

# Study of predictors of hypoxemia in children with Pneumonia

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## ABSTRACT

### Objective

To study the sign and symptoms of hypoxemia in children with pneumonia and to identify its clinical predictors in children between two months to five years of age.

### Methods

Children between two to five years of age suffering from cough or difficult breathing were assessed. Arterial oxygen saturation was measured with a pulse oxymeter and child was labeled hypoxic if <90%. The children were categorized into four types according to WHO criteria-Cough and cold, pneumonia, severe pneumonia and very severe pneumonia.

### Results

Out of 200 patients that were included in the study population, 101(51%) were found hypoxemic and was found in all grades of pneumonia. Frequency of hypoxemia increased with the severity of pneumonia being 100% for very severe pneumonia, 84% for severe pneumonia and 9% for pneumonia. None of the patients in the cough and cold category was found hypoxic. On univariate analysis, different predictors for hypoxemia found were inability to feed and drink, lethargy, tachypnoea, central cyanosis, chest indrawing and grunting.

### Discussion

Prevalence of hypoxemia decreased with increasing age of the child. Significantly more number of infants (2–12months) were hypoxemic as compared to elder children.

### Conclusion

Pneumonia in infants is risk factor for hypoxemia. Children less than one year with cough and difficult breathing were at more risk for hypoxemia. Prevalence and clinical predictors of hypoxemia validated WHO classification of pneumonia based on severity.

**Key Words:** hypoxaemia, children, pneumonia

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## **INTRODUCTION**

Globally, well being of children has been given much importance and this is evident by the facts that decrease in child mortality has been included as one of the Millennium Development Goals (MDG 4). Child mortality commonly known as under five mortality rate is a sensitive indicator of development of a country. The main principal cause for < 5 mortality are Pneumonia (19%), Diarrhea (17%), AIDS, Malaria and Measles (15%). Malnutrition when combined with pneumonia contributes to more devastating effects than that of pneumonia alone.<sup>1</sup>

Nepal, a developing country has under five mortality rate of 59/1000 live birth and an infant mortality rate of 46/1000 live birth. One third of Hospital OPD is due to Acute Respiratory Infection (ARI), 30% of them admitted in hospital for pneumonia. About 90% of ARI deaths from Pneumonia are bacterial in origin.<sup>2</sup> Incidence of ARI is similar in developed and developing country. However incidence of pneumonia in developed country is 3-4%, in comparison to 20 to 30% of developing countries.<sup>3</sup> Forty percent of global ARI mortality occurs in Bangladesh, India, Indonesia and Nepal.

Hypoxemia is a serious manifestation of severe pneumonia in children, is evident by the fact that mortality is inversely related to arterial O<sub>2</sub> saturation. The Integrated Management of childhood Illnesses (IMCI) also makes use of clinical features to classify pneumonia into various categories based on severity. Therefore detection and effective management of hypoxemia plays an important role in management of hypoxemia in children with pneumonia. Hypoxic children with pneumonia are five times more likely to die than those without hypoxia.

The most reliable and non invasive means to diagnose hypoxemia is by determination of the percentage of O<sub>2</sub> saturation of hemoglobin in arterial blood by a pulse Oxymeter. However, it is an expensive tool, needs constant maintenance and is not available in most of the health institutions of our country. Studies have been done to correlate clinical signs and symptoms of pneumonia with hypoxemia. The studies have been able to identify clinical predictors of hypoxemia in children with pneumonia, but very few studies have been done in our country. This study was planned to study the prevalence of hypoxemia in children with pneumonia and to identify its clinical predictors.

## **METHODS**

The Study was conducted from May 2007 to June 2009 at Janaki Medical College and Hospital, Ramdaiya, Janakpur, Nepal. The Study population included 200 children between age 2 months to 60 months attending the OPD, Emergency, or indoor of the hospital before the child received any treatment.

Children suffering from cough and difficulty in breathing were included in the study. Relevant history was taken and examination conducted according to questionnaire prepared for the purpose of study. During examination arterial O<sub>2</sub> saturation was recorded by pulse oxymeter with sensor device.

**Exclusion criteria:** Children suffering from Congenital Heart Disease, Bronchial Asthma, Severe Anemia, Severe malnutrition or had needed resuscitation were excluded from the study.

**Sample size:** 200 cases.

The cases were classified based on WHO guideline<sup>4</sup> as (i) No pneumonia, cough and cold, (ii) Pneumonia (iii) Severe pneumonia and (iv) Very severe pneumonia.

