Acute Respiratory Infections in Infants and Children

*Dr. Pushpa Raj Sharma**

Magnitude of the Problem :

Respiratory infections are major causes of morbidity and mortality in children. Of the fifteen million children who die every year about one third die of pneumonia, and ninety percent of them are from the developing countries. (Table 1) Although the total number of Acute Respiratory Infections (ARI) episodes per child per year are somewhat similar in developing and developed countries the mortality is far higher in the former. Investigators from a number of developing countries have shown that most of these infections are caused by bacteria whereas in the developed nations these are mostly viral in origin. Prevalence of risk factors for ARI like low birth weight, malnutrition, diarrhoea, domestic smoke pollution and low coverage by immunization programme makes the situation of ARI, at present very gloomy. (Fig. 10)

The problem of ARI is particularly important in the Nepalese context, perhaps because of the climate, terrain and the living conditions of the people. Analysis of the data from Kanti Children's Hospital showed 37.8% admissions due to ARI. The highest admission rate was in 0-1 year age group. The case fatality rate was 9.6%. In a retrospective study of the deaths of children aged less than 10 in Dhankuta and Sankhuwasha district in east Nepal, 30% were reported to have had fever and cough and 26% had diarrhoea as the main symptom at the time of death. A retrospective study conducted during May 1981 in Jumla showed ARI to be a very important cause of infant mortality.

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The total infant mortality rate per thousand was 488.9 of which 333.3 were due to ARI. Such high infant mortality rate due to ARI in different parts of Nepal could be explained by the high rate of parental smoking, incidence of measles, malnutrition, diarrhoea and heavy exposure to domestic smoke pollution as well as by the very backward and poor living conditions of the people.

It can be estimated from a community based study that on an average a child in urban area during the first five years of life may suffer from 4-8 episodes of ARI per year. Based on the assumption of severe episode of ARI 0.8 per child per year approximately 50000 children in the age group of 0-5 years will be dying annually due to ARI in Nepal.

To prevent these deaths nearly fifty million rupees will have to be spent annually. It is a tragedy and irony of fate since a large proportion of these deaths could be prevented if the existing technology, knowledge and established medical practice were applied to provide comprehensive health care particularly to develop strategies at primary health care level. To reduce the infant mortality rate from 110 (1986) to 90 per thousand (1991) and to 45 per thousand by 2000, ARI in infant and children must receive top priority to reduce the morbidity and mortality from this cause.

Risk Factors Associated with the Development of Lung Disease in Children

The risk of a child developing a lung disease depends upon the interaction of intrinsic and extrinsic factors. Intrinsic abnormalities include congenital anatomic abnormalities in the airways, problems secondary to defects in other organ systems, congenital, metabolic and immunologic deficiencies. Extrinsic factors include infection, environmental pollution and aspirated foreign material.

Anatomic Abnormalities :

Early diagnosis and treatment of the anatomic abnormalities may be life saving by minimizing their effect on the developing lung. Repair of laryngeal cleft or tracheoesophageal malformation will prevent most further aspiration of ingested food. The effect of left to right shunting in congenital heart diseases can have severe impact on future lung function even after appropriate repair. In those conditions associated with impaired ciliary function or illnesses associated with the ineffective cough, the persistent presence of secretions in the respiratory tract, precipitates inflammatory reaction and damages the lung.

Anatomic abnormalities :

1. Tracheoesophageal fistula.
2. Diaphragmatic hernia.
3. Cyanotic congenital heart diseases.
4. Spinal column deformities.
5. Immotile cilia syndrome.

Metabolic and genetic diseases :

The group of metabolic and genetic diseases listed below present during infancy to childhood. Knowledge of the primary abnormality and attention to the sequelae of the defect will allow a more rapid diagnosis and therapy.

Metabolic and genetic abnormalities :

1. *Thalassaemia.*
2. *Chronic granulomatous disease of childhood.*
3. *Alpha-1- antitrypsin deficiency.*
4. *Neuromuscular diseases.*

Inflammatory diseases :

A list of chronic inflammatory diseases is given below. Inclusion of these illnesses in one's differential may aid in early diagnosis and treatment. In a child with tachypnea, anaemia, and mixed interstitial alveolar infiltrates a diagnosis of pulmonary haemosiderosis should be considered.

