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Community-acquired Pneumonia in Hospitalized Urban Young Nigerian Children: Clinical and Haematological Correlates of Diagnosis and Outcome

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Summary

Johnson A'WBR, Aderele WI, Osinusi KO, Gbadero DA. Community-acquired Pneumonia in Hospitalized Urban Young Nigerian Children:Clinical and Haematological Correlates of Diagnosis and Outcome. *Nigerian Journal of Paediatrics* **2001:28:101.** As part of a comprehensive hospital-based study of acute lower respiratory infections (ALRI) in under-five urban Nigerian children, we sought to identify the possible clinical and investigative correlates of lobar versus bronchopneumonia, and the possible determinants of mortality in community-acquired pneumonia. Over a 30-month period, 419 cases of ALRI were studied; pneumonia accounted for 323(77.1 per cent) of these. Of those with pneumonia, bronchopneumonia (BP) was diagnosed in 234 (72.4 per cent), lobar pneumonia (LP) in 66 (20.4 per cent), while 23(7.1 per cent) had features of both. BP alone (BPA) and LP alone (LPA) without concomitant respiratory syndromes were diagnosed in 127(39.4 per cent) and 39 (12.1 per cent) cases , respectively. Although there was an overall annual preponderance of BP admissions, the peak admissions for LP was recorded in the harmattan months of November through January. The overall mean age was 15.7 months, but compared with those with LPA, BPA cases were significantly younger (mean ages, 14.2 ±13.8mo. for BPA vs. 19.5±14.2mo. for LPA, p=0.021), had a significantly shorter mean duration of cough (p=0.044), and a higher prevalence of convulsion (p=0.02). Furthermore, concomitant measles, heart failure, and severe anaemia were significantly commoner among cases with a diagnosis of BP (p=0.018, 0.033, & 0.009 respectively). On the other hand, LPA cases were associated with a significantly higher prevalence of cigarette smoking in the household (p=0.038; RR=1.86; 95%CI=0.93-5.80), grunting respiration (p=0.01), and a higher mean admission temperature (p=0.03). Also, pleural effusion and sickle cell disease correlated more frequently with a final diagnosis of LP (p=0.00 & 0.01 respectively). Similarly, compared with BPA cases, significantly higher white blood cell (WBC) counts and polymorphs were recorded in LPA cases (p=0.002 & 0.01). A fatal outcome was recorded in 35(10.8 per cent) cases. Mortality was significantly higher in those with pre-admission antimicrobial use (p=0.04), a combination of diarrhoea and vomiting (p=0.025), domestic firewood burning (p=0.023), and malnutrition (p=0.0003). A fatal outcome was also significantly associated with longer symptom duration for cough (p=0.002), fever (p=0.002), poor feeding (p=0.016), higher mean WBC counts and polymorphs (p=0.013 & 0.023 respectively). Harmattan season, grunting respiration, longer symptom-duration, and pleural effusion correlated most frequently with a final diagnosis of LP, while a younger age, anaemia, heart failure and measles were more frequently associated with BP. The association of fatality with malnutrition, pre-admission antibiotic use, concomitant alimentary symptoms, longer symptom-duration, and high WBC/polymorph counts suggests the need for factoring these parameters into evolving a regional paediatric pneumonia severity index and therapeutic decision algorithms.

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Introduction

AN estimated one-third of the 12-15 million annual deaths in under-five children has been ascribed to acute respiratory infections (ARI).[1-3] Pneumonia alone accounts for over 75 per cent of ARI-related mortalities and 22-28 per cent of all paediatric deaths.[1,4] In spite of these awesome ARI-related mortality statistics, a commensurate research priority and control strategies have evolved only in the last decade-and-a-half.[5] The potential therapeutic value of a pathogen-based diagnostic screening remains incontrovertible,[5-7] but its clinical usefulness in third-world countries has been largely stalled by the logistic limitations of collecting safe and appropriate clinical specimens, non-

availability of facilities, and the cost of comprehensive microbiological investigations.[2,8,9] Thus, against the background of these subsisting investigative limitations, there is a dire need for evolving simple, and yet sufficiently sensitive diagnostic tools for identifying severe cases for in-patient care. Besides enabling the practitioner to make a more judicious use of available investigative modalities, a knowledge of sufficiently discriminative correlates of the diagnostic categories of community acquired pneumonia (CAP), and the possible determinants of disease outcome, would undoubtedly enable the clinician to set appropriate management goals, encourage an earlier anticipation and treatment of possible complications.[6] With the aim of enhancing a more accurate diagnostic evaluation and hence, appropriate management of CAP, we report the clinical and investigative correlates of lobar versus bronchopneumonia, as well as the short-term prognostic determinants of CAP in pre-school children.

Patients and Methods

Study Population and Setting

This study was carried out over a 30-month period (March 1, 1985 - August 30, 1987) at the Children's Emergency Ward of the University College Hospital (UCH), Ibadan in south-western Nigeria. The relevant background data on the catchment population and the study setting had been detailed in an earlier communication.[10]

Subjects' Selection and Data Collection

Children aged 2 weeks – 59 months with symptom-complex of a lower respiratory infection, who satisfied the ALRI syndrome definition of Denny and Clyde[11] were recruited prospectively on alternate weekdays. For the purpose of determining disease prevalence and seasonality, a separate register of all paediatric ALRI admissions (from two weeks to 12 years of age) was compiled regardless of study eligibility. A maximum of four eligible cases per week were studied to allow for detailed clinical and laboratory evaluation, but up to six subjects were recruited if there was a shortfall in the preceding week. The present communication concerns the subset whose ALRI symptomatology and radiographic findings were consistent with the syndrome definition of pneumonia,[11] with or without the clinical features of measles, or pertussis. Using a pre-coded questionnaire, the relevant disease symptoms and physical signs were recorded, as were selected risk factors[5] such as immunization status, feeding practices, household circumstances including indices of overcrowding, the presence or otherwise, of domestic cigarette and culinary smoke exposure, and the relevant parental socio-economic variables. Socio-economic categorization was based on the criteria of Oyedeji,[12] while demographic, socio-economic, and some locally relevant household parameters/risk-factors of ALRI[5,13] were identified according to the CAP diagnostic categories. Anthropometric parameters were also determined to enable subsequent nutritional categorization, using the Wellcome criteria.[14] Details of treatment, clinical progress and outcome parameters (i.e. death, survival and duration of stay) were subsequently recorded in the pre-coded proforma. Convalescence sera were obtained at the follow-up consultations in the respiratory clinic.

