CHAPTER 4

INCIDENCE AND EVOLUTION OF PNEUMONIA IN CHILDREN AT THE COMMUNITY LEVEL

Claudio F. Lanata, M.D., M.P.H.

I. INTRODUCTION

This chapter provides a review of community studies conducted in an effort to assess the incidence of pneumonia in children under 5 years of age with acute lower respiratory infections (ALRI) in industrialized and developing countries. Also included is a report on the incidence and natural history of pneumonia as seen in children under 35 months, in a study on the epidemiology of acute respiratory diseases conducted in a peri-urban community in Lima, Peru.

II. DEFINITION OF PNEUMONIA OR ALRI IN COMMUNITY STUDIES

Before reviewing study results, it is important to briefly discuss definitions of pneumonia or ALRI used in these studies, as well as the methodology used, given the impact on the rates recorded.

The studies performed in industrialized countries (Table 1) generally use clinical diagnosis, sometimes complemented by radiology, to identify pneumonia (*1-10*). Only one study used the respiratory symptoms reported during weekly visits by the mother concerning episodes of respiratory diseases (*1*). This study defined ALRI by the presence of productive cough, painful breathing, or wheezing. Few studies required the presence of infiltrate in the chest X-ray for a diagnosis of pneumonia (*6*). However, the studies conducted in developing countries have for the most part used the presence of respiratory symptoms either reported by the mother or identified by field workers in examinations specifically performed for this purpose (*11-32*). The earlier studies had diagnoses of pneumonia made by physicians, which were sometimes complemented by radiography (*11, 13, 16, 17, 20*).

However, beginning with pioneer studies conducted in the community of Narangwal, India (*25, 26*), and in the areas of Tari and Goroka, Papua New Guinea (*32, 33*), the earliest studies were done to identify ALRI episodes by using the association with such symptoms as respiratory difficulty, elevated respiratory frequency, intercostal retraction, and wheezing (*34*).

In a major effort to minimize variations in ALRI rates arising from methodological variations, the U.S. Board on Science and Technology for International Development (BOSTID) of the National Academy of Sciences sponsored multiple epidemiological studies on ALRI in communities in developing countries, using a standardized methodology (*12, 15, 18, 19, 21, 22, 30, 31*). Cases of ALRI were defined through medical examinations by the presence of at least one of the following signs: crepitant rale in auscultation, wheezing, stridor, respiratory frequency >50 per minute, cyanosis, or intercostal retraction.

The World Health Organization (WHO) initially recommended that a child with coughing and tachypnea (defined as respiratory frequency >50 per minute) be considered as a pneumonia case. More recent studies have shown that the sensitivity and positive predictive value of coughing and tachypnea vary according to the prevalence of pneumonia in the population under study, and they recommend that the definition of a case of pneumonia should depend on whether hospital or community studies are conducted (*35*).

In hospital studies, using a respiratory frequency of 40 per minute in children between 12 and 35 months was more sensitive for detecting pneumonia than the single criterion of 50 breaths per minute (*36*). Other studies show the importance of combining tachypnea with the presence of subcostal retraction for pneumonia detection in children (*37*). These studies led to a debate in the literature on the best way to combine respiratory signs and symptoms for diagnosing pneumonia (*38, 41*). This debate hinges on such issues as variability in respiratory frequency according to the age of healthy children (*42*), potential variability in measurements of respiratory frequency according to the methods employed (*43*), the considerable variability among observers when patients are examined for signs of respiratory disease (*44-46*), reporting of cases as results of anatomopathological examinations in autopsies, showing the presence of pneumonia in children whose premortem X-rays were normal (*47*), and the absence of coughing in newborns with pneumonia (*11, 48*). This led the WHO to amend its recommendation on case management in clinical institutions, establishing that children under 5 years of age with coughing or respiratory difficulty should be treated as possible cases of pneumonia if they have accelerated breathing or subcostal retraction (*40-49*). Accelerated breathing is defined as ≥60 breaths per minute for children under 2 months of age; ≥50 breaths per minute for children from 2 to 11 months of age; and 40 breaths per minute for children from 1 to 4 years of age. These recommendations have been successfully evaluated in health services in developing countries (*50, 51*). Nevertheless, their usefulness in community studies has not yet been assessed.

As shown below, the different criteria used to define a case of pneumonia in the epidemiological studies that are described preclude the possibility of making a valid comparison of

reported rates. The studies using a clinical definition with radiological confirmation yielded the lowest incidence rates (*6, 13*). However, the studies defining pneumonia or ALRI on the basis of the symptoms reported by the mother yielded the highest incidence rates (*1, 28*). This higher incidence is likely caused by the inclusion of several kinds of ALRI in the pneumonia category, given the low specificity of symptoms reported for differentiating between pneumonia and other kinds of ALRI.

Another methodological factor that influences the reported rates is the screening of pneumonia cases. Only two of the seven studies conducted in industrialized countries were based on active surveillance of children studied at the household level (*1, 7*). The majority were based on passive surveillance in health centers. By contrast, only one of the 20 studies in developing countries was based on passive surveillance (*13*). The vast majority were based on active surveillance at the household level. Active surveillance has a greater probability of recording a larger number of pneumonia cases, but it is sensitive to the frequency of household visits. As was shown in the review of the BOSTID-sponsored research, the studies that programmed more frequent visits (two per week) recorded higher rates of ALRI than those that programmed visits every seven or 14 days (*19*). This may be due to a loss in the capacity to record the presence or absence of respiratory symptoms and signs as the period between the recorded observations grows in length, which other studies have shown (*52, 53*).

Finally, other methodological factors (i.e., the staff involved, their training and level of consistency, and criteria used to define a new episode of pneumonia) have an impact on the results of the studies (*54*). It is important to bear all of these factors in mind before interpreting the rates of pneumonia or ALRI documented in the studies.

III. Incidence of pneumonia or ALRI in community studies

a) In industrialized countries

Six of the seven studies reviewed were conducted in the United States. The incidence of acute respiratory diseases in general was from 4 to 9 episodes per child per year (Table 1). The incidence of pneumonia varied between 0.02 and 0.03 episode per child per year as reported in studies conducted in Seattle (*2, 3*), Chapel Hill (*4, 5*), Tucson (*6*), and Houston (*7*), in which clinical and/or radiological diagnosis of pneumonia was used. Studies in Gallup (*8*) and London (*9, 10*) (Table 1) found 0.1 and 0.2 episode per child per year. The overall incidence of ALRI recorded by other studies varied between 0.06 and 1.09 episodes per child per year. The highest rate, 2.1 episodes per child per year in male children under 1 year, was recorded in a study conducted in Tecumseh, Michigan, which defined ALRI on the basis of symptoms reported by the mother (*1*).

