



# Improving the diagnosis, management, and outcomes of children with pneumonia: where are the gaps?

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Pneumonia is the greatest contributor to childhood mortality and morbidity in resource-poor regions, while in high-income countries it is one of the most common reasons for clinic attendance and hospitalization in this age group. Furthermore, pneumonia in children increases the risk of developing chronic pulmonary disorders in later adult life. While substantial advances in managing childhood pneumonia have been made, many issues remain, some of which are highlighted in this perspective. Multiple studies are required as many factors that influence outcomes, such as etiology, patient characteristics, and prevention strategies can vary between and within countries and regions. Also, outside of vaccine studies, most randomized controlled trials (RCTs) on pneumonia have been based in resource-poor countries where the primary aim is usually prevention of mortality. Few RCTs have focused on medium to long-term outcomes or prevention. We propose different tiers of primary outcomes, where in resource-rich countries medium to long-term sequelae should also be included and not just the length of hospitalization and readmission rates.

**Keywords:** pneumonia, acute respiratory infections, diagnosis, treatment, outcomes

## WHY CHILDHOOD PNEUMONIA IS IMPORTANT

Childhood pneumonia is of worldwide importance for several reasons. Firstly, while many illnesses receive relatively more attention, pneumonia remains the most important cause of mortality and morbidity in young children globally (1, 2). Secondly, deaths from pneumonia are largely preventable in this age group. Thirdly, pneumonia, especially when recurrent, is linked to future chronic lung disease (3). Thus, interventions that reduce pneumonia and acute lower respiratory infections (ALRIs) have both short and long-term benefits. This perspective is not a comprehensive review of childhood pneumonia and its management. Instead, it aims to highlight the many gaps in our knowledge so as to stimulate and improve clinical research in pneumonia that will lead subsequently to improved clinical care.

## GLOBAL PNEUMONIA BURDEN

Pneumonia is the largest (18%) single cause of death in children aged <5-years (1). Global estimates of the annual incidence of pneumonia in children aged <5-years range from 120 to 160 million episodes, with more than 99% occurring in resource-limited countries (1). While there are substantial inter-country and inter-continental differences in the annual incidence of pneumonia [0.33 episodes per child-year in Africa, 0.05 in developed countries (1, 2)], there is also intra-continental (4) and wide intra-country variability (1, 5). For example, in South America, the percentage of childhood deaths under the age of 5-years attributable to pneumonia is much lower in Chile and

Uruguay (5–10%) than in Bolivia, Peru, and Guyana (15–20%) (4). Also, in contrast to the rest of affluent Australia, ALRIs (encompassing pneumonia) are the commonest cause of preventable deaths in infants, emergency medical retrievals from remote communities, and hospitalizations among Indigenous children aged <5-years (6, 7). Hospitalized-pneumonia incidence of infants in the Northern Territory of Australia (the region with the highest proportion of Indigenous people) is 0.43 per child-year (8). Similarly, Indigenous children in New Zealand and the United States (US) also bear a substantially disproportionate burden of disease (9, 10). Nevertheless, while there is little doubt that socio-economic issues are important, pneumonia remains one of the most common causes of hospitalization in children, even in resource-rich countries where before the widespread adoption of pneumococcal conjugate vaccines (PCVs) an estimated 1.5 million children aged <5-years were admitted annually.

## THE KNOWLEDGE GAPS

Epidemiological estimates of pneumonia depend upon the accuracy of data collection, which is problematic because of: (a) absence of a diagnostic gold standard, (b) lack of resources to collect data systematically (especially in resource-poor countries), and (c) considerable intra-country variation making extrapolation of data subject to biases, especially when universal health systems are sub-optimal and people seek treatment in the private sector (where data capture is more difficult).