Consents

Institutional approval was obtained before the commencement of the study from the UCH Ethical Committee. Informed consent was obtained from parents/guardians after a preceding detailed explanation of the goals of the study, and what it entailed. No potential subject, whose parents/guardians refused to give consent, was denied the usual prompt initiation of appropriate treatment measures.

Laboratory Investigations

Except when considered clinically inexpedient, or precluded by logistic considerations, each subject was investigated as follows:

a) A postero-anterior (PA) chest radiograph to confirm the diagnosis of pneumonia, delineate the anatomical extent, identify pleural and other intra-thoracic complications, as well as some associated ALRI syndromes like bronchiolitis.[10,11] A few subjects with concomitant upper airway symptom-complex had cervical radiographs to exclude features of associated croup, epiglotittis or retropharyngeal abscess.[11,15] Radiographic films were reported along with other routine radiographs from the ward, by consultant radiologists who were not part of the study.

b) Haematocrit, white blood cell and differential counts were obtained. In addition, a few cases with significant anaemia at presentation had haemoglobin genotype determined.

c) Viral pathogens were sought from immuno-fluorescence (IF) examination of naso-pharyngeal aspirates (NPA) and serological analyses, while the diagnosis of a bacterial aetiology was made principally from blood cultures. A few had bacteriological studies of pleural aspirates. Also, those who had poor response, or deterioration after empirical antimicrobial therapy, and those with a fatal outcome soon after admission had lung aspirates taken for microscopy, culture and sensitivity. Laboratory techniques for the virological and bacteriological analyses had been detailed elsewhere.[9,10]

Treatment

Each subject received standard supportive therapy and empirically chosen antimicrobials based on pre-study institutional practice at the UCH for paediatric pneumonia.

Packed cell transfusions, digoxin, closed thoracostomy tube drainage, and oxygen therapy were given as appropriate.

Outcome Variables

Diagnostic categorization was based on radiographic corroboration of the clinical findings. Outcome variables comprised "death" or "survival." Clinical improvement without complete resolution of the presenting symptoms and signs was designated as "partial recovery," while those with little or no residual symptomatology at discharge, were adjudged to have "full recovery." The duration of hospital stay was recorded for both fatal cases and survivors.

Statistical Analyses

Significant differences were sought in the distribution of demographic/host-related, clinical and haematological variables among the major diagnostic categories, and in relation to the outcome variables. The chi-squared (with or without Yates' or Mantel-Haenzel correction), or the Fisher's exact tests (FET) were used for categorical variables, and the Student's t-test, and/or the analysis of variance (ANOVA) for continuous variables. Significance was presumed if the p-value was < 0.05. In appropriate cases, the relative risks (RR), odds ratios (OR), and the 95% confidence intervals (95%CI) were determined using the EPI-INFO 6 statistical package (May 1994 version) of a micro-computer.

Results

Over the 30-month study period, the children's emergency room recorded 1,306 admissions; 419(32.1 per cent) of these, comprising those eligible by virtue of age and symptom-duration were recruited for the ALRI study. Of the 419 cases, croup was diagnosed in 29(6.4 per cent), bronchiolitis in 67(16.0 per cent), and pneumonia (with or without other respiratory syndromes) in 323(77.1 per cent). The croup: bronchiolitis: pneumonia ratio was 1:2.3:11.

Fig. 1 shows the gender-related diagnostic categories of the 323 cases with pneumonia. Accounting for 234(72.4 per cent) of the 323, bronchopneumonia (BP) was diagnosed in a significantly higher proportion of cases compared with the 66(20.4 per cent) with lobar pneumonia (LP)($p=0.00$; $\chi^2=60.7$; $df=1$). The remaining 23(7.1 per cent) cases had features of both BP and LP. Of the 234 cases with BP, 127(54.3 per cent) had bronchopneumonia alone (BPA), 107 others had concomitant respiratory syndromes. These included 56(23.9 per cent) with concomitant measles (with or without croup), 20(8.5 per cent) with bronchiolitis, 18(7.7 per cent) with pleural complications (i.e. pleural effusion ± pneumothorax), and eight (3.4 per cent) pertussis. One case of BP also had retropharyngeal abscess. On the other hand, of the 66 cases with LP, 39(59.1 per cent) had lobar pneumonia alone (LPA), 24(36.4 per cent) had associated pleural complications, while concomitant measles, croup and bronchiolitis were diagnosed in one case (1.5 per cent) each. With a coexisting bronchiolitis in 20(8.5 per cent) of the 234 cases of BP, as against one (1.5 per cent) case in the LP category of 66 cases, acute bronchiolitis was more frequently diagnosed in BP cases ($p=0.033$,1-tailed FET). Also, non-measles associated laryngotracheobronchitis (croup) coexisted with BP in nine (3.9 per cent) cases, as against one case (1.5 per cent) with LP.

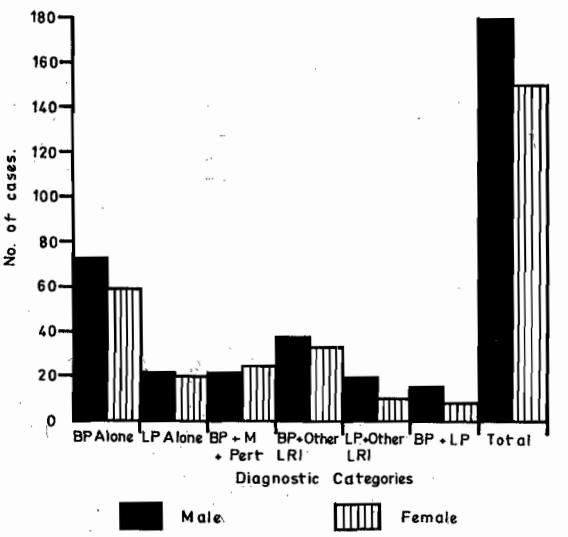

Fig. 1. Diagnostic categories and gender distribution in 323 cases of community- acquired pneumonia. Note the significantly higher proportion of cases in whom a diagnosis of bronchopneumonia alone (BP Alone) was made when compared with that of cases with isolated lobar lesions. An overall majority of male subjects is also evident.
ALRI = Acute lower respiratory infection(s); BP = Bronchopneumonia; LP = Lobar pneumonia
M = Measles; Pert.= Pertussis (Whooping Cough)