Table 1. Incidence (episodes per child per year) of pneumonia or acute lower respiratory infections from studies performed in developed countries

Place	Year	Area	Type of Study	No. of Children	Rate of ARI	Definition of ALRI	Age (years) <1	1	2	3	4	0-4	Refs.
USA													
Tecumseh, MI	65-71	Urban	Weekly surveillance	707 (5)[a]	4.7-6.1	Productive cough Pain in breathing Sibilance	2.1-1.5	1.6-1.2	NR[b]	NR	NR	NR	1
Seattle, WA	66-71	Urban	Passive surveillance	13,434 (<6)	4.5-5.0	Pneumonia Clinical radiology	0.024-0.049	0.037	0.036	—	0.024	0.03	2, 3
						ALRI Clinical	0.043-0.066	0.056	0.044	0.044	0.027	NR	
Chapel Hill, NC	64-75	Urban	Passive surveillance	6,500 (<15)	NR	Pneumonia Clinical	NR	NR	0.046	—	NR	0.036 (<6)[c]	4, 5
						ALRI Clinical	0.24	0.23	0.19	0.18	0.16	0.143 (<15)	
Tucson, AZ	80-85	Urban	Passive surveillance	1,179 newborns	NR	Pneumonia clinical and radiological	0.02	—	—	—	—	—	6
						ALRI: Cough, sibilance, abnormal auscultation, stridor	0.033						
Houston, TX	75-80	Urban	Surveillance every 7-14 days	131 newborns	8.9	Clinical Pneumonia	0.02-0.09	—	—	—	—	—	7
						Clinical ALRI	0.85-1.00						
Gallup, NM	72-73	Rural	Passive surveillance	2,454 (<5)	6.7	Cough, fever and radiology	0.25	0.0499	0.0499	0.0499	0.0499	0.0913	8
United Kingdom													
London	63-80	Urban	Passive surveillance	2,074 newborns	NR	Clinical	0.115	—	—	—	—	0.094-0.129	9, 10

a. Age at beginning of the study

b. NR = Not reported

c. Age range (years) when different from 0-4

b) In developing countries

A review was conducted of 20 community studies recorded in the literature. Eight of them were conducted in the Americas, three in Africa, six in Asia, and three in the South Pacific (Table 2). The incidence of acute respiratory infections (ARI) in those studies where it was documented generally varied from 4 to 7 episodes per child per year, similar to the incidence reported in industrialized countries. A single study conducted in Bangkok, Thailand, reported 11.2 episodes per child per year (*30*). There were no major differences between regions.

In general, the incidence of pneumonia or ALRI varied between 0.06 and 2.96 episodes per child per year. This considerable variation is a function of the different definitions of pneumonia or ALRI and the different epidemiological methods used in the studies. The only study using passive surveillance, performed in Cali, Colombia (*13*), recorded one of the lowest incidence rates of clinically defined pneumonia with the assistance of radiology: 0.07 to 0.08 episode per child per year in children under 2 years old and 0.05 episode in children from 3 to 4 years old. Four studies conducted in Latin America used a clinical definition of pneumonia, with or without radiology, as part of active case surveillance at the household level.

The pioneer study conducted in Santa María Cauque, Guatemala (*11*), documented an incidence of 0.53 episode per child per year in children under 3 years of age. A study done in San José, Costa Rica (*16*) reported an incidence of 0.04 episode per child per year in children under 5 years. Another study in Fortaleza, Brazil (*17*) reported an incidence of 0.19 episode per child per year in children under 5. Finally, a study conducted in Lima, Peru (*20*), found 0.33 episode per child per year in children under 1 year of age (Table 2). Another study, conducted in Basse, Gambia (*23, 24*) reported a radiological incidence of pneumonia of 0.17 episode per child per year in children under 5 who had been referred by field workers to health centers due to the presence of potential signs of pneumonia.

The studies under review defined ALRI on the basis of symptoms or signs reported by the mother as well as examinations performed by field workers. The reported rates varied between 0.07 and 2.96 episodes per child per year in children under 5. The seven studies reviewed, sponsored by BOSTID and using similar methodologies and a standardized definition, were not free from variations. The definition used by the BOSTID-sponsored studies required the presence of coughing and a respiratory frequency above 50 per minute or another sign of ALRI such as wheezing, crepitant rale, intercostal retraction, cyanosis, or laryngeal stridor. The incidence rates for ALRI reported in the BOSTID-sponsored studies varied from 0.07 episode per child per year in children under 5 in Bangkok, Thailand (*30*), to 2.96 episodes per child per year in children under 3 in a cohort study conducted in Montevideo, Uruguay (*18*). These differences persist even after standardizing the analytical methods for defining ALRI episodes in a subsequent review (*19*). Other studies used definitions of ALRI that included coughing with respiratory frequency >50 per minute, subcostal retraction, or laryngeal stridor (*29*), or the same definition in addition to wheezing (*23, 24*). Two studies used only coughing with an increase in respiratory frequency as reported by the mother (*27, 28*), and four others used a definition that included the presence of fever (*25, 26, 32, 33*). These studies reported an incidence of ALRI

Table 2. Incidence (episodes per child per year) of pneumonia or acute lower respiratory infections from studies performed in developed countries

Place	Year	Area	Type of Study	No. of Children	Rate of ARI	Definition of ALRI	Age (years) <1	1	2	3	4	0-4	Refs.
AMERICA													
Guatemala Santa Maria Cauque	64-69	Rural	Weekly surveillance	45 newborns	6.44	Clinical Pneumonia	NR[a]	NR	NR	NR	NR	0.53 (<3)[b]	11
Guatemala City	85-86	Urban	Surveillance every 14 days	521 (<5)[c]	7.28	BOSTID[d]	0.43-0.6	0.3-0.47	0.23	0.2	0.13	NR	12
Colombia Cali	76-78	Urban	Passive surveillance	4.958 (<5)	NR	Clinical Pneumonia +/- radiology	0.072	0.08	0.08	0.052	0.052	NR	13, 14
Cali	86-88	Urban	Weekly Surveillance	340 newborns	6.59	BOSTID	1.85-2.07	0.97	0.97	—	—	1.71 (<18 mo.)	15
Costa Rica San Jose	66-67	Urban	Weekly surveillance	54 (<5, eutrophic)	6.15	Clinical Pneumonia	NR	NR	NR	NR	NR	0.037	16
Brazil Fortaleza	84-86	Urban	Surveillance 3 x week	175 (<5)	NR	Clinical Pneumonia +/- radiology	NR	NR	NR	NR	NR	0.19	17
Uruguay Montevideo	85-87	Urban	Surveillance every 10 days	166 newborns	5.62	BOSTID	NR	NR	NR	—	—	2.96 (<3)	18, 19
Peru Lima	82-84	Urban	Surveillance 3 x week	153 newborns	NR	Clinical Pneumonia +/- radiology	0.33	—	—	—	—	—	20
						Clinical ALRI	1.0	—	—	—	—	—	
AFRICA													
Nigeria Ibadan	85-87	Urban	Weekly surveillance	NR	7.0	BOSTID	NR	NR	NR	NR	NR	0.22	21

Table 2. Incidence (episodes per child per year) of pneumonia or acute lower respiratory infections from studies performed in developed countries

Place	Year	Area	Type of Study	No. of Children	Rate of ARI	Definition of ALRI	Age (years) <1	1	2	3	4	0-4	Refs.
Kenya Maragua	85-88	Rural	Surveillance every 8 days	470 (<5)	6.62	BOSTID	NR	NR	NR	NR	NR	0.21	19, 22
Gambia Basse	87-88	Rural	Weekly surveillance	500 (<5)	NR	Radiological Pneumonia	NR	NR	NR	NR	NR	0.165	23, 24
						Cough + RF > 50 per min or subcostal retraction or sibilance or stridor	0.7	0.52	0.41	0.25	0.25	0.45	
ASIA													
India Narangwal	68-73	Rural	Weekly surveillance	1,415 (<3)	4.3	Cough or fever or cough with nasal flaring or intercostal retraction	NR	NR	NR	NR	NR	0.94	25, 26
Godchiroli	88-89	Rural	Surveillance every 14 days	692	6.47	Cough with rapid breathing	0.14	0.13	0.13	0.13	0.13	0.13	27
Pakistan	85-87	Rural	Surveillance every 10–14 days	4,665 (<5)	5.12	Cough with rapid breathing	NR	NR	NR	NR	NR	1.33	28
Nepal Katmandu	84-85	Rural	Surveillance every 14 days	904 (<2)	5.04	Cough + RF > 50 per min or subcostal retraction or sibilance or stridor	0.26	—	—	—	—	0.26 (<2)	29
Thailand Bangkok	86-87	Urban	Surveillance 2 x week	674 (5)	11.2	BOSTID	NR	NR	NR	NR	NR	0.07	30
Philippines Manila	85-87	Urban	Weekly surveillance	1,978 (<5)	6.1	BOSTID	0.62-0.95	0.78	0.52	0.37	0.24	0.53	31

