

Clinical signs of pneumonia in children attending a hospital outpatient department in Lesotho

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To determine the value of clinical findings for the diagnosis of pneumonia, we evaluated 950 children who presented with respiratory illness to the outpatient department of the Queen Elizabeth II Hospital, Maseru, Lesotho. Those children at high risk for pneumonia and a systematically selected 20% sample of children at low risk were examined in turn by a nurse, a general practitioner, and a paediatrician; a chest radiograph was recorded for each child. Pneumonia was defined as radiographic findings compatible with the disease as interpreted by a paediatric radiologist. A respiratory rate ≥ 50 breaths/minute was a sensitive sign for pneumonia among infants (sensitivity range for the three examiners: 59–79%), but identified a progressively smaller proportion of children with pneumonia in older age groups. Adjusting the respiratory rate for age using a threshold of ≥ 40 breaths/minute for children aged ≥ 12 months improved the sensitivity, but identified $< 30\%$ of children with pneumonia aged ≥ 24 months. No drop in sensitivity with age was found when respiratory rate thresholds were evaluated for children with more severe radiographic evidence of pneumonia.

Introduction

Acute respiratory infections (ARI) are a major cause of mortality among children in developing countries, accounting for over 4 million deaths per year (1) — nearly one-third of all childhood deaths (2). In addition to promoting routine childhood immunization against measles and pertussis, the WHO Control of Acute Respiratory Infections programme stresses improved case management to prevent deaths from ARI, principally by treating children with pneumonia with antimicrobial drugs. For the case management strategy to be effective, episodes of pneumonia must be promptly identified and treated, often by persons with limited training and access to advanced medical technology.

To determine the value of clinical findings to identify children with pneumonia, particularly the findings recommended by WHO, we evaluated 950 children with respiratory illness who had been brought to a hospital outpatient department. Chest radiographs were used to document pneumonia, and children who, on preliminary screening, appeared to be at low risk for pneumonia were also included. Three health workers examined most of the children, enabling us to compare the findings of different observers.

Methods

The study was conducted in Maseru, Lesotho, at the Queen Elizabeth II Hospital, the central referral hospital for Lesotho, which also serves as a source of primary health care for many residents of Maseru. Approximately 40 under-5-year-olds, not limited to those with respiratory illness, were seen at the outpatient department each work day during the study.

Children aged 3 months to 5 years with a cough, blocked or runny nose, ear pain, or breathing difficulties, who were brought to the outpatient department over a 3-month-period were eligible for enrolment in the study. After the verbal, informed consent of the child's carer had been obtained, a trained nurse assessed each child. In order to identify as many cases of pneumonia as possible, but minimize the radiation exposure to children at low risk for

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pneumonia, we classified children into high-risk and low-risk groups based on this initial assessment. Children with a history of rapid breathing, a history of difficulty in drinking, elevated respiratory rate (>40 breaths/minute for children aged ≥ 12 months; >50 breaths/minute for children aged 3–12 months), wheezing, nasal flaring, or chest indrawing were defined as being at risk for pneumonia. Children without any of these findings were classified as being at low risk for pneumonia. All high-risk children and a systematically selected 20% sample of the low-risk children underwent further standard clinical examinations. Children were examined, in order, by a general practitioner and a paediatrician, and lastly a chest radiograph was recorded. The examinations were conducted within approximately a two-hour interval.

The complete examinations by the general practitioner and paediatrician included measurement of respiratory and pulse rates, rectal temperature, assessment for chest indrawing and nasal flaring, auscultation of the chest, otoscopy, and measurement of height and weight. The respiratory rate was measured for one minute using electronic sounding timers on calm, awake children. The proportion of children who were crying and could not be consoled at the time of examination ranged between 1% and 4% for the three examiners; the results of these examinations were included in the analyses. Chest indrawing was defined as either intercostal, subcostal, or lower chest wall indrawing, in accord with WHO recommendations from 1988, which differ from the current definition that includes only lower chest wall indrawing.^a

