Lower Respiratory Tract Infections

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BACKGROUND AND BURDEN OF DISEASE

Indigenous populations living in affluent countries bear a high burden of ill health from acute and chronic respiratory disease.\textsuperscript{1–3} Acute lower respiratory infections (ALRIs) unfortunately remain a persistently dissonant health issue in Indigenous communities in developed countries. In Australia, ALRIs account for the greatest number of hospitalizations in young Indigenous children younger than 5 years and are the commonest cause of preventable deaths in infants.\textsuperscript{4,5} In the period 2005 to 2006, the ALRI-associated hospitalization rate for Indigenous infants was 3.2 times more than that for non-Indigenous Australian infants (201.7/1000 vs 62.6/1000).\textsuperscript{5} Although there are limited data from urban settings, the ALRI attack rate in Australian Aboriginal children is much higher in poor, remote populations. It is likely that poverty and remoteness are the key drivers rather than indigeneity itself. Hospitalization rates for respiratory infections in American Indian/Alaska Native (AI/AN) children in the United States

KEYWORDS

- Acute lower respiratory infection
- Indigenous/nonindigenous comparison
- Bronchiolitis
- Pneumonia
were almost double that for the rest of the population (116.1/1000 vs 63.2/1000) from 1999 to 2001, and ALRI has been formally identified by the American Academy of Pediatrics as one of the many remaining health disparities disadvantaging AI/AN communities. ALRIs accounted for almost 75% of AI/AN infant infectious disease hospitalizations in the United States. The same preponderance of ALRI in Indigenous children is also seen in New Zealand and Canada.

The importance of acute respiratory illnesses is reflected not only in morbidity and mortality but also in long-term consequences, especially when recurrent. This article outlines the sequelae of ALRIs, preventative measures, and management of the 2 most common and important causes of ALRI, bronchiolitis and pneumonia, in Indigenous children. Readers are referred elsewhere for management of laryngo-tracheo-bronchitis (croup) for which treatment is relatively simple through use of oral corticosteroids. Indigenous children do not have an increased incidence of croup, and the illness severity and management is similar to croup in non-Indigenous children.

CONSEQUENCES OF LOWER RESPIRATORY TRACT INFECTION IN INDIGENOUS CHILDREN

The antecedents of a substantial amount of chronic respiratory disease occur during early childhood. Low birth weight and preexisting small lungs are important determinants of future lung function, and there is increasing evidence that pulmonary events in early life impact on adult pulmonary function. Parenchymal lung growth in the first 2 years of life occurs by increasing alveoli number, thus events such as severe ALRIs during this critical period may incur long-term negative effects leading to adult pulmonary dysfunction. Indeed it has been shown that young Indigenous children with ALRIs are at risk of later respiratory morbidity. Risk factors for bronchiectasis in Indigenous children include recurrent hospitalization for ALRIs and severity of previous ALRIs (measured by length of stay and requirement for oxygen during hospitalization). In Alaskan children, previous bronchiolitis has been shown to be a risk factor for the development of chronic productive cough, the most common symptom of chronic supplicative lung disease and bronchiectasis. Infections by adenovirus, mycoplasma, and other respiratory viruses may also result in bronchiolitis obliterans, with or without bronchiectasis.

PREVENTATIVE MEASURES FOR RESPIRATORY ILLNESSES

In addressing prevention of acute respiratory illness, the undeniable importance of the social determinants of health is recognized but cannot be adequately addressed here. Health is intertwined with every aspect of life: education, human rights, social justice, the environment, economy, and employment. Redressing health equity through action on the social determinants of health has been recently advocated by the World Health Organization (WHO). A Canadian study on pneumonia and influenza identified that low education, being Aboriginal, behavioral factors (daily smoking and heavy drinking), environmental factors (passive smoking, poor housing, temperature), and health care factors (influenza vaccination) were all significantly associated with increased rates in different age- and gender-specific models.

Specific (as opposed to socioeconomic-educational) primary prevention measures for respiratory disease are only briefly discussed here, and broadly categorized into (1) promoting normal lung development and (2) removing risk factors for development of respiratory disease. Both share common intervention features presented herein. These factors have limited randomized controlled trial (RCT) evidence, and it is highly unlikely such studies will ever be ethically performed. Nevertheless, it is
recommended that the factors listed here are implemented for population health (Recommendation GRADE: strong; Evidence: low to moderate).

- Avoidance of in utero and environmental tobacco smoke exposure. Tobacco smoke exposure is a major issue affecting Indigenous children.