Table 2. Incidence (episodes per child per year) of pneumonia or acute lower respiratory infections from studies performed in developed countries

Place	Year	Area	Type of Study	No. of Children	Rate of ARI	Definition of ALRI	Age (years) <1	1	2	3	4	0-4	Refs.
OCEANIA													
Papua New Guinea Tari	72-73	Rural	Surveillance every 14 days	NR	NR	Cough with phlegm, difficulty in breathing, RF > 50 per min, fever, crepitation	0.26	0.06	0.06	0.06	NR	NR	32
Tari	81-82	Rural	Surveillance every 14 days	NR	NR	Cough with phlegm, difficulty in breathing, RF > 50 per min, fever, crepitation	NR	NR	NR	NR	NR	0.67	33
Goroka	80-83	Rural	Surveillance every 14 days	3,614 (<5)	NR	Cough with phlegm, difficulty in breathing, RF > 50 per min, fever, crepitation	1.04	—	0.39	—	—	NR	33

a. NR = Not reported
b. Range of age (years) if different from 0-4
c. Age at the beginning of the study
d. BOSTID = definition applied in the BOSTID studies: cough + respiratory frequency (RF) > 50 per min, intercostal retraction, sibilance, stridor, or cyanosis

that varied from 0.13 episode per child per year in Gadchiroli, India (*27*), to 1.33 episodes per child per year in Pakistan (*28*). Both studies used a similar definition for ALRI—coughing with accelerated breathing.

The episodes of ALRI defined on the basis of respiratory symptoms or signs without clinical examinations probably differ not only because of possible regional variations in the incidence of pneumonia but also because of the presence of other ALRI, in particular diseases associated with wheezing, which become defined as pneumonia because they present symptoms similar to those of clinical pneumonia.

IV. Epidemiological study in Lima, Peru

a) Description of the study and its methodology

For the purpose of developing greater epidemiological knowledge about ARI, a prospective study was done in Canto Grande, a densely populated area with poor socioeconomic conditions in northeast Lima, Peru (*55, 56*). This community is marked by a humid climate (average humidity of 79%, ranging from 55% to 95%), an absence of rain, and an average temperature of 25° C (with a range from 11° to 33° C). The majority of homes are thatched or made of brick with dirt floors that are generally damp around the house because the residents dispose of water outside the dwellings after using it. Water is supplied by tank trucks and is stored in household tanks or barrels. Most dwellings have electricity, although almost all of the cooking was done with kerosene during the study.

As part of two studies done to assess the effectiveness of rotavirus vaccines, 1,500 children were registered at birth or upon returning from the hospital during twice-weekly visits of field workers trained for the study. This cohort was followed until the children reached 30 months of age, after which surveillance ceased and they were removed from the study. The screening of the children for the rotavirus vaccine study took place between July 1987 and October 1989, inclusive. In January 1989 a cohort was added to the study to describe the epidemiology of ARI. Participants in the study included 1,371 children from the rotavirus vaccine studies and 379 children registered exclusively for the ARI study at birth, who participated only until reaching 3 months of age. Thus, a total of 1,750 children participated in the ARI study between January 1989 and February 1991, when the study concluded.

The methods used in the study were detailed in another publication (*57*). In short, interviews were held twice a week with the mothers of the children targeted for epidemiological surveillance for the presence or absence of respiratory signs and symptoms. Mothers were queried about their children on the day of the visit and for each previous day dating back to the prior visit up to a maximum 7-day period. The field workers examined all of the children less than 3 months of age at each home visit regardless of their clinical condition. Older children were examined only if the mother reported coughing on the day of the visit or if the field worker observed the child coughing. In the examination, the field workers counted respiratory frequency for a minute, using a digital chronometer as a timer.

If the first measurement yielded a frequency ≥60 breaths per minute in children under 3 months of age, 50 per minute in children 3 to 11 months, or 40 per minute in children 12 months of age or older, then a second measurement would be immediately taken. The field worker also noted the presence of other respiratory signs detected in the examination, which did not include auscultation. All of the data were recorded in a precoded format that was then entered in a computerized data base.

Following the guidelines of the Program for Control of Acute Respiratory Infections of the WHO, the workers referred the children suspected of having pneumonia or other respiratory pathologies to one of four doctor's field offices set up for the study. At the clinic, four pediatricians examined all of the children referred by the field workers and all of the children from the study with respiratory problems who went on their own for consultations. The pediatricians documented the clinical findings and their diagnoses in a precoded format that was then entered into the data base. The diagnosis of pneumonia was made by the pediatricians according to their clinical criteria. When the pediatricians or the coordinating physician for the field study requested (for cases diagnosed as a new ALRI episode, when changes occurred in clinical status, children having a history of contact with tuberculosis, and children from a sample of patients with upper respiratory disease), chest X-rays were taken on average one day after the visit to the health center. All of the X-rays were interpreted by a radiologist who had no access to the children's clinical history. The radiological findings were recorded in a precoded format and then entered into the data base.

The children participated in the study if their parents gave written authorization. The study offered antibiotic treatment free of charge for diagnosed cases of pneumonia and dysentery. Free treatment was also offered for cases of bronchospasm, and oral rehydration was given for diarrhea. The field clinic operated from 8 a.m. to 6 p.m., Monday through Friday, and the project provided transportation to the clinic for families that requested it. The hospitalized children were visited by the coordinating physician to keep a record of the presence of pneumonia, prior to being evaluated by the pediatricians in the study. This was how screening was done for children in the study who had pneumonia or serious ALRI episodes.

b) Incidence of pneumonia

For this review, episodes of pneumonia were defined as beginning on the first day for which there was a clinical record of diagnosis. The length of the episode was arbitrarily defined as the date of the pediatric clinic visit that resulted in a positive diagnosis followed by a period of at least 14 days without a clinic visit with a diagnosis of pneumonia.

Detection was made for 646 episodes of pneumonia, which yielded an incidence of 0.34 episode per child per year in children under 35 months. This incidence was very similar to the incidence of 0.33 found in the same area in a study conducted between 1982 and 1984 (*20*). The incidence of pneumonia was highest among children between 2, and 17 months for whom 0.40 episode per child per year was found. Incidence was slightly higher in male children and in summer and winter months; it was lower in female children and in the months of spring and

autumn. Of the 1,759 children studied, 1,326 were not diagnosed with pneumonia; 474 had pneumonia; and 150 had more than one diagnosis of pneumonia. Chest X-rays (anteroposterior and lateral) were taken in 80% of the diagnosed cases of pneumonia. Of these, 162 cases of pneumonia were identified through radiography, resulting in an incidence of clinical pneumonia with radiological confirmation of 0.08 episode per child per year. It is important to note that for the first year of the study, the X-ray machine that was used did not have sufficient speed or power to take X-rays of children in motion; as a result, many of the X-rays presented diagnostic problems due to the movement of the children. The machine was upgraded at the start of the second year of the study, which led to significant improvement in quality. Several clinical cases of pneumonia with negative X-rays might have been interpreted as positive had the necessary equipment been in place from the start.

c) Natural history of pneumonia in the community

Attempts were made to research what the variation was in the respiratory signs and symptoms reported by the mothers in the epidemiological surveillance and variations in the results of the examinations performed by the field workers before and after a diagnosis of pneumonia. The breakdown of the results is presented in another publication (*57*). For the review, the following kinds of pneumonia were identified and controls were selected as indicated:

- Clinical pneumonia: episodes of pneumonia with clinical diagnosis and with radiography.
- Clinically and radiologically confirmed pneumonia: episodes of pneumonia in which there was a positive radiography for pneumonia within 7 days of a clinical diagnosis.
- Radiologically confirmed pneumonia: cases in which a diagnosis of pneumonia was made through radiography when the initial diagnosis had not been for pneumonia.
- Controls from the community: randomly chosen to match each case of pneumonia, a child of the same sex, of an age ±45 days within the age of the confirmed case. The matched cases in the control group would not have visited the pediatric clinic ±10 days within the date of the visit of the confirmed case. Children who at some point in the study had pneumonia were not eligible as control cases.