The radiographs were reviewed in the USA after the end of patient enrolment. Pneumonia was defined as the presence of a pulmonary parenchymal density compatible with pneumonia on chest radiography as interpreted by the paediatric radiologist (E.L.P) in the USA. Technically poor radiographs were classified as unreadable, while those with equivocal findings were classified as uninterpretable. Those chest radiographs with pulmonary findings compatible with pneumonia and a systematically selected 20% sample of those without pneumonia were re-read by the same paediatric radiologist. Radiographs for which the two interpretations did not agree were reviewed a third time and assigned to an indeterminate category if the readings could not be definitively reconciled. Radiographs with abnormalities that were consistent with pneumonia were also rated as

being severe (lobar or more than one lobe of involvement) or not severe.

The frequencies of the clinical findings were compared in children with and without radiographic evidence of pneumonia, excluding unreadable and uninterpretable radiographs. The results were weighted to calculate the sensitivity and specificity of single and combined clinical findings for identifying children with radiographic pneumonia as if all low-risk patients had been examined. The definitions of sensitivity and specificity used were standard (3). Continuous variables were assessed using Wilcoxon's rank sums test (4). The mean difference in respiratory rate measurements between examiners was calculated for the children assessed by each pair of examiners.

The study protocol was approved by the Lesotho National Research Review Committee and the Centers for Disease Control Institutional Review Board.

Results

A total of 950 children with respiratory infection were potentially eligible for the study (277 at high risk and 673 at low risk for pneumonia). All the high-risk children and 128 of the 134 eligible low-risk children (96%) were enrolled. A total of 382 (94% of those enrolled) were examined by the general practitioner and 251 (62% of those enrolled) by the paediatrician. There were no differences in the age, sex distribution, or proportion of children diagnosed as having pneumonia among those examined or not examined by the paediatrician. Chest radiographs were available for 393 children (97% of those enrolled).

The median age of the enrolled children was 11.8 months (range, 3–59 months); high-risk children were significantly younger (median age, 9.9 months) than low-risk children (median age, 19.5 months, $P < 0.0001$, Wilcoxon's rank sums test). Of the 391 enrolled children whose sex was recorded, 228 (58%) were male. Presenting complaints, indicating that enrolled children had respiratory illness, included cough (403 (99%)), runny nose (323 (80%)), blocked nose (217 (54%)), problems in breathing (70 (17%)), and earache (8 (2%)). Only 16 (4%) of the children had received treatment with an antimicrobial drug before entering the study.

The radiographs of 78 of the children (20%) were initially interpreted as being compatible with pneumonia; upon review, 64 (82%) were categorized as having evidence of pneumonia. The radiographs of 52 children initially held not to show evidence of pneumonia were re-examined, and one child (2%) was interpreted as having pneumonia. The 15 radiographs that had different first and second interpreta-

^a *Acute respiratory infections in children: case management in small hospitals in developing countries.* Unpublished document WHO/ARI/90.5, 1990.

tions were examined a third time; five were interpreted as indicating atelectasis rather than pneumonia; five were judged to be uninterpretable; four as not showing pneumonia; and one as showing pneumonia. Thus, 65 children (17%) had radiographic findings consistent with pneumonia—53 in the high-risk group and 12 in the low-risk group. The radiographs of 299 of the children (76%) did not show evidence of pneumonia; 17 (4%) were uninterpretable; and 12 (3%) could not be read because their quality was poor.

To assess how well the 20% sample of children at low risk for pneumonia who were enrolled in the study was representative of all the children at low risk for pneumonia, we compared the characteristics of the 128 enrolled; children with those of the 236 children not enrolled and for whom questionnaires were available. There were negligible differences in the respiratory rates (mean, 34.2 breaths/minute for enrolled, compared with 33.5 breaths/minute for non-enrolled children), age (mean, 22.5 months for enrolled; 21.7 months for non-enrolled), and sex distribution (59% male for enrolled; 55% for non-enrolled), suggesting that the low-risk children not enrolled in the study had the same clinical manifestations of ARI and risk for pneumonia as the low-risk children who were enrolled. We therefore, weighted each observation from a low-risk child by a factor of five to estimate the distribution of pneumonia and clinical findings among all the study children attending the outpatient department with a respiratory illness.

