ORIGINAL ARTICLE

Children with pneumonia: how do they present and how are they managed?

Julia E Clark, Donna Hammal, David Spencer, Fiona Hampton

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See end of article for authors' affiliations

Correspondence to: Dr Julia Clark, Department of Paediatric Infectious Disease, Newcastle General Hospital, Westgate Road, Newcastle NE4 6BE, UK; Julia.clark@nuth.nhs.uk

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Objective: To describe the spectrum of clinical features and management of community acquired pneumonia in the UK.

Design: Prospectively recorded clinical details for all children with possible pneumonia and chest *x* ray (CXR) changes in 13 hospitals in the North of England between 2001 and 2002.

Results: 89% of 711 children presenting to hospital with pneumonia were admitted; 96% received antibiotics, 70% intravenously. 20% had lobar CXR changes, 3% empyema and 4% required intensive care. Respiratory rate (RR), hypoxia and dyspnoea all correlated with each other and prompted appropriate interventions. Admission in children, not infants, was independently associated with RR, oxygen saturation, lobar CXR changes and pyrexia. Neither C-reactive protein, lobar CXR changes or pyrexia were associated with severity. Children over 1 year old with perihilar CXR changes more often had severe disease ($p=0.001$). Initial intravenous antibiotics were associated with lobar CXR changes in infants and children and with dyspnoea, pyrexia and pleural effusion in children. The presence of pleural effusion increased duration of antibiotic treatment ($p<0.001$). Cefuroxime was the most often used intravenous antibiotic in 61%. Oral antibiotics included a penicillin in 258 (46%), a macrolide in 192 (34%) and a cephalosporin in 117 (21%). Infants stayed significantly longer ($p<0.001$) as did children with severe disease ($p<0.01$), effusions ($p=0.005$) or lobar CXR changes ($p\leqslant 0.001$).

Conclusions: There is a high rate of intravenous antibiotic administration in hospital admissions for pneumonia. Despite lobar CXR changes not being independently associated with severe disease, initial lobar CXR changes and clinical assessment in children independently influenced management decisions, including admission and route of antibiotics.

Community acquired pneumonia (CAP) is a common cause of hospital admission for children.[1] Clinical features are not specific, especially in young children, and optimal diagnostic criteria are still under debate.[2–4] These criteria are mainly derived from work in developing countries and are usually developed to improve clinical diagnoses without radiography and to create simple treatment algorithms for antibiotics or hospital care.[5–7]

Despite recent evidence based guidelines for the management, investigation and treatment of CAP,[8] there is no information from the UK relating to the actual presentation and management of childhood pneumonia. We describe the clinical features and management of CAP and assess how admission and treatment decisions are made.

PATIENTS AND METHODS

This was a prospective, observational, non-interventional review of paediatric pneumonia seen by a paediatrician in 13 hospitals in the North East of England between August 2001 and July 2002.

Most children were initially seen by a general practitioner or casualty staff and then referred to a hospital paediatrician for further assessment. Inclusion criteria were children aged 0–15 years with any history, signs or symptoms suggestive of lower respiratory tract infection and a chest *x* ray (CXR) consistent with infection as determined by the local paediatrician. Signs included fever, tachypnoea, dyspnoea, cough and respiratory distress. Radiological findings were confirmed by local radiologists' reports and children excluded if normal. Where reports differed between the paediatrician and radiologist, the films were reviewed by a paediatric radiologist whose report was taken as final. The local centres identified children fulfilling these criteria when seen and completed a standard form. This included information on demographics, clinical history, admission observations, investigations performed, treatment, antibiotics, intensive care, length of stay, complications and organisms found. This form was sent to the investigating centre after discharge. Results from investigations performed were not always available.

Children were excluded if there was a clinical diagnosis of bronchiolitis, if they had been in hospital in the preceding 3 weeks or if their main place of residence was not in the North of England. Local paediatricians managed children according to local practice.

CXR changes were categorised into three broad groups on the basis of the radiologist's report; lobar, patchy consolidation or perihilar infiltrates. These groups correspond to WHO categories recently developed but not available at the time of analysis.[9] Severity criteria were constructed and were similar to those given in management guidelines from the British Thoracic Society (BTS)[8] (table 1).

The North Tyneside Ethics Committee and North and Yorkshire MREC chairpersons reviewed and accepted the protocol; no formal committee approval was required.