It was possible to match only 528 bouts of pneumonia with control cases: 358 clinical cases of pneumonia; 134 clinically and radiologically confirmed cases; and 36 radiologically confirmed cases, all of whom were included in the review. Assessment was made of the data reported in the household epidemiological surveillance, and the prevalence was calculated (positive days for the sign or symptom divided by the total number of days observed) for each day of the ±30 days before or after the day of pneumonia diagnosis (i.e., the day of the visit to the clinic in the case of positive diagnosis in the radiologically confirmed cases), which was referred to as day 0. Data were also reviewed for the same calendar days for the matched control cases from the community.

The prevalence of coughing reported by the mother began to increase as of 10 days prior to diagnosis, reaching almost 100% on day 0 for the three types of pneumonia without disparities in the three types in the curves generated (Figure 1). By contrast, prevalence of coughing in the community control group was around 25% of the days reported. The mothers were asked about the intensity of coughing and its distribution throughout the day. In 40 to 50% of the confirmed cases the mother reported moderate to severe coughing on day 0 as compared to 2% for the control cases from the community (Figure 1). Coughing reported exclusively at night had a low association with pneumonia and had a 10% prevalence in the control cases from the community (Figure 1). The coughing associated with "phlegm," also called "moist cough" by some mothers, was also associated with pneumonia and reached an 80% prevalence on day 0 as compared to 16% among the control group cases (Figure 2). Prevalence of coughing, both with and without phlegm, was significantly higher than among the control group cases on any given day during the study, whether before or after the episode of pneumonia. This suggests that some children present a basic pathological picture that leaves them more susceptible to pneumonia. This is a question to be addressed in future studies of the data. Higher prevalence was not found for other signs and symptoms studied.

With regard to the presence of tachypnea, mothers were asked whether they noticed difficulty in breathing in their children and to what it was attributed in order to explore whether or not accelerated breathing was present. The field workers were instructed in the appropriate use of the terms to be explored, after a study was done with the mothers in the pediatric office on the best way to describe the symptoms of a child with tachypnea. It was found that a report of any breathing difficulty would include a large proportion of children who only had a stuffy nose and did not present accelerated breathing. The presence of accelerated breathing reported by the mother began to increase 6 days prior to the diagnosis of pneumonia and reached a 55% prevalence in the clinically and radiologically confirmed cases, significantly higher than the 37% in the cases of clinical pneumonia and 35% in the radiologically confirmed cases. By contrast, accelerated breathing was reported in only 1% of the community control group (Figure 3).

The prevalence of fever reported by the mother was also significantly higher in the clinically and radiologically confirmed cases, in which after beginning to rise 10 days prior to day 0, it reached 64% prevalence on day 0. The maximum value was 53% in the clinical pneumonia cases and 35% in the cases that were radiologically but not clinically confirmed, figures that are statistically significant (Figure 4). The prevalence of fever in the control group from the community was 3%. It is interesting to note that in the clinical and radiological-clinical cases, fever prevalence abruptly falls after day 0, reaching a level similar to that of the control group by day 3. This fall in prevalence was observed only with fever and not any other respiratory symptoms or signs reported, indicating a likely response to the antibiotic therapy employed in all cases diagnosed as pneumonia. Thus, the cases confirmed only by radiology without the initial clinical diagnosis of pneumonia and which consequently did not receive antibiotic therapy under the project, did not present a similar drop in fever. The radiological pneumonia cases presented a greater prevalence of fever before and after diagnosis than did the other pneumonia classifications or the control group from the community (Figure 4).

Figure 1. Prevalence of coughing, moderate to severe coughing, and nocturnal coughing among four kinds of cases: those reported by the mother for the period 30 days prior to and after clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.

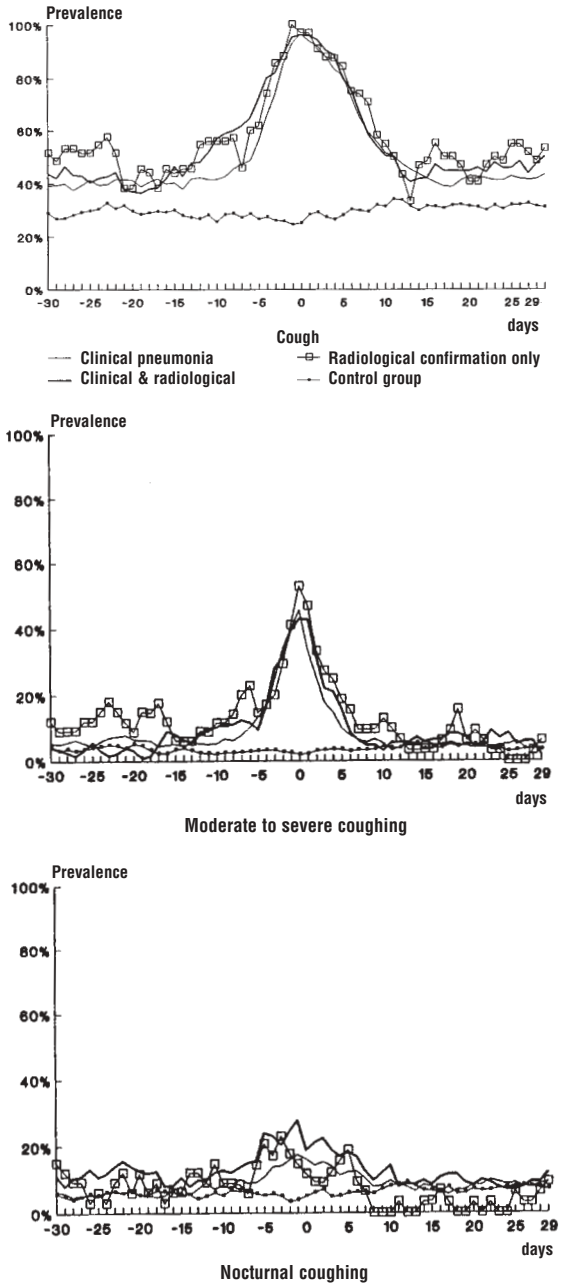
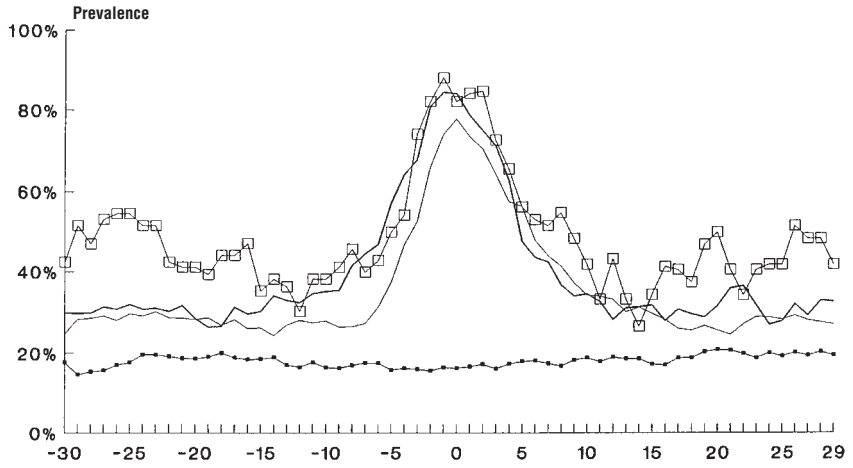
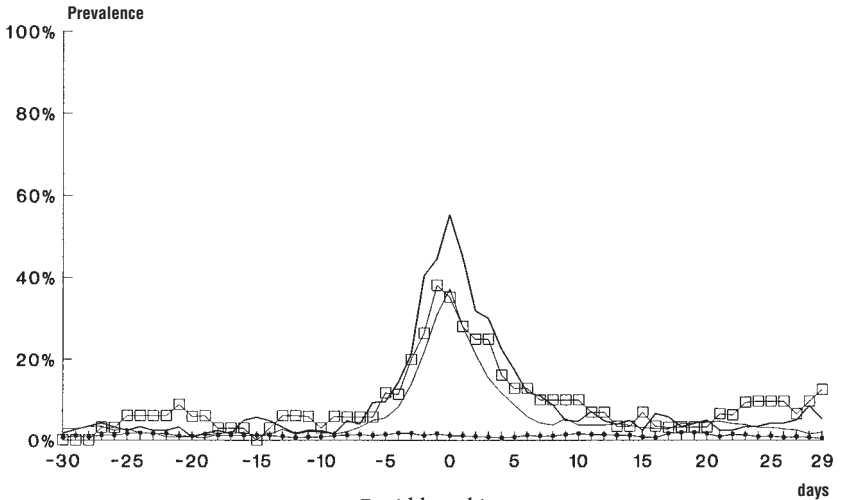


