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Research Article

Pneumonia in Under-5 Children: Evaluation of Epidemiological Risk Factors and Predictors of Hypoxemia

Anurag A Fursule[1]*, Subodh S Saha[2], G Malini[3], Dinesh D Pawale[4] and Dattatray V Kulkarni[5]

[1]Registrar Trainee, Perth Children Hospital, CAHS, Perth, WA, Australia

[2]Joint Director and Senior Consultant, Department of Pediatrics, Jawaharlal Nehru Hospital and Research Centre, Bhilai, Chhattisgarh, India

[3]Ex Joint Director and Head of Department of Pediatrics, Jawaharlal Nehru Hospital and Research Centre, Bhilai, Chhattisgarh, India

[4]Registrar in Neonatology, Senior Registrar, Perth Children Hospital, CAHS, Perth, WA, Australia

[5]Assistant Professor, Department of Pediatrics, MIMSR Medical College (MIT), Latur, Maharashtra, India

***Corresponding Author:** Anurag A Fursule, Associate Consultant in Neonatal Intensive Care Services, Surya Mother and Child Care Super Speciality Hospital, Pune, India.

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Abstract

Background: Pneumonia is the most common cause of under 5 mortality in developing countries. There is limited data on risk factors for pneumonia from state of Central India. Identifying such risk factor may help in formulating health policies which can reduce burden on of pneumonia in India and other developing countries.

Objectives: Present study was planned to identify risk factors and report clinical profile of admitted infants with pneumonia under 5 years of age.

Methods: This was a case control study carried out in the Paediatrics Wards of a tertiary care hospital in Central India. The period of study was August 2013 to July 2014. Children aged 2 months to 59 months diagnosed with Pneumonia or Severe Pneumonia as per the WHO guidelines were included. Parents of enrolled children were enquired for risk factors after consent. Epidemiological risk factors for pneumonia and clinical features predicting hypoxemia were evaluated.

Results: Risk factors significantly associated with pneumonia included less duration of maternal and paternal education, incomplete immunization, history of upper respiratory tract infection in mother and siblings, under nutrition, lack exclusive breastfeeding, use of biomass fuel, overcrowding, parental smoking and living in thatched house. On multiple logistic regression, URTI in mother/siblings and maternal education < 10 yrs were found to be independent risk factors for pneumonia. Among clinical features presence of inability to feed, grunting and altered consciousness are reliable predictors of hypoxemia in children under five.

Conclusion: The epidemiological risk factors could help national programmes in reducing the mortality associated with childhood pneumonia. Specific predictors can help diagnose pneumonia needing urgent hospital care.

Keywords: *Childhood Mortality; Childhood Pneumonia; Hypoxemia*

Introduction

Pneumonia is caused by acute respiratory infection of lungs. Pneumonia is the most common cause of under 5 mortality worldwide and accounts for 15% of all under 5 deaths. It contributed to 808694 under 5 childhood deaths in 2017 [1]. The disease burden is mainly contributed by fifteen countries i.e. 75% and India alone bears brunt of 25% disease burden [2]. Infectious aetiology of includes viruses, bacteria and fungi. Common bacteria include: *Streptococcus pneumoniae*, *Haemophilus influenzae* type b (Hib), respiratory syncytial virus (RSV). Presenting features of pneumonia are cough, fever, respiratory distress, wheezing, chest retraction [1]. Pneumonia (severe or non-severe) is treated by antibiotics and supportive care [3].

The Millennium Development Goals number 4 calls for reduction in under 5 mortality by two thirds [4]. UNICEF and WHO in collaboration have developed 'Integrated Global Action Plan for the Prevention (GAPPD)' which focuses on prevention and control of pneumonia. Goals of GAPPD are: reduce mortality from pneumonia in children less than 5 years of age to fewer than 3 per 1000 live births; reduce the incidence of severe pneumonia by 75% in children less than 5 years of age compared to 2010 levels [5].

Risk factors for pneumonia are infancy, malnourished children, non-exclusively breastfed children, and those with exposure to solid biomass fuel use. Other risk factors are crowding, nutritional factors, and parental smoking. But due to major differences in living conditions and environmental exposures, the certainty of these factors remains controversial. There is limited data on risk factors for pneumonia from state of Chhattisgarh, India. So, present study was planned to identify risk factors and report clinical profile of admitted infants with pneumonia under 5 years of age.

Methods

This was a case control study carried out in the Paediatrics Wards of a tertiary care hospital in Central India. The period of study was August 2013 to July 2014. Children aged 2 months to 59 months diagnosed with Pneumonia or Severe Pneumonia as per the WHO guidelines were included [6]. Children with history of chronic respiratory illnesses, tuberculosis, previously diagnosed bronchial asthma, congenital heart disease and congenital malformations were excluded. Controls in the study included healthy age matched children below 5 years of age attending Paediatric out-patient department during the study period for immunization and without previous history of pneumonia. The respondents were the caregivers of the children. All the caregivers were explained the purpose of the study and were ensured strict confidentiality. An informed written consent was obtained from the parents. Institutional ethical committee approved the study.