The respiratory rate was the best sign for distinguishing children who had pneumonia from those who did not. Children with pneumonia had a mean \pm SD respiratory rate of 53.0 ± 13.9 breaths/minute, as

measured by the nurse, compared with 44.3 ± 11.1 for children without pneumonia (unweighted data, $P = 0.0001$, Wilcoxon's rank sums test). Similar mean rates were reported by the general practitioner and the paediatrician.

We evaluated different respiratory rate cut-offs to identify children with pneumonia, as proposed by the WHO Control of Acute Respiratory Infections programme (Table 1). For children under 12 months of age, a respiratory rate ≥ 50 breaths/minute was 59–79% sensitive for identifying those with pneumonia, according to the three examiners. This cut-off identified a progressively smaller proportion of children with pneumonia in the older age groups (Table 1). A respiratory rate threshold of ≥ 40 breaths/minute identified a higher proportion of children with pneumonia than a threshold of ≥ 50 , but for children under 12 months of age the specificity for the lower respiratory rate threshold was $<50\%$ for all three examiners. The paediatrician exhibited the largest gain in sensitivity for the 12–23-month age group (Table 1). Neither of these respiratory rate thresholds classified correctly more than 30% of children over 24 months old with pneumonia. The specificity increased with the age of the child for all three examiners. Of other clinical findings, neither crepitations nor nasal flaring was more than 50% sensitive at identifying children with pneumonia (Table 2). A history of rapid breathing, according to the mother, was more sensitive, but for young children was less than 50% specific (Table 2). Combined definitions of respiratory rate cut-offs with other clinical findings improved the sensitivity minimally (by 2–5%, data not shown).

Table 1: Prevalence of elevated respiratory rates, as measured by a nurse, general practitioner, and paediatrician, and radiographic evidence of pneumonia among the study children.

Age group (months)	<i>n</i> ^b	Rate measured by nurse ^a		<i>n</i> ^b	Rate measured by GP ^a		<i>n</i> ^b	Rate measured by paediatrician ^a	
		≥ 50	≥ 40		≥ 50	≥ 40		≥ 50	≥ 40
<i>Sensitivity</i> ^c									
3–11	22/2	59	84	21/2	65	81	14/1	79	100
12–23	19/4	41	49	18/4	40	42	13/4	21	73
≥ 24	11/6	24	27	11/6	15	27	6/3	14	24
<i>Specificity</i> ^d									
3–11	132/29	72	44	124/29	60	24	90/21	59	25
12–23	44/32	90	64	42/32	76	48	30/22	85	52
≥ 24	16/45	97	87	16/41	96	83	10/24	97	88

^a Rate in breaths per minute.

^b No. of children at high risk/No. of children at low risk.

^c Sensitivity to identify children with radiographic evidence of pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

^d Specificity to identify children with no radiographic evidence of pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

Table 2: Clinical findings, as reported by a nurse, general practitioner, and paediatrician, for identification of the study children with radiographic evidence of pneumonia

Age group (months)	Nurse		GP		Paediatrician	
	Fast breathing ^a	Nasal flaring	Nasal flaring	Crepitations	Nasal flaring	Crepitations
<i>Sensitivity^b</i>						
3–11	69	19	42	19	32	32
12–23	49	24	26	13	27	27
≥24	24	8	17	32	14	38
<i>Specificity^c</i>						
3–11	51	93	93	93	95	96
12–23	71	97	95	89	94	87
≥24	92	99	90	92	93	87

^a History reported by mother.