Inflammatory lung diseases :

1. *Collagen vascular disorders.*
2. *Interstitial pneumonias.*
3. *Pulmonary haemosiderosis.*
4. *Loeffler syndrome.*

Infective diseases :

Children have repeated infections of the respiratory tract and may experience as many as four to eight acute illnesses a year during early childhood. These repeated infections can cause loss of ciliated cells, mucosal or muscular hypertrophy and alveolar deformity. They have long term implications in the development of lung function in children

Infective diseases are :

1. *Bronchiolitis.*
2. *Pneumonias.*
3. *Asthma.*

Environmental Pollution :

The clinical evidence that passive smoking is detrimental to childhood respiratory health was identified first in 1974 by Cooley, who found that the evidence of pneumonia and bronchitis in the first year of life in a cohort of children studied in Harrow, England was associated with parent's smoking habits. In a prospective study in Bombay a higher proportion (26%) of persons having common cold were in more environmentally polluted areas compared to those in other areas (11-14%). Although the use of gas for cooking is

controversial as the risk factor for ARI, there is evidence to suggest that exposure to burning biomass fuel, common in Nepal and many developing countries may play an important role in the aetiology of ARI. In South Africa, among 132 infants with severe lower respiratory tract infection studied, 70% of the cases, compared to only 30% of control had a history of heavy exposure to smoke from cooking and heating fires.

Chilled or dry air :

There are some evidences to suggest that the cold or dry weather can act as a risk factor. In developed countries, respiratory infections usually occur more frequently in the cold winter months than in summer in developing countries, many of which are in tropics, differences in incidences have also been demonstrated. Respiratory infections are twice or three times more common in colder months. ARI in Beijing, China occurred much more frequently in cold winter months than in summer. Experiences in Kathmandu and nearby villages shows more episodes of ARI in summer months and in the month of Ashwin (Sept-Oct).

Malnutrition :

Synergistic action between malnutrition and infection is well recognised, as the presence of one predisposes and aggravates the other. In a malnourished child, there is significant impairment in immunity particularly of cellular type which increases susceptibility particularly to ARI and secondary infection. The average duration of illness in a malnourished child is significantly longer, bronchitis occurs three times and pneumonia 10 times more frequently compared to normal children (Table 3). Adverse effect of malnutrition can best be seen in measles, vitamin A deficiency which often accompanies protein energy malnutrition, results in keratinization of the respiratory epithelium, thus presumably decreasing local resistance and increasing the risk of bacterial colonization and infection.

Bottle feeding :

Several studies have recognised that breast feeding reduces the risk of ARI morbidity and mortality. The median relative risk of moderate to severe ARI is about 2.5 times higher in bottle fed infants compared to breast fed infant (Table 4). In an analysis of 2354 Rawandies children under 2 years of age hospitalised for pneumonia, bronchiolitis and laryngo-tracheo-bronchitis it was found that the case fatality rate for these illnesses was 1.9 times higher in weaned infants as compared to breast fed infants.

Crowding :

As ARI spreads by droplet infection, crowding and the presence of high density population affect the transmission of disease. It has been shown, in western communities, that ARI is introduced into the family by school age children, & that the family size affects the probability of infections. Of several social factors including, range of outside contact,

dampness and ventilation in the house (five members in one room) was found to be the one which was intimately related to the high incidence of respiratory illness. Several studies in India show that there is a greater likelihood of ARI in larger families than those with fewer family members.

Measles :

It accounts for nearly 6-10% of all ARI episodes and 40% of all moderate to severe ARI episodes. It has been estimated that an effective measles immunization programme using currently available vaccine strains and covering more than 70% of the children of less than 12 months of age will reduce measles incidence by 80%.