- Prevention of low birth weight infants and prematurity. Low birth weight babies are at greater risk of poor health and respiratory illnesses. Contributors to low birth weight include socioeconomic disadvantage, size of parents, age of the mother, number of babies previously born, mother’s nutritional status, smoking and alcohol intake, and illness during pregnancy.

- Promotion of breast feeding (preferably exclusive for at least 4 months). Breast feeding has been recurrently shown to be a protective factor for acute respiratory infections and other illnesses.

- Improvement in the living environment, particularly running water, overcrowding, and ventilation.

- Appropriate and early treatment of respiratory infections including adequate follow-up, and detection of treatment failure and recurrent infections.

- Avoidance of biomass combustion (particularly indoor cooking fires) and other air pollutants that contribute to acute respiratory infections.

- Promotion of improved nutrition and postnatal growth.

- Complete and timely immunizations, particularly that of yearly influenza vaccinations, for which uptake is currently poor despite being recommended in national guidelines in North America and Australia for children from 6 months of age.

- Improved parenting. Parenting moderates the effects of poverty and underclass status. Although no data exist on the effect of nurse home visiting programs on infectious diseases, parenting programs has been shown to improve birth weight, breast feeding, and hospitalization. Preliminary studies in Alaskan populations using paraprofessionals described efficacy in improving maternal knowledge and infant behavior outcomes, thus suggesting parenting interventions may be useful in such communities.

**BRONCHIOLITIS**

*Background and Epidemiology*

Bronchiolitis, the most common ALRI in young children, is characterized by extensive inflammation of the airways accompanied by increased mucous production and necrosis of airway epithelial cells. Bronchiolitis is primarily caused by infection of the respiratory epithelial cells by viruses. Respiratory syncytial virus (RSV) is the major causative agent, but other viruses (eg, adenovirus, influenza, parainfluenza, human metapneumovirus, rhinovirus) and newly discovered viruses are also implicated. Bacteria such as *Simkania negevensis* (a *Chlamydia*-like microbe) has been implicated in Canadian Inuit infants.

In pediatrics, bronchiolitis is a clinical diagnosis characterized by tachypnea, wheeze, or crepitations in infants following a preceding upper respiratory illness. The upper age limit for a clinical diagnosis of bronchiolitis differs between countries; in Australia the upper limit accepted is usually 12 months, in the United States 24 months. The clinical syndrome is nevertheless similar, as it is a clinical diagnosis based on typical history and examination findings, with no specific confirmatory or exclusionary diagnostic test or gold standard.

The prevalence or severity of bronchiolitis is greater in Indigenous children than in non-Indigenous children in Australia, United States, Canada, and New Zealand. In a regional Australian center, the bronchiolitis-associated hospitalization incidence in
Indigenous infants was 190 per 1000 infants. Among United States Indigenous infants, the overall bronchiolitis-associated hospitalization rate was 61.8 per 1000 (in comparison, the 1995 rate among all United States infants was 34.2 per 1000). Several studies have described being Indigenous as an independent risk factor for hospitalization from bronchiolitis, but a retrospective Australian study found this did not hold in RSV hospitalizations, once socioeconomic risks factors were taken into account. More consistently described sociodemographic and environmental risk factors for bronchiolitis include birth to a young mother, being born in the first half of the RSV season, tobacco exposure, lower maternal socioeconomic status, low birth weight, male gender, crowding, prematurity, chronic lung disease/congenital heart disease, and lack of breast feeding.

**Important Differences Between Bronchiolitis in Indigenous and Non-Indigenous Infants**

In addition to the higher incidence of bronchiolitis in Indigenous infants, Indigenous children have higher rates of coexistent clinical pneumonia, and negative postbronchiolitis consequences. The former is thought to result from aspiration of nasal secretions which, in these children, contains large bacterial load. This load potentially overwhelms the local lung defenses (mucosal and innate immunity) already impaired by the viral infection. In Indigenous children, bacterial (Streptococcus pneumoniae, nontypeable Haemophilus influenzae, Moraxella catarrhalis) colonization of the nasopharynx occurs earlier (as early 2 weeks of age) and heavier than in non-Indigenous children. Some children are susceptible to bacterial infections during, or shortly after, a viral respiratory tract infection. Viral-bacterial interactions are more likely to occur when the upper airway respiratory epithelium is densely colonized with respiratory pathogens or with repeated infections. Australian Indigenous infants (24%) with bronchiolitis have a higher readmission rate for bronchiolitis within 6 months of discharge of the index infection than non-Indigenous infants (19%), but this difference is not statistically significant.