Figure 2. Phlegm: Prevalence of moist cough with phlegm as reported by the mother on each day in the period 20 days before and after the clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.



Phlegm

Figure 3. Rapid Breathing: Prevalence of rapid breathing reported by the mother each day of the period 30 days before and after the clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.



Rapid breathing

The prevalence of loss of appetite and the mothers' sense that the child looked ill followed similar lines to the prevalence of other respiratory symptoms, reaching values close to 80% in the radiological-clinical cases of pneumonia, 67% in the clinical cases, and between 47 and 50% in the cases confirmed solely by radiology (Figures 5 and 6). These figures showed significant differences among themselves and greater still with those for the community control group, where the values ran around 10%.

The study of the prevalence of nasal mucus was revealing. With a prevalence around 50% in the control group, prevalence rose to levels of between 74 and 80% in the pneumonia cases, but in a more gradual fashion than observed with the other respiratory symptoms (Figure 7). Most of the mucous material was transparent or milky. When prevalence of greenish-yellow nasal mucus was examined, no clear association emerged with the pictures of pneumonia, notwithstanding the belief that this type of nasal mucus may be a risk factor for developing pneumonia (Figure 7).

Results of examinations performed by the field workers were also reviewed. As indicated earlier (*42*), respiratory frequency is shown to be related to the age of the child, and did not vary when measured in a still child as compared with one who was nursing. The project used a WHO-recommended criterion of classifying respiratory frequency as elevated if it was over 60 per minute in the first 2 months of life; over 50 from 3 to 11 months, and over 40 after 12 months of age. Because the field visit examinations were performed only twice a week, the three kinds of pneumonia were grouped together for comparison with the community control group, with an average of 40 to 50 examinations performed every day for each group. The prevalence of elevated respiratory frequency increased in the cases of pneumonia 5 to 10 days prior to diagnosis, but with a marked increase in the 48 hours prior to day 0, reaching an 80% prevalence in the pneumonia cases as opposed to 10% in the cases from the community control group (Figure 8). The project required second measurements of respiratory frequency to be taken after an initial elevated measurement. In examining both measurements of respiratory frequency, the second measurement scarcely dropped in the cases of pneumonia, but it fell markedly in the cases from the community control group, heightening the specificity of this indicator (Figure 8).

The frequency of clinical signs—such as nasal flaring (14 to 17%), respiratory grunting (18 to 29%), wheezing audible to the field worker (11 to 35%), intercostal retractions (22 to 42%), and subcostal retractions (2 to 9%)—was very low, of short duration, and associated with all kinds of pneumonia. This suggests that these signs not be considered as part of the diagnosis of pneumonia, but rather only as indicators of seriousness once a positive diagnosis is established.

d) Duration of respiratory signs and symptoms

The previous figures represent the reported prevalence for each day for all the cases studied, although they do not necessarily show the duration of the symptoms in each case. On examining the duration of the symptoms and signs reported by the mother around the day of the pneumonia diagnosis, it was noted that coughing lasted an average of 15 days, phlegm 12 days, acceler-

Figure 4. Fever: Prevalence of fever reported by the mother on each day of the 30 days before and after clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.

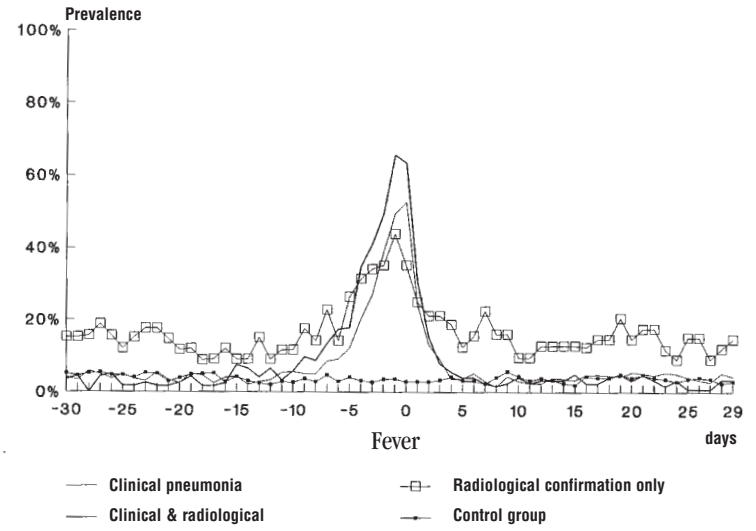


Figure 5. Loss of Appetite: Prevalence of loss of appetite as reported by the mother on each day of the 20 days before and after clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.

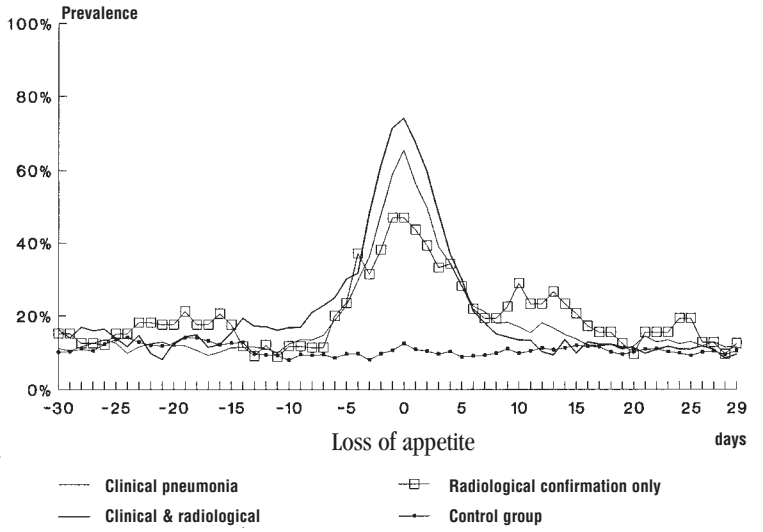
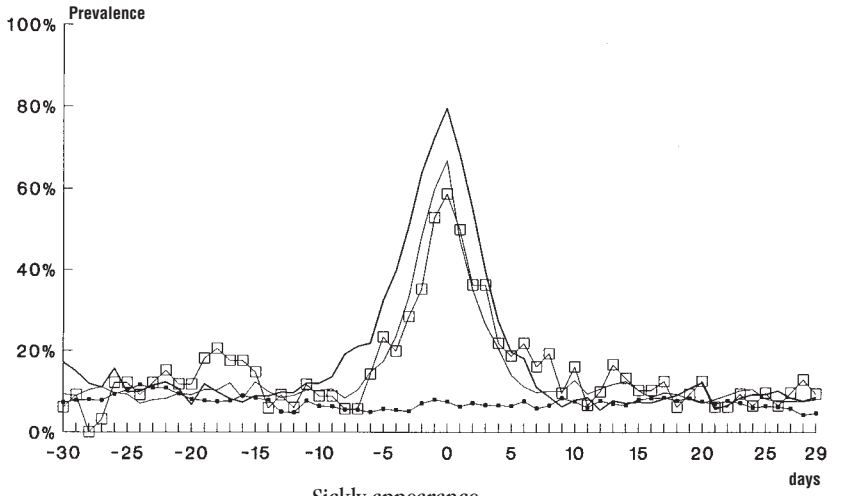


Figure 6. Sickly Appearance: Prevalence of days in which the child does not look well as reported by the mother on each day of the 30 days before and after clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in cases from the community control group, which were matched by age and sex.