^b Sensitivity to identify children with radiographic evidence of pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

^c Specificity to identify children with no radiographic evidence of pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

We also evaluated the two above-mentioned respiratory rate thresholds in children with more severe radiographic evidence of pneumonia, defined as evidence of lobar pneumonia or involvement of more than one lobe. Although there were few cases in any specific age stratum, elevated respiratory rate thresholds identified a high proportion of cases of radiographically severe pneumonia, especially among children aged ≥12 months (Table 3). There was no drop in sensitivity for older children; however, a respiratory rate threshold of ≥50 breaths/minute identified less than half the children under 12 months of age with radiographically severe pneumonia who were examined by the nurse and general practitioner. In evaluating children with radiographic evidence of pneumonia, but who did not have radiographically severe pneumonia, both respiratory rate thresholds were less sensitive for older children (Table 2).

Comparison of the respiratory rate measurements made by the three examiners indicated that the nurse's mean measurement was 2.3 breaths/minute less than the general practitioner's, and 1.2 breaths/minute less than the paediatrician's; the general practitioner's mean measurement was 0.9 breaths/minute higher than the paediatrician's.

Discussion

The results of this study support the recommendations of the WHO Control of Acute Respiratory Infections programme for identifying children with pneumonia;^b clinical signs can be used to classify

children who have or do not have pneumonia without recourse to expensive laboratory tests that are frequently not available in developing countries. Our data confirm the reports of other workers (5–11) that rapid breathing in young children with a cough is the best sign for identifying those with pneumonia. Our findings extend these previous observations by including multiple examiners in a single study and by analysing in more detail the effect of age on the value of rapid breathing as a marker for children with pneumonia. The weighting system we used avoided verification bias (12) and incomplete assessment of the population under study. The low prevalence of pneumonia in our study population (13% (125/950)) is much less than that reported in previous studies and could indicate that we investigated a less severely ill population than other workers.

For infants, the clinical definition of pneumonia (respiratory rate ≥50 breaths/minute) proposed by WHO effectively identified children with radiographic evidence (Table 1). The reported sensitivities (6–8, 10) for pneumonia in infants lie in the range 71–89%, with the lowest sensitivity (10) being from a study that compared clinical signs with radiographic findings, as did our study. Other clinical findings were insufficiently sensitive to be useful for identifying children with pneumonia, and combined definitions did not improve detection of children with pneumonia.

We further documented (6–10) that a respiratory rate of ≥50 breaths/minute was less sensitive at identifying pneumonia in older children than in infants. By evaluating the findings of the three examiners separately, we were able to determine the effect of reducing the respiratory rate threshold to 40 breaths/minute for children aged ≥12 months. For all

^b *Supervisory skills: management of the young child with acute respiratory infection.* Unpublished WHO document, 1991.

Table 3: Association of elevated respiratory rate, as reported by a nurse, general practitioner, and paediatrician, and radiographic evidence of lobar or multi-lobe pneumonia, among the study children

Age group (months)	n ^b	Rate measured by nurse ^a		n ^b	Rate measured by GP ^a		n ^b	Rate measured by paediatrician ^a	
		≥50	≥40		≥50	≥40		≥50	≥40
<i>Sensitivity (severe pneumonia)^c</i>									
3–11	10/1	38	67	9/1	38	64	5/0	60	100
12–23	8/0	88	100	8/0	75	88	6/0	67	67
≥24	7/0	100	100	7/0	57	100	5/0	60	80
<i>Sensitivity (non-severe pneumonia)^d</i>									
3–11	22/1	74	100	20/1	83	92	15/1	75	85
12–23	19/7	29	44	18/7	30	30	11/6	15	68
≥24	5/8	9	11	5/8	6	12	1/4	0	5

^a Rate in breaths per minute.

^b No. of children at high risk/No. of children at low risk.