Similarly, children with O2 saturation < 90% were labeled hypoxic and with saturation > 90% as non hypoxic .

Data was entered and analysis was done with the

help of SPSS 14 software. P value d” 0.05 was considered significant.

The sensitivity and specificity of clinical sign and its ability to predict hypoxemia was calculated.

## RESULTS

### Age group and sex distribution of the study cohort:

Of the study population (n=200), 130(65%) were male and 70(35%) were female. Similarly, children of age 2 to 12 months constituted 101(51%) and 13 to 60 months 99(49%) of the study population.

**Table 1: Distribution of study population according to age and sex**

Age groups	Male (n=130)	Female (n=70)	Total	p-value
	n (%)	n (%)	n (%)	
2-12 months	59 (45%)	42 (60%)	101 (51%)	0.124
13-60 months	71 (55%)	28 (40%)	99 (49%)	
<b>Total</b>	130	70	200	

### Distribution of severity of pneumonia in different age groups:

Children in the ge group 2-12 months were seen to suffer from different grades of pneumonia. Milder form of the disease (cough and cold) was almost equally distributed in both age groups. Severe (58%) and very severe pneumonia (60%) was also observed more in the infants.

**Table 2: Distribution of severity pneumonia in different age groups**

Age group	Diagnosis				Total
	Cough and Cold	Pneumonia	Severe Pneumonia	Very Severe	
	n (%)	n (%)	n (%)	n (%)	n (%)
2-12 months	20 (47%)	16 (35%)	50 (58%)	15 (60%)	101
13-60 months	23 (53%)	30 (65%)	36 (42%)	10 (40%)	99
<b>Total</b>	43	46	84	25	200

### Prevalence of hypoxemia in the study cohort:

Of the study population 101 (51%) were found to be hypoxic. Among the 157 cases of pneumonia, 101 (64%) were found to be hypoxic. The frequency of hypoxia increased with the severity of the disease, being 100% for very severe pneumonia, 84 % for severe pneumonia and 9 % for pneumonia.

**Table 3: Prevalence of hypoxemia in the study cohort by diagnosis**

Oxygen saturation	Diagnosis			Total
	Pneumonia	Severe Pneumonia	Very Severe Pneumonia	
	n (%)	n (%)	n (%)	
>90%	42 (91%)	14 (16%)	0 (0%)	56
<90%	4 (9%)	72 (84%)	25 (100%)	101
<b>Total</b>	46	86	25	<b>157</b>

**Prevalence of hypoxemia in the study cohort by different age group**

Prevalence of hypoxemia decreased with increasing age of the children. Significantly more numbers of infant (2-12 months), 58(57%) were found hypoxic as compared to children (13- 60 Months) 43%, (P< 0.005)

**Table 4: Prevalence of hypoxemia in different age groups**

Age groups	Oxygen saturation		Total	p- value
	>90%	<90%		
	n (%)	n (%)		
<b>2-12 months</b>	43 (43%)	58 (57%)	101	0.002
<b>13-60 months</b>	56 (57%)	43 (43%)	99	
<b>Total</b>	99	101	<b>200</b>	

**Distribution of various symptoms and signs of study cohort associated with hypoxemia**

Among the symptoms, fast breathing (98%,p<0.001), breathing difficulty (86%,p<0.001), and inability to feed/drink (20%,p<0.001) had significant association with hypoxemia. Among clinical signs, lethargy (24%), nasal flaring (68%), central cyanosis (6%), grunting, chest indrawing,tachycardia,tachypnoea,increased temperature, crepitations, were found to be significantly associated with hypoxemia. Inability to feed/drink, central cyanosis, and head nodding had predictive values of 100% each for positive and negative tests.

Signs with high sensitivity and specificity associated were difficulty in breathing,(86%and 63%), chest indrawing, (73% and 89%), nasal flaring (68% and 86%) and inability to feed/drink (20% and100%) . Lethargy and central cyanosis had 100% specificity with hypoxemia.