All children with signs and symptoms of pneumonia as per WHO were evaluated with complete blood count, C reactive protein, blood culture, chest radiograph. Empirical antibiotics were started as per institutional guidelines. Children showing growth of a pathogenic organism in blood culture were treated with antibiotics as per sensitivity. Parents of enrolled children were enquired for risk factors after consent. Risk factors included: age of child (< 1 year of age), gender, educations status (maternal and paternal), history of URTI in family members, immunization status of infants, nutritional status, use of biomass fuel, history of smoking, overcrowding, home type. Nutritional status was assessed as per WHO classification for malnutrition [7]. Immunization was considered complete if child had received all vaccines for age as per Universal Immunization Programme [8]. Adequate breast feeding was defined as exclusive breast feeding for at least 6 months with complimentary feeding afterward in an infant while inadequate breast feeding was taken as no breastfeeding or mixed feeding in the first 6 months of an infant [9]. Overcrowding was defined as per standard textbook definition [10]. Clinical features predicting hypoxemia were evaluated.

In the NFHS 3 survey the prevalence of pneumonia in children was 4% [11]. For allowable permissible error limit of 5% and prevalence of 4%, a total of 96 children were needed as cases and equal number control were enrolled.

Data was entered in MS Excel Spreadsheet and subsequently analysed with SPSS 17. Quantitative data with normal distribution was compared using student t-test and in those with skewed distribution, Mann Whitney U Test was used. Categorical data was compared using Chi-square test or Fisher exact test. Relative risk odds ratio, confidence interval, p value (Fisher's Exact test) were also calculated. Multiple logistic regression was used to evaluate significant risk factors. Two-sided P value of < 0.05 was considered significant. Sensitivity, specificity, positive predictive value, negative predictive values were calculated and were compared.

Results

A total of 192 children were enrolled during study period, 96 in cases and control group each. Median (IQR) of age in months for cases and control were 12 (9, 24) vs 14 (9, 24), hence were comparable (p = 0.99). Majority of children belonged to infant age group i.e. 52 (54%). Particular gender was not found to influence risk of pneumonia. Risk factors significantly associated with pneumonia included less duration of maternal and paternal education, incomplete immunization, history of upper respiratory tract infection in mother and siblings, under nutrition, lack exclusive breastfeeding (Table 1). Other risk factors related to living conditions were use of biomass fuel, overcrowding, parental smoking and living in thatched house were significant (Table 2). On multiple logistic regression, URTI in mother/siblings and maternal education < 10 yrs were found to be independent risk factors for pneumonia (Table 3). Utility of signs and symptoms showed that inability to feeds had highest sensitivity and specificity while crepitations, Intercostal retractions/subcostal retractions and fast breathing had higher sensitivity and altered consciousness and grunting had higher specificity (Table 3).

Risk Factors	Cases (n = 48)	Controls (n = 48)	OR	C.I	p value
Age < 12months	52 (54.1)	46 (47.9)	1.2	0.7-2.3	0.47
Male	67 (69.7)	62 (64.5)	1.2	0.8-1.5	0.53
Maternal Education < 10 years	41 (42.7)	10 (10.4)	6.4	3.1- 3.2	<0.01
Paternal Education < 10 years	25 (26)	7 (7.3)	4.4	1.9-10.4	<0.01
Incomplete Immunization	19 (19.8)	8 (8.3)	2.7	1.2-6.4	0.03
URTI in mother	34 (35.4)	9 (9.3)	5.3	2.5-11.3	<0.01
URTI in father	7 (7.3)	4 (4.1)	1.8	0.5-6.3	0.53
URTI in siblings	23 (23.9)	8 (8.3)	3.4	1.5-7.9	<0.01
Weight for age < -2Z	40 (41.6)	26 (27.1)	1.9	1.1-3.5	0.048
Weight for Length/height for age < -2Z	33 (34.3)	19 (19.8)	2.1	1.1-4.1	0.034
Exclusive breast feeding	19 (19.8)	8 (8.3)	2.7	1.2-6.4	0.037
Use of Biomass fuel	13 (13.5)	4 (4.1)	3.6	1.2-10.8	0.04
Thatched House	13 (13.5)	4 (4.1)	3.6	1.2-10.8	0.04
Overcrowding	52 (54.1)	28 (29.2)	2.8	1.6-5.2	<0.01
Parental smoking	23 (23.9)	8 (8.3)	3.4	1.5-7.9	<0.01

Table 1: *Epidemiological risk factors for pneumonia.*

Data expressed as n (%) unless specified, O.R: Odds Ratio, <-2Z: less than 2 Z score, URTI: Upper Respiratory Tract Infection.