Statistical methods

Categorical factors of interest between different groups of children were compared using χ^2 tests. Correlation coefficients were calculated to examine the association between pairs of continuous variables. Symptoms, signs and treatment for severe CAP (compared to mild/moderate CAP) were investigated using logistic regression. The statistical package Stata 8.0 was used for analysis.

Abbreviations: BTS, British Thoracic Society; CAP, community acquired pneumonia; CRP, C-reactive protein; CXR, chest *x* ray; IF, immunofluorescence; NG, nasogastric; RR, respiratory rate

Table 1 Definitions of severity

Severity	Criteria
Severe (any of given criteria)	Tachypnoea (RR>70 for infants ⩽1 year old, >50 for children >1 year old) Dyspnoea Sa_{O_2} <93% Oxygen given NG feeds Intravenous fluid infusion Septicaemia Empyema HDU or ITU care
Mild (any of given criteria)	Immediate home discharge Hospital stay <3 days and no oxygen, no intravenous or NG feeds
Moderate	None of the above

HDU, high dependency unit; ITU, intensive care unit; NG, nasogastric; RR, respiratory rate.

RESULTS

Of 792 identified children, 81 were excluded at review (six duplicates, 72 with normal CXRs, three outside the defined age range), leaving 711. Four hundred and four (57%) were male, 37% were <2 years old, 55% were <3 years old and 80% were ⩽5 years old.

Most children seen by a paediatrician were admitted (636), but 65 (9%) were sent home with antibiotics and 10 (1%) without. Of the 103 patients under 1 year old (henceforth referred to as infants), 97 (94%) were admitted, and five went home with, and one without, antibiotics. Of 608 patients 1 year old or more than 1 year old (henceforth referred to as children), 539 (89%) were admitted, and 60 (10%) went home with, and nine (1%) without, antibiotics. Overall, 56 (8%) patients were referred for tertiary care and none died. Thirty one (4%) required intensive care, including 12 of 103 (12%) infants and 19 (3%) children. Twenty five of these received intermittent positive pressure ventilation and six continuous positive airway pressure ventilation.

Preadmission antibiotics were taken by 214 (30%) patients. In infants there was no difference in rates of empyema ($p = 0.78$) or disease severity ($p = 0.93$) between those receiving preadmisssion antibiotics and those not, but children without preadmission antibiotics were more likely to have severe disease ($p = 0.05$).

An underlying medical condition that may predispose to pneumonia was seen in 152 (21%).

Clinical features

The clinical features of the patients are listed in table 2

There was a significant correlation at all ages between respiratory rate (RR) and oxygen saturation ($r = -0.28$, $p<0.001$) and RR was significantly higher in those with dyspnoea ($p<0.001$). RR was significantly higher in those children receiving oxygen ($p<0.001$) or intravenous fluid ($p = 0.027$) than in those who were not; however, no differences were seen in infants.

For all ages, a significantly lower oxygen saturation was seen in those with dyspnoea and in those receiving oxygen, nasogastric (NG) feeds or intravenous fluid ($p<0.001$ for all). Those with dyspnoea were more likely to receive oxygen ($p<0.001$). Children with dyspnoea were also more likely to get intravenous fluid ($p = 0.005$). In children but not in infants, temperature was significantly higher in those with either lobar ($p = 0.04$) or patchy ($p = 0.02$) CXR changes. Pyrexia (>38℃) was not associated with severity. Forty eight of those with no clinical signs (RR, auscultation, dyspnoea) had CXR changes.

Three children with severe disease were sent home without, and 19 with, antibiotics, and none returned.

A multiple logistic regression analysis of symptoms and signs suggested that RR (OR = 1.03 for a one unit increase in RR, 95% CI 1.01 to 1.05), oxygen saturation (OR = 0.81 for a one unit increase in Sa_{O_2}, 95% CI 0.73 to 0.89), lobar CXR changes (OR = 5.97, 95% CI 1.82 to 19.62) and temperature >38℃ (OR = 2.25, 95% CI 1.31 to 3.86) were all independently significantly associated with admission in children but not in infants.

Radiology

Pleural fluid was noted in 65 (9%) patients: 28 (20%) together with lobar changes, 38 (9%) with patchy and two (2%) with perihilar. Empyema was noted in 24 patients, with 13 (9%) lobar and 11 (2.5%) patchy changes.