**Table 5: Distribution of various symptoms and signs (and their combinations) of study cohort associated with hypoxemia.**

Clinical Features	Non-hypoxemic children	Hypoxemic children	p-value	Sensitivity	Specificity	Predictive value of a positive test	Predictive value of a negative test
<b>Cohort</b>	n (%) 99	n (%) 101					
<b>Symptoms</b>							
Cough	99 (100%)	100 (99%)	1.000	99%	0%	50%	0%
Fever	68 (69%)	94 (93%)	<0.001	93%	31%	58%	35%
Nasal discharge	86 (87%)	73 (72%)	<0.05	72%	13%	46%	13%
Breathing difficulty	37 (37%)	87 (86%)	<0.001	86%	63%	70%	66%
Fast breathing	54 (55%)	99 (98%)	<0.001	98%	45%	65%	60%
Inability to feed/drink	0 (0%)	20 (20%)	<0.001	20%	100%	100%	100%
<b>Signs</b>							
Lethargy	0 (0%)	24 (24%)	<0.001	24%	100%	100%	100%
Nasal flaring	14 (14%)	69 (68%)	<0.001	68%	86%	83%	87%
Central cyanosis	0 (0%)	6 (6%)	<0.05	6%	100%	100%	100%
Grunting	5 (5%)	33 (33%)	<0.001	33%	95%	87%	95%
Chest indrawing	11 (11%)	74 (73%)	<0.001	73%	89%	87%	89%
Crepitations	20 (20%)	86 (85%)	<0.001	85%	80%	81%	84%
Tachypnoea	57 (58%)	94 (93%)	<0.001	93%	42%	62%	47%
Tachycardia	3 (3%)	14 (14%)	0.009	14%	97%	82%	97%
Wheeze	14 (14%)	35 (35%)	0.001	35%	86%	71%	86%
Bronchial breath sound	4 (4%)	9 (9%)	0.251	9%	96%	69%	96%
Diminished breath sound	1 (1%)	9 (9%)	0.019	9%	99%	90%	99%
Increased temperature	97 (98%)	99 (98%)	1.000	98%	2%	51%	3%
Head nodding	0 (0%)	3 (3%)	0.246	3%	100%	100%	100%
<b>Combination of signs</b>							
Tachypnoea or chest indrawing	58 (59%)	98 (97%)	<0.001	97%	41%	63%	55%
Tachypnoea or nasal flaring	58 (59%)	97 (96%)	<0.001	96%	41%	63%	51%
Chest indrawing or nasal flaring	17 (17%)	79 (98%)	<0.001	78%	83%	82%	86%

**Association of different respiratory cut-off rates with hypoxemia**

- i. Incidence of respiratory rate of 60 or more in infants and 50 or more in children (13 – 60 months) was more in hypoxemic children.
- ii. Cut-off respiratory rate value of 70 or more in infants and 60 or more in children (13 – 60 months) was present in all hypoxemic cases.

**Table: Association of different respiratory cut-off rates with hypoxemia**

Age groups	Respirator Rate	Hypoxemic children n%	Non-Hypoxemic children n%	Total	p-value	Sensitivity	Specificity
2-12 Months	s/50/min	14(23%)	48(77%)	62	<0.000	148%	86%
13-60 Months	s/40/min	43(49%)	44(51%)	87	0.985	44%	57%
2-12 Months	s/60/min	2(11%)	16(89%)	18	<0.001	16%	98%
13-60 Months	s/50/min	12(31%)	27(69%)	39	<0.0	27%	88%
2-12 Months	s/70/min	0(0%)	6(100%)	6	<0.0	6%	100%
13-60 Months	s/60/min	0(0%)	4(100%)	4	0.121	4%	100%

## DISCUSSION

### Age

According to Hassan MK infants between 2 – 6 months are at greater risk for developing severe diseases.<sup>5</sup> Demers AM et al presented in their study that age < 1 year and acute malnutrition were associated with higher risk of death from ARI.<sup>6</sup> In present study, significant no. of infants were observed to have pneumonia (81 out of 157). Among the cases, hypoxemia was observed in half. Two third of these hypoxemic children were infants

### Etiology

Infants are more vulnerable to infections due to (i) Relative immaturity of immune system.(ii) Inability to communicate their distress verbally. Several studies conducted in Papua New Guinea and Central Africa also reported that children below 1 year were at risk of severe disease or death<sup>7,8,9,10</sup> In the present study 71% of cases with pneumonia, i.e. 111 out of 157, presented with severe and very severe pneumonia and among them more than half were infants. This indicates severe and very severe pneumonia are more common in the infants.

