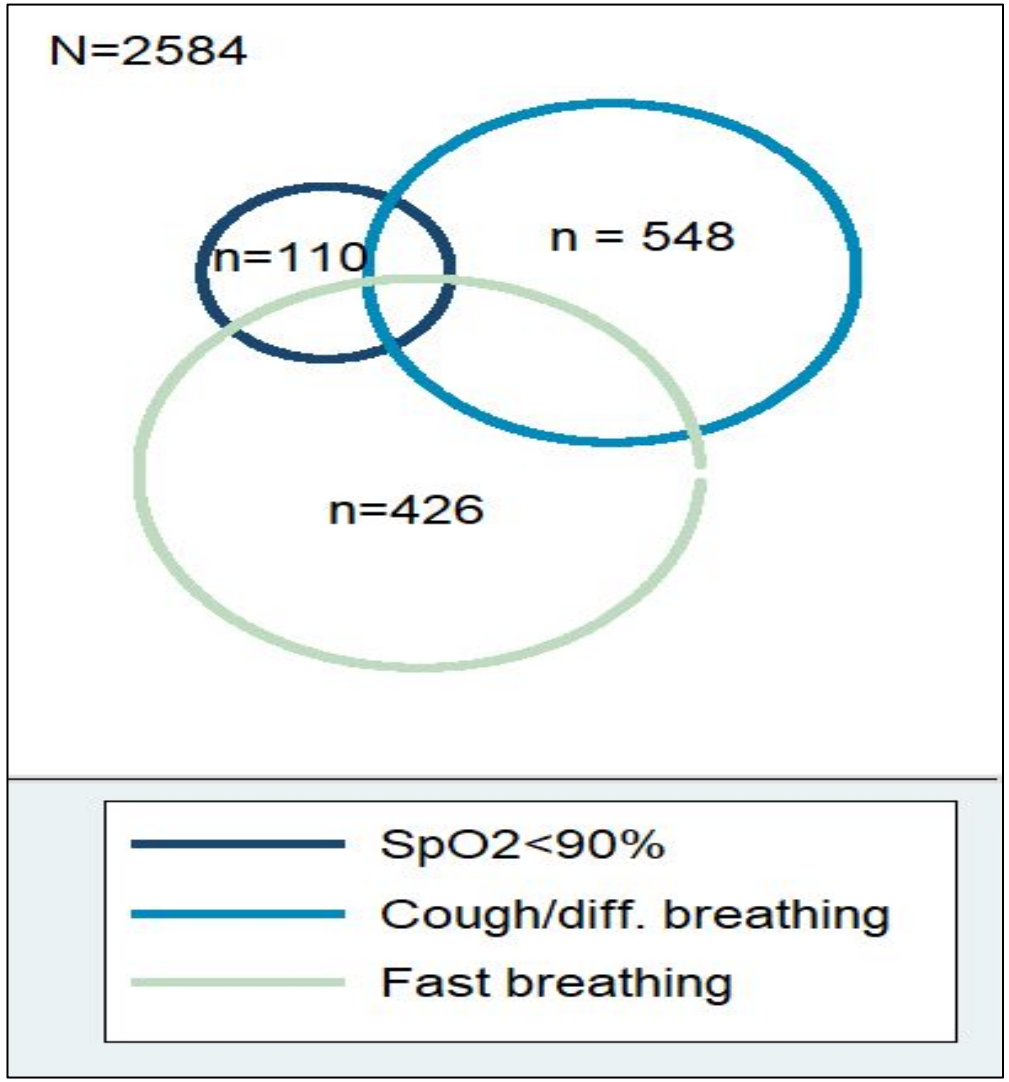
1.9% (n=58)
Excessive child movement & uncooperative main reasons