For infants CXR appearance was not associated with severity, dyspnoea, RR, temperature or oxygen saturation, although infants with lobar changes were more likely to receive oxygen ($p = 0.019$) and NG feeds ($p = 0.025$). Children with lobar changes were more likely to be pyrexial ($p = 0.04$) but had no association with other signs or symptoms or with severe disease.

Children with perihilar changes more often had severe disease ($p = 0.001$), dyspnoea ($p<0.001$) or a higher RR ($p = 0.03$), or were given oxygen ($p = 0.016$), and those with patchy changes were less likely to have severe disease ($p = 0.012$).

Investigations

One routine investigation at least was carried out in 590 (83%) patients in addition to a CXR (table 3).

C-reactive protein (CRP) was more often measured in children than in infants ($p = 0.024$), but there was no difference in the frequency with which full blood count ($p = 0.630$) or blood culture ($p = 0.232$) was performed. Blood culture was positive in 20 (4%); the yield of blood culture was no different by age. In infants, blood cultures were more likely to be drawn if the infants were receiving oxygen ($p<0.001$) or had lobar CXR changes ($p<0.001$). In children, blood cultures were taken in those with significantly higher temperatures ($p \leqslant 0.001$), dyspnoea ($p = 0.012$), effusion ($p = 0.001$) or lobar *x* ray changes ($p = 0.019$) or in those receiving oxygen ($p = 0.002$), and were less likely to be taken in those with perihilar changes ($p<0.001$). In children, there was no relationship between taking blood cultures and temperature, dyspnoea, oxygen or perihilar changes. Positive blood cultures included nine *Streptococcus pneumoniae*, five *Staphylococcus aureus*, four *Haemophilus influenzae* type b (all immunised) and two *Streptococcus pyogenes*. All but one of these patients were under 7 years old, 16 (85%) were <5 years old, 12 <3 years old and four <1 year old.

A CRP result was available in 207 patients and was high (>100 mg/l) in 33% (24% of infants, 35% of children) (table 4). For infants there was no significant difference in CRP with different CXR changes. However, CRP in children was more often low with perihilar changes (7%; $p = 0.003$) and high with pleural effusions (71%; $p<0.001$). There was no difference in CRP with severity.

A result was available for viral immunofluorescence (IF) from secretions in 114 children with 26 (23%) being positive. Requesting viral IF was age dependent and was obtained in 34% of children <2 years old, 20% of 3–5 year olds, 21% of 6–10 year olds and 14% of 11–15 year olds. The yield from IF secretions decreased with age; no viruses were identified in this way in children over 10 years old.

Management

More than one intravenous antibiotic was given to 82 (12%) patients and 117 (16%) received an oral antibiotic only. Intravenous antibiotics were significantly more likely in moderate

Table 2 Clinical features at presentation and treatment

Clinical features	0–15 years, n = 711 n (%)	Infants, n = 103 (14%)* n (%)	Children, n = 608 (86%)* n (%)
Preadmission antibiotics	214 (30)	23 (22)	191 (31)
Mild disease	155 (22)	15 (15)	140 (23)
Moderate disease	138 (19)	15 (15)	123 (20)
Severe disease	418 (59)	73 (71)	345 (57)
Mild admitted	102 (66)	10 (67)	92 (66)
Moderate admitted	138 (100)	15 (100)	123 (100)
Severe admitted	403 (94)	73 (99)	330 (92)
Dyspnoea	310 (44)	56 (54)	254 (42)
SaO_2 <93%	213 (30)	36 (35)	177 (29)
Temperature >38˚C	435 (61)	52 (50)	383 (63)
Lobar CXR	141 (20)	23 (22)	118 (19)
Patchy CXR	435 (61)	58 (56)	377 (62)
Perihilar CXR	127 (18)	20 (19)	107 (18)
Effusion (includes empyema)	65 (9)	3 (3)	62 (11)
Empyema	24 (3)	1 (1)	23 (4)
Oxygen	276 (39)	54 (52)	222 (37)
Days given, median (IQR)	2 (1, 4)	4 (2, 6)	2 (1, 3)
Range	1–57	1–38	1–57
IV fluid	147 (21)	33 (32)	114 (19)
Days given, median (IQR)	2 (1, 3)	2 (1, 4)	2 (1, 3)
Range	1–21	1–21	1–20
Nasogastric feed	61 (9)	30 (29)	31 (5)
Days given, median (IQR)	4 (2, 10)	4 (2, 8.5)	4.5 (2, 13)
Range	1–28	1–28	1–28
Antibiotics given	682 (96)	96 (93)	586 (96)
IV antibiotics	501 (70)	73 (71)	428 (70)
Days given, median (IQR)	2 (2, 4)	3 (2, 4)	2 (2, 4)
Range	1–22	1–12	1–22
Oral antibiotics	564 (79)	77 (75)	487 (80)
Days given, median (IQR)	6 (5, 7)	6 (5, 7)	6 (5, 7)
Range	1–90	1–21	1–90

*Infants are <1 year old and children are ⩾1 year old.

