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CLINICO RADIOLOGICAL CORRELATION OF COMMUNITY ACQUIRED PNEUMONIA IN CHILDREN AND THEIR UTILITY IN PREDICTING CLINICAL OUTCOME

Paediatrics

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ABSTRACT

Community-acquired pneumonia (CAP) is a leading cause of morbidity and mortality among children, particularly in developing countries. Radiological evaluation, especially chest X-rays, plays a pivotal role in diagnosing and managing CAP in pediatric patients. Accurate interpretation of radiological findings is crucial not only for confirming clinical suspicions but also for evaluating the severity of the disease and predicting clinical outcomes. The present study is conducted to study the clinico-radiological correlation of community acquired pneumonia in children and their utility in predicting clinical outcome. This was a record based observational scientific study conducted from December 2022 to July 2024 at department of paediatrics, tertiary care centre. Total 250 children enrolled in this study & prevalence of community acquired pneumonia was 31%. Age between 6-10 years, clinical symptoms like cough, wheeze, convulsion, cyanosis and sign like chest retraction, crepitation, ronchi, abnormal sound presence of danger sign, requirement of mechanical ventilation, higher PSI score and days of hospitalization were significantly associated with clinical outcome of children with CAP. Overall, the study contributes valuable insights into the clinical and radiological presentation of pediatric pneumonia, reinforcing the importance of timely diagnosis, early and accurate identification of high-risk children, particularly those presenting with severe clinical signs, requiring mechanical ventilation or having prolonged hospital stays, to improve survival outcomes in pediatric CAP.

KEYWORDS

Community-acquired pneumonia, X-ray findings, PSI score

INTRODUCTION

Acute lower respiratory tract infections (ALRTI) are leading cause of morbidity and mortality in young children.[1] The most common childhood illness is acute respiratory infections (ARI). According to recent WHO estimates, ALRTI is responsible for 20% of deaths in children under the age of five, with more than 2 million children under the age of five dying of acute respiratory infection each year, with 90% of these deaths occurring in developing countries.[2]

With nearly 156 million new episodes each year, ALRTI is the leading cause of under-5 childhood morbidity in the world, with India accounting for the lion's share of 43 million. It was estimated that 7-13 percent of the 156 million pneumonia cases diagnosed each year in the world would progress to severe disease and necessitate hospitalisation..[3]

There were approximately 12 million episodes of hospitalisation for severe ALRI and 3 million for very severe ALRI, resulting in approximately 0.3 million deaths in-hospital in young children. 99 percent of these deaths occurred in developing countries, and in-hospital deaths accounted for approximately 19 percent of the total number of ALRI deaths in young children in 2010.[4]

In 2010, infectious diseases killed 4.9 million (64 percent) of the 7.6 million children who died in their first five years of life. Pneumonia was responsible for 1.4 million deaths (18.3 percent) of all deaths in children under the age of five, with 4 percent of those deaths occurring during the neonatal period. Every year, an estimated 4 lakh people die from pneumonia in India, making it the most dangerous country in the world.[5]

Community-acquired pneumonia (CAP) is a leading cause of morbidity and mortality among children, particularly in developing countries. Radiological evaluation, especially chest X-rays, plays a pivotal role in diagnosing and managing CAP in pediatric patients. Accurate interpretation of radiological findings is crucial not only for confirming clinical suspicions but also for evaluating the severity of the disease and predicting clinical outcomes. Chest X-rays are widely used due to their availability, cost-effectiveness, and ability to reveal key features such as lobar consolidation, interstitial infiltrates, and pleural effusion. However, interpreting these images in children is challenging, as radiological features of CAP often overlap with those of other respiratory conditions like viral infections, which require different management approaches.[144]

The diagnosis of pneumonia is based mainly on clinical parameters including respiratory symptoms and signs, which incur no cost and are sensitive, but are also nonspecific and could lead to unnecessary prescription of antibiotics and drug resistance. According to World Health Organization (WHO) guidelines, severe pneumonia is diagnosed when there is cough and fast breathing (defined based on respiratory rate for age) with one or two of the severity signs including chest in-drawing (in infants <2 months of age), grunting, cyanosis, inability to feed, lethargy, or convulsion[6]

Chest X-ray (CXR) has been the main stay modality in the investigation of chest infection since its invention in the late 19th century, despite the advances in imaging modalities[7]. The WHO recommends CXR for all patients clinically diagnosed with severe pneumonia at tertiary centers.[8–11] Chest radiograph improves the diagnosis of pediatric community acquired pneumonia to a certain degree and may prevent overtreatment with antibiotics.[12] However, it is important to understand that interpretation is subject to perceptual and cognitive limitation and errors.[13]

The present study is conducted to study the clinico-radiological correlation of community acquired pneumonia in children and their utility in predicting clinical outcome.

