Policy Brief

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Evaluation of pulse oximetry as a tool to prevent childhood pneumonia related morbidity and mortality

Summary

Pneumonia is the leading cause of death in children <5 years of age and it is estimated that pneumonia is responsible for 15% of childhood deaths worldwide.[1,2] This study primarily aimed to determine the cost-effectiveness of pulse oximetry devices in the screening of childhood pneumonia by health workers in resource-poor settings. Using a systematic review, a decision-tree modeling exercise and a budget impact analysis, the following findings were observed;

- ➔ *The evidence from the systematic review was **in favour of the use of pulse oximetry along with the existing guidelines***
- ➔ ***The deaths averted due to childhood pneumonia when IMCI+PO is used instead of IMCI alone is 21 and 36 per 1000 patients when the sensitivity of pulse oximetry is assumed at 70% and 85% respectively.** The ICER for both sensitivities shows a negative value suggesting that **PO, when added to the existing IMCI, would become a cost-saving intervention.***
- ➔ *The costing and budget impact analysis showed that the introduction of pulse oximeter along with existing IMCI **will increase the cost per patient per year by INR 0.36 only. The overall cost of roll-out of pulse oximeters in PHC's in India would amount to INR 9,04,59,000.***

Recommendations

- Integrated Management of Childhood Illness (IMCI) guidelines along with Pulse Oximetry (PO) is a cost-saving prognostic tool as compared to IMCI alone provided there is supplementary oxygen availability.
- IMCI should be the basic prognostic tool for childhood pneumonia but PO is beneficial in the referral of cases. Pulse oximetry, in general, may be used to measure oxygen saturation in cases wherever required.
- Among outpatients with pneumonia, peripheral oxygen saturations (SpO2)<90% were associated with increased morbidity and mortality. A hospital admission threshold of <92% would be safer and clinically better justified. All severe cases irrespective of the availability of Pulse oximeter will be referred to a tertiary care facility for expert management.
- In tertiary care, when SpO2 ≥ 80%, pulse oximetry has high accuracy in estimating oxygen saturations and may be used instead of (Arterial Blood Gas) ABG; in patients with SpO2 < 80%, however, the evaluation of oxygenation by pulse oximeter is not a good substitute for ABG analyzer.
- In tertiary care hospitals, especially in ICU's, multipara monitors which measures advanced parameters like ECG, Respiration, Pulse Rate, Temperature should be preferred

Background

Globally, pneumonia is the leading cause of death in children <5 years of age. Despite interventions being available, it is estimated that pneumonia is responsible for 15% of childhood deaths worldwide.[1,2] The present recommended strategy for diagnosis and prognosis of pneumonia is IMCI tool for professional health workers at health facilities and Integrated Community Case Management (iCCM) tool for community health workers. In the absence of appropriate prognostic tools at the frontline, currently recommended World Health Organization (WHO) guidelines for integrated management of childhood illness (IMCI) often lead to an overuse of antibiotics and the under-referral of patients with severe pneumonia who require hospital care.[3,4] Currently, the identification of these IMCI symptoms remains inconsistent and unreliable among health-care personnel.

Objectives:

To determine the effectiveness (i.e. sensitivity, specificity, positive and negative predictive values) and cost-effectiveness of pulse oximetry devices in the screening of childhood pneumonia by health workers in resource-poor settings (LMICs) & to identify whether children have lower mortality rates, lower morbidity, and shorter length of stay where pulse oximeters are used to inform diagnosis and treatment compared with where pulse oximeters are not used.

Methods:

A systematic literature review (SLR) was conducted with PICO as a population consisting of patients aged 0-5 years with pneumonia in low and middle income countries (LMICs). Intervention was IMCI +Pulse Oximetry and the comparator was IMCI alone. The outcomes were diagnostic accuracy of pulse oximetry, cost per Quality Adjusted Life Years (QALY) gained, and incremental deaths averted with the introduction of pulse oximetry. The SLR was conducted using electronic databases such as Database of Cochrane, PubMed, Web of Science, ProQuest, Google Scholar and WHO Global Health Library, with no language restrictions.

We extracted the costs of the IMCI implementation in Indian primary healthcare settings from previous studies. The average number of hospital visits (outpatient and inpatient) were calculated including the associated out of pocket health expenditure for each category. We indexed the amount to the current INR rate using inflation tools. Pulse oximeters which fit the predefined specifications were shortlisted and their net average cost was taken for costing purposes. The training cost was derived from consultation with the program implementers.