Sickly appearance

ated respiration 5 days, and loss of appetite and general listlessness noted by the mother around 8 days. It is important to recall that this study performed a very intensive epidemiological household surveillance with excellent case screening for respiratory disease. At the same time, appropriate and timely treatment was offered to cases that required it. This last factor must have had an definite impact on the duration of the respiratory symptoms and signs that were found.

e) Prognosis for community pneumonia

It is important to note that of the 646 pneumonia cases and over 1,000 cases of lower respiratory problems detected in this study, the majority with a bronchospastic component, only 10 cases had to be referred to a hospital for treatment. Outpatient treatment with oral antibiotics (cotrimoxazole) for 5 days was highly effective in treating the pneumonia cases. The treatment of bronchospasm cases used albuterol inhalation over a short period of a few days. The acute cases were treated with foot-pump-operated nebulizers, while holding the patients at the field clinics under observation to determine how they responded and whether they would require hospital referral. With this simple treatment arrangement, the vast majority of clinical ALRI cases were resolved. Moreover, given the early detection and treatment, no cases were recorded in which there were complications such as empyema or pulmonary abscess, which

Figure 7. Prevalence of nasal mucus and greenish-yellow mucus as reported by the mother on each day of the 30 days before and after clinical diagnosis of pneumonia, diagnosis with radiological confirmation, radiological confirmation without clinical diagnosis, and in community control group cases, matched by age and sex.

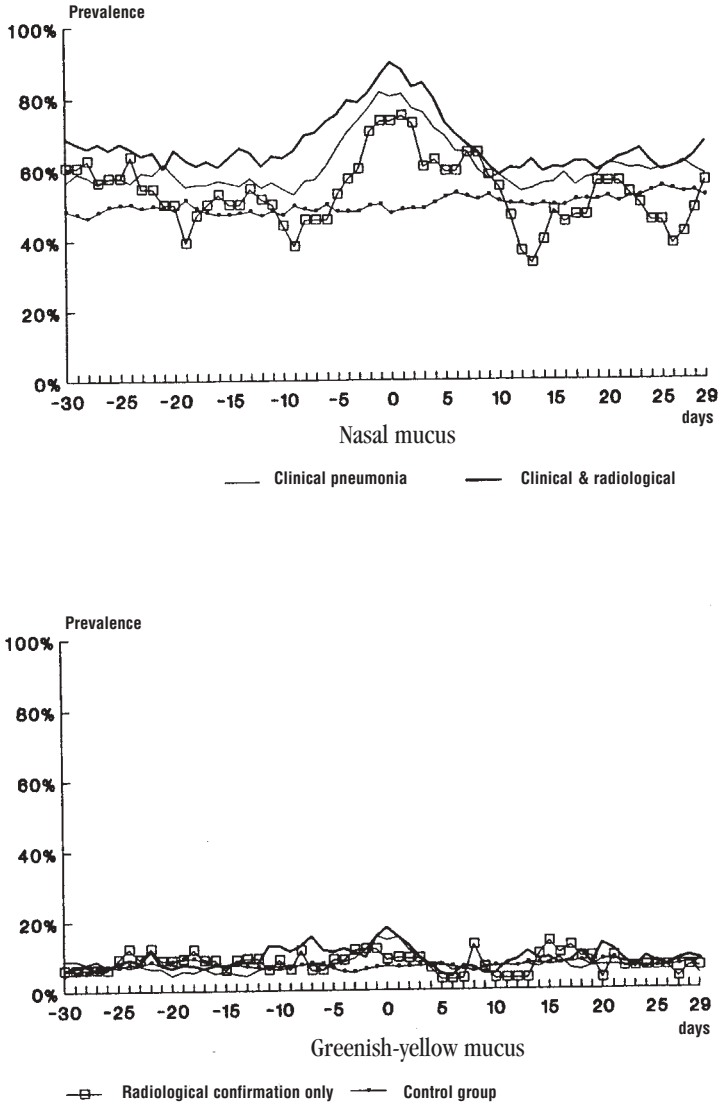
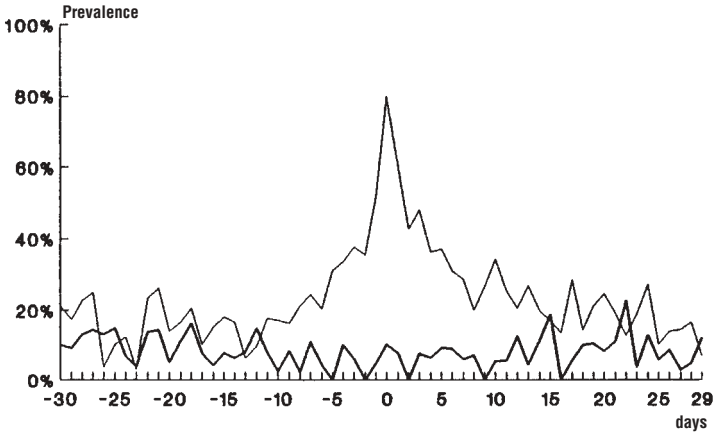
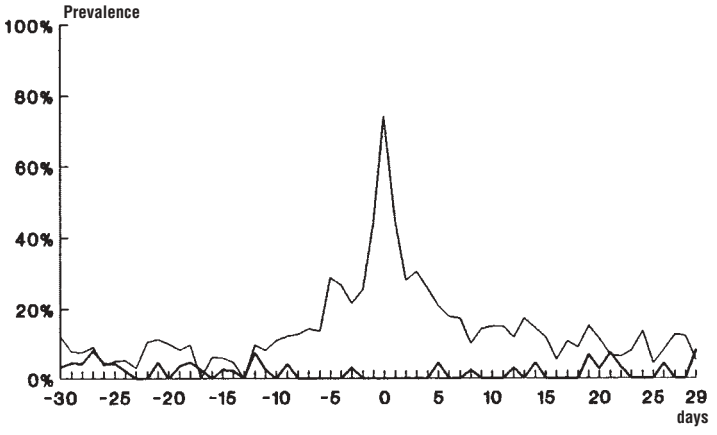


Figure 8. Prevalence of elevated respiratory frequency with the first and second measurements taken by field workers from children with pneumonia for the period 30 days before and after clinical diagnosis of pneumonia and in community control group cases matched by age and sex.



First measurement



Second measurement

are common in the hospital wards of Lima. Fewer than 20 of the 1,750 children who participated died during the study, far below the expected figure according to the infant mortality observed in the areas where the study was conducted.

V. Comments and conclusion

At first blush it appears that the cases of radiologically confirmed clinical pneumonia are the most severe; however, the clinical pneumonias without radiological confirmation behave similarly to those that have it, even in their response to antibiotic therapy as evidenced by the fall in fever, suggesting that the vast majority involve similar infectious processes. Several mechanisms can explain this.