^c Sensitivity for children with radiographic evidence of lobar or multi-lobe pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

^d Sensitivity for children with radiographic evidence of non-severe pneumonia (calculated by counting each observation for a high-risk child and weighting each observation for a low-risk child by 5).

the examiners the sensitivity increased for the 12–23-month age group (Table 1); the increase was 52% for the paediatrician but only 2% for the general practitioner. The differences in the patient populations that each examiner evaluated, changes in respiratory rate that may have occurred between the first and last examination, and the large effect of misclassifying low-risk patients who had pneumonia account for the differences in sensitivity. Previous studies have reported increases in sensitivity of between 9% (7) and 21% (8) caused by lowering the respiratory rate threshold to 40 breaths/minute for the age group ≥12 months. For children aged ≥24 months neither respiratory rate threshold (40 or 50 breaths/minute) was adequate for identifying pneumonia, and for all the examiners the sensitivities were below 30%.

Our evaluation of children with radiographic evidence of severe pneumonia is not an assessment of the recommendations made by the WHO Control of Acute Respiratory Infections programme for referral of children with severe pneumonia. Radiographic evidence of the severity of pneumonia may not be a good indicator of the likelihood of a poor outcome (13), and may be even less useful for the youngest children. Our appraisal of severity may be more useful in assessing the likelihood that a child really has pneumonia, those with the most severe changes most probably having bacterial pneumonia (14). For children aged ≥12 months with radiographic evidence of severe pneumonia, we found that either the 40 or 50 breaths/minute threshold would have correctly classified almost all children as having pneumonia. Although there were few patients in any particular

age stratum, it is reassuring that even if the overall sensitivity is low most children with radiographic evidence of severe pneumonia would be identified.

Our data suggest that a single respiratory rate threshold of 50 breaths/minute may be adequate for identifying children with severe pneumonia, although the sensitivity can be increased by using an age-adjusted respiratory rate threshold. These findings could explain why intervention studies that have used a single respiratory rate threshold to identify cases of pneumonia for all age groups have demonstrated substantial reduction in mortality rates.^c Ministries of health in countries with substantial child mortality from pneumonia should develop control programmes based on the case management strategy. An assessment algorithm for pneumonia based on measuring the respiratory rate in children with respiratory illness is the key to this strategy.

^c *Technical bases for the WHO recommendations on the management of pneumonia in children at first-level health facilities.* Unpublished document WHO/ARI/91.20, 1991.

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Résumé

Signes cliniques de pneumopathie chez des enfants vus dans le service de consultations externes d'un hôpital au Lesotho

La stratégie de prise en charge des cas visant à éviter les décès par pneumopathie chez l'enfant dans les pays en développement exige une méthode simple d'identification des cas. Afin de déterminer la valeur des observations cliniques conduisant au diagnostic de pneumopathie, nous avons évalué 950 enfants amenés pour une maladie respiratoire à la consultation externe de l'Hôpital Queen Elizabeth II, Maseru, Lesotho. Les enfants à haut risque ont été examinés tour à tour par une infirmière, un médecin généraliste et un pédiatre; pour chaque enfant, une radiographie pulmonaire a été faite. La pneumopathie était définie par des observations radiographiques compatibles avec cette maladie, interprétées par un radiologue spécialisé en pédiatrie. Une fréquence respiratoire ≥ 50 respirations par minute était un signe sensible chez les nourrissons (la sensibilité du diagnostic pour les trois examinateurs allait de 59 à 79%), mais la proportion d'enfants atteints de pneumopathie qu'elle permettait d'identifier diminuait progressivement avec l'âge. Lorsqu'on corrigeait la fréquence respiratoire de l'âge en prenant un seuil de 40 respirations par minute pour les enfants de 12 mois et plus, on améliorait la sensibilité, mais on identifiait moins de 30% des cas chez les enfants de 24 mois et plus. Aucune diminution de la sensibilité avec l'âge n'a été trouvée lorsque les seuils de fréquence respiratoire ont été évalués chez les enfants présentant des signes radiographiques plus sévères. Ces observations vont dans le sens des recommandations actuelles de l'OMS pour l'identification des enfants atteints de pneumopathie. Bien que la sensibilité chez l'enfant de 12 mois et plus soit plus faible dans notre étude que dans les études antérieures,

les enfants présentant des signes radiographiques sévères ont été facilement identifiés.

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