METHODOLOGY

This was a record based observational scientific study conducted from December 2022 to July 2024 at department of paediatrics , tertiary care centre. Children aged 1 months to 14 years with community acquired pneumonia were enrolled in this study by simple random sampling method. Sample size was calculated using formula $N = [Z_{1-\alpha/2}{}^2 * P * (1-P)]/ d^2$ with prevalence of acute lower respiratory tract infection is (31.9%).[14] Calculated sample size was 232 but total 250 patients were enrolled in this study. Children with diagnosed Tb cases and HIV cases ventilator associated pneumonia and hospital acquired pneumonia & Pneumonia in immunocompromised state and in chronic lung disease were excluded. Data related to clinical history including symptoms like (fever cough cold rapid breathing and their duration) clinical examination finding (temperature, heart rate, respiratory rate, spo2, cyanosis, pallor, icterus, edema), systemic examination finding in chest (crepitations, crackles, wheeze, ronchi, rales, chest retractions ,suprasternal retractions), radiological finding and other history of breast feeding, immunisation, development, anthropometry, overcrowding, indoor air pollution etc.

The data were collected and entered in Microsoft Excel sheet and then

statistically analyzed using SPSS version 20.0. Continuous variables were expressed as means+_SD and categorical variables were summarized as frequencies and Percentage for comparing continuous variables one-way ANOVA was used and for categorical variables chi-square test Was used .P values <0.05 was considered statistically significant and p value <0.001 was considered statistically highly Significant.

RESULTS

Total 800 children were attended the paediatric OPD, out of that 250(31%) were had community acquired pneumonia. About 50.8% patients were from 11–14-year age group, 60.1% were male. About 62.8% patient had kutcha house and 59.2% (148) were LPG user. Most of the cases were from middle class. Almost all patient had smoking exposure. Most of the patients 184 (73.6%) were totally immunized, 121 (48%) patient had no malnutrition. (Table 1) Cough was most common presenting symptoms. (fig 1) Lethargy (41.6%) & stridor (27.2%) was more prevalent among danger sign while convulsion was least common (4%) (fig 2). Bronchopneumonia 115 (46%) was most common finding. (Fig 3)

Table 1: Distribution Of Children According To Demographic Parameter

Demographic parameter		Frequency	Percentage
Age group	1 Month - 5 Years	80	32%
	6-10 years	43	17.20%
	11-14 years	127	50.80%
Sex	Male	151	60.40%
	Female	99	39.60%
Type of House	Pucca House	93	37.20%
	Kutcha House93	157	62.80%
Type of Fuel	LPG	148	59.20%
	Non-LPG	102	40.80%
SES	Upper	43	17.20%
	Upper middle	60	24%
	Lower middle	78	31.20%
	Upper lower	47	18.80%
	Lower	22	8.80%
Smoking Exposure	With parental smoking	126	50.40%
	Without parental smoking	124	49.60%
Immunization Status	Totally immunized	184	73.60%
	Partially Immunized	48	19.20%
	Un immunizes	18	7.20%
Feeding practices	Exclusively Breast feed	193	77.20%
	Bottle feed	57	22.80%
PEM Status	Normal	121	48.40%
	Grade I	43	17.20%
	Grade II	60	24%
	Grade III	12	4.80%
	Grade IV	14	5.60%