It is known that many children with pneumonia do not initially have a positive radiography, which appears after a few days or after the child has been appropriately hydrated. Autopsies of children with anatomopathological confirmation of the presence of pneumonia, but who had normal radiographies immediately prior to their deaths, confirm these observations (*47*). Moreover, the radiological pneumonia cases that the pediatrician did not diagnose as such were the least severe cases in this study, which explains why they were not clinically detected. All of this suggested that radiography is not necessarily the "gold standard" for diagnosis of pneumonia, that a good clinical diagnosis is important, and that in epidemiological studies, use of clinical criteria to detect pneumonia is sufficient, even though the radiology may be useful mainly as a quality control measure.

There are many respiratory and nonrespiratory signs and symptoms associated with pneumonia. Coughing is an important symptom for identifying pneumonia, even in children under 3 months old (data not shown). This is important for case management, because the presence of coughing may be used with assurance as a screening criterion for case evaluation.

It was distressing to see that other signs, considered more specific for pneumonia, did not have a very high sensitivity. Although a report of accelerated respiration and a second measurement to reconfirm elevated respiratory frequency were associated with pneumonia cases, they did not attain over an 80% sensitivity, in contrast with studies on the sensitivity of these signs conducted in hospitals. This is due in part to the majority of cases having been detected relatively early on, thanks to the household epidemiological surveillance. It is likely that if these cases had continued their natural course, some of the cases would have sought care at a hospital and been more serious, and consequently the respiratory signs and symptoms would have been more prevalent.

It is also important to note that even though the signs and symptoms studied were associated with pneumonia (i.e., they are sensitive), they are also present in other ALRI patterns. An evaluation of the diagnostic usefulness of these signs and symptoms should be complemented with a study of their specificity for patterns of other upper and lower respiratory diseases. The preliminary results of this review would seem to indicate that the respiratory signs and symptoms reported by the mother or found in examinations by the field workers are also present in

a high proportion in other respiratory patterns and so are not very specific for pneumonia. This explains why the episodes of "pneumonia" created on the basis of symptoms and signs examined were to or three times higher than the number of clinical cases. It also explains why the proportion of these cases that coincided with clinical pneumonia (a predictive positive value) is no higher than 20%. These issues will be taken up again in future publications.

In conclusion, the major results may be summed up as follows:

1. The incidence of clinical pneumonia fluctuated between 0.01 to 0.02 episode per child per year in industrialized countries and between 0.03 and 0.53 episode per child per year in developing countries.
2. Using a definition of pneumonia based on respiratory signs and symptoms is probably not appropriate for discriminating between pneumonia and other ALRI in community studies. The incidence of pneumonia based on respiratory signs and symptoms varied between 0.07 and 2.96 episodes per child per year.
3. Radiology is important but not indispensable for diagnosing pneumonia in community studies. A clinical diagnosis of pneumonia would seem to be at least as important.
4. Early and appropriate ambulatory care for pneumonia and other ALRI is highly effective for managing these cases; it prevents the appearance of signs of seriousness, complications, and deaths.
5. To confirm that a child has an elevated respiratory frequency, it is recommended that the frequency be measured twice for a minute each time with at least five minutes lapse between measurements.
6. The methodology and definition of pneumonia used by these community studies has a large impact on the rates reported. Standardization of procedures to be followed is recommended in community studies investigating the incidence of pneumonia in children.

VI. References

1. Monto AS, Ullman BM. *Acute respiratory illness in an American community: The Tecumseh Study.* J Am Med Assoc 1974;227:164-169.
2. Foy HM, Cooney MK, Maletzky AJ, Grayston JT. *Incidence and etiology of pneumonia, croup and bronchiolitis in preschool children belonging to a prepaid medical care group over a four-year period.* Am J Epidemiol 1973;97:80-92.
3. Fox HM, Cooney KM, Hall CE. *The Seattle Virus Watch. V. Epidemiologic observations of rhinovirus infections, 1965-1969, in families with young children.* Am J Epidemiol 1975;101:122-143.
4. Murphy TF, Henderson FW, Clyde WA, Collier AM, Denny FW. *Pneumonia: An eleven-year study in a pediatric practice.* Am J Epidemiol 1981;113:120-121.
5. Glezen WP, Denny FW. *Epidemiology of acute lower respiratory disease in children.* N Engl J Med 1973;288:498-505.

6. Wright AL, Taussig LM, Ray CG, Harrison HR, Holberg CJ. *The Tucson children's respiratory study. II. Lower respiratory tract illness in the first year of life.* Am J Epidemiol 1989;129:1232-1246.

7. Gardner G, Frank AL, Taber LH. *Effects of social and family factors on viral respiratory infection and illness in the first year of life.* J Epidemiol Comm Health 1984;38:42-48.

8. Oseasohn R, Skipper BE, Tempest B. *Pneumonia in a Navajo community: A two-year experience.* Am Rev Respir Dis 1978;117:1003-1009.

9. Leeder SR, Corkhill R, Irwig LM, Holland WW, Colley JRT. *Influence of family factors on the incidence of lower respiratory illness during the first year of life.* Brit J Prev Soc Med 1976;30:203-212.

10. Holland WW. *Acute respiratory disease in children.* Bull Int Union Against Tuberc 1983;58:212-214.

11. Mata LJ. *The children of Santa María Cauque: A prospective field study of health and growth*. Cambridge, MA: MIT Press; 1978.

12. Cruz JR, Pareja G, Fernández A, Peralta F, Cáceres O, Cano F. *Epidemiology of acute respiratory tract infections among Guatemalan ambulatory preschool children.* Rev Infect Dis 1990;12(Suppl 8):S1029-S1034.

13. Berman S, Dueñas A, Bedoya A, Constain V, León S, Borrero I, Murphy J. *Acute lower respiratory tract illnesses in Cali, Colombia: A two year ambulatory study.* Pediatrics 1983;71:210-218.

14. Berman S, McIntosh K. *Selective Primary Health Care: Strategies for control of disease in the developing world. XXI. Acute respiratory infections.* Rev Infect Dis 1985;7:674-691.

15. Borrero HI, Fajardo PL, Bedoya MA, Zea A, Carmona F, Borrero MF. *Acute respiratory tract infections among a birth cohort of children from Cali, Colombia, who were studied through 17 months of age.* Rev Infect Dis 1990;12(Suppl 8):S950-S956.

16. James JW. *Longitudinal study of the morbidity of diarrheal and respiratory infections in malnourished children.* Am J Clin Nutr 1972:25:690-694.

17. Arruda NE, Hayden FG, McAuliffe JF, Sousa MA, Mota SB, McAuliffe MI, Geist FC, Carvalho EP, Fernandes MC, Guerrant RL, Gwaltney JM. *Acute respiratory viral infections in ambulatory children of urban northeast Brazil.* J Infect Dis 1991;164:252-258.

18. Hortal M, Benitez A, Contera M, Etorena P, Montano A, Mey M. *A community-based study of acute respiratory tract infections in children in Uruguay.* Rev Infect Dis 1990;12(Suppl 8):S966-S973.

19. Selwyn BJ. *The epidemiology of acute respiratory tract infection in young children: Comparison of findings from several developing countries.* Rev Infect Dis 1990;12(Suppl 8):S870-S888.

20. López de Romaña G, Brown KH, Black RE, Creed-Kanashiro H. *Longitudinal studies of infectious diseases and physical growth of infants in Huáscar, an underprivileged peri-urban community in Lima, Peru.* Am J Epidemiol 1989:129:769-784.

21. Oyejide CO, Osinusi K. *Acute respiratory tract in children in Idikan community, Ibadan, Nigeria: Severity, risk factors and frequency of occurrence.* Rev Infect Dis 1990;12(Suppl 8):S1042-S1046.