Clinical features	Hypoxemic n=36	Non- Hypoxemic n=60	p value	Sensitivity	Specificity	PPV	NPV
Fever	25	35	0.38	69.4	41.7	41.7	69.4
Cough	25	47	0.46	69.4	21.7	34.7	54.2
Fast Breathing	35	48	0.03	97.2	20	42.2	92.3
Inability to feed	33	7	<0.05	91.7	88.3	82.5	94.6
Altered consciousness	17	00	<0.01	47.2	100	100	100
Grunting	14	00	<0.01	38.8	100	100	100
ICR/SCR	34	46	0.04	94.4	23.3	42.5	87.5
Crepitation	32	41	0.04	88.9	31.7	43.8	82.6
Bronchial breath sounds	14	15	0.19	38.9	75	48.3	67.2

Table 2: *Clinical risk factors predicting hypoxemia.*

Data expressed as n (%) unless specified, ICR/SCR: Intercostal retractions/Subcostal retractions, PPV: Positive Predictive Value, NPV: Negative Predictive Value.

Risk factors	Odds ratio	C.I	P value
Maternal Education < 10 years	0.24	0.08 - 0.71	<0.01
Paternal Education < 10 years	0.50	0.14 - 1.77	0.28
URTI in mother	5.95	2.38 - 14.88	<0.01
URTI in siblings	3.18	1.18 - 8.54	0.02
Weight for age < -2Z	1.73	0.55 - 5.48	0.34
Weight for Length/height for age < -2Z	0.58	0.17 - 1.95	0.38
Exclusive breast feeding	0.80	0.27 - 2.38	0.70
Use of Biomass fuel	1.07	0.06 - 1.95	0.22
Thatched House	1.17	0.05-1.73	0.18
Overcrowding	1.38	0.64 - 3.00	0.40
Parental smoking	1.97	0.72 - 5.42	0.18

Table 3: *Multiple logistic regression of significant risk factors.*

Discussion

Current study aimed to identify epidemiological risk factors for pneumonia and clinical features predictive of hypoxemia.

In present study its was found that age (< 12 months) is not a risk factor predisposing under five children to pneumonia. Study done by Broor., *et al*. in Delhi and Ujunwa., *et al*. in Nigeria had similar findings [12,13]. In the study done by Hemagiri., *et al*. pneumonia was more common among infants but there was no statistical significance [14]. Gender was not found to be risk factor in present study (p = 0.53). This was in contrast with study by Broor., *et al*. as per statistics above [12]. Male distribution was prominent in most of studies

[12-15]. Poor maternal education (< 10 years of formal education) has association with pneumonia which could be due to poor symptom recognition and delayed reporting to health facility. Same agreement has been found in study as below except in a study done by Hemagiri and Ujunwa., *et al* [13,14]. Similarly, poor paternal education (< 10 years of formal education) is significantly associated to childhood pneumonia as concluded by other investigators [12-15]. Poor immunization status was found to be significantly risk factor for pneumonia. This is consistent with studies done by other investigators from other parts of world [12-14]. This asserts the importance of adequate childhood immunization in prevention of diseases, which may be complicated by pneumonia such as measles, tuberculosis, and pertussis. In the study from Baghdad by Janabi., *et al*. has disagreement with our findings [15]. Study done by Broor., *et al*. assumed null hypothesis vice versa hence the values appear to be in disagreement [12]. Positive history of URTI in mother predisposes child to Pneumonia and similar results have been obtained in study done by Broor., *et al*. Positive history of URTI in father does not predispose child to pneumonia and similar results have been obtained in study done by Broor., *et al*. Positive history of URTI in sibling predisposes child to pneumonia and similar results have been obtained in study done by Broor., *et al*. Positive history of URTI in grandparents does not predispose child to pneumonia and similar results have been obtained in study done by Broor., *et al*. So as evident from above data positive family history of URTI in mother and siblings is significantly associated with occurrence of pneumonia. Similar association was reported by Muhi Al Janabi., *et al*. Present study reflects that undernourished children had an increased risk of pneumonia as compared to normal participants. In present study it was found that undernourished children had an increased risk of pneumonia as compared to normal participants. With respect to malnutrition Broor., *et al*. had similar findings where age independent criteria of weight/height^2 was used. Hence, a strong statistical difference exists between diseased and non-diseased participants in terms of the poor nutritional status of the child. The study from Ahmadabad reported in the prevalence of under-five, significant statistical association of ARI was seen in regard to malnutrition [16]. Present study found that lack of exclusive breast feeding to be significantly associated with occurrence of pneumonia. Lamberti., *et al.* estimated that the relative risk of prevalent pneumonia was higher among partially and not breastfed infants 0-5 months of age compared to those exclusively breastfed as in table above [17]. The relative risk of prevalent pneumonia was also elevated among infants 6 - 23 months of age who were not breastfed compared to those who were.