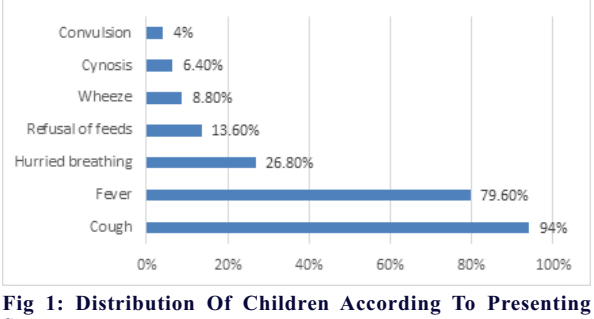

Fig 1: Distribution Of Children According To Presenting Symptoms

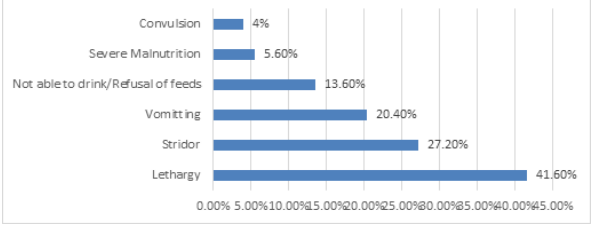

Fig 2: Distribution Of Children According To Danger Sign

Table 2: Distribution Of Children According To Clinical Parameter

Clinical parameter		Frequency	Percentage
Clinical Sign	Crepitation	55	22%
	Abnormal Breath Sounds	49	19.60%
	Chest retraction	34	13.60%
	Ronchi	17	6.80%
Mode of oxygen	02 Nasal prongs	95	385.00%
	Mask	39	15.60%
	CPAP	60	24%
	BiPAP	11	2.50%
	Mechanical Ventilation	45	18%
PSI Score	I	68	27.25%
	II	78	31.20%
	III	90	36.40%
	IV	3	0.80%
	V	11	4.40%
Radiological pattern	Bacterial Infection	145	58%
	Lobar Consolidation	40	16.40%
	Alveolar Infiltatres	17	6.80%
	Viral	10	4%
	Normal	68	27.20%
Blood culture	Positive	84	33.60%
	Contaminated	36	14.40%
	Not sent	90	36.00%
	No growth	40	16.00%
Duration of hospitalization	<3 Dyas	70	28%
	4-7 Days	105	42%
	8-14 Days	30	12%
	>14 Days	45	18%
Outcome	Discharge	237	94.80%
	Dead	13	5.20%

On chest auscultation crepitation 55 (22 %) was most common finding, Oxygen requirement at admission fulfilled by o2 nasal prongs in 95(38%) cases, 68 patients fell into the no pneumonia category (PSI-I), 168 had pneumonia (PSI-II & III), 3 had severe pneumonia (PSI-IV), and 11 were classified as very severe pneumonia (PSI-V).

Most of the x-ray 145 (58%) were probably suggestive of the bacterial infection, 84 (33.6%) were positive had blood culture. About 105(42%) had stay between 4-7 days, while 70(28%) patient had stay of less then 3 days. Out of 250 patients, 237 (94.8%) were alive at the end of the study period, while 13 (5.2%) had died. (Table 2)

Table 3: Distribution Based On Respiratory Rate At Admission

Age group	Respiratory rate	Frequency	Percentage
1month-1 Year (n =20)	>80/ min	3	15%
	60-80/min	5	25%
	<60/ min	12	60%
1 Year- 5 Year (n =60)	>60/ min	10	16.60%
	50-60/ min	35	59%
	40-50/ min	15	25%
	4-7 Days	14	51.85%
	8-14 Days	3	11.11%
	>14 Days	10	37.04%

In age group below 1 year out of 20 cases 60%(12) cases had respiratory rate within 60/min while 25 % (5) had respiratory rate between 60-80 per min while 15%(3) had respiratory >80 per min. (Table 3) In our study ,those with normal x-ray most patient (53) had less then 3 days stay rest 15 patients had stay for 4-7 days, In Bronchopneumonia category 60 had stay for 4-7 days, in lobar pneumonia category 16 patient were admitted for 4-7 days. (Table 4)

Table 4: Chest X Ray Finding And Duration Of Stay

X-ray Findings	Days of hospitalization	Frequency	Percentage
Normal	<3 Dyas	53	77.94%
	4-7 Days	15	22.06%
	8-14 Days	0	0.00%
	>14 Days	0	0.50%
Bronchopneumonia	<3 Dyas	11	9.57%
	4-7 Days	60	52.17%
	8-14 Days	22	19.13%
	>14 Days	22	19.13%

Lobar Pneumonia	<3 Dyas	6	15%
	4-7 Days	16	40%
	8-14 Days	5	12.50%
	>14 Days	13	32.50%
Interstitial Pneumonia	<3 Dyas	0	0.00%
	4-7 Days	14	51.85%
	8-14 Days	3	11.11%
	>14 Days	10	37.04%