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

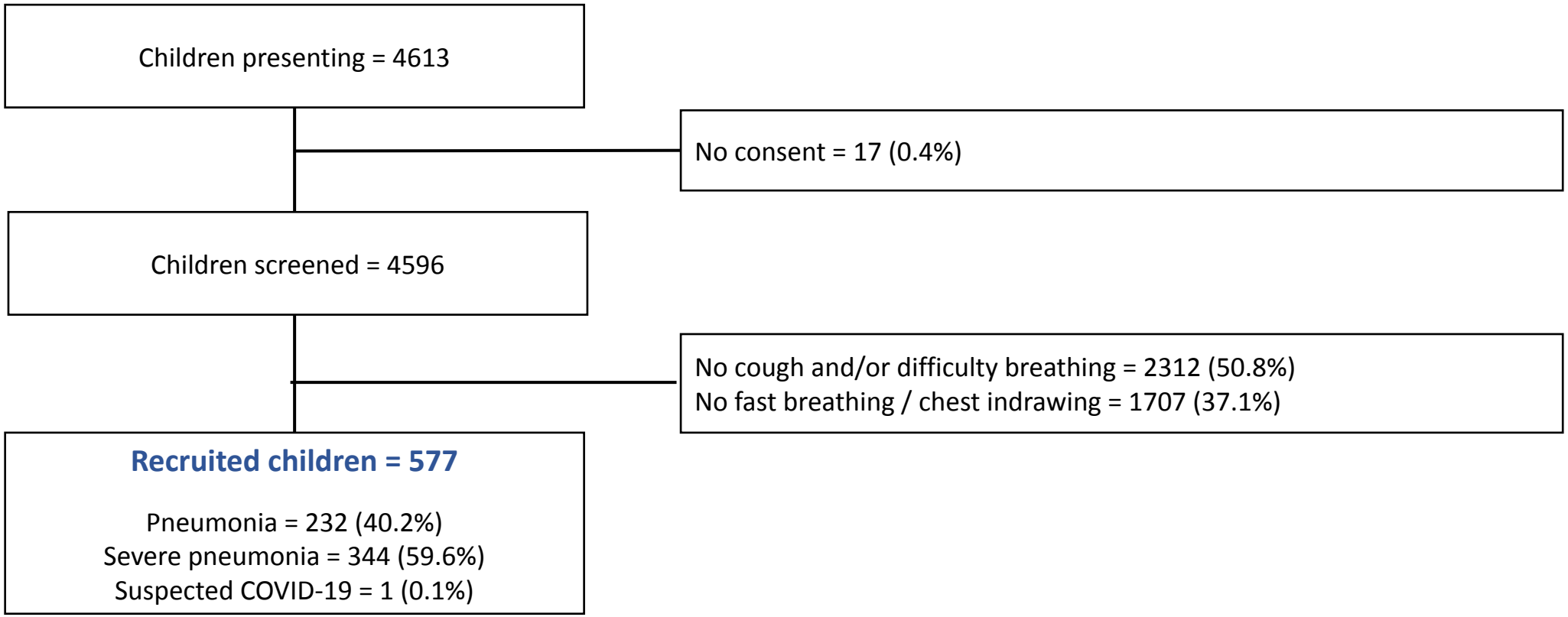


29% had no other measured clinical sign of illness

- 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)