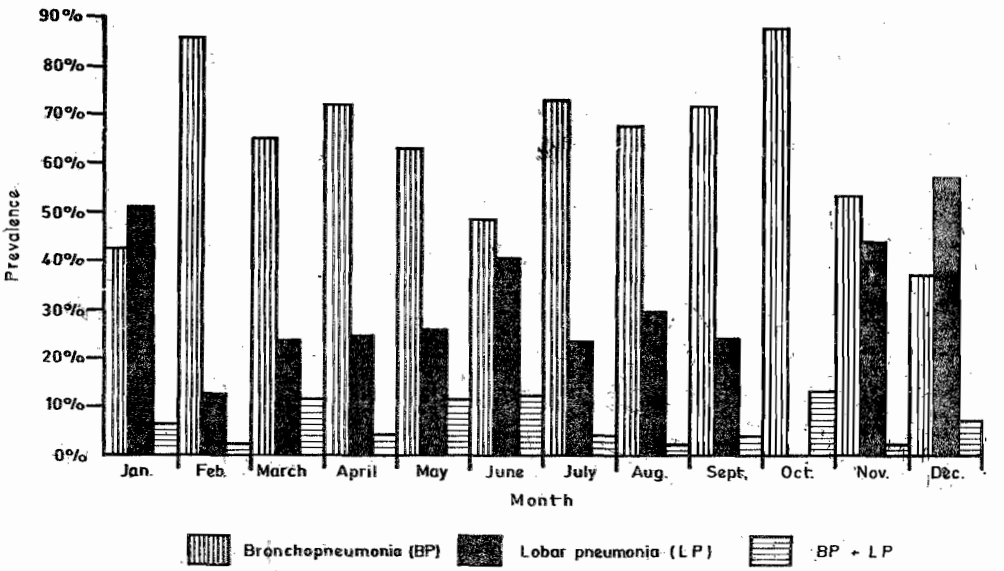

Fig. 2. Seasonal prevalence of paediatric community-acquired pneumonias according to the final diagnoses. Note the overall annual preponderance of BP - related admissions, compared to those of LP.

Figure 2 shows the seasonal distribution according to the final diagnoses. A significantly greater proportion of all cases {180[55.7 per cent]} presented during the wet season (April-September), compared with the proportion {143(44.3 per cent)} seen during the dry season (October-March) ($p=0.04$; $\chi^2=4.22$; $df=1$). In contrast to an overall annual preponderance of BP admissions {168 (75.7 per cent) of BP, versus 54(24.3 per cent) of LP}, the harmattan stretch (November through January) recorded the highest prevalence of LP admissions; 47(56.6 per cent) of the total of 83 cases seen during the harmattan season had a final diagnosis of LP, as against 36 (43.4 per cent) with BP. However, the difference in the proportions of BP and LP admissions in the harmattan season did not reach a significant level ($p= 0.24$, $\chi^2 = 1.38$, comparisons of proportions). With 128 of the 234 cases of BP, as against a corresponding 37 of the 66 with LP presenting during the rainy season, the wet seasonal prevalence was comparable for BP and LP cases ($p=0.84$; $\chi^2=0.04$).

Diagnostic Categories and Selected Epidemiological and Host-Related Risk Factors

Table I shows the distribution of some selected epidemiological and host-related risk factors of CAP in the 323 cases, according to the diagnostic categories. The gender distribution, nutritional categories, immunization status, as well as the pre-consultation use of antimicrobials were comparable among subjects with LPA and BPA (Table I). However, compared with that of LPA cases, the mean age of subjects with BPA was significantly lower (t-value=2.06; $p=0.02$; F-statistics=4.28; $p=0.04$). With regard to the comparative prevalence of some domestic risk factors, none of the mothers indulged in cigarette smoking, but paternal cigarette smoking was significantly commoner in the LPA category ($p=0.038$; $\chi^2=0.32$; RR=1.86; OR=2.38; 95%CI=0.93-5.80). It is noteworthy that only 16.7 per cent of the entire CAP cohort of 323 cases had potential exposure to the combustive products of domestic cooking with firewood. This contrasts with a corresponding prevalence of 92 per cent who came from homes where kerosene was the regular cooking fuel with occasional use of cooking gas, or fire-wood. Furthermore in 67.8 per cent of cases, the cooking area was located in one of either the common corridor, in close proximity to the sleeping room, or in a poorly ventilated kitchen area within the apartment. Approximately 38 per cent of the entire cohort came from overcrowded homes, but the prevalence of overcrowding was comparable in LPA and BPA cases (Table I).

Clinical Parameters, Associated Conditions/Complications and Diagnostic Categories

Table II shows the comparative prevalence and duration of some selected clinical parameters among the d gnostic categories. Despite a comparable frequency of cough among subjects with LPA and BPA ($p=0.35$), its mean duration was significantly longer in LPA subjects ($p=0.04$; $t=1.72$). The mean duration of fever as a symptom was however, comparable in the two diagnostic categories. Besides a significantly higher prevalence of convulsion in BPA cases ($p=0.02$), the prevalence and duration of other symptoms were comparable across the diagnostic divide (Table II). The diagnostic distribution of some selected physical signs are shown in Table III. LPA subjects recorded a significantly higher mean temperature at admission than their peers with BPA ($p=0.03$; $t=1.92$). Grunting respiration was also significantly commoner in LPA subjects (12.8 per cent vs. 1.6 per cent; $p=0.01$; $\chi^2=6.77$).

With regard to the comparative diagnostic distribution

Table I

Distribution of Demographic/Host-related Parameters, and Household Risk factors According to Diagnostic Categories of Pneumonia

	Lobar pneumonia Alone(LPA)	*Broncho-pneumonia Alone(BPA)*	*Mixed Lesions¶*	*All Cases(%)*	*LPA vs. BPA. t / F-stats. / χ^2 (p-value)*
Demographic/ host factors					
Age (Months)					
< 12	16	69	74	159(49.2)	
12 – 24	11	34	46	91(28.2)	2.48(0.12)
> 24	12	24	157	73(22.6)	
Mean (n)	19.46(39)	14.24(127)	12.61(23)	15.72(323)	
Range (SD) **	1-52(14.15)	1-59(13.78)	1-48(12.73)	1-59(13.45)	2.06(0.02) §
Gender					
Male	20	70	87	177(54.8)	
Female	19	57	70	146(45.2)	0.18(0.674)
Nutritional Status					
Satisfactory	19	55	67	141(43.7)	
Underweight	14	53	77	144(44.6)	0.47 (0.79)
Severe malnutrition¶¶	6	18	12	36(11.2)	
Unknown*	-	1	1	2(0.6)	
Immunization					
Yes	30	89	106	225(69.7)	
No	9	35	46	90(27.9)	0.40 (0.53)
Unknown*	-	3	5	8(2.5)	
Preconsultation Antibiotics					
Yes	15	33	67	115(35.6)	
No	22	76	69	167(51.7)	1.32(0.25)
Unknown*	2	18	21	41(12.7)	
Household factors					
Cooking Fuel					
Gas ± Electricity	2	8	8	18(5.6)	
Kerosene ± Gas	28	96	119	243(75.2)	1.24(0.54)
Wood ± Kerosene	9	19	26	54(16.7)	
Unknown*	0	4	4	8(2.5)	
Cooking Area					
(a) Living room	18	70	69	157(48.6)	
(b) Corridor adjacent to "a"	9	23	30	62(19.2)	1.38
(c) Others #	12	30	54	96((29.7)	(0.50)
(d) Unknown*	0	4	4	8(2.5)	
Crowding					
< 3 Co-habiters	21	75	93	189(58.5)	
> 3 Co-habiters	16	46	60	122(37.8)	0.32(0.5)
Unknown*	2	6	4	12(3.7)	
Smokers in the House					
Yes	12	20	33	65(20.1)	4.33(0.038) §
No	27	107	124	258(79.9)	*RR=1.9;OR=2.4*
Unknown*	-	-	-		