**Management of Bronchiolitis in Indigenous Children**

The principles of managing bronchiolitis in Indigenous children are similar to that of the general population. Guidelines are widely available, and key management issues when evaluating an infant with bronchiolitis are:

- Assessment of severity of illness (oxygen status, ability to feed, signs of respiratory distress, hydration status).
- Assessment of risks of increased severity and thus lower threshold for hospitalization.

The majority of children can be managed at home and asked to re-present if severity increases. Adoption of the following steps is recommended:

- Indications for hospitalization include pulse oximetry saturation (SpO₂) from 92% to 94%, poor feeding, dehydration, history of apnea, presence of moderate respiratory distress (chest recession, respiratory rate >70/min). (GRADE: high; Strength of evidence: moderate.)
- Other considerations for hospitalization include transportation difficulty, challenging social circumstances, pattern of illness (such as rapidity of illness severity), presence of significant comorbidity (chronic neonatal lung disease, prematurity, congenital heart disease). (GRADE: low; Strength of evidence: low.)
- Oxygen therapy when SpO₂ is less than 93% with respiratory distress. (Grade: high; Strength of evidence: moderate.) It is uncertain at what exact SaO₂ supplemental oxygen should be initiated, and guidelines vary between 90% and 94%. Initiation and weaning of oxygen should take into account the clinical context including degree of respiratory distress, presence of comorbidity, feeding difficulty, apnea, and oxygen availability.
- Nasogastric feeds or intravenous fluids should be implemented when the child is dehydrated, safe oral feeding cannot be maintained, or risk of aspiration is high. (Grade: high; Strength of evidence: low.)
- Nebulized hypertonic (3%) saline should be considered as it may reduce the length of hospital stay and improve the clinical severity. (Grade: high; Strength of evidence: high.)
- Bronchodilators (α-adrenergic or β-adrenergic agents, ipratropium) and corticosteroids should not be used routinely. (Grade: weak; Strength of evidence: moderate.)

Inhaled bronchodilators may be tried under close monitoring in selected individuals such as those with recurrent wheeze, a family history of asthma, or previous response to bronchodilators. A Cochrane review found a transient improvement in clinical score may occur in some children treated with bronchodilators, but the clinical relevance is unclear. A recent trial described reduction in hospitalization in those receiving nebulized adrenaline combined with oral dexamethasone (1 mg/kg on day 1 followed by 0.6 mg/kg daily for 5 days). Potential side effects should also be considered.
- Chest physiotherapy should not be used as it increases morbidity. (Grade: strong; Strength of evidence: moderate.)
- Corticosteroids or leukotriene receptor antagonists do not influence the presence of postbronchiolitis symptoms and should not be routinely used. (Grade: strong; Strength of evidence: moderate to low.)
- Use of palizumab and infection control measures are well described. The application of these are similar in both Indigenous and non-Indigenous infants, and thus is not discussed here.

Additional management considerations in Indigenous children are:
- Antibiotics are not routinely recommended in bronchiolitis but may be used in Indigenous children suspected of concomitant bacterial pneumonia. Further, it is often difficult to establish a diagnosis of pneumonia in a child with bronchiolitis. Antibiotic use should be guided by local resistance patterns of common pathogens. (Grade: weak; Strength of evidence: low.)
- Chest radiographs, not generally recommended in bronchiolitis, may be considered in Indigenous children specifically when bronchiolitis is recurrent or pneumonia suspected. (Grade: weak; Strength of evidence: low.)
- Indigenous children should be reviewed post episode to ensure symptoms resolve for risk of chronic wet cough and readmission risk.

**PNEUMONIA**

**Background and Epidemiology**

Pneumonia kills more children globally than AIDS, malaria, and measles combined, yet little attention is given to pneumonia. Over 2 million children die each year from pneumonia worldwide. Pneumonia in Indigenous children occurs in various contexts for example, community, hospital acquired, immunodeficient children, and so forth.
and the management differs in these different settings. This article is restricted to community-acquired pneumonia (CAP) in otherwise healthy children older than 2 months. Children with immunodeficiency (congenital or acquired) and those with specific predisposition to pneumonia such as sickle cell anemia, human immunodeficiency virus (HIV), and malaria are not discussed here. Infants aged 2 months or younger with pneumonia require hospitalization and often have a different etiology, and thus are also not discussed in this article. Tuberculosis, an important infection in Indigenous populations, is also not described here, and readers are referred to other sources.59

Estimates of pneumonia incidence vary depending on definition. Clinical definitions, developed in the 1970s for use in resource poor countries, were primarily aimed at determining which children presenting with breathing problems required antibiotics. Subsequent research has aimed at refining these algorithms and improving their sensitivity and specificity.61 More recently the WHO established a radiological definition primarily for research purposes, in particular to measure the impact of vaccine trials on pneumonia outcomes, which has limited clinical use. Clinical definitions remain important in CAP not requiring hospitalization (for which chest radiographs and investigations are not routinely recommended), as well as in remote Indigenous populations for whom management is dependent on algorithms, as it is in many regions of resource-poor countries. In this article, for practicality the authors define pneumonia based on clinical symptoms and signs (Box 1).