PRELIMINARY RESULTS

4. Lagos Results

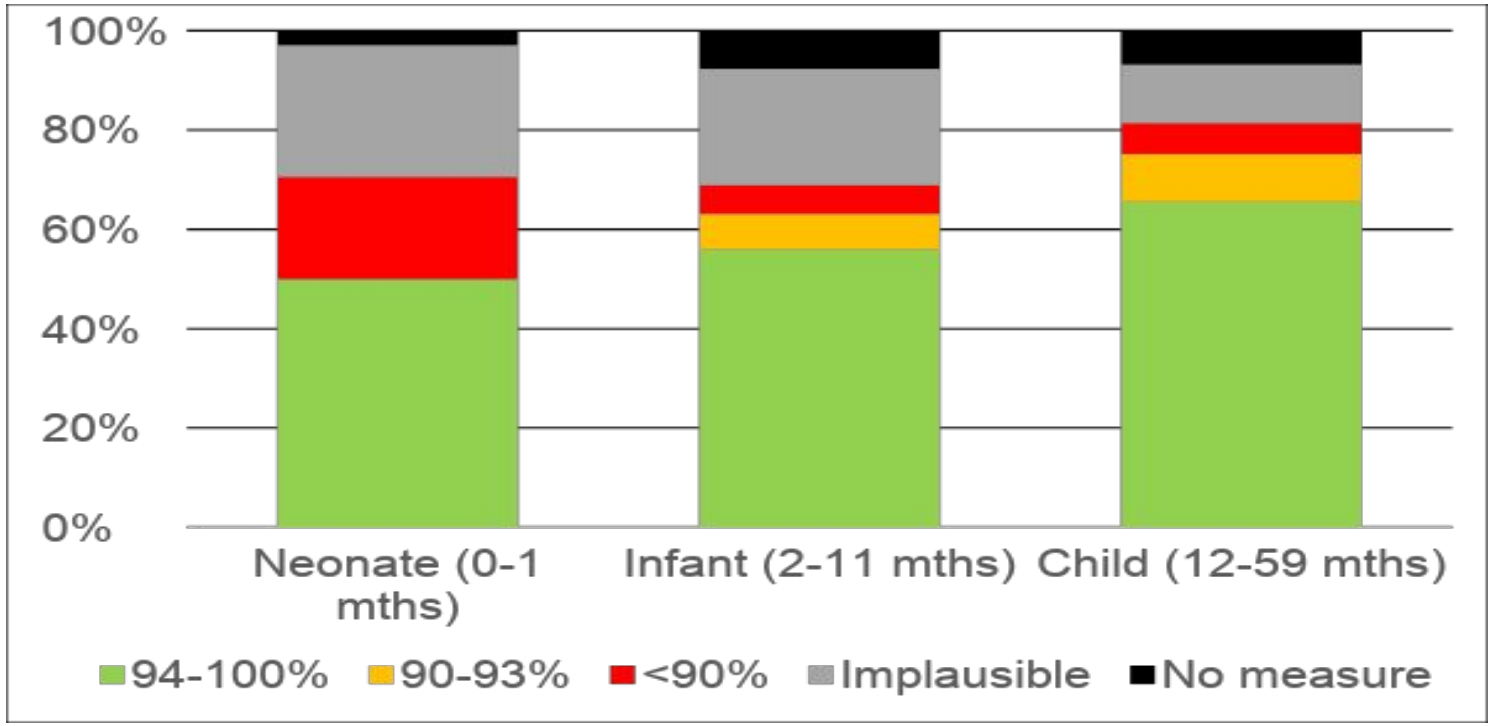
70% child non-compliant

CFR = 0.8%

70% of hypoxaemic patients had a danger sign

(52% with any danger sign)