§ Statistically significant differences shown.

Comprises open space or separate kitchen outside the house.

¶ Represents cases with lobar and bronchopneumonia with other ALRI syndromes ±complications, measles or pertussis

¶¶ Comprises subjects with features of marasmus, marasmic-kwashiorkor, or kwashiokor

* Attributable to incomplete documentation.

** Variances generated from SD^2 for the analyses of variance test used for comparing LPA and BPA variables; F-statistic values as indicated

Table II

Symptom Prevalence and Duration in Relation to Final Diagnoses in Paediatric CAP

Symptom Prevalence/ Duration (Days)	*BPA (n=127)*	*BP+M+ Pert. (n=43)*	*BP+ Other ALRI/ Compl. (n=64)*	*LPA (n=39)*	*LP+ Other ALRI/ Compl. (n=27)*	*BP+ LP (n=23)*	*No. Analysed# (Total)*	*BPA vs. LPA χ^2/t(df); p-value#*
Cough								
n	109	38	58	31	25	18	279	0.91(1);0.35
Mean duration	4.52	5.37	4.76	5.97	4.68	5.67	(292)	1.72(138);0.04**(S)**
Range	1-21	1- 21	1-21	1.22	1-10	2-14		
SD	3.87	3.63	3.73	4.96	2.51	4.14		
Fever								
N	103	38	57	35	26	22	281	1.59(1);0.21
Mean duration (n)	5.1	5.45	5.14	6.03	4.62	5.32	(288)	1.11(136);0.14
Range	1-21	2-14	1-15	1-22	1-10	1-14		
SD	4.69	2.53	3.15	4.96	2.9	3.63		
Breathlessness								
N	84	31	48	26	17	16	222	0.00(1);0.95
Mean duration	3.12	3.19	3.02	4.08	3.35	4.13	(228)	1.42(108);0.08
Range	1-21	1-7	1-9	1-14	1-8	1-14		
SD	2.98	1.94	2.26	3.07	2	4.13		
Poor Feeding								
N	51	29	32	20	18	13	163	1.51(1); 0.21
Mean duration	4.63	4.97	4.34	4.05	5.06	4.31	(168)	- 0.456(69)
Range	1-28	1-21	1-14	1-14	1-21	1-14		
SD	5.33	3.59	3.22	3.02	4.8	3.64		0.33
Others								
Nasal discharge	33	24	16	11	5	6	95	0.076(1); 0.78
Skin rash	17	37	21	3	3	6	87	0.91(1); 0.50
Vomiting	21	8	18	11	6	3	67	1.92(1), 0.17
Restlessness	15	10	15	5	8	3	56	0.013(1); 0.68
Diarrhoea	15	10	6	1	5	3	40	1.96(1); 0.07
Diarrhoea & vomiting	13	13	6	6	-	2	40	0.36(1); 0.88
Convulsion*	15	4	1	-	1	-	21	3.73(1); 0.02**(S)**
Abdominal distension	5	-	2	-	-	1	8	0.52(1); 0.59
Eye discharge	2	3	1	-	-	1	7	0.003(1); 0.58

 # p-value from Yates' Corrected χ^2 or Fisher's Exact Test as appropriate

* Relative Risk of convulsion = 1.35

Disparity between total no. of cases and no. analyzed attributable to incomplete documentation.

BP= Bronchopneumonia; BPA= Bronchopneumonia alone; LP= Lobar pneumonia; LPA= Lobar pneumonia alone; M= Measles ; Pert .= Pertussis ; ALRI= Acute lower respiratory infection(s) , compl=complications

Table III

Physical Findings, Associated Conditions/Complications, According to Diagnostic Categories of Pneumonia

Physical signs, associated conditions/ complications	*BPA (n=127)*	*BP+M/ Pert. (n=43)*	*BP+ Other ALRI/ Compl. (n=64)*	*LPA (n=39)*	*LP+ Other ALRI/ Compl. (n=27)*	*BP+LP# (n=23)*	*No. Analyzed*	*X^2 / t;p-value BPA vs. LPA (All BP vs. All L)P¶*
Temp.(T) in °C								
N	125	43	64	39	27	23	321	
Mean T#	38.57	39.07	38.52	38.89	38.95	38.93		1.92;0.03(S)
Range	35.0-41.0	36.6-41.0	36.9-40.1	37.4-40.7	37.0-40.8	37.0-40.7		
SD	0.94	0.96	0.76	0.86	1.03	0.87		
Respiratory Signs								
Respiratory rate (RR)/min								
N	124	43	64	38	27	23	319	
Mean(n) ##	62.02	57.67	62.8	58.68	59.63	61.09		1.92;0.03(S)
Range	21-112	30-102	28-100	34-88	36-88	40-100		
SD	16.38	18.54	14.68	13.49	12.62	16.42		
Hoarse cry/ voice	3	3	13			1	20	0.08;0.45
Grunting respiration	2	-	2	5	6	-	15	6.8;0.01(S)
Chest pain	-	-	1	1	2	1	5	-
Wheezing	-	-	3	-	-	1	4	-
Stridor	-	-	4	-	-	-	4	-
Other Signs								
Lethargy	5	3	7	-	3	1	19	0.52;0.59
Abdominal distension	5	-	2	-	-	1	8	0.52;0.59
Eye discharge	2	3	1	-	-	1	7	1.0(FET)
Sore mouth	-	3	1	-	1	-	5	
Associated Conditions/ Complications ¶								
Heart failure*	39	5	13	2	6	10	75	10.5;0.001(HS) (4.54;0.033)(S)
Measles	-	36	20	-	1	5	62	- (5.63;0.018)(S)
Severe anaemia	21	5	6	11	7	2	52	251;0.106 (6.85;0.009)(HS)
Pleural effusion± pneumothorax**	-	4	14	-	24	-	42	- (35.15;0.000)(HS)
Sickle cell dis.***	7	-	1	7	1	3	19	0.022,FET(S) (0.011,FET)(S)
Pertussis	-	7	1	-	-	-	8	-
Bacterial meningitis	3	-	1	-	-	-	4	(0.21,FET)

Excluded from statistical analyses of All BP vs. All LP

FET = Fishers' exact values ; S = Significant difference suggested ; HS= Highly Significant difference

¶Comparisons for statistical significance were for All BP vs. All LP; Yates' corrected chi-square values provided .