Low birth weight

There is enough information available on contribution of ARI to total mortality of low birth weight babies. Infant weighing less than 2.5 kg. at birth are more prone to infection and to deaths from pneumonia and other forms of ARI. It is estimated that amongst preterms, 13.4% deaths were attributed to pneumonia during first 3 months of age. During neonatal period pneumonia related mortality is three times higher amongst L. B. W. babies. (Table 5)

Infective Agents of ARI :

It is generally appreciated how greatly quite minor variations in laboratory technique will affect results in studies of respiratory pathogens. This is particularly true of culture methods. The methods of selection of patients, the administration of antibiotics before a specimen collection, the distance between the hospital wards and laboratory, the medium used, the temperature control of incubators and the ability of the technical staff to identify the suspected colonies will all affect the isolation rate and the range of organism identified. Study from India which examined the relative frequencies of both viral and bacterial agents by culturing lung aspirates and doing viral serology in 16 preschool children hospitalised with 18 episodes of pneumonia, nearly one quarter had bacterial pathogens only, 17% had viruses only. Mycoplasma infection was found in additional 11%. (Table 6, A)

A pilot study of acute respiratory viral infection was carried out in Vellore, India from 1981 to 1982. The results indicated that 17% of the 184 samples were positive in cell culture para influenza type 3 accounted for a third of the isolates. Influenza was present in 16%. (Table 6, B)

In a study done by WHO, collaborating more than 135, 703 reports on respiratory diseases associated with virus infections showed influenza A, Adenovirus, R. S. V. para influenza and mycoplasma pneumonia accounting for three quarters of the total numbers of reports, enterovirus infections were responsible for an additional 8% viral respiratory diseases in children below one year of age were associated with R. S. V; in almost 40% of

cases. In children 1-4 years, RSV had to some extent given way to parainfluenza and adenovirus, each of which accounted for 20%, of the cases of respiratory diseases reported in this age group. Respiratory viral diseases in the age group 5-14 years showed more adult like pattern in that *M. pneumoniae* and influenza A virus were the dominating agents accounting for 21% and 19% of the reported cases, respectively. (Table 7)

Lung aspirate studies have most recently been reviewed by Shan and his co-workers in reporting their series from Goroka. In their prospective study of children admitted to the hospital in Goroka, Papua New Guinea, *Haemophilus influenzae* & *Strep. pneumoniae* and other bacteria as *S. aureus* were isolated from lung aspirates or blood cultures from 51 (61%) of 83 children and viruses were isolated from 26 (31%) of 83 children. However in their later studies they have shown that *P. Carini*, RSV, *C Trachomatis*, *M. pneumoniae* and Cytomegalo virus as a cause of pneumonia in the developing countries.

Physiological basis for infants and young children becoming more symptomatic in respiratory diseases :

There are many ways in which infants and young children differ from older children and adults and these differences may affect their symptomatology when suffered from respiratory diseases.

1. Small size and large surface area in relation to weight:

A newborn infant weighing 3.5 kg is one-twentieth of the weight of a 70 kg. man, but the surface area of an infant is one-eighth as great. Thus the area of body surface that can lose heat is 2.5 times as great per unit body weight in a naked child as in a naked adult.

Because infants and young children have a larger cooling surface per unit body weight than adults, and because they are growing rapidly they have higher resting metabolic rate and rate of consumption per unit body weight. The oxygen consumption of an infant between one week and one year, at rest in a thermoneutral environment, is about 7ml/kg body weight per minute. That of an adult, under the same conditions is 3.5ml/kg per minute.

An environmental temperature below the thermoneutral one increases the metabolic rate and the requirement for oxygen. Since the thermoneutral temperature is higher for infants than for adults, the same moderately low environmental temperature will cause the increase in oxygen consumption of the infant before that of adult, and in fact, cold and crying are the main causes of increase in oxygen consumption in infants.

2. The respiratory organ continues to develop till adolescent :

It has been estimated that a circumferential narrowing by one m. m. of the air way of small infants will cause 75% reduction in the cross sectional area whereas a similar narrowing will reduce the area by only 20% in adults.

After the age of 18 months respiratory structures increase in size with the progressive increase in elastic fibres bundles in the alveolar wall up to the age of 18 years. Thus repeated insults to the walls will produce permanent damage and stiff lung.