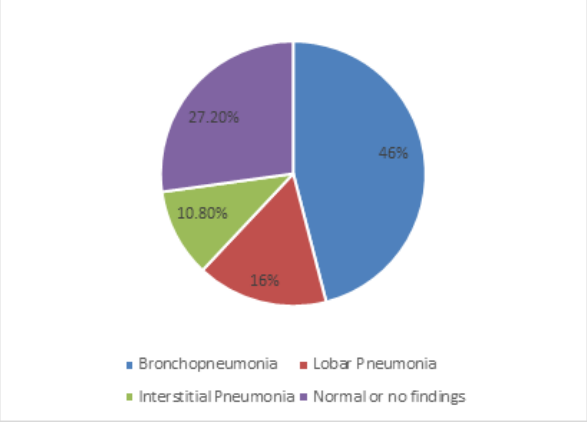

Fig 3: Distribution Based On Radiological Pattern On X-ray

Table 5: Association Between Clinic-social Parameter And Outcome

		Discharge		Dead		p Value
		Fre-quency	Percen-tage	Fre-quency	Percen-tage	
Age group	1 Month - 5 Years	78	32.9	2	15.4	0.0159
	6-10 years	37	15.6	6	46.2	
	11-14 years	122	51.5	5	38.5	
Sex	Male	144	60.8	7	53.8	0.619
	Female	93	39.2	6	46.2	
Symptoms	Cough	225	94.9	10	76.9	0.0077
	Fever	186	78.5	13	100	
	Hurried breathing	54	22.8	13	100	
	Refusal of feeds	21	8.9	13	100	
	Wheeze	10	4.2	12	92.3	<0.0001
	Cynosis	7	3	9	69.2	<0.0001
	Convulsion	2	0.8	8	61.5	<0.0001
Danger Sign	Lethargy	21	8.9	13	100	
	Stridor	45	19	6	46.2	0.0179
	Vomiting	2	0.8	8	61.5	<0.0001
	Not able to drink/ Refusal of feeds	92	38.8	12	92.3	<0.0001
	Severe Malnutrition	56	23.6	12	92.3	<0.0001
	Convulsion	6	2.5	8	61.5	<0.0001
Clinical sign	Crepitation	25	10.5	9	69.2	<0.0001
	Abnormal Breath Sounds	48	20.3	7	53.8	0.0044
	Chest retraction	12	5.1	5	38.5	<0.0001
	Ronchi	38	16	11	84.6	<0.0001
Mode of oxygen	02 Nasal prongs	95	40.8	0	0	
	Mask	39	16.45	0	0	
	CPAP	60	25.31	0	0	
	BiPAP	10	4.21	1	7.6	0.552
	Mechanical Ventilation	33	13.92	12	92.4	<0.0001
PSI Score	I	68	28.7	0	0	
	II	78	32.9	0	0	
	III	90	37.97	0	0	
	IV	1	0.4	2	15.38	<0.0001
	V	0	0	11	84.6	
Radiological pattern	Bacterial	106	44.72	9	69.23	0.084
	Lobar Con-solidation	36	15.25	4	30.76	0.135
	Alveolar Infiltrates	7	7.1	0	0	
	Viral	10	4.21	0	0	
	Normal	68	28.69	0	0	
Clinical Diagnosis	Bronchopneumonia	106	44.72	9	69.23	0.084
	Lobar Pneumonia	36	15.25	4	30.6	0.135
	Interstitial Pneumonia	27	11.39	0	0	
	Normal or no findings	68	28.69	0	0	
Duration of hospitalization	<3 Dyas	69	29.1	1	7.7	0.0044
	4-7 Days	102	43	3	23.1	
	8-14 Days	28	11.8	2	15.4	
	>14 Days	38	16	7	53.8	

Age between 6-10 years, clinical symptoms like cough, wheeze, convulsion, cyanosis and sign like chest retraction, crepitation, ronchi, abnormal sound presence of danger sign, requirement of mechanical ventilation, higher PSI score and days of hospitalization were significantly associated with clinical outcome of children with CAP. (Table 5)

DISCUSSION

Community-acquired pneumonia (CAP) is a leading cause of morbidity and mortality among children, particularly in developing countries. Radiological evaluation, especially chest X-rays, plays a pivotal role in diagnosing and managing CAP in pediatric patients. Accurate interpretation of radiological findings is crucial not only for confirming clinical suspicions but also for evaluating the severity of the disease and predicting clinical outcomes. Chest X-rays are widely used due to their availability, cost-effectiveness, and ability to reveal key features such as lobar consolidation, interstitial infiltrates, and pleural effusion. However, interpreting these images in children is challenging, as radiological features of CAP often overlap with those of other respiratory conditions like viral infections, which require different management approaches.[15]

Several studies have highlighted the importance of correlating clinical findings with radiological evidence to improve diagnostic accuracy and guide treatment strategies.[16,17] The present study aims to explore the clinico-radiological correlation of community-acquired pneumonia in children and assess the utility of chest X-rays in predicting clinical outcomes.