* For BPA vs. LPA,, *RR=1.35; OR=8.20; 95%CI=1.93-73.02* ; For all BP vs. All LP, *RR=1.16; OR=2.33;95%CI=1.02-5.99*

** For all BP vs. All LP, *RR=0.51; OR=0.15; 95%CI= 0.07-0.31.*

*** For BPA vs. LPA,, *RR=0.63; OR=0.27; 95%CI=0.07-0.97;* For all BP vs. All LP, *RR=0.63; OR=0.26; 95%CI=0.08-0.83.*

Degrees of freedom for T in °C and RR are 162 and 160, respectively

Table IV

Haematological Parameters and Diagnostic Categories of CAP

Parameters	*BP Alone*	*BP+M/ Pert. (n=43)*	*BP+ Other ALRI/ Compl. (n=64)*	*LPA (n=39)*	*LP+ Other ALRI/ Compl. (n=27)*	*BP+LP (n=23)*	*Total No. Analyzed*	¶*p-value; X^2/ F-Stats. BPA vs. LPA*
PCV (%)								
N	90	30	43	21	19	12	215	
range	10-47	10-44	22-40	15-38	15-44	18-37	10-47	
SD	8.01	7.01	4	5.6	6.71	5.55	6.94	
Mean	28.97	33.13	31.77	27.57	30.63	27.97	30.06	0.45; 0.57
Total WBC($x10^9$/L)								
N	73	17	28	13	14	11	156	
Range ($x10^9$/L)	1.5-37.5	3.5-42.4	3.5-36.2	7-42.0	4.1-31.0	4.2-8.0	1.5-8.0	
SD	5.99	0.93	0.796	1.417	0.812	2.12	0.97	
Mean	11.67	11.57	11.36	19.85	16.25	18.04	13.14	0.002;10.18§
Polymorphs(%)								
≤ 50	25	3	11	1	2	2	44	
> 50	39	12	14	10	9	8	92	0.0495(*FET*)§
N	64	15	25	11	11	10	136	
Range ($x10^9$/L)	17-91	38-89	12-91	25-91	38-89	42-86	12-91	
SD	29.82	17.02	22.67	19.45	16.38	16.22	20.49	
Mean	55.9	65.2	57.16	73.55	63.73	65.1	59.88	0.011; 6.87§
Lymphocytes(%)								
≤ 50	43	12	15	10	9	8	97	
> 50	21	3	10	1	2	2	39	0.103(*FET*)
N	64	15	25	11	11	10	136	
Range ($x10^9$/L)	9-83	11-62	9-84	8-63	11-59	14-56	8-84	
SD	19.88	16.18	22.18	16.43	16.03	15.21	19.54	
Mean	41.81	33.07	40.52	24.27	34.64	33.9	38.03	0.007; 7.64§#

¶ Analysis of variance (*ANOVA*) were used for statistical testing as indicated; cell variances generated from SD^2

FET= Fishers' Exact Test ; Other abbreviations as detailed in the preceding tables.

§ Indicates statistically significant differences in the mean values of variables in the BPA *and* LPA categories

Table VA

Diagnostic Categories and Outcome Parameters of CAP

Parameters	*BP Alone (BPA)*	*BP+M+ Pertussis*	*BP+ Other ALRI*	*All BP*	*LP Alone (LPA)*	*LP+ other ALRI*	*All LP*	*Mixed Lesions (BP+LP)*	*p- value¶; X^2 BPA vs. LPA (All BPvs All LP)*
All cases									
Survived	104	39	54	197	34	24	58	19	
Died	16	2	8	26	3	2	5	4	0.57(FET)
Unknown	7	2	2	11	2	1	3	0	(0.40; 0.70)
Total	127	43	64	234	39	27	66	23	
Survivors									
Type of Recovery									
Full Recovery	26	11	4	41	1	2	3	2	
Partial Recovery	78	28	50	156	33	22	55	17	0.01;6.58§
Unknown/DAMA	7	2	2	11	2	1	3	0	(0.01;6.62)‡§
Total	111	41	56	208	36	25	61	19	
Duration of Stay									
≤ 7 days	76	25	40	141	28	8	36	15	0.33; 0.94
> 7 days	30	14	15	59	7	16	23	4	(0.17; 1.84)
n (range)	106(1-84)	39 (1-107)	55(1-36)	200	35(2-16)	24 (2-38)	59	19 (1-44)	
Mean	6.63	9.31	6.09		5.03	11.63		6.74	0.35
SD(SD^2)##	10.0	17.5	6.6		3.0(9.2)	9.8(95.7)		10.1(101)	(0.86,F-Stats)
Deaths									
Duration Of Stay									
≤ 7 days	13	1	6	20	3	2	5	4	
> 7 days	2	0	2	4	0	0	0	0	0.69
(FET)									
Unknown	1	1	0	2	0	0	0	0	
(0.44,FET)									
n(range)	15 (1-15)	1(13)	8 (1-54)	24	3 (2-4)	2 (1-2)		4 (1-2)	
Mean	3.13	3	8.5		2.67	1.5		1.25	0.73
SD(SD^2)##	2.13(4.54)	0	18.5(342)		1.2(1.44	0.71(0.50)		0.5 (0.25)	(0.13,F-Stats)

Table VB

Outcome Parameters of Isolated and Complicated Cases of Lobar Pneumonia##

Parameters	*Lobar Pneumonia alone (LPA)*	*Lobar Pneumonia + Pleural Effusion ±Other ALRI (LP+)*	*Total*	*LPA vs. LP+¶ p-value (X^2 / t or F-Stats.)*
Duration of Stay (Survivors)				
≤ 7 days	28	23	51	0.014(5.99)§*
> 7days	7	20	27	
Unknown	1	1	2	
Mean	4.8	8.6	6.95	
N	36	44	80	0.029 (4.92)§¶
SD(SD^2)##	3.0 (9)	9.9 (98.01)	7.8 (60.84)	
Mean Duration of Stay				
(Fatal Cases) Actual	2,2,4	1,1,1,1,2,2	1(x4),2(x4),4	
Mean	2.7	1.3	1.78	0.026§¶
N	3	6	9	(6.64)
SD (SD^2)##	1.2 (1.44)	0.5 (0.25)	1.0 (1.0)	

§ Significant difference suggested by the *p-value*

#The prevalence and values of the clinical and haematologic parameters, explored as in Table VB were comparable among survivors and fatal cases with LP ± pleural complications.