The exposure of infants and children to atmospheric pollutants may be enhanced compared with that of adults, if the pollutants are emitted close to the ground.

Symptoms and signs in ARI :

It is difficult to know how closely the respiratory symptoms are related to the type of respiratory diseases. However certain signs and symptoms correlate well with the severity of the Acute Respiratory Infections. Parent often describe symptoms of his / her child to a doctor / health worker who has never experienced the symptoms, this difficulty in communication may be compounded if the vocabulary of the parent is limited and unsophisticated (often happens with different ethnic group) therefore it is vital to rely on the signs in a child suffering from ARI,

The findings of Laventhol and Shan et al confirm that tachypnoea is the best clinical predictor for severity of the respiratory infection. The other important clinical signs that correlate well with the severity of the acute lower respiratory infection is subcostal intercostal retractions. Nasal flaring, cyanosis, grunting and failure to suck all point to severe form of pneumonia. At this time the presence of tachypnoea (over 50 breath per minute) or a history of rapid breathing appear to be best predictors of the need for anti-biotic therapy in a child with cough.

The following signs should not be given importance to give antibiotics in a child with cough namely fever, toxic appearances, purulent sputum and noisy breathing.

The anatomical diagnosis often made has got little value to the type of the treatment given in Acute Respiratory Infections. The commonest sign that is present in different variety of ALRI is again tachypnoea and recession.

Clinical features, radiological finding in three major types of ALRI

	Bronchiolitis	Bronchopneumonia	Lobar/Lobular Pneumonia
Age:	Infancy	Infancy and under 5 yrs	Infancy and under 5 yrs
Main symptoms:	Tachypnoea Inspiratory recession Hyperinflated chest Fine ronchi	Tachypnoea Inspiratory recession Crepitations	Tachypnoea Recession Crepitations Bronchial breathing
Radiology:	General emphysema with micro- atelectasis	Bilateral general mottling with emphysema	Consolidation

Management of ARI:

Antibiotics to treat pneumonia in children less than five years old must be active against *S. pneumoniae* and influenzae. If an oral antibiotic is to be used to treat a child with pneumonia at home the best choice is co-trimoxazole or amoxycillin. Cotrimoxazole has the advantage that it is active against *Chlamydia* and *pneumocystis*, which may be an important cause of pneumonia. Over 20% of *H. influenzae* are now resistance to ampicillin. Erythromycin is not a very good drug to treat a child with pneumonia. The cephalosporins are expensive and most of them are ineffective against *H. influenzae*. The aminoglycosides (gentamycin) are ineffective against *S. pneumoniae*, they are expensive and they may mask the diagnosis of tuberculosis. Chloramphenicol is bactericidal against *H. influenzae* and most strains of *S. pneumoniae*. Treatment plan for pneumonia.

- A) Outpatient Treatment
 - Procaine penicillin
 - or
 - Amoxycillin
 - or
 - Co-trimoxazole
- B) Inpatient treatment
 - Intra muscular Benzyl penicillin six hourly
 - or
 - in severe pneumonia
 - Chloramphenicol every six hourly
- C) Neonatal pneumonia
 - Penicillin and Gentamycin.

Supportive therapy:

Oxygen : It should be given by intranasal catheter at one litre per minute. If a nasogastric feeding is required it should be inserted through same nostril as the oxygen catheter and the other nostril should be kept clear of mucous.

Fluid : It is very important not to give too much intragastric or intravenous fluid. Children with pneumonia may secrete more antidiuretic hormone than normal. They may be easily overloaded with fluid which can contribute to pulmonary oedema and the respiratory failure.

Thermal

environment : Heat stress and cold stress both increase the child's oxygen consumption two or three fold, increase carbon dioxide production and precipitate respiratory failure.

Antipyretic is not indicated up to 40°C as moderate elevation of body temperature improves the body's defence against infection. However very high fever increases oxygen consumption and may cause convulsion. Children should not be sponged with cold or tepid water as this is not comfortable and it greatly increases oxygen consumption.