The age and gender distribution in this study shows higher incidence of pneumonia in the 11–14-year age group, comprising of 50.8% with male predominance (60.1%). This observation aligns with previous research indicating a notable incidence of pneumonia in older children.[15,18] In contrast, our data reveals a lower incidence among younger children, with only 32% of patients aged 1 month to 5 years and 17% aged 6 to 10 years. This distribution reflects trends observed in prior studies[16,17] Furthermore, the gender distribution in current study indicated that 60.1% of patients were male and 39.6% were female, suggesting a male predominance in cases of CAP. Similar findings were observed in the study conducted by in Goyal DK et al[16]. The findings from present study reveal that cough was the predominant symptom. This aligns with previous research that highlights cough as a hallmark sign of pneumonia in children, indicating its role as a primary clinical manifestation in this population.[19] Similarly, in Kumar AMK et al[14] study majority of children presented with cough and fever. Regarding danger signs, lethargy and stridor were more prevalent

among the study's population. Hazir et al[20] identified lethargy as a strong indicator of severe pneumonia, correlating it with adverse outcomes in over 35% of cases, a rate similar to what was observed in the current study. A majority of patients, 184 (73.6%), were fully immunized against common pathogens associated with pneumonia, which is comparable with the study done by Vinaykumar et al[21]. In present study, 77.2% of infants were reported to be exclusively breastfed, while 22.8% received bottle feeding. This rate aligns with findings from Pandolfi E et al[22]. Regarding the nutritional status of the patients, the study found that 48% of children had no malnutrition, while there were notable cases of Protein-Energy Malnutrition (PEM), with 4.8% classified as grade 3 and 5.6% as grade 4. In Vinaykumar et al[21] study, the majority of the SP-affected children had grade I (54.17%) and II (77.78%) malnutrition. A previous study by Pandolfi E et al[22] have linked poor housing conditions to a higher incidence of respiratory illnesses in children, often due to factors such as crowding, inadequate sanitation, and exposure to environmental hazards.[149] The cooking fuel analysis showed that 59.2% of families used LPG, while 40.8% relied on non-LPG sources. The use of traditional fuels has been associated with increased indoor air pollution, which poses health risks, especially for children.[149] Economic status was another factor assessed, with a considerable percentage of patients from the middle class (upper middle 24% and lower middle 31.2%). In Vinaykumar et al[21] study majority of the children with severe pneumonia in the present study belonged to upper lower (IV) and lower middle (III) class. The present study observed respiratory rates among children with pneumonia across different age groups, highlighting that in the group under 1 year, 60% (12 out of 20 cases) had a respiratory respiratory rate within 60 breaths per minute, while 25% (5 cases) exhibited rates between 60-80 breaths per minute, and 15% (3 cases) had rates exceeding 80 breaths per minute. This distribution is consistent with findings from earlier studies[141-143], which indicate that elevated respiratory rates are commonly associated with acute respiratory infections in infants. In the current study, the most prevalent clinical sign observed during chest auscultation was crepitations, this finding is consistent with previous research conducted by Goyal DK et al et al[16], Kumar AMK et al[14] and Barnett ED et al.[23] The current study observed that the majority of patients required oxygen support at admission, with nasal prongs being the most utilized method. This finding is consistent with prior research by Kumar AMK et al[14] and Barnett ED et al[23] that indicates nasal prongs as a common initial intervention for delivering supplemental oxygen, particularly in children with mild to moderate respiratory distress. The study identified bronchopneumonia as the most prevalent chest X-ray finding, which is comparable with the study done by Goyal DK et al.[16] The current study reported that 145 out of the evaluated chest X-rays (58%) were suggestive of bacterial infection, This finding was comparable with the study done by Bakka S and Vasundhara N.[24] and Rees CA et al[25]. In the present study patients with normal X-ray findings, the majority (53 out of 68) had a length of stay of less than 3 days, while the remaining 15 patients stayed for 4-7 days. Earlier research[16,17] has demonstrated that normal chest X-rays often allow for quicker discharges, suggesting that such findings correlate with milder disease presentations. . Hazir T et al[20] found that the length of stay was strongly associated with the severity of pneumonia, particularly in cases of bronchopneumonia and lobar pneumonia, where a longer hospital stays often correlated with adverse outcomes. Out of the 250 patients, 84 (33.6%) had positive blood cultures, 36 (14.4%) were contaminated, 40 (16%) showed no growth, and blood cultures were not sent for 90 (36%) cases. These findings are in line with study conducted by Lee CH et al[18] noted that a significant proportion of cases (approximately 30%) were positive for blood cultures in patients with febrile neutropenia, which is comparable to the 33.6% positivity rate in our study. In present study, the distribution of pneumonia severity based on the Pneumonia Severity Index (PSI) revealed that 68 patients fell into the no pneumonia category (PSI-I), 168 had pneumonia (PSI-II & III), 3 had severe pneumonia (PSI-IV), and 11 were classified as very severe pneumonia (PSI-V). These findings are consistent with prior studies that have utilized the PSI to categorize pneumonia severity and predict patient outcomes. In the present study, 46% of cases were diagnosed with bronchopneumonia. Jain et al[26] conducted a comprehensive study on CAP and found that bronchopneumonia accounted for 40-50% of pneumonia cases, similar to the 46% observed in our study. In present study, the majority of children (42%) had a hospital stay of 4-7 days. Similarly, Williams et al[27] similarly found that the majority of pediatric patients hospitalized for respiratory infections had a stay of 4-6 days. Out of 250 patients, 237 (94.8%) were alive at the end of the study period, while 13 (5.2%) had died which is comparable to the findings in similar studies by Williams et al[27]