¶ Values obtained from Yates or Mantel-Haenzel corrected X^2, or ANOVA as appropriate; FET= Fishers' Exact Value

Variances for ANOVA test generated from SD^2

‡ Relative risk (RR) & 95%CI=1.26 & 1.44 - 25.18; Odds' ratio was 4.82

* RR & 95% CI= 2.12 & 1.14 - 11.37; Odds' ratio was 3.48

of co-morbid states and complications, the prevalence of associated measles was significantly higher among subjects in the BP category (23.9 per cent, all BP vs.1.5 per cent all LP; p=0.018 χ^2=5.63; RR=1.18; OR=2.83; 95%CI=1.14-8.41). On the other hand, with a prevalence of 36 per cent in LP cases and 3.4 per cent in those with BP, pleural effusion was significantly commoner among those with a final diagnosis of LP, compared with BP cases. Similarly, as shown in Table III, associated sickle cell disease (SCD) was more frequently (p=0.0000; χ^2=35.15; OR=0.15; 95%CI=0.07-0.31) identified among cases with LP, either alone (LPA) or associated with other respiratory syndromes (All LP) (p=0.022 FET, for LPA vs. BPA; p=0.011 FET, for All LP vs. All BP; OR=0.26; 95% CI=0.08-0.83). On the other hand, a complicating heart failure was significantly commoner among BPA cases in particular, and all BP cases in general (p=0.001, for BPA vs. LPA; RR=1.35; 95%CI=1.93-73.02; p=0.033 for All BP vs. All LP; RR=1.16; OR=2.33; 95%CI=1.02-5.99). Similarly, a strong association was shown between severe anaemia and a final diagnosis of BP (p=0.009; χ^2=6.85; OR=0.42; 95%CI=0.21-0.87). The number of cases with other associated conditions such as meningitis (four cases), pyomyositis, osteomyelitis (two cases each), and herpes labialis (one case), were too few for meaningful comparisons (Table III).

Diagnostic Categories and Haematological Parameters

Compared with BPA cases, those with LPA had a significantly higher mean total WBC (p=0.002, F-statistic=10.18, df=84) [Table IV]. Furthermore, when all cases with lobar consolidations with or without other lesions (All LP) were compared with the corresponding category of cases with bronchopneumonia alone, or with other ALRI diagnoses/associated lesions (All BP), a total WBC in excess of $10x10^9$/l was more frequently recorded in the All LP category (p=0.03; 95%CI=1.02-8.28); the relative risk of WBC > $10x10^9$/l was 2.8 in LP vs. BP cases. Significantly higher mean percentage of polymorphs was also recorded in the LPA category (p=0.011; t=6.87), while polymorphs above 50 per cent was significantly commoner among the LPA and All LP categories (p=0.0495 & 0.032 respectively). The corresponding lymphocyte-related variables were significantly lower in the same diagnostic categories of CAP (Table IV).

Selected Parameters of Isolated and Complicated Lobar Pneumonia

Against the background of the overlapping symptomatology of isolated lobar consolidation, and one with pleural complications (with or without other lesions), the possible discriminative parameters between LPA and LP with associated complications were sought in 66(74.2 per cent) of the 89 cases with radiographic features of lobar or segmental consolidation(s); the remaining 23 with concomitant features of BP and LP were excluded. A coexisting pleural effusion, frequently an empyema or pyopneumothorax, was present in 24(36.4 per cent) cases. One case each of LP, had associated bronchiolitis, croup or measles. Besides a significantly higher prevalence of vomiting (17 out of 39 for LPA, vs. 9 out of 50 for LP and effusion (LP+); p=0.008), and a combination of vomiting with diarrhoea (6 out of 39 LPA vs. 1 out of 50 LP+; p=0.04), the distribution of the selected clinical and investigative parameters were comparable in cases with isolated lobar consolidation (LPA), and those with pleural effusion. Although this failed to reach a significant level, a predominant 84 (62.2 per cent) had right-sided consolidation(s), as against 51(37.8 per cent) on the left; the right upper and left lower lobes were involved in 41(30.4 per cent) and 23(17.0 per cent) cases, respectively. The right-sided preponderance was comparable in isolated and complicated disease (p=0.7;χ^2=0.15).

Outcome Parameters and Possible Determinants

Overall, there were 35(10.8 per cent) deaths. As shown in Table VA, mortality was comparable between the major diagnostic categories, as were the mean durations of admission. However, out of the 46 (16.0 per cent) survivors adjudged to have fully recovered at discharge, BPA cases recorded a significantly higher proportion (p=0.01; RR (BPA vs. LPA)=1.37; OR=11; 95%CI=1.64-464.4). Table VB shows the admission outcome characteristics in the subset with LP. Understandably, a significantly longer mean duration of stay was recorded in the subset of LP survivors with associated pleural complications, with or without other ALRI lesions (p=0.029; For a stay duration >7 days, OR=3.5 & RR=2.1). Compared with their peers with LPA, fatal cases of LP with pleural complications (with or without other lesions) had a significantly shorter stay before death (p=0.026;F-stats. =6.64){Table VB}.