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



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

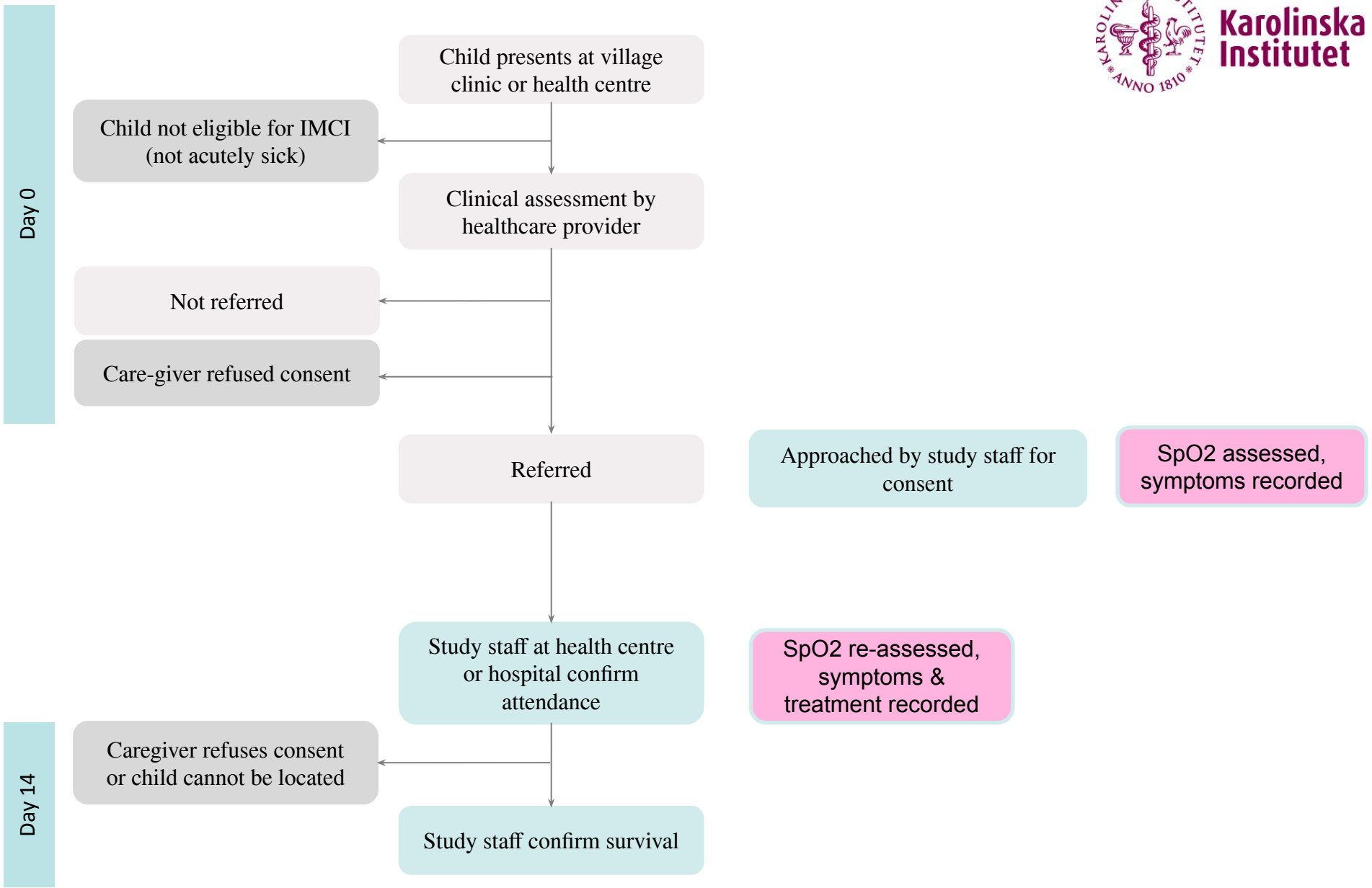
PRELIMINARY RESULTS

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
Child not eligible for IMCI (not acutely sick)
Clinical assessment by healthcare provider
Not referred
Care-giver refused consent
Referred
Approached by study staff for consent
SpO2 assessed, symptoms recorded
Study staff at health centre or hospital confirm attendance
SpO2 re-assessed, symptoms & treatment recorded