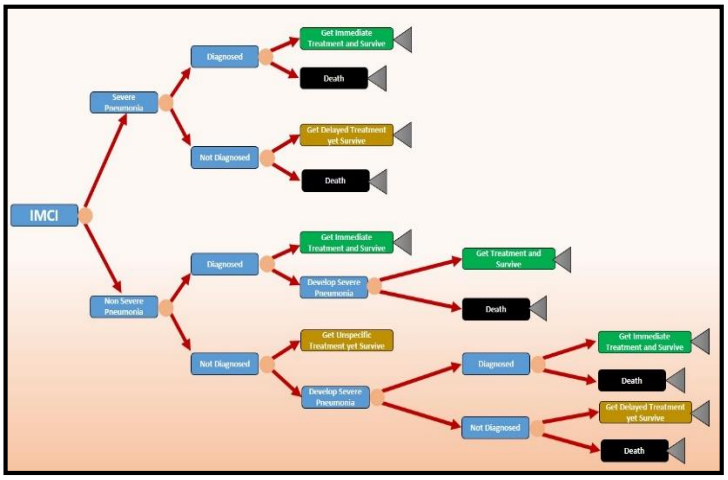
A decision tree model was developed for estimating the Incremental Cost Effectiveness Ratio (ICER). For populating the model, we required data pertaining to disease progression, care-seeking, healthcare, prognostic and cost parameters. In addition to data gathered from SLR, we did a scoping review wherever necessary to extract data for the decision model.

Systematic Review – Result Summary

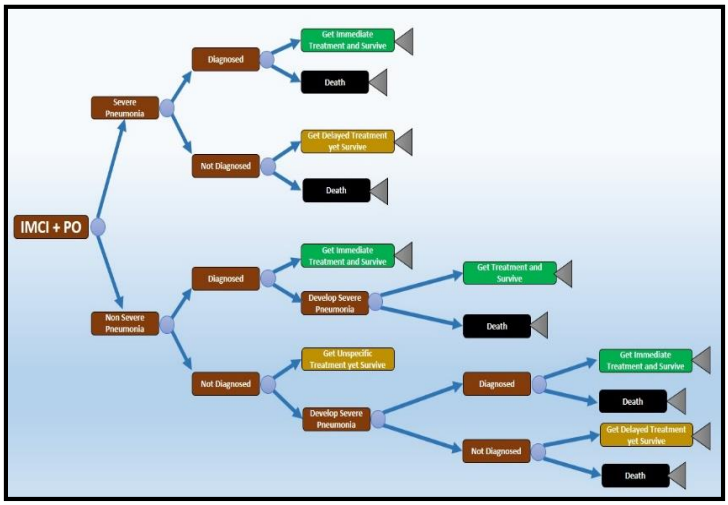
Out of the seven studies which were eventually shortlisted, 6 of them favoured the use of Pulse Oximetry. In general, the states having a high prevalence of pneumonia risk factors and poor access to health services had a higher burden of pneumonia cases and deaths.[5] Although hypoxemia is common, the absence of routine pulse oximetry results in most hospitalized hypoxemic children not receiving available oxygen treatment. It is important to recognize that referral/ admission rates are dependent on the thresholds for oxygen therapy.

Clinical signs alone are poor predictors of hypoxemia, and using pulse oximetry in resource-poor health facilities to target oxygen therapy is likely to save costs. The fingertip pulse oximeter was deemed the most usable and scalable in most of the studies. There is evidence to indicate that pulse oximetry may lead to improved health outcomes, with lower mortality rates (when combined with improved/adequate oxygen administration); pulse oximetry may change physicians' decisions regarding illness severity, and increase hospital admissions related to previously unrecognized hypoxemia. Oximetry can reduce resource waste by indicating when to end treatment, and by decreasing false positives.

Economic Evaluation – Result Summary



A decision tree was parameterized on a spreadsheet to estimate the incremental cost-effectiveness of implementing pulse oximetry + IMCI program over IMCI alone. A lifetime study horizon starting from the base year of 2019 was considered appropriate to cover all costs and effects comprehensively. Pneumonia has a predominant risk within the first 5 years of life, with gradually declining risk until about 15 years.



In absolute terms, the introduction of pulse-oximetry devices to IMCI is estimated to result in annual reductions in pneumonia deaths in India. The deaths averted per year for PO2 within a cohort of 10000 pneumonia cases would be 367 if the sensitivity is 85% and 213 if the sensitivity is 70%. Owing to the large under-five population (128 million) India could significantly reduce the mortality due to childhood pneumonia by the introduction of PO into the existing IMCI. We found that the ICER is -117.32 and -18.75 when the sensitivity of the IMCI+PO is 85% and 70% respectively. This suggests that it is a cost-saving intervention from a societal perspective.