Table 3 Number of investigations performed

Full blood count	538
Blood culture	498
C-reactive protein	438
Secretions, viral immunofluorescence	172
Secretions, bacterial culture	131
ASOT	97
Mycoplasma IgM	94
ESR	49
BAL, viral immunofluorescence	7
BAL, bacterial culture	9
PCP, immunofluorescence	7
No investigation	121

or severe cases than in mild (p<0.01) (table 5). Of the 102 admitted with mild disease, 41 did not receive any treatment intervention requiring hospital admission; the other 61 had intravenous antibiotics.

Multiple logistic regression analysis suggested that for infants initial intravenous antibiotics were significantly and independently associated with lower oxygen saturations (OR = 0.91, 95% CI 0.83 to 1.00) and lobar CXR changes (OR = 4.82, 95% CI 1.03 to 22.62). For children, intravenous antibiotics were associated with dyspnoea (OR = 1.79, 95% CI 1.21 to 2.64), temperature >38℃ (OR = 2.27, 95% CI 1.55 to 3.32), pleural effusion (OR = 6.19, 95% CI 2.17 to 17.62) and lobar CXR changes (OR = 2.93, 95% CI 1.59 to 5.40).

For all ages, antibiotics were continued longer when effusions were present (p<0.001), but the duration of treatment was not influenced by any other measured parameter or by severity (p = 0.49).

Where the antibiotic was stated, cefuroxime was the most often used intravenous antibiotic and was given to 304 (61%) patients, amoxycillin was given to 56 (11%), benzylpenicillin to 57 (11%) and cefotaxime to 50 (10%). In total, a cephalosporin was used in 353 (70%) and a penicillin in 181 (36%). Infants under 1 year old were more likely to be given cefotaxime than older children (p<0.001).

Oral antibiotics included amoxycillin in 134 (25%), augmentin in 103 (19%), erythromycin in 114 (20%), azithromycin in 80 (14%) and cephalexin in 73 (13%). A penicillin antibiotic was used in 258 (46%), a macrolide in 192 (34%) and a cephalosporin in 117 (21%).

A macrolide was given to more children aged >5 (45%) than aged <5 (31%) (p = 0.003).

Length of hospital stay varied from 1 to 122 days (median 3; IQR 2, 5). Infants stayed significantly longer (p<0.001) (infants: median 4; IQR 2, 7; children: median 3; IQR 2, 5). Children, but not infants, with severe disease stayed longer than with moderate disease (p<0.01) as did those with effusions (p = 0.005) or lobar CXR changes (p⩽0.001).

DISCUSSION

This detailed information on over 700 children with CAP enables us to examine the clinical presentation of pneumonia to hospital in a developed country and determine current clinical practice. It allows us to compare actual with BTS recommended practice.[8] BTS guidelines were published in 2002 to improve and aid assessment and management of CAP in children. Specific areas were examined, including aetiology and epidemiology, clinical features, radiological, general and microbiological investigations, severity assessment, general and antibiotic management, complications and prevention. The evidence base for the guidelines relied heavily on expert opinion with 45% (19/42) of evidence either un-graded or grade D and only 14% (6/42) grade A. Despite this, the guidelines provide a good baseline of recommendations. They emphasise the importance of clinical signs such as RR or difficulty breathing in older children, the value of oxygen saturation and the role of investigations (blood culture, CRP, nasopharyngeal aspirate for culture). They provide severity parameters and offer guidance on the role of antibiotics, oxygen and fluids.

It is important to remember that only patients seen by a hospital paediatrician with CXR-confirmed pneumonia were included. Some children with pneumonia may therefore not have been included if a CXR was not performed, although these are likely to be few in number.

Consistent with other series,[1 10] most patients were 5 years old or less. Most were admitted, at least 14% of these probably unnecessarily with mild disease. Parental anxiety and ability to monitor children cannot be assessed from our information, but 41 children admitted to hospital did not receive any care that was not possible at home. Another 61 only received intravenous antibiotics and might have been able to go home with oral treatment.