Day 14
Caregiver refuses consent or child cannot be located
Study staff confirm survival

Results – Cross Sectional

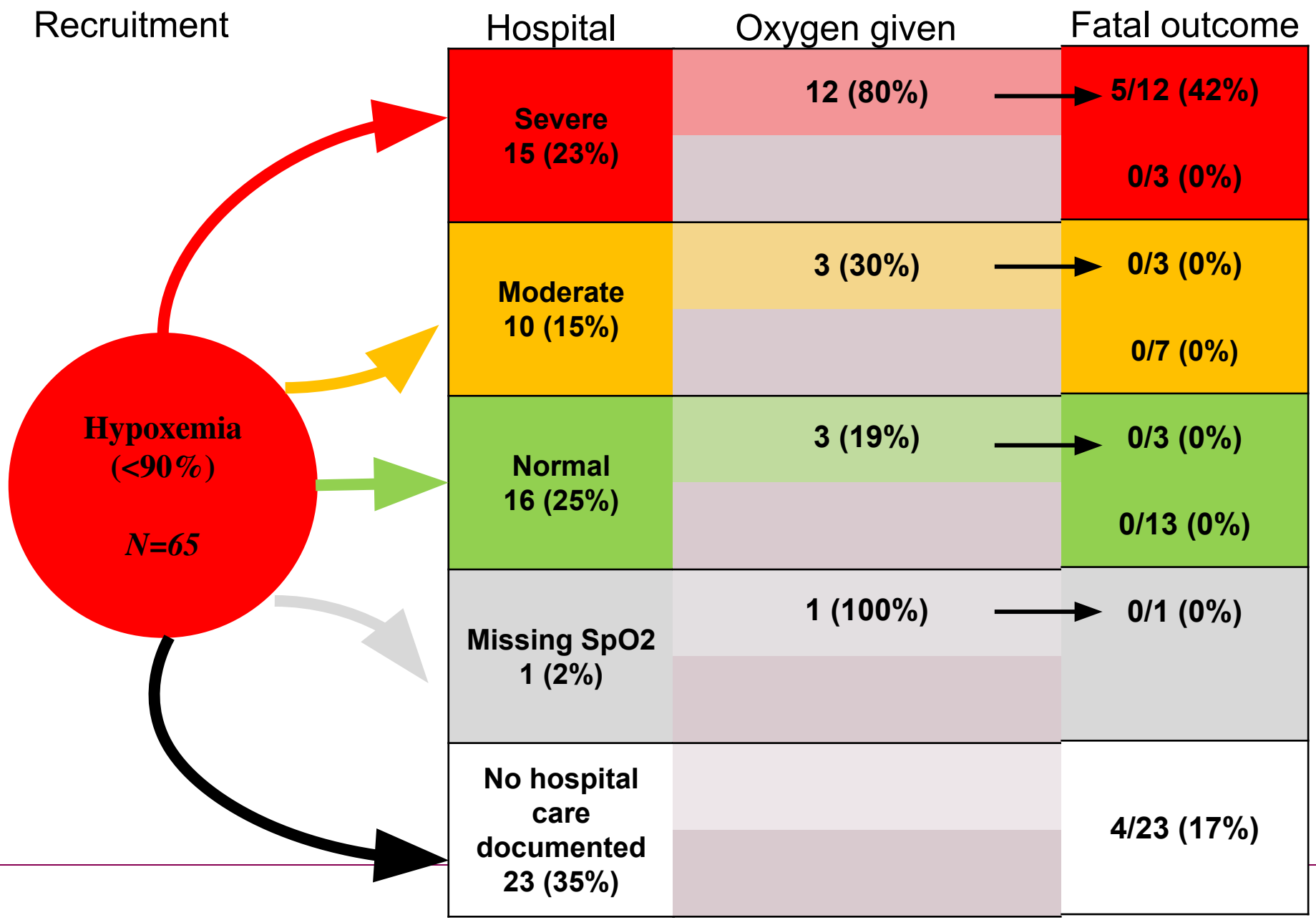
- 2943 children enrolled
- 49.2% (1447/2,943) diagnosed with malaria and 24.2% (712/2943) with non-pneumonia respiratory tract infection
- Two data collectors frequent unexpected results and excluded (n=306)
- Three refusals
- 124/2943 (4.2%) unstable curve
  - 2643 children with saturation result
 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