In the present study, found that statistically significant difference in outcomes based on age. Similarly Jain et al[26] observed a similar findings in their study. Although the survival rate was slightly higher among male children compared to females, the difference was not statistically significant ($p = 0.619$). These findings align with previous studies done by Bradley et al[28]. In the present study, we observed that danger signs such as convulsions, lethargy, stridor, and severe malnutrition were significantly associated with higher mortality in children diagnosed with community-acquired pneumonia (CAP). These findings are consistent with previous studies conducted by Rudan et al[3] In the present study, clinical signs such as chest retractions, crepitations, rhonchi, and abnormal breath sounds were significantly associated with higher mortality in children diagnosed with CAP. A study by Duke et al[29] found that chest retractions were strongly associated with severe pneumonia and higher mortality rates in children. In the present study, we found that children requiring mechanical ventilation at the time of admission had a significantly higher risk of mortality, with a p-value of <0.0001. This finding is consistent with previous research done by Goyal DK et al[16] The children with alveolar infiltrates, viral patterns, or normal X-rays had favorable outcomes with no reported mortality. While bacterial patterns, particularly lobar consolidation, were associated with higher mortality. This finding aligns with a study by Mahabee-Gittens et al[30]. In the present study, we observed that children with higher Pneumonia Severity Index (PSI) scores, particularly those classified into Classes IV and V, were at a significantly greater risk of mortality. Similarly, Fine et al[31], who originally developed the PSI score, reported that patients categorized in Classes IV and V had a markedly higher risk of mortality compared to those in lower classes. The present study found that a relatively high survival rate among children with bronchopneumonia, which is consistent with the findings of Harris et al[32]. The highest mortality rate (53.8%) was observed in children who had hospital stays longer than 14 days, whereas those with shorter hospital stays of less than 3 days exhibited significantly lower mortality rates. The p-value of 0.0044 indicates a statistically significant relationship between the duration of hospital stay and clinical outcomes. This finding aligns with previous research done by Nair et al[4] found that children with severe pneumonia requiring extended hospital care had higher mortality rates, particularly those who stayed beyond two weeks.

CONCLUSION

This study highlights the significant burden of LRTIs, particularly pneumonia, among hospitalized children. The majority of cases presented with cough, fever, and lethargy, with bronchopneumonia being the most frequent diagnosis on chest X-ray. The predominance of bacterial patterns such as lobar consolidation and alveolar infiltrates supports the utility of X-ray in diagnosing bacterial pneumonia, while the lower prevalence of viral patterns reflects the challenges of detecting viral pneumonia radiologically. Moreover, the significant proportion of normal X-rays, despite clinical suspicion of pneumonia, emphasizes the need for comprehensive clinical evaluation in pediatric pneumonia cases. These findings reinforce the utility and limitations of chest X-rays in guiding the diagnosis and management of community-acquired pneumonia in children.

Overall, the study contributes valuable insights into the clinical and radiological presentation of pediatric pneumonia, reinforcing the importance of timely diagnosis, early and accurate identification of high-risk children, particularly those presenting with severe clinical signs, requiring mechanical ventilation or having prolonged hospital stays, to improve survival outcomes in pediatric CAP.

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