Cough medicine: Expectorants, cough suppressants, mucolytics, decongestants and anti-histaminics are ineffective or even harmful in pneumonia.

Vaccines: (H. influenzae and pneumococcal polysaccharide vaccines):

Reduction of the mortality due to the primary causes of ARI-related deaths must rely primarily on improved case management for the near future.

Although 8-10 capsular types comprise most of the strains of pneumococcus causing invasive infection 84 capsular polysaccharides have been identified. However the existing pneumococcal vaccine seems to be effective in young children (6 months to 5 years age group) in reducing mortality caused by acute lower respiratory infections. The existing capsular type b H. influenzae vaccine does not seem to be of potential efficacy in reducing ARI mortality in less developed countries as only a fraction of the isolates from patients with the pneumonia in developing countries were found to be capsular type b strains.

An approach to improving the immune responses elicited in younger children by polysaccharide vaccine has been to bind them covalently to a protein conjugate, rendering the mechanism of the response "T-dependant". The delivery of polysaccharide vaccines in association with diphtheria tetanus toxoid - pertusis series or BCG vaccination is currently being studied.

Intraplacental protection: Immunization of mothers to prevent neonatal tetanus suggest the intriguing possibility that polysaccharides, possibly delivered in conjunction with tetanus toxoid during the last trimester may provide sufficiently high titres to confer transplacental passive protection against bacterial ARI during early infancy.

Table 1
HIGH MORTALITY IN CHILDREN - DIFFERENT DISEASES
MORTALITY RATE FROM: ARI
(Per 100,000 population)
1970-73

Continent	Infant	Children	
		1-4yr	5-14yr
Africa	1454.1	467.0	21.6
Asia (LDC)	1242.4	204.1	23.4
Europe	390.3	15.3	2.1
Oceania	177.6	9.2	1.2
N. America	146.3	8.0	1.5

(Bull. WHO 1978; 56)

Table 2
ASSOCIATION BETWEEN MALNUTRITION / & ARI

Author / Country	Summary of findings
James, 1972 ¹ (Costa-Rica)	Duration of ARI longer in PEM
Escobar, 1976 ¹ (Colombia)	ARI case fatality rate PEM : 16% Normal : 3%
Tupasi, 1985 ² (Philippines)	ARI case fatality rate Mod. to severe PEM : 7.7% Mild PEM : 2.3% Normal : 0.6%

1. Am. J. Clin. Nutr 1972; 25, 690

2. Proc. Int. Workshop. Sydney. 1984: 68-71

Table 3

RELATIVE RISK OF ARI IN NON-BREAST FED INFANTS

Author / Country	Median relative risk
Elliott, 1975 ¹ (New Zealand)	3.2
Cunningham ² (U. K.) 1979	5.0
Kumar (India), ³ 1981	3.0
Frank (1982) ⁴ U. S. A.	1.5

1. Nz Med J 1973 : 81
2. Br. J. Prev. Soc. Med: 1979 : 33
3. Indian Paed. 1981: 8
4. Paediatrics 1982 : 239-245: 70

Table 4

EFFECT OF LBW ON ARI RELATED MORTALITY

ARI Deaths (% of total deaths)	L. B. W. 7.1%	N. B. W. 0.9%
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(Div. of Family Health, World Health State 1980; 33)

Table 5 a

BACTERIAL AND VIRAL AGENTS IN 16 CHILDREN
WITH 18 EPISODES OF ALRI

Agent	No.	%
H. Influenzae	3	17
S. Pneumoniae-H. Infi.	1	6
M. Pneumoniae	2	11
Virus alone	3	17
Bacterial-virus	2	11
-ve culture/serology	7	38

Table 5 b

FREQUENCY OF VIRAL AGENTS

Among 32 isolates from 184 Children

Virus	%
Parainfluenza	44
Influenza	16
Coxsackie	10
RSV	6
Mumps	6
Measles	6
Herpes	6
ECHO	3
Not identified	3

Table 6

RELATIVE FREQUENCY OF VIRUS ASSOCIATED ARI BY AGE %

(Tech. Report Series: 642 WHO 1980)

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