Karolinska Institutet

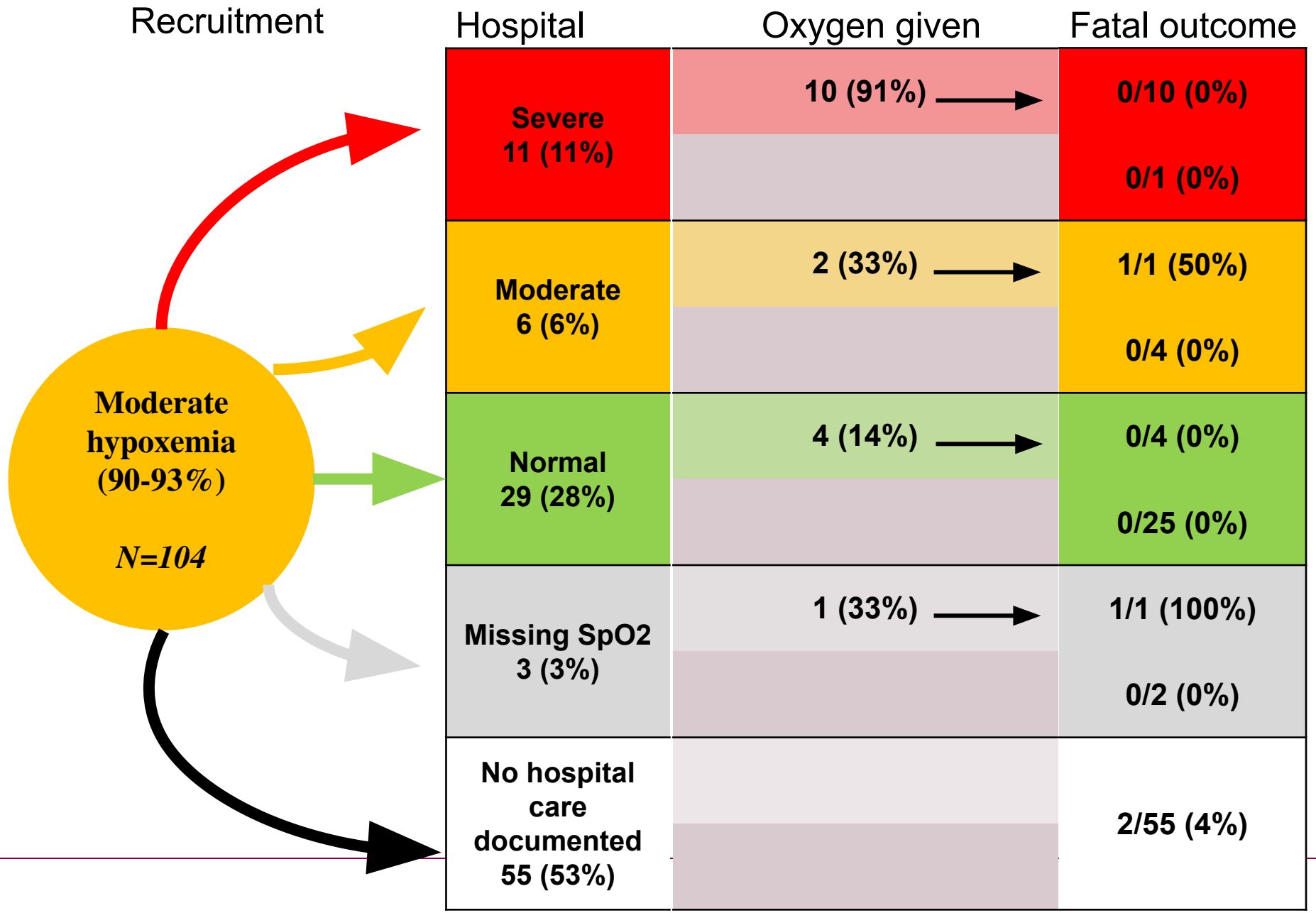
Results - Cohort

- 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



PRELIMINARY RESULTS



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

PRELIMINARY RESULTS