Despite these constraints of definition there is substantial evidence that the burden of pneumonia is high in Indigenous populations. Studies from the late 1980s documented extremely high rates of invasive pneumococcal disease (and high rates of pneumonia) in American Indian and remote Australian Aboriginal children.64,65 Hospitalization rates for AI/AN infants with pneumonia in the United States were 54.7 per 1000 children in the period 1999 to 2001 and, while trending downwards, remain a major health disparity for AI/AN communities.7 In New Zealand, Maori children hospitalized with pneumonia

<table>
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<tr>
<th>Box 1</th>
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<tr>
<td><strong>Definitions used for pneumonia</strong></td>
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<tr>
<td><strong>Clinical definition of pneumonia</strong></td>
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<tr>
<td><strong>Symptoms:</strong> Fever (&gt;38.5 axilla) and cough or difficult breathing; and,</td>
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<tr>
<td><strong>Signs:</strong> breathing &gt;50/min for infants age 2 months up to 1 year; breathing &gt;40/min for children age 1 to 5 years.</td>
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<tr>
<td>In resource-poor settings, pneumonia is diagnosed (WHO guidelines), based only on cough and tachypnea, that is, although fever is often present it is not an essential requirement for administration of antibiotics.</td>
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<tr>
<td><strong>Definitions of severity</strong></td>
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<tr>
<td>Nonsevere pneumonia: Symptoms and signs of pneumonia plus no chest indrawing, grunting, or “danger signs.”</td>
</tr>
<tr>
<td>Severe pneumonia: Difficult breathing, plus any general danger sign or chest indrawing or grunting in a calm child.</td>
</tr>
<tr>
<td>“Danger signs” for children age 2 months to 5 years: Unable to drink or breastfeed, vomiting, convulsions, lethargy, or unconsciousness.</td>
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have more severe pneumonia than children of European descent, and double the annual hospitalization rate at 6.7 versus 2.7 per 1000. Western Australian Indigenous children younger than 2 years had a 13.5 times increased risk of hospitalization for pneumonia in the period 1990 to 2000. In Newfoundland and Labrador, Canada, the hospitalization rate due to pneumonia for the Innu/Inuit communities was 11.6 compared with 3.0 per 1000 population for non-Aboriginal communities, with infants bearing the highest rates (93.4 per 1000 population). Other Canadian studies have also reported increased rates (3.6 to 5 times) of CAP and ALRI in Indigenous Canadians of other regions compared with non-Indigenous Canadians.

**Etiology of Pneumonia**

Establishing the causative pathogen(s) in pneumonia remains a major challenge, due predominantly to the great variation in sensitivity and specificity of different tests for bacteria and viruses. Blood cultures have low sensitivity in pneumonia, especially when antibiotics have already been administered. Lung aspirates are rarely done because of concern about complications. Sputum examination is particularly difficult in children and contamination by upper airway colonization makes interpretation problematic. Antigen detection techniques for pneumococcus are improving, but their utility in populations with dense bacterial colonization of the nasopharynx has not been established. Viral detection is difficult to interpret because high rates are reported in asymptomatic children. In addition, existing data on etiology are dominated by hospital-based populations with severe disease. The impact of vaccines on reducing pneumonia burden suggest that *S. pneumoniae* is a leading cause of childhood pneumonia in Indigenous children, as it is in developing countries. *H. influenzae* type b, a previous major cause of pneumonia in developing countries, has been reduced by immunization. Non-serotypeable *H. influenzae* may be an important but less frequently identified organism; community-acquired multiresistant *S. aureus* resulting in a necrotizing fulminant pneumonia has emerged, and is of particular concern for the spread in indigenous communities with poor living conditions. Viral agents include RSV, adenovirus, parainfluenza virus, rhinovirus, influenza virus, human bocavirus, and human metapneumovirus. Some pathogenic agents of pneumonia are age related; mycoplasma is more common in older children whereas viral agents predominate in the very young. Some studies suggest that viral etiologies are more likely in the presence of wheeze. Mixed infections are also commonly reported and viral-bacterial coinfections are likely to be more important in Indigenous children, as described earlier. A study of Aboriginal children with ALRI in Central Australia found 48% of cases had evidence of an acute viral infection. In a recent Brazilian study using sensitive diagnostic methods, 23% of the 143 children with CAP had mixed viral-bacterial infection.