The high use of intravenous antibiotics is of concern, especially as oral amoxicillin has been shown to be as effective as injectable penicillin even in severe pneumonia.[11 12] One reason for this may be practical, in that junior staff often insert a cannula when taking blood samples in case it should be needed, and so because it is available, it is then used for intravenous antibiotics.

The question of which children need supportive care is fairly well agreed,[8] but more children than expected were admitted. In a US study where 9.4% of paediatric pneumonia admissions were ''inappropriate'', such admissions subsequently reduced after study results were fed back.[13] Admission itself is costly both to the NHS and to the family, and should be avoided where possible.

Initial clinical features are important in the diagnosis of pneumonia. In developing countries RR is a well recognised

Table 4 C-reactive protein and chest *x* ray type and severity

CRP	n	Range	Median (IQR)	No. with CRP >100	No with CRP >150
Effusion	42	2, 473	197 (65, 283)	30	27
Lobar	55	2, 480	60 (15, 253)	9	6
Patchy	116	2, 410	50 (16, 166)	26	19
Perihilar	36	1, 203	19 (8, 45)	3	2
Mild	25	4, 230	63 (26, 163)	8	7
Moderate	38	5, 480	23 (13, 140)	10	8
Severe	144	1, 478	44 (11, 169)	51	40

CRP, C-reactive protein.

useful indicator[5 6] and has also been identified as a good marker for risk of hypoxia with a specificity of 67–89%.[14 15] Its use is frequently extrapolated to developed countries,[8 16] although the positive predictive value may be lower in developed countries[17] and combinations of symptoms and signs are being explored[2] for diagnosis. As hypoxaemia increases risk of death,[15] confirmation that increasing RR and dyspnoea are both associated with decreasing oxygen saturation and thus both appear useful predictors for oxygen requirement is reassuring.

Suggested indications for admission to hospital include Sao_2 <93%, tachypnoea, difficulty in breathing, grunting, not drinking or social reasons.[8] We found no specific symptoms and signs influenced admission decisions in infants in practice (presumably because most were admitted and total numbers were lower), but in children the decision to admit was influenced not only by low oxygen saturation or RR but also by pyrexia or lobar CXR change. This is important as we have also shown that lobar CXR changes are not more likely to be severe or associated with RR, hypoxia or dyspnoea. Not only does a lobar *x* ray pattern appear to influence admission in children but also, for both infants and children, the initial route of antibiotic and treatment decisions such as oxygen and NG feeds in infants. Length of stay in children was also associated with specific CXR changes. These findings should be interpreted with caution, however, as they are likely to be influenced by other evolving factors not recorded, such as continuing symptoms and signs and subsequent investigations. Perihilar changes, on the other hand, surprisingly were associated with severity but not with treatment decisions. We were unable to assess other possible influences such as social factors, availability of beds or experience of junior staff, although these are unlikely to confound the strong associations seen.

The choice of initial antibiotic route and the obtaining of blood cultures were influenced by lobar CXR changes, hypoxia in infants and dyspnoea or high temperature in children. This suggests that these criteria are perceived as being markers for bacterial infection.

CXR changes are required for definitive confirmation (and exclusion) of pneumonia, establishing extent of disease and identification of fluid, although performing a CXR makes no difference to outcome in mild uncomplicated disease.[18] If knowledge of CXR patterns increases interventions and hospital stay, this lends support to the BTS recommendation not to perform CXR in uncomplicated disease.

There are real difficulties in making a distinction between bacterial and viral pneumonia clinically, leading to significant antibiotic use. Markers of bacterial infection such as CRP have been discarded as non-discriminatory,[8] although CRP is a good discriminator in other clinical settings.[19] Both radiological and inflammatory marker studies are hampered by the difficulty in reliably identifying pathogens in children. Many studies have used a CRP level that is too low, as a high (>100 mg/l) CRP does have good specificity for bacterial pneumonia although a low CRP does not exclude it.[20 21] We have found that one third of children with pneumonia who have a CRP taken have a high level of >100 mg/l. At this level aetiology is unlikely to be viral and this is a good marker for bacterial infection. Interestingly, this is consistent with the pneumococcal conjugate vaccine studies in the US which suggest that about 30% of pneumonias are pneumococcal.[22] CRP, like lobar CXR, does not correlate with severity, consistent with the suggestion that severity is not dependent on aetiology.