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

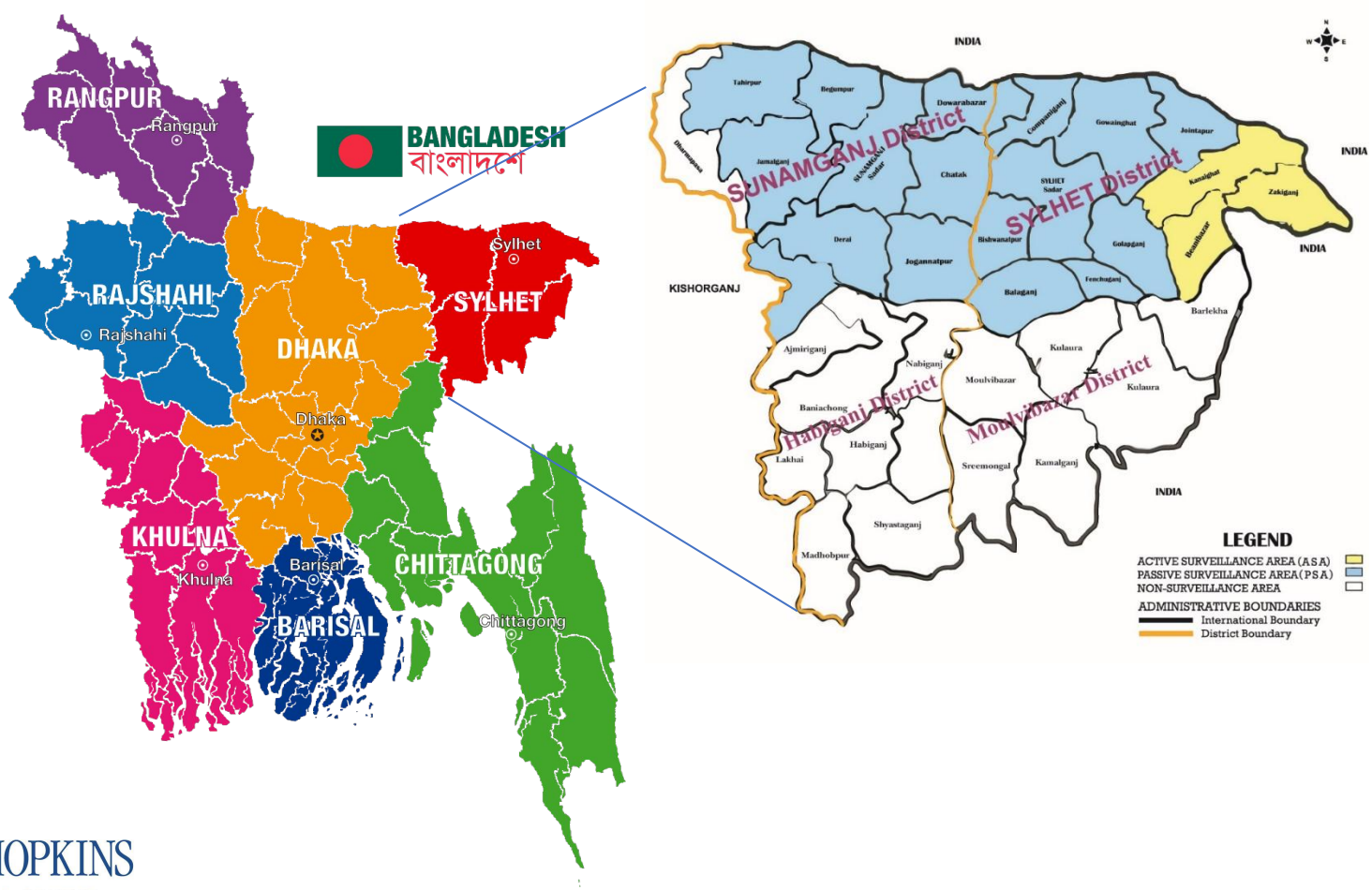
- Design – prospective observational substudy of children with suspected pneumonia nested within a pneumococcal conjugate vaccine effectiveness study in rural Bangladesh