**Important Differences Between Pneumonia in Indigenous and Non-Indigenous Children**

In addition to the increased rates to pneumonia and ALRI, Indigenous children have an increased frequency of repeated hospitalizations for pneumonia and development of chronic suppurative lung disease, increased likelihood of coinfection or viral-bacterial interactions (speculated rather then proven), and differential impact of routine vaccinations. In Australia, New Zealand, and the United States, repeated pneumonias in Indigenous children have been described and linked with the development of bronchiecstasis. Western Australian children born between 1990 and 2000 were 3 times more likely than other children to have multiple admissions for pneumonia.
Routine conjugate pneumococcal and *H. influenzae* type b (Hib) vaccinations have reduced invasive disease related to these organisms in Indigenous and non-Indigenous children.\(^75,76,79\) However, despite high rates of Hib vaccine coverage, *H influenzae* type b disease rates among rural Alaskan Native children younger than 5 years remains higher than in non-Native Alaskan and other United States children.\(^75\) In the circumpolar region, serotype replacement with nonvaccine serotypes has resulted in a reemergence of invasive disease for both *Haemophilus* and pneumococcal infection.\(^76,79\) A study in American Indian children described a substantial reduction in invasive pneumococcal disease from conjugate pneumococcal vaccine.\(^80\) However, in the Alaskan Yukon Delta, while the use of palivizumab prophylaxis may be responsible for a decrease in the RSV hospitalization rate among premature infants, non-RSV pneumonia hospitalizations have not declined since the introduction of the pneumococcal conjugate vaccine (PCV).\(^81\) Despite evidence of decreased pneumonia rates in the United States and other developed countries after introduction of PCV, at present, the long-term effect of PCV on pneumonia rates in Indigenous populations remain uncertain.

**Management**

In Indigenous children the determinants of management are primarily remoteness, availability of medical resources, ease of access to hospital, and family resources rather than indigeneity alone. In regions with developed country resources, most children with CAP can be managed in the community, and the role of the community doctor includes\(^63\):

(a) to identify that the child has pneumonia;
(b) to assess the severity and select those who require referral to a hospital or evacuation from a remote site;
(c) to provide information/management advice on temperature control and fluids;
(d) to identify and provide medical treatment where necessary; and
(e) to monitor progress and follow-up.

**Assessment**

In the management of pneumonia, the priorities include early recognition of a sick child and seeking appropriate care. Only about 20% of caregivers in developing countries recognize difficult or fast breathing as signs of pneumonia, and only about half of the children with pneumonia are taken to an appropriate provider.\(^57\) Poorer children, rural children, and children with poorly educated mothers more often lack appropriate care.\(^57\) These findings from developing countries are likely to be particularly relevant to Indigenous children in remote locations. Thus, education of caregivers on the “danger signs” of a sick child may be an important part of the community approach to the reduction of mortality and morbidity from pneumonia.

The Integrated Management of Childhood Illness (IMCI),\(^82\) which includes that of pneumonia, developed by the WHO, is a broad strategy that includes several complementary interventions at first-level health facilities and in communities. This case management approach has been shown to reduce pneumonia mortality in a meta-analysis.\(^83\) In remote regions of developed countries, without radiography or laboratory facilities, an adapted IMCI approach may be useful. An important example of adapting IMCI is in the assessment of severity of pneumonia (see **Box 1**). Detection of hypoxemia is an important component of the assessment and part of a case management strategy. No single clinical sign best predicts presence of hypoxia, and in resource-poor settings this is best predicted by a combination of signs including respiratory rate (>40/min when age 2–11 months, >50/min age 12–59...
months), inability to feed, altered mental status, central cyanosis, and head nodding. In developed countries portable pulse oximeters allow accurate assessment of oxygenation. However, these signs are indicative of the severity of pneumonia.