As shown in Table VI, when selected clinical and investigative parameters were explored in relation to outcome for all cases studied, significantly longer mean duration of fever, cough and poor feeding were recorded in fatal cases compared with survivors (p=0.002, 0.002,

Table VI

Relationship between Selected Parameters and Admission Outcome of CAP

Parameters	*Admission Outcome*		*Survivors vs. Deaths*	
	Survival	*Death*	*X^2/or t-value (p)*	*F-Stats. {p}#*
Risk Factors				
Age in months (n)	288	35		
Mean ± SD**	15.32 ± 13.23	18.97±14.94	-1.52 (0.06)	2.29 (0.13)
Range	1-53	1-59		
Nutritional Status				
Satisfactory / Well nourished	136	5		
Underweight	127	17	13.14 (0.00029)§	-
Severe malnutrition	24	12	*(95%CI=1.92-17.7)*	
Not known/ Not determined	1	1	RR=*1.15'*	-
Pre-Admission Antimicrobial				
Yes	99	16		
No	156	11	4.22 (0.04) §	-
Not known	33	8	*[95%CI=0.18-1.005]*	
Cooking Fuel¶				
I	17	1		
II	223	20	7.58 (0.023) §	-
III	43	11	*[95%=1.14 -6.76]*	
Unknown	5	3		
Symptom & Duration				
Fever (n)	252	29	-2.91 (0.002)§	-
Mean duration ± SD**	4.97± 3.86	7.24 ± 5.42	1.14 (0.133)	2.19 (0.15)
Range	1-21	1-22		
Cough (n)	250	29	0.6 (FET)	-
Mean duration ± SD**	4.71 ± 3.59	6.86± 5.42		
Range	1-21	1-22	-2.87 (0.002) §	2.08 (0.16)
Difficult Breathing (n)	201	21	1.39	0.24
Mean duration ± SD**	3.3 ± 2.76	3.43 ± 2.86	-2.15 (0.42)	0.04 (0.84)
Range	1-21	1-14		
Poor Feeding/Anorexia (n)	143	20	0.70	0.403
Mean duration ± SD**	4.32 ± 3.95	6.45 ± 5.35	-2.15 (0.016)§	1.72 (0.20)
Range	1-28	1-21		
Physical Findings				
Admission Temp. (in ^{0}C)				
N	287	34	0.21(FET)	-
Mean ± SD**	38.75 ± 0.92	38.56 ± 0.93		
Range	36.3-41.0	35 - 40.5	1.14 (0.13)	1.29 (0.26)
Respiratory Rate (per min.)				
N	285	34	0.37 (FET)	-
Mean ± SD**	61.3 ±15.77	57.79 ±15.48		
Range	28-112	21-100	1.23 (0.11)	1.51 (0.22)
Others				
Diarrhoea & vomiting	31	9	5.12 (0.025)§	-
Restlessness	51	5	0.26 (0.61)	-
Grunting respiration	13	2	0.67(FET)	-
Convulsion	18	3	0.49 (FET)	-
Associated measles	56	6	0.11(0.74)	
Haematological (Mean values)‡				
(i) Mean PCV ± SD**	30.05±6.92	30.16±7.24	-0.08 (0.47)	
N(range)	190 (10-44)	25(15-47)		0.01 (0.94)
(ii) Mean WBCx10^9/l ±SD**	12.54±7.96	18.1±18.5	-2.26 (0.013)	
N(range)	39(3.5-2.4)	17 (1.5-80)		1.23 (0.285)
(iii) Mean % Polymorphs ±SD**	58.6±20.4	69.5±19.1	-2.02 (0.023)	
N(range)	120(12-91)	16 (18-91)		3.94 (0.049)

¶ I = Gas ± Electricity; II = Kerosene ± Gas; III = Firewood ± Kerosene. § Significant differences identified.
# Mantel-Haenszel or Yates' corrected values provided as appropriate; FET = Fishers' Exact Test Value.
** Variances generated from SD^2 for the analyses of variance (ANOVA) test as appropriate; F-statistic values as indicated.
‡ t - and corresponding p-values derived from total count expressed as cells per cubic millimeters.

and 0.016 respectively). Similarly, the prevalence of concomitant diarrhoea and vomiting was significantly commoner in fatal cases (p=0.025), as were each of pre-consultation antimicrobial usage, malnutrition, and domestic firewood burning (p=0.04, 0.00029 & 0.023 respectively).

Discussion

The classification of pneumonia remains contentious, but for the clinician working in small hospitals with limited investigative tools, the formidable logistic prerequisites of establishing a specific microbiological diagnosis[6] continue to justify the more practical clinical approach of predicating the individual case management on appropriate ranking of the likely pathogens.[6,7] Such decisions are usually taken after a summation of the clinical; epidemiological and non-microbiological investigative clues.[6,7] The WHO case-management approach[1,16] has proved a useful strategy in reducing pneumonia-associated mortality, but many skilled health personnel (particularly clinicians) in the developing world have, for a variety of reasons, remained skeptical about the clinical relevance of this management strategy beyond the level of the primary care health worker with limited training and skill. For the trained clinician in a tropical setting with some investigative facilities, who is seeking appropriate diagnostic discrimination, criteria for inpatient care, and choice of cost-effective investigative modalities, there is a clear need for a more comprehensive clinical and investigative data-base, as against a "cook-book" therapeutic approach. Against the background of the clinical difficulties, and indeed sometimes misleading physical and radiographic signs in children with the symptom-complex of CAP,[17-20] some of the findings of the present study constitute potentially useful non-microbiological tools for a more accurate prediction of paediatric CAP diagnoses and severity.

Unlike in the community where viral upper respiratory infections (URI) predominate, [2,5] pneumonia was predictably the commonest ALRI syndrome in the current hospital-based study. Similarly, that over 75 per cent of our subjects were infants and toddlers, a particularly vulnerable age group to bronchopneumonia, [17,20] would account for the relative predominance of BP in the current series. The continuing local morbidity burden of measles-associated BP and pertussis in the same age group may also be contributory. The epidemiological import of this finding is that in tropical Africa, infants and children under two years should constitute the desirable target population of any childhood ARI control program, including virus-specific immunization. Similarly, the close proximity of the poorly ventilated cooking area to the sleeping or living room in the majority of our subjects, underscores the reality of the risk of culinary smoke exposure in the study population. This risk is particularly worse in infants who are helplessly strapped to their mothers' backs in the kitchen/cooking areas.[13] Whereas firewood was used in only 17 per cent of our subjects, it was interesting to observe that pre-morbid wood-smoke constituted a significant risk-factor of a possible fatal outcome. The related association of paternal cigarette smoking with LP in the present series, is in accord with a recent report[21] in which cigarette smoking was identified as "the strongest independent risk factor for invasive pneumococcal disease"; pneumococcal pneumonia are usually associated with lobar lesions.