IAP caused by biofuel combustion has statistically significant association with pneumonia in present study. Sparing study done by Farzana Islam., *et al*. [18] and all other studies show association pneumonia with IAP caused by incomplete combustion of biomass fuel. Present study statistics shows significant association between pneumonia and poor housing conditions and has similar conclusion to Broor., *et al*. and Farzana Islam., *et al* [12,18]. Presumably overcrowding, thatched house, poor socioeconomic conditions, poor ventilation collectively lead to poor housing condition. Researchers from Maharashtra noted that incidence of pneumonia among under-five children was influenced by environmental factors like type of house [19]. Present study reflected positive association of overcrowding with risk of pneumonia. Overcrowding may increase the probability of transmission of infections among family members. The Bangladesh study observed that the prevalence of ARI in under-fives in a rural community was significantly higher in overcrowded condition than not (62 vs. 38%) [20]. Similar study from Ahmadabad reported that significant statistical association of ARI was seen in regard to overcrowding [16]. Mysore study on ARI in under-fives reported overcrowding as a significant socio-demographic risk factor [21]. Present study statistics shows significant association between pneumonia and parental smoking. Environmental tobacco smoke (ETS) is another indoor pollutant that reduces local defence mechanisms and predisposes children to invasive infection [22,23]. These include physical defences such as cough and mucociliary clearance, circulating and resident cellular defences and a range of humoral or secretory mechanisms [24]. A study from Brazil noted that ARI in children under five years was not associated with the passive smoking in the family [25]. The Bangladesh study noted that the prevalence of ARI in under-fives in the community was significantly associated with parental smoking (61 vs. 39%) when compared to those without ARI [20]. However, in the prevalence of ARI in under-five years of age, significant difference was not observed with parental smoking in a study from Ahmadabad [16]. On multiple logistic regression, URTI in mother/siblings and maternal education < 10 yrs were found to be independent risk factors for pneumonia. In study by Hemagiri., *et al*. the independent

significant factors included incomplete immunization, maternal literacy, crowding, use of biomass fuel, use of pre lacteal feed, poor nutrition, lack of breastfeeding [14].

Present study validates inability to feed, altered consciousness, grunting as positive and reliable predictors of hypoxemia in infants. In present study among the symptom, inability to feed/drink was significantly associated with hypoxemia. Most sensitive and specific signs were altered consciousness and grunting. In study by Kumar., *et al*. presence of fever >100ºF had 88% sensitivity and 76.4% specificity for diagnosis of bronchopneumonia in an infant [26]. Rijal., *et al*. in their study found that among the symptom, inability to feed/drink was significantly associated with hypoxemia [27]. 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. This study therefore validates WHO criteria for the recognition of children with severe and very severe pneumonia. Inability to feed can predict hypoxemia with both high sensitivity and specificity. Lodha., *et al*. in their study concluded that there are no symptoms or signs which are both sufficiently sensitive and specific to identify hypoxemia. The table 4 shows comparison of findings in other similar studies.

Clinical Features	Present study (%)	Naresh Kumar., *et al*. (%)	Muhi Al Janabi (%)	Rakesh Lodha (%)
Fever	62.5	88	--	--
Cough	75	100	--	--
Refusal of feeds	41.6	22	59	--
Altered Consciousness	17.7	--	12	--
Grunting	13.5	--		9.2
Crepitation	77	100	44	41.3
Bronchial Breath sounds	30.2	--		--
Sub Costal/Intercostal Retraction	78.1	--	95	12.8/17.4
Complications	5.2	--	5	--

Table 4: *Comparison with other studies.*

Conclusion

Current study concludes that poor parental education, incomplete immunization, family history of URTI, poor nutritional status, non-exclusive breast feeding, incomplete immunization, overcrowding, indoor air pollution by biomass fuel, poor housing condition, parental smoking predispose to pneumonia and its complications. Among clinical features presence of inability to feed, grunting and altered consciousness are reliable predictors of hypoxemia in children under five [28].

Contributors' Statement

Dr Saha conceptualized the case report, was involved in the review of the literature and reviewed and revised the manuscript.

Dr Fursule, Dr Kulkarni, Dr Pawale drafted the initial manuscript, edited the manuscript and reviewed the literature.

Dr Fursule collected the data, drafted the initial manuscript and made the tables and graphs.

Dr Malini designed the manuscript critically reviewed the manuscript for important intellectual content. Final editing was done by him.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Conflict of Interest Disclosures

Authors have no conflicts of interest to disclose.

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