Treatment

Antibiotics In principle, knowledge of local resistance patterns should assist in the choice of empiric and directed antibiotic therapy (summarized in Table 1). Narrow-spectrum antibiotics should be used wherever possible. In general, amoxycillin is the preferred initial antimicrobial of choice in nonsevere pneumonia; 3 to 5 days of amoxycillin therapy (50 mg/kg/d in 2 divided doses) should be used in children age 2 months up to 5 years. Other original studies, however, used higher doses (80–90 mg/kg/d). Thus the authors recommend between 50 and 90 mg/kg/d in 2 doses. Although some studies have recommended that children with wheeze should not receive antibiotics, a recent multicenter placebo-controlled RCT in 1671 children younger than 5 years showed that children randomized to placebo (compared with amoxycillin) had higher morbidity and clinical failure (adjusted odds ratio = 1.28). The choice of alternatives to amoxycillin should be guided by activity against S. pneumoniae and H. influenzae as well as safety. In developing countries, cotrimoxazole has been widely used but its use is driven strongly by cost advantage. The majority of studies have been performed in children younger than 5 years, and there is little high-grade evidence for older children (see Table 1).

Short courses (3 days) of antibiotics have been shown to be as efficacious as 5 days. A problem with these studies is that adequate follow-up was not performed with respect to risk of symptoms of bronchiectasis such as chronic wet cough. The studies were not primarily designed for equivalence in current standards whereby the noninferiority margin for outcomes is prespecified. In children older than 5 years, erythromycin is an alternative first-dose antibiotic treatment in view of increasing rates of Mycoplasma pneumonia.

When pneumonia is severe and hospital referral not possible, intramuscular penicillin is recommended for treatment of severe pneumonia. When injection is not available, high-dose oral amoxycillin could be given to children with severe pneumonia. Children with very severe pneumonia should receive injectable ampicillin plus gentamicin, although some centers prefer ceftriaxone, which has not been examined in a similar way to ampicillin and gentamicin. Complications of pneumonia are increasingly described; these include parapneumonic effusions, empyema, bronchiolitis obliterans, among others. All these complications require hospital management, which is beyond the scope of this article.

Oxygen Oxygen therapy is beneficial in reducing mortality in hypoxic children and should be used when the SpO2 is 92% or less. Any child requiring oxygen should be transferred to a hospital. While awaiting transfer, oxygen is routinely best delivered by nasal prongs and any child requiring more than 1.5 L/min requires an alternative delivery mechanism such as a face mask.