Parental preference for empirical antimalarial treatment at home for the older child with pneumococcal LP presenting with high fever, shaking chill, malaise and headache, [16,17] which are equally associated with malaria, may explain the longer symptom-duration in the LP category. On the other hand, the frequently frightening respiratory distress in the BP-vulnerable infant and toddler, as exemplified by RSV bronchiolitis and pneumonia, [10] would prompt an earlier hospital consultation in the majority with BP. As a pointer to a possible bacterial aetiology of CAP, the association of LP with pleural effusion in the present series, is consistent with the traditional view.[6, 20,22] Whereas the diagnosis of pleural effusion in adults is fairly easy with the identification of the classical stony dullness, and the frequently absent breath sounds, a high index of suspicion is required in infants and young children. In this age group, the small size of the thoracic wall, as well as the inevitable thinness of the fluid layer and hence, the short path required for sound transmission, may preclude the detection of the classical signs of pleural effusion.[18] Yet, an early diagnosis of pleural effusion in infants and young children remains crucial in taking the initial management decisions, especially the need or otherwise, for in-patient care, or perhaps, referral to a higher tier. Indeed, as shown by the present study, the significantly shorter duration of stay in fatal cases of LP with pleural complications, as well as the frequently long hospitalization required in survivors, constitute compelling grounds for a timely recognition of pleural complication at presentation. In view of the aforementioned clinical difficulties of detecting pleural complications in infants and young children, Smith[18] had earlier suggested that when dullness to percussion is readily detectable in an infant, pleural effusion or empyema should be suspected. In this regard, the diagnostic utility of an early diagnostic thoracocentesis in our setting, is self-

evident. The preponderance of right-sided lesions in those with LP can be ascribed to a greater tendency for pathogen aspiration into the more obtusely angulated right main-stem bronchus, especially in recumbent infants.[18]

The association of LP with severe anaemia in the present series, is putatively attributable to the greater likelihood of a bacterial aetiology in lobar lesions.[18,20,22] Also, despite the small sample-size of patients with sickle cell disease (SCD), the significant correlation of SCD with LP is consistent with the reported susceptibility of SCD patients to pneumococcal pneumonia,[23] and perhaps the inevitable radiological misdiagnosis in some cases with acute chest syndrome of infarctive origin.[23] Yet another clinical soft clue of LP in this series, was the significantly higher prevalence of grunting respiration. Interestingly however, unlike "chest in-drawing" for severe pneumonia,[16,24] and "stridor" for extra-thoracic airway obstruction,[11,15] the diagnostic utility of grunting respiration in lobar consolidation (with or without an effusion), or extensive atelectasis had not been appropriately factored into the subsisting case management recommendations for developing countries.[1,16,24] While the current finding regarding grunting respiration confirms our earlier observation,[15] we suggest that in the pre-school tropical child with the symptom-complex of pneumonia, a long symptom-duration and grunting respiration constitute potentially useful clues of a lobar lesion (possibly of bacterial aetiology), with or without parapneumonic effusion.

The high prevalence of pleural complications in the present series compares favourably with earlier observations.[15, 25] Furthermore, the preponderance of empyema in this series is pointedly in accord with the aetiological importance of *Staphylococcus aureus* identified in our preliminary report.[9] Puri and Khanna[26] had earlier attributed a similar aetiological profile in Indian children with CAP to the subsisting high prevalence of malnutrition, intermittent or inadequate/ incomplete course of antimicrobials. These risk factors of staphylococcal pneumonia and empyema also abound in the current study population, and along with the preponderance of subjects below two years in whom staphylococcal pneumonia and measles are reportedly common,[18,27] the high prevalence of complicating empyema is hardly surprising.

The significantly higher total WBC and polymorphs in children with LP is consistent with the conventional wisdom of a higher likelihood of a bacterial, rather than a viral aetiology in lobar consolidation.[6,20] This contrasts with the corresponding aetiological expectation(s) in those with a broncho- or interstitial pattern.[20] Indeed, while bronchopneumonic changes may supervene in either a viral or bacterial pneumonia, a lobar pattern of consolidation is an unusual solitary radiographic finding in viral pneumonias.[6,19,22] A similar explanation of a greater likelihood of a bacterial aetiology may be proffered for the more frequently fatal outcome in our cases with polymorphonuclear leucocytosis. Based on the current findings therefore, it can be surmised that in the absence of opportunities for aetiological identification in a child with symptom-complex of CAP, polymorphonuclear leucocytosis constitutes an important investigative parameter of a lobar pneumonia, frequently of bacterial aetiology. The therapeutic import of this finding in a preschool child with CAP is the need for empirical antimicrobial therapy, and/or referral, depending on the available expertise and facilities.

That subjects in the BP category had a greater propensity for full recovery, can be attributed to the greater likelihood of a viral aetiology in this category of CAP,[20] as against a bacterial pathogen with LP. In viral pneumonia, a complete resolution is the rule with or without antimicrobial treatment.[6,7,20] With regard to the subset with LP, a shorter duration of stay was recorded in fatal cases, while disease survivors with coexisting pleural and other ALRI complications stayed significantly longer. These observations are noteworthy corroboration of the WHO case-management guidelines which emphasizes a timely recognition, as well as a prompt institution of specific therapy as appropriate.[1,16,24] In this regard, the identification of certain risk factors of fatality like pre-admission antimicrobial treatment may be superficially surprising. It is however, pertinent to note that in the majority of cases that received such treatment before consultation, the choice of antimicrobial(s) was likely to be inappropriate, or more often than not, cost-considerations might have precluded course completion. The consequence of this is a severe disease, or a fatal outcome because of drug-resistant pathogens. Synergism between virulent pathogens and an underlying malnutrition in some cases may account for the related finding of a significantly higher mortality in our subjects with overt malnutrition.[9,28] Severe malnutrition is associated with impairment of host immunological defense, including mucosal protection.[28,29] A similar impairment of respiratory defence mechanisms following exposure to some bye-products of wood-burning,[13,30] may explain the current finding of a poor prognostic association. The prognostic implication of a delay in hospital presentation is reflected by the significantly longer symptom-duration recorded in fatal cases. Finally, while haematological indices are admittedly non-specific,[17,18] the adverse prognostic implication of polymorphonuclear leucocytosis in the present series suggests a potential value in a resource-poor tropical setting. Thus, a high polymorphonuclear cell count may be usefully factored into the criteria for deciding the need for in-patient care in a preschool child with CAP.

In conclusion, we surmise that in evolving appropriate guidelines for in-patient care in a tropical hospital setting

with limited facilities, the current findings provide a broader clinical and investigative data-base for possible diagnostic discrimination, determination of a pneumonia severity index, and hence the guidelines for appropriate management in a resource-poor setting. While we admit the need for future validation of the utility of some of the parameters identified here, there is clearly an urgent local need for reducing CAP-associated mortality, and ensuring qualitative care at minimal cost by evolving from the present data-base, a critical management pathway (CMP). Even in an affluent community like the USA, a recent controlled trial,[31] identified the usefulness of this therapeutic approach in achieving a cost-effective disease control. Clearly, in resource-poor countries, evolving such locally-relevant CMP for pneumonia would not only complement, but may also facilitate a wider acceptability of the current WHO initiatives at stemming the tide of the ARI scourge.

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