Tachypnoea is a reliable predictor of pneumonia. WHO defines tachypnoea as respiratory rate of 50 or more for infants (2-12 months) and 40 or more for children (13 months – 60 months) of age. Many studies have also reported fast breathing as a

reliable predictor of pneumonia. Different studies have used higher cut-off values, compared to WHO guideline, to show association of tachypnoea with hypoxemia.<sup>11,12,13</sup> According to a study conducted by Onyango et al, hypoxemia was seen in infants, 3 to 11 months of age with a respiratory rate of 70 or more and in older children with a respiratory rate of 60 or more. Where as in a study conducted by Usen et al in Gambian children, children were found hypoxic with a respiratory rate of 90 or more.<sup>11,12</sup> Basnet et al also reported that RRe” 70/min was significantly associated with hypoxemia, and Lozano et al used respiratory rate e” 50/min in their study to show association of tachypnoea with hypoxemia at high altitude. In another study conducted by Lozano et al, a respiratory rate of 50 or more per minute more had good sensitivity (76%) & specificity (71%) for hypoxemia in infants.<sup>14</sup>

In present study, 89% of infants with R.R. 60 or more /min and 69% of children (13months-60months)with R.R. of 50 or more were hypoxemic. Cut off value 70 or more in infants and 60 or more in children (13 – 60 months) were only present in hypoxemic children.

### Hypoxemia

Prevalence of hypoxemia decreased with increasing age of the children. In patients with pneumonia, 57% of infants were suffering from hypoxemia in

comparison to 43% of 13 – 60 months of age (P = 0.005).

In the present study hypoxemia was present in half of the cohort. All the children with very severe pneumonia, 84 % of severe pneumonia and 9% of pneumonia were hypoxemic. Basnet et al observed that all cases of very severe pneumonia, 80% severe pneumonia and 18% cases of pneumonia were hypoxemic.<sup>5</sup> Fast breathing, grunting and chest retraction were found to be the best predictor of hypoxemia by Onyango et al.<sup>11</sup> Cyanosis, rapid breathing , grunting, head nodding and no spontaneous movement during examination were the best independent predictors of hypoxemic in the study conducted by Usen et al.<sup>12</sup> In another study conducted by Weber et al, over half of the children with hypoxemia could be identified with combination of 3 signs, Extreme respiratory distress, cyanosis and severe compromised general status .<sup>15</sup>

In present study fast breathing, inability to feed/drink had significant association with hypoxemia. Among clinical signs lethargy, central cyanosis, nasal flaring, grunting, chest indrawing, tachypnoea and crept were found to be significantly associated with hypoxemia. Various other studies have reported that nasal flaring is significantly associated with hypoxemia.<sup>12,15</sup> Grunting has also been reported in the past with significant association with hypoxemia.<sup>12,13</sup> Six children with central cyanosis had hypoxemia in the current study. Significant association of central cyanosis with hypoxemia was also reported by Onyango et al <sup>11</sup> Usen et al,<sup>16</sup> Basent et al,<sup>13</sup> Weber et al<sup>15</sup> and Banajeh et al reported presence of cyanosis a significant predictor of death with pneumonia. <sup>7</sup>

Crepitation was found to be significantly associated with hypoxemia with a sensitivity of 55% and specificity of 80%. In the present study, chest indrawing was also found to be a good predictor of hypoxemia with a sensitivity of 73% and specificity of 73%.

This study shows that hypoxemia in children was directly proportional to the increasing severity of pneumonia. Lethargy, grunting, nasal flaring, chest indrawing, central cyanosis, inability to feed/drink have been used for the diagnosis of severe and very severe pneumonia in children of 2-60 months.<sup>17</sup> These predictors were significantly associated with hypoxemia. Hence this study validates WHO criteria for diagnosis of children with severe and very severe pneumonia. Lozano and others have supported similar finding by stating that hypoxemia is more frequent with increasing severity of pneumonia<sup>18</sup>

WHO criteria for giving O<sub>2</sub> to children with pneumonia are inability to feed/drink, central cyanosis, grunting, chest indrawing, head nodding or respiratory rate of 70/min or above.<sup>16</sup> In this study, all these signs are significantly associated with hypoxemia and thus shows that the guideline is appropriate for management of children with severe and very severe pneumonia.

Similar observation such as cyanosis, head nodding, drowsiness, respiratory rate more than 60/min, grunting and nasal flaring was seen in a study by Onyango et al to be significantly associated with hypoxemia.<sup>11</sup>

## **CONCLUSION**

The prevalence of hypoxemia in children aged 2-60months with diagnosis of pneumonia was found to be significantly more in infants below 12 months of age. Among the symptom, inability to feed/drink was significantly associated with hypoxemia. Among the sign, lethargy, nasal flaring, grunting, Tachypnoea, central cyanosis could predict severe hypoxemia. These are the simple clinical signs which could be taught to health workers which then could be used to identify hypoxemic children with pneumonia and provide oxygen therapy. Since hypoxemia was associated with severe form of pneumonia, children who had severe or very severe

pneumonia would require oxygen administration as part of treatment.

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