Other therapies Children with wheeze and fast breathing or lower chest in-drawing should be given a trial of rapid-acting inhaled bronchodilator before they are classified as pneumonia and prescribed antibiotics. However, if coexistent symptoms and signs of pneumonia are present, amoxycillin should be given. Adjunctive measures include provision of adequate nutrition, micronutrient supplements, and antipyretics when appropriate. Signs of malnutrition should be addressed in all children, as this increases the risk of death due to pneumonia. Children with CAP should continue feeding. Those unable to feed, have persistent vomiting, or are dehydrated require
<table>
<thead>
<tr>
<th>‘Intervention’</th>
<th>Recommendation</th>
<th>Recommendation Grade</th>
<th>Quality of Supporting Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case management</td>
<td>Use a case management strategy (see text)</td>
<td>Strong</td>
<td>High^83</td>
</tr>
<tr>
<td>Assessment of severity</td>
<td>Assess severity of pneumonia using respiratory rate, presence of chest in-drawing, SpO₂, ability to feed</td>
<td>Strong</td>
<td>Moderate^57,63</td>
</tr>
<tr>
<td>Transfer to hospital</td>
<td>Child should be admitted into hospital if:</td>
<td>Strong</td>
<td>Moderate to high^63</td>
</tr>
<tr>
<td></td>
<td>• Hypoxic: SpO₂ ≤ 92%</td>
<td></td>
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<tr>
<td></td>
<td>• Severe pneumonia symptoms/sign present; OR</td>
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<td></td>
<td>• Family is unable to supervise or observe sick child</td>
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<td></td>
<td>• Significant comorbidities present</td>
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<tr>
<td><strong>Community management for nonsevere pneumonia</strong></td>
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<tr>
<td>Antibiotics</td>
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<tr>
<td>&lt;5 years</td>
<td>First line: amoxycillin (50–90 mg/kg/d in 2 doses) for 3–5 days</td>
<td>Strong</td>
<td>High^86,87</td>
</tr>
<tr>
<td></td>
<td>Alternative: cefaclor</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td>5 years and over</td>
<td>First line: amoxycillin (50–90 mg/kg/d in 2 doses) for 3–5 d or erythromycin or a macrolide</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Alternative: cefaclor</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td>Antibiotics if fails to improve</td>
<td>If persistent tachypnea, consider transfer to hospital for alternative diagnosis. However if pneumonia present and no indications for hospitalization, use amoxil-clavulanic acid (80–90 mg/kg/d in 2 doses) or add erythromycin or a macrolide</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Use oxygen if SpO₂ is ≤ 92% and transfer child to hospital</td>
<td>Strong</td>
<td>Moderate^63</td>
</tr>
<tr>
<td>Feeding and fluids</td>
<td>Feeding should be continued unless there is a risk of aspiration</td>
<td>Strong</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Fluid intake should be maintained but not increased</td>
<td>Weak</td>
<td>Low^88</td>
</tr>
<tr>
<td>Micronutrients</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>Not recommended for universal use</td>
<td>Strong</td>
<td>Moderate^89</td>
</tr>
<tr>
<td><strong>Vitamin A</strong></td>
<td>Not recommended for nonmeasles pneumonia</td>
<td>Strong</td>
<td>High$^{90,91}$</td>
</tr>
<tr>
<td><strong>Vitamin C</strong></td>
<td>Not recommended for universal use</td>
<td>Weak</td>
<td>Moderate$^{92}$</td>
</tr>
<tr>
<td><strong>Any</strong></td>
<td>For all micronutrients, their use may be considered if malnutrition present, or deficiency of micronutrients suspected</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Bronchodilators</strong></td>
<td>Use salbutamol as a trial (600 μg) if wheeze is present Consider adding amoxycillin even if wheeze is present or if symptoms and signs of pneumonia coexist</td>
<td>Weak</td>
<td>Low$^{93}$</td>
</tr>
<tr>
<td><strong>Antipyretics</strong></td>
<td>Antipyretics are not routinely recommended unless there are additional reasons (pain, discomfort from fever, risk of febrile seizures, etc). However if tachypnea is significant, antipyretics can reduce tachypnea from fever and thus should be considered</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Antivirals</strong></td>
<td>Consider influenza viral therapies in children with proven influenza pneumonia</td>
<td>Weak</td>
<td>Moderate$^{95,96}$</td>
</tr>
<tr>
<td><strong>Radiology</strong></td>
<td>Routine CXR is not universally indicated in mild pneumonia Perform CXR if recurrent pneumonia</td>
<td>Weak</td>
<td>Moderate$^{97}$</td>
</tr>
<tr>
<td><strong>Chest physiotherapy</strong></td>
<td>Chest physiotherapy is not recommended</td>
<td>Strong</td>
<td>High$^{98}$</td>
</tr>
<tr>
<td><strong>Blood tests</strong></td>
<td>Routine blood tests for mild pneumonia are not recommended</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Follow-up of progress</strong></td>
<td></td>
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<tr>
<td><strong>Clinical</strong></td>
<td>Review the child at 24 and 48 hours, and assess for improvement or deterioration (hospitalize if indications present) Review child at 5–7 d or until total resolution of symptoms</td>
<td>Strong</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Radiological</strong></td>
<td>Routine follow-up radiograph is not universally indicated. Follow-up radiograph is recommended for those with recurrent pneumonia</td>
<td>Weak</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Further investigations</strong></td>
<td>Refer children with persistent symptoms and/or abnormal radiological features for further investigation to evaluate for an underlying respiratory problem</td>
<td>Strong</td>
<td>Moderate$^{18,99}$</td>
</tr>
<tr>
<td><strong>Preventative factors</strong></td>
<td>Review for presence of risk factors and implement preventative measures such as vaccination (see text for preventative factors)</td>
<td>Strong</td>
<td>(see text)</td>
</tr>
</tbody>
</table>

Management in the hospital is discussed in the text.

*Abbreviation:* CXR, chest radiograph.
hospitalization. \textsuperscript{63} Intake of fluids should be maintained but not increased. \textsuperscript{88} Micronutrient supplementation in children without evidence of deficiency is not recommended. \textsuperscript{89,90,92} Chest physiotherapy in the acute period is not recommended. As an adjunctive treatment to standard care, chest physiotherapy does not hasten clinical resolution of children hospitalized with acute pneumonia, and may prolong duration of coughing and rhonchi. \textsuperscript{98} Specific antiviral agents (such as neuraminidase inhibitors and rimantadine for influenza) are available, and have been shown to reduce the mean duration of illness. \textsuperscript{95} However, their cost and benefit ratios are yet to be determined.

**Review**  Children started on antibiotics require daily review. Treatment failure is defined in IMCI as the development of lower chest-wall in-drawing, central cyanosis, grunting while calm, any “danger signs,” or a persistently raised respiratory rate at 72 hours (48 hours in an area of high HIV prevalence). In developed countries these signs would mandate urgent referral and assessment in hospital. Treatment failure may be due to a range of problems, which include poor adherence, development of complication such as empyema, and wrong diagnosis (eg, asthma or tuberculosis). It is important that treatment failure in this setting is not assumed to mean that antibiotic resistance is the mechanism. However, it is likely in this setting that alternative antimicrobials will be introduced with hospital admission; especially for older children macrolides may be added to cover the possibility of mycoplasma, chlamydia, or possibly legionella.