- 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



JOHNS HOPKINS CHILDREN'S CENTER

JOHNS HOPKINS BLOOMBERG SCHOOL of PUBLIC HEALTH

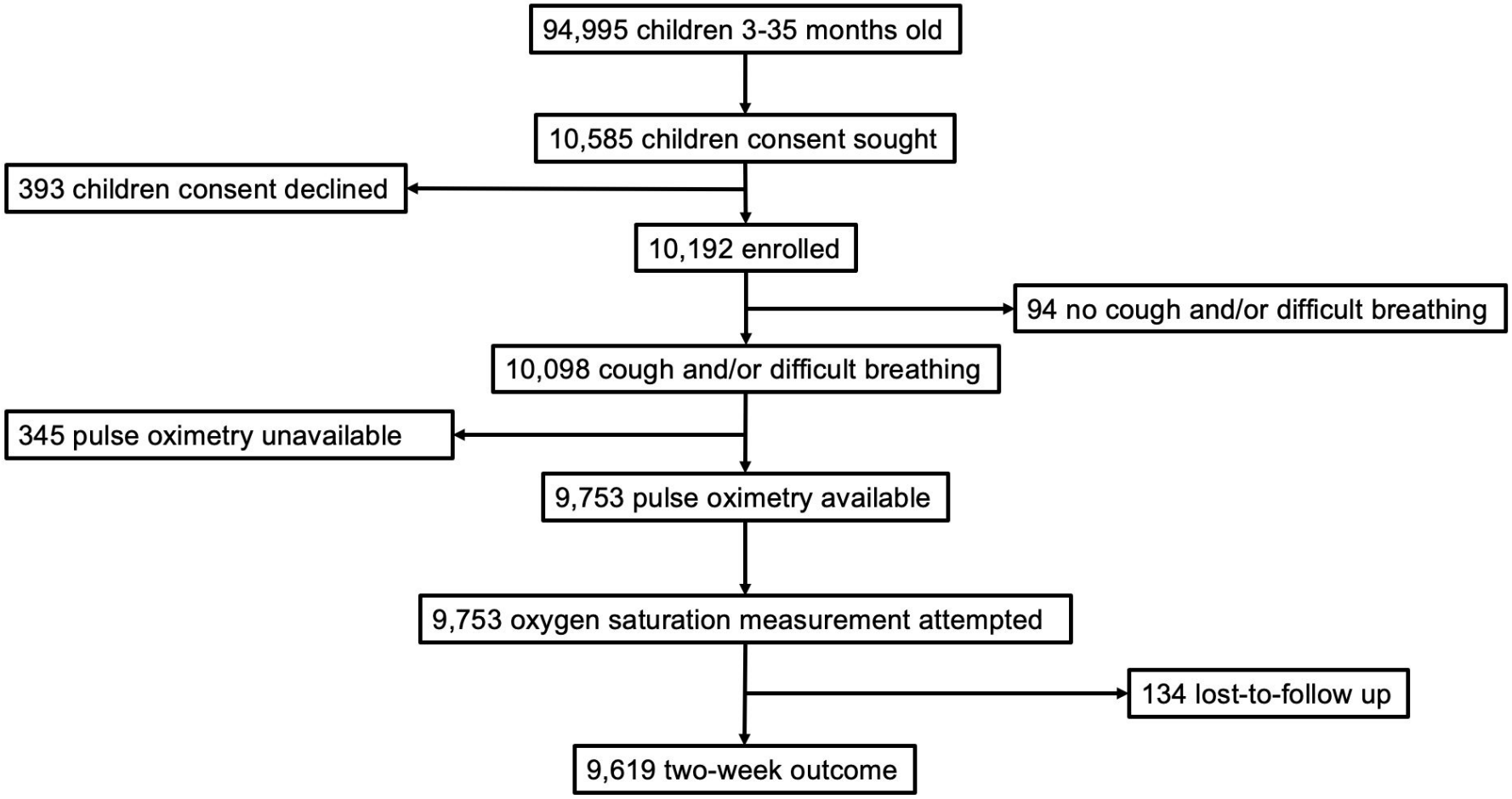
Study eligibility & Data collection

- 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 SpO_2 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

Figure: Study Profile



PRELIMINARY RESULTS

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

Characteristic		No pneumonia N=1,250	Non-severe pneumonia N=7,347	Severe pneumonia N=1,022	Total N=9,619
Age, in months	Median (IQR)	10 (6, 17)	11 (6, 19)	15 (8, 23)	11 (6, 19)
Sex	Females, n (%)	523 (42%)	3,120 (42%)	375 (37%)	4,018 (42%)
Fast breathing for age, n (%)		0	6,897 (94%)	896 (88%)	7,793 (81%)
Lower chest wall indrawing		0	2,523 (34%)	385 (38%)	2,908 (30%)
WHO general danger signs		0	0	1,022 (100%)	1,022 (11%)
SpO_2 in room air	Median (IQR)	97 (96, 98)	97 (96, 98)	97 (95, 98)	97 (96, 98)
	94% – 100%	1,164 (93%)	6,607 (90%)	871 (85%)	8,642 (90%)
	90% – 93%	65 (5%)	482 (7%)	90 (9%)	637 (7%)
	< 90%	5 (0%)	138 (2%)	28 (3%)	171 (2%)
	Failed measurement	16 (1%)	120 (2%)	33 (3%)	169 (2%)
Hospitalization		26 (2%)	517 (7%)	127 (12%)	670 (7%)
Mortality		3 (0.2%)	20 (0.3%)	8 (0.8%)	31 (0.3%)

PRELIMINARY RESULTS

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

Characteristic N=9,619		**Alive (%) N=9,588**	**Dead (%) N=31**	**p value**
SpO_2	94% – 100%	8,627 (99.8%)	15 (0.2%)	<0.001
	90% – 93%	630 (98.9%)	7 (1.1%)	
	< 90%	167 (97.7%)	4 (2.3%)	
	Failed SpO_2 measurement	164 (97.0%)	5 (3.0%)	
Outpatient clinic	Beanibazar	3,031 (99.5%)	14 (0.5%)	0.007
	Zakiganj	2,316 (99.5%)	12 (0.5%)	
	Kanaighat	4,241 (99.9%)	5 (0.1%)	
Age, in months	Median (IQR)	11 (6, 19)	6 (4, 9)	<0.001
WHO general danger signs[1]	None	8,568 (99.7%)	23 (0.3%)	0.006
	At least one present	1,014 (99.2%)	8 (0.8%)	
Hospitalization	Yes	657 (98.1%)	13 (1.9%)	<0.001
Oxygen treatment	Yes	277 (96.2%)	11 (3.8%)	<0.001

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 SpO_2

Characteristic N=9,612		Odds ratio	95% CI	p value	Adjusted odds ratio[1]	95% CI	p value
SpO_2	94% – 100%	Ref			Ref		
	90% – 93%	6.39	2.60, 15.73	<0.001	3.04	1.16, 7.99	0.024
	< 90%	13.77	4.52, 41.94	<0.001	4.95	1.46, 16.76	0.010
	Failed SpO_2 measurement	17.53	6.29, 48.81	<0.001	8.00	2.53, 25.26	<0.001

[1]Random-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

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

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*

Review and suggest subgroup activities here, find resources: http://bit.ly/QoCworkingdoc

Join the QoC Network for MNCH: www.qualityofcarenetwork.org/engage-peers/register

Become a member of the Child Health Task Force: www.childhealthtaskforce.org/subscribe

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