22. Wafula EM, Onyango FE, Mirza WM, Macharia WM, Wamola I, Ndinya-Achola JO, Agwanda R, Waigwa RN, Musia J. *Epidemiology of acute respiratory tract infections among young children in Kenya.* Rev Infect Dis 1990;12(Suppl 8):S1035-S1038.

23. Campbell H, Byass P, Lamont AC, Forgie IM, O'Neaill KP, Lloyd Evans N, Greenwood BM. *Assessment of clinical criteria for identification of severe acute lower respiratory tract infections in children.* Lancet 1989;i:297-299.

24. Forgie IM, Campbell H, Lloyd-Evans N, Leinonen M, O'Neill KP, Saikku P, Whittle HC, Greenwood BM. *Etiology of acute lower respiratory tract infections in children in a rural community in Gambia.* Pediatr Infect Dis 1992;11:446-473.

25. McCord C, Kielmann AA. *A successful programme for medical auxiliaries treating childhood diarrhoea and pneumonia.* Trop Doctor 1978;8:220-225.

26. Kielmann AA, Taylor CE, DeSweemer C, Uberoi IS, Takulia HS, Masih N, Vohra S. *The Narangwal experiment on interactions of nutrition and infection: II. Morbidity and mortality effects.* Indian J Med Res 1978;68(Suppl):21-41.

27. Bang AT, Bang RA, Tale O, Sontakke P, Solanki J, Wargantiwar R, Kelzarkar P. *Reduction in pneumonia mortality and total childhood mortality by means of community-based intervention trial in Gadchiroli, India*. Lancet 1990;336:201-206.

28. Khan JA, Addiss DG, Rizwan-Ullah. *Pneumonia and community health workers.* Lancet 1990;336:939.

29. Pandey MR, Neupane RP, Gautam A, Shrestha IB. *Domestic smoke pollution and acute respiratory infections in a rural community of the hill region of Nepal.* Environ Intern 1989;15:337-340.

30. Vathanophas K, Sangchai R, Raktham S, Pariyanonda A, Thangsuvan J, Bunyaratabhandu P, Athipanyakom S, Suwanjutha S, Jayanetra P, Wasi C, Vorachit M, Puthavathana P. *A Community-based study of acute respiratory tract infection in Thai children.* Rev Infect Dis 1990;12(Suppl 8):S957-S965.

31. Tupasi T, Leon LE, Lupisan S, Torres CU, Leonor ZA, Sunico MES, Mangubat NV, Miguel CA. Medalla F, Tan St, Dayrit M. *Patterns of acute respiratory tract infection in children: A longitudinal study in a depressed community in Metro Manila*. Rev Infect Dis 199;12(Suppl 8):S940-S949.

32. Riley I, Carrad E, Gratten H, Lovuro K, Philipps R, Pratt D, Rose A, Siwi H, Smith D. *The status of research in acute respiratory infections in children in Papua New Guinea.* Pediatr Res 1983;17:1041-1043.

33. Riley I. Gratten H, Gratten M, Lehmann D, Phillips P, Smith D, Carrad E. *Results of studies on acute respiratory infections in Papua New Guinea since 1979.* Geneva: World Health Organization; 1985. (WHO/TRI/ARI.TAG.II/85.17).

34. Shann F, Hart K, Thomas D. *Acute lower respiratory tract infections in children: Possible criteria for selection of patients for antibiotic therapy and hospital admission.* Bull WHO 1984;62:749-753.

35. Lucero MG, Tupasi TE, Gómez MLO, Beltrán GL, Crisóstomo AU, Romano VV, Rivera LM. *Respiratory rate greater than 50 per minute as a clinical indicator of pneumonia in Filipino children with cough.* Rev Infect Dis 1990;12(Suppl 8):S1081-S1083.

36. Cherian T, John TJ, Simoes E, Steinhoff MC, John M. *Evaluation of simple clinical signs for the diagnosis of acute lower respiratory tract infection.* Lancet 1988;ii:125-128.

37. Campbell H, Byass P, Greenwood BM. *Simple clinical signs for diagnosis of acute lower respiratory infections*. Lancet 1988;ii:742-743.

38. Gove S, Kumar V. *Simple signs and acute respiratory infections.* Lancet 1988;ii:626-627.

39. Harari M, Shann F, Spooner V, Meisner S, Carney M, de Campo J. *Clinical signs of pneumonia in children*. Lancet 1991;338:928-930.

40. Gove S, Pio A, Campbell H, Cattaneo A. *WHO Guidelines on detecting pneumonia in children.* Lancet 1991;338:1453.

41. Shann F. *WHO definition of tachypnoea in children.* Lancet 1992;339:176-177

42. Berman S, Simoes EAF, Lanata C. *Respiratory rate and pneumonia in infancy.* Arch Dis Child 1991;66:81-84.

43. Simoes EAF, Roark R, Berman S, Esler LL, Murphy J. *Respiratory rate: Measurement of variability over time and accuracy at different counting periods.* Arch Dis Child 1991;66:1199-1203.

44. Godgrey S, Edwards RHT, Campbell EJM, Armitage P, Oppenheimer EA. *Repeatability of physical signs in airways obstruction.* Thorax 1969;24:4-9.

45. Mulrow CD, Domarch BL, Delong ER, Feussner JR, Benyunes MC, Dietz JL, Lucas SK, Pisano ED, Svetkey LP, Volpp BD, Ware RE, Neelon FA. *Observer variability in the pulmonary examination.* J Gen Intern Med 1986;1:364-367.

46. Spiteri MA, Cook DG, Clarke SW. *Reliability of eliciting physical signs in examination of the chest.* Lancet 1988;i:873-875

47. Doherty JF, Dijkhuizen MA, Wieringa FT, Moule N, Golden MHN. *WHO guidelines on detecting pneumonia in children.* Lancet 1991;338:1454.

48. Singhi S, Singui PD. *Clinical signs in neonatal pneumonia.* Lancet 1990;336:1072-1073.

49. WHO Programme for the Control of Acute Respiratory Infections. *Acute respiratory infections in children: Case management in small hospitals in developing countries: A manual for doctors and other senior health workers.* Geneva: World Health Organization; 1990. (WHO/ARI/90.5).

50. Mulholland EK, Simoes EAF, Costales MOD, McGrath EJ, Manalac EM, Gove S. *Standarized diagnosis of pneumonia in developing countries.* Pediatr Infect Dis J 1992;11:77-81.

51. Simoes EAF, McGrath EJ. *Recognition of pneumonia by primary health care workers in Swaziland with a simple clinical algorithm.* Lancet 1992;340:1502-1503.

52. Ross DA, Vaughan JP. *Health interview surveys in developing countries: A methodological review.* Studies Family Planning 1986;17:78-94.

53. Lanata CF, Quintanilla N, Verastegui HA. *Validity of a respiratory questionnaire to identify pneumonia in children in Lima, Peru.* Submitted, Int J Epidemiol. Paper IJE3843.

54. Programme for the Control of Acute Respiratory Infections. *Report of a meeting on methodological issues related to the measurement of episodes of childhood pneumonia in prospective home surveillance studies*. Geneva: World Health Organization; 1990. (WHO/ARI/90.15).

55. Lopez de Romana G, Brown K, Black, RE. *Health and growth of infants and young children in Huáscar, Peru*. Ecol Food Nutr 1987;19:213-229.

56. Yeager BAC, Lanata CF, Lazo F, Verastegui H, Black RE. *Transmission factors and socioeconomic status as determinants of diarrhoeal incidence in Lima, Peru*. J Diarrhoeal Dis Res 1991;9:186-193.

57. Lanata CF, Quintanilla N, Linares A, Butron B, Verastegui HA, Del-Pino L. *Childhood pneumonia: Its natural history. A community study in Lima, Peru.* Submitted for publication.