Results of Cost-effectiveness of IMCI + PO as compared to IMCI Alone

Intervention	Cost (in INR)	LY	QALY	ICER
IMCI (0.55)	3,22,47,526	601736.1	601736.1	**-117.32**
IMCI+PO (0.85)	2,95,03,112	625127.9	625127.9	
Intervention	**Cost (in INR)**	**LY**	**QALY**	**ICER**
IMCI (0.55)	3,22,47,526	601736.1	601736.1	**-18.7521**
IMCI+PO (0.7)	3,19,93,096	615304.17	615304.17	

Number given in brackets in the first column is the sensitivity of each intervention

Budget Impact Analysis - Results Summary

The cost of the roll-out of pulse oximeters for 1.5 lakh health and wellness centres

- Number of health and wellness centres: 150000
- Cost of PO: INR 2500
- Overall cost of PO: 150000*2500 = INR 37,50,00,000

But, as on 31st March 2017, there were only 25650 Primary Health Centres (PHCs) functioning in India[6]. If we were to provide a pulse oximeter to all the PHC's in India, the cost of the roll-out of pulse oximeters would be INR 6,41,25,000 (25650*2500). The cost of training frontline health workers to use PO is INR 2,63,34,000. The overall cost of the roll-out of pulse oximeters in PHC's would amount to INR 9,04,59,000. The number of functioning Community Health Centres (CHCs) in India was 5510 as on 31st March, 2016.[7] Each community health centre would require at least 4 finger-tip pulse oximeters which should ideally be placed in the casualty, OP and inpatient ward. The cost of equipping all the CHC's with the specified number of pulse oximeters amount to INR 5,51,00,000 (5510*2500*4).

Key Findings

- ➔ Pulse oximetry, used in conjunction with clinical guidelines like the IMCI, is beneficial in screening and diagnosis of pneumonia in the community. It is important to note here that such diagnoses have to be coupled with the prompt provision of oxygen therapy at the community level institutions, in order to reap the benefits of a more early and accurate diagnosis.
- ➔ The deaths averted due to childhood pneumonia when IMCI+PO is used instead of IMCI alone is 21 and 36 per 1000 patients when the sensitivity is 70% and 85%. When we take a lifetime horizon this results in a QALY gain of 1356 and 2339 years respectively.
- ➔ The ICER for both sensitivities shows a negative value suggesting that PO, when added to the existing IMCI, would become a cost-saving intervention.
- ➔ The costing and budget impact analysis showed that the introduction of pulse oximetry along with existing IMCI will increase the cost per patient per year by INR 0.36 only.
- ➔ The overall cost of the roll-out of pulse oximeters in PHC's in India would amount to INR 9,04,59,000. The cost of equipping all the CHC's with the specified number of pulse oximeters amount to INR 5,51,00,000. The overall domestic general government health expenditure per capita for India is US$61.40[8]. For a three trillion dollar economy which spends 1.15% of its GDP on healthcare, the implementation of the IMCI+PO would cost only 0.003% of its annual budget.
- ➔ The decision tree was able to show that on top of the large reduction in deaths due to pneumonia, the addition of pulse oximetry to IMCI has the potential to increase the correct treatment of severe cases. Thus, pulse oximetry appears to be both an effective and cost-effective option for the government to contemplate implementation of the same in the primary healthcare institutions.
- ➔ In the case of IMCI+PO, the value of ICER was less than the GDP per capita in all simulations as part of the probabilistic sensitivity analysis. The sensitivity analysis also showed that the majority of the values fell into the right lower quadrant, signifying ICER to be negative with gain in QALYs and less cost incurred in the intervention scenario.

Conclusion

The evidence from the systematic review was overwhelmingly in favour of the use of pulse oximetry along with the existing guidelines. **The deaths averted due to childhood pneumonia when IMCI+PO is used instead of IMCI alone is 21 and 36 per 1000 patients when the sensitivity of pulse oximetry is assumed at 70% and 85% respectively.** When we take a lifetime horizon this results in a QALY gain of **1356 and 2339 years respectively**. The ICER for both sensitivities shows a negative value suggesting that **PO, when added to the existing IMCI, would become a cost-saving intervention.** The costing and budget impact analysis showed that the introduction of pulse oximeter along with existing IMCI **will increase the cost per patient per year by INR 0.36 only**. **The overall cost of roll-out of pulse oximeters in PHC's would amount to INR 9,04,59,000**. The cost of equipping all the CHC's with the specified number of pulse oximeters amount to INR 5,51,00,000. The overall domestic general government health expenditure per capita for India is US$61.40[7]. For a three trillion-dollar economy which spends 1.15% of its GDP on healthcare, the implementation of the IMCI+PO would cost only 0.003% of its annual budget.

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