In Italy, 98% of children seen in hospital received antibiotics[23]; similarly high rates were seen previously in the UK[24] as well as in this survey.

There was a wide variation in antibiotic used. The very high intravenous cephalosporin use was interesting, especially as a theoretical suggestion may link this to the increasing empyema rates now noted.[25] Cephalosporins or coamoxiclav are at present recommended as first line empirical intravenous therapy in severe disease.[8]

Amoxycillin is the suggested first line oral antibiotic, but less than half the patients received any sort of penicillin orally. One fifth of those given oral antibiotics received oral cephalosporin, including cephalexin, cefixime and cefuroxime axetil. This probably reflects local availability as cefaclor (despite its association with skin reactions[26]) is the BTS recommended oral cephalosporin,[8] presumably in view of its greater activity against *S pyogenes* and *S pneumoniae* compared to cephalexin. Cefixime is not active against *S aureus* and cefuroxime axetil is poorly absorbed orally. Despite this, no differences in clinical efficacy have been identified.[27] Oral macrolide use is also

Table 5 Route and duration of antibiotic treatment by chest *x* ray change and severity

Antibiotic	Effusion (65)	Lobar (141)	Patchy (435)	Perihilar (127)	Mild (155)	Moderate (138)	Severe (418)
None	4	5	60	20	55	4	28
Oral alone	1	14	74	28	39	16	62
IV alone	5	16	26	9	3	5	43
IV+oral	55	106	275	70	58	113	285
Days IV antibiotics, median (IQR)	4 (2, 6)	3 (2, 5)	2 (2, 4)	2 (2, 3)	2 (1, 2)	3 (2, 4)	2 (2, 4)
Days oral antibiotics, median (IQR)	14 (7, 28)	6 (5, 9)	6 (5, 7)	5 (5, 7)	6 (5, 7)	6 (5, 7)	6 (5, 7)
Days total antibiotics, median (IQR)	10 (6.5, 28)	7 (5, 10)	6 (5, 7)	5 (5, 7)	5 (5, 7)	6 (5, 7)	6 (5, 7)
Days in hospital, median (IQR)	5.5 (4, 8.5)	4 (2, 7)	3 (2, 5)	3 (2, 4)	2 (1, 2)	3 (3, 5)	3 (2, 6)

What is already known on this topic

- Guidelines for the management of CAP have been produced, although most knowledge of signs, symptoms and severity of pneumonia is derived from work in developing countries.
- Oral antibiotics are as effective as intravenous antibiotics, although the intravenous route is frequently used in hospital.

What this study adds

- Lobar CXR changes and pyrexia may influence admission decisions and the initial route of antibiotics in a developed country but do not reflect severity.
- Most children seen in hospital with pneumonia are given an intravenous antibiotic, with highly variable antibiotic choices and cephalosporins the most frequent antibiotics administered intravenously.

significant, even in under 5 year olds, although it is not suggested as first line treatment.[8]

The importance of appropriate antibiotic policies is evident in light of pneumococcal penicillin resistance rates of 20–40% seen in Europe and the USA and the worrying macrolide resistance seen in pneumococci (up to 40%) and *S pyogenes* (57%) in Europe.[28] Penicillin resistance can be overcome by high dose amoxycillin, but macrolide resistance is of concern, although only occasional clinical problems have so far been reported.[29 30]

Firm antibiotic policies are therefore valuable both as most effective therapy and to control antibiotic resistance. The suggestions that antibiotic use should be avoided in young children with mild disease and that amoxycillin should be used as first line therapy should be emphasised.[8]

This is the largest survey of childhood pneumonia in the UK and provides extremely valuable insight into decisions around admission and initial investigations and treatment which may be influenced not only by clinical criteria but also by specific *x* ray signs. Perhaps continuing education and the development of local protocols may help to improve admission rates and the high rate of intravenous antibiotic use. The introduction of BTS guidelines may result in consistency of admission and treatment, and further studies into the efficacy of oral antibiotics in pneumonia may inform antibiotic use.

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Authors' affiliations

Julia E Clark, Department of Paediatric Infectious Disease, Newcastle General Hospital, Newcastle, UK
Donna Hammal, SCMS (Child Health), Sir James Spence Institute, Royal Victoria Infirmary, Newcastle, UK
David Spencer, Department of Respiratory Paediatrics, Freeman Hospital, Newcastle, UK
Fiona Hampton, Department of Paediatrics, James Cook University Hospital, Middlesbrough, Cleveland, UK

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