**Hospital management**  Standardized hospitalized management is recommended, and readers are referred to the British Thoracic Society (BTS) guidelines for the evidence. \textsuperscript{63}

- Choose antibiotics in accordance with age and local drug susceptibility data. Oxygen should be utilized in those with hypoxemia to maintain SpO\textsubscript{2} 92\% or greater. Those unable to maintain oxygenation with supplemental oxygen require transfer to intensive care. (\texttt{GRADE}: strong; \texttt{Strength of evidence}: moderate.)
- Continue feeding child unless there is persistent vomiting or risk of aspiration with severe tachypnea or dyspnea. Intravenous fluids may be required in those who are dehydrated or who are unable to feed. If intravenous fluids are required, use 80\% maintenance unless dehydrated. \textsuperscript{63} (\texttt{GRADE}: strong; \texttt{Strength of evidence}: moderate to low.)
- Obtain standard tests (chest radiograph, blood cultures, nasopharyngeal aspirate, full blood count, electrolytes). The evidence for this is low but it is recommended that these standard tests are performed in those severe enough to require hospitalization. (\texttt{GRADE}: strong; \texttt{Strength of evidence}: low.)
- Chest physiotherapy is not recommended. (\texttt{GRADE}: strong; \texttt{Strength of evidence}: high. \textsuperscript{98})
- Children requiring oxygen therapy should be regularly monitored (continuously if very severe, minimum 4 hourly). (\texttt{GRADE}: strong; \texttt{Strength of evidence}: low.)
- Children who fail to respond (persistent fever or symptoms/signs) require evaluation for complications of pneumonia (eg, empyema, pleural effusion). (\texttt{GRADE}: strong; \texttt{Strength of evidence}: low.)
- As noted in the management of CAP, routine use of micronutrients is not recommended.
- Preventative measures for pneumonia should be explored and attended to (see earlier discussion).

**Follow-up**  All children with pneumonia require regular review until all symptoms and signs resolve. Children with repeated episodes of lower respiratory infections or persistent symptoms should raise consideration of an underlying predisposing
medical condition such as bronchiectasis, and congenital or acquired immunodeficiency states. Given the known increased incidence of bronchiectasis in Indigenous children in Australia, New Zealand, and the United States, it is strongly recommended that all children with pneumonia are followed until all symptoms (especially wet cough) resolve. In some children, pneumonia may be the first presentations of an underlying chronic lung disease such as bronchiectasis (Fig. 1A–C). Untreated protracted bacterial bronchitis is likely a precursor to chronic suppurative lung disease and bronchiectasis.21

In general, there is no consensus on the use of follow-up chest radiography in children with pneumonia, although it is recommended for children with lobar pneumonia.63 A small study demonstrated that predischarge chest radiographs were predictive of chronic respiratory morbidity when they showed no or minimal resolution.18 Radiological features predictive of future bronchiectasis include persistent atelectasis, parenchymal densities, and linear markings on multiple episodes.18,100 Finally, follow-up of the illness episode should be taken as an opportunity to counsel the family on key prevention issues and aspects of general child health.

**SUMMARY**

Bronchiolitis and pneumonia account for the majority of the ALRI burden in young children. These diseases are indicators of the socioeconomic and health disparities that persist between Indigenous and non-Indigenous children in developed countries. RSV
is the major causative agent of bronchiolitis, and \textit{S. pneumoniae} and \textit{H. influenzae} are important etiological agents in pneumonia. Coinfection and concomitant clinical syndromes in Indigenous children are common.

The early detection, diagnosis, and management of these diseases in Indigenous children are critical to improving outcomes and to minimizing the consequent development of bronchiectasis and other chronic lung disorders. The prevention of repeat infections should be a clinical and public health priority. Ongoing surveillance of disease and regular review of management guidelines is critical, given increasing concerns surrounding antibiotic resistance and the changing epidemiology of both viral and bacterial pathogens. Any measures to reduce the burden of disease in Indigenous children cannot operate independently of the social, economic, and environmental factors that are key determinants of child health in these populations.

REFERENCES

5. ABS. The health and welfare of Australia’s Aboriginal and Torres Strait Islander Peoples. Canberra: Australian Bureau of Statistics; 2008. ABS Catalogue No. 4704.0.


