



CLINICAL COURSE, DIAGNOSIS, AND EVALUATION OF TREATMENT EFFECTIVENESS OF PNEUMONIA IN CHILDREN

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Abstract: Pneumonia remains one of the most important causes of morbidity and mortality among children worldwide, particularly among children younger than five years of age. It is a heterogeneous clinical syndrome caused by bacterial, viral, and, less frequently, fungal pathogens. The clinical presentation varies according to age, causative organism, disease severity, nutritional status, immunization history, and the presence of underlying conditions. Early recognition of respiratory distress and hypoxaemia is essential because delayed treatment may result in respiratory failure, sepsis, pleural complications, and death. This review evaluates the clinical course, diagnostic approaches, and methods for assessing treatment effectiveness in childhood pneumonia using evidence from World Health Organization recommendations, international pediatric guidelines, systematic reviews, and epidemiological studies. Clinical assessment remains the foundation of diagnosis, with tachypnoea, increased work of breathing, cough, fever, crackles, hypoxaemia, and reduced oxygen saturation being important findings. Pulse oximetry is particularly important for identifying hypoxaemia and determining the need for oxygen therapy. Chest radiography is not routinely required in uncomplicated outpatient pneumonia but has an important role when the diagnosis is uncertain, when hypoxaemia or severe respiratory distress is present, or when complications are suspected. Lung ultrasound is increasingly supported as an alternative imaging technique, particularly for detecting consolidation and pleural complications. Treatment depends on severity and probable aetiology. Antibiotic therapy is indicated when bacterial pneumonia is suspected, whereas supportive treatment, including oxygen therapy for hypoxaemia, adequate hydration, nutritional support, and monitoring, is essential in severe disease. Treatment effectiveness should be evaluated primarily through clinical improvement, respiratory status, oxygenation, fever resolution, oral intake, and absence of complications. Evidence-based diagnosis and systematic reassessment can reduce mortality, inappropriate antibiotic use, and unnecessary diagnostic procedures.

Keywords: Childhood pneumonia; community-acquired pneumonia; pediatric pneumonia; tachypnoea; hypoxaemia; pulse oximetry; chest radiography; lung ultrasound; antibiotics; amoxicillin; oxygen therapy; treatment effectiveness.

Introduction

Pneumonia is an acute infection of the lower respiratory tract involving the pulmonary parenchyma and is characterized by inflammation of the alveoli and surrounding tissues. It may be caused by bacteria, viruses, fungi, or mixed infections. In children, the relative contribution of individual pathogens varies substantially according to age, geographic location, vaccination coverage, season, underlying disease, and healthcare setting [1,2].

Historically, childhood pneumonia has represented a major global health problem. Earlier epidemiological estimates indicated approximately 156 million new episodes of childhood

pneumonia annually worldwide, with the overwhelming majority occurring in developing countries [3]. Although substantial progress has been achieved through vaccination, improved nutrition, breastfeeding promotion, access to antibiotics, oxygen therapy, and better case management, pneumonia remains a major cause of preventable childhood mortality. The World Health Organization estimated that pneumonia caused approximately 740,180 deaths among children younger than five years in 2019, representing 14% of all deaths in this age group [4]. More recent WHO guidance emphasizes that pneumonia and diarrhoeal diseases together remain responsible for a substantial proportion of childhood mortality and that improved diagnosis and management are required through the age of 10 years [1].

The clinical manifestations of pneumonia are not uniform. Infants may present with nonspecific symptoms such as poor feeding, irritability, lethargy, or apnoea, whereas older children are more likely to demonstrate fever, cough, tachypnoea, chest pain, and localized auscultatory abnormalities. Severe pneumonia may be accompanied by lower chest-wall indrawing, grunting, cyanosis, altered consciousness, inability to drink, or hypoxaemia [1,5].

Accurate diagnosis is clinically important because pneumonia cannot reliably be distinguished as bacterial or viral solely on the basis of symptoms or routine radiographic findings. At the same time, unnecessary antibiotic exposure contributes to antimicrobial resistance and avoidable adverse effects. Consequently, modern management emphasizes clinical severity assessment, appropriate use of pulse oximetry and imaging, rational antimicrobial treatment, and systematic reassessment of response to therapy [1,6].

This review summarizes evidence concerning the clinical course, diagnosis, treatment, and evaluation of treatment effectiveness in children with pneumonia.

Methodology

This article was prepared as an evidence-based narrative review of published scientific literature and international clinical guidelines concerning pneumonia in children. Sources were identified from World Health Organization publications, international pediatric infectious disease guidelines, systematic reviews, peer-reviewed journal articles, and epidemiological studies.

Particular attention was given to evidence concerning the clinical manifestations of childhood pneumonia, diagnostic accuracy of clinical signs and imaging, identification of hypoxaemia, antimicrobial treatment, oxygen therapy, management of complicated pneumonia, and criteria for evaluating clinical response. Current WHO guidance published in 2025 and the updated 2026 Pediatric Infectious Diseases Society/Infectious Diseases Society of America guideline materials were considered alongside established peer-reviewed evidence [1,7].

No original patient cohort, hospital database, questionnaire, experimental intervention, or unpublished clinical observations were used. Therefore, the “Results” section represents a synthesis of previously published evidence rather than results from a newly conducted clinical study.

Results

Clinical course of pneumonia in children

The clinical course of childhood pneumonia depends on the child's age, immune status, nutritional condition, causative pathogen, vaccination status, and severity at presentation. In otherwise healthy children, uncomplicated community-acquired pneumonia may resolve with



appropriate treatment and supportive care. Severe disease can progress rapidly, particularly when hypoxaemia, dehydration, sepsis, or respiratory failure develops [1,5].

Common clinical manifestations include cough, fever, tachypnoea, increased work of breathing, reduced appetite, and abnormal lung auscultation. Tachypnoea is particularly important in young children because it may be present even when auscultatory findings are limited. Grunting, retractions, crackles, fever, and the overall clinical impression are among the findings associated with radiographic pneumonia [8].

The clinical spectrum also differs according to the infectious agent. The PERCH multicountry case-control study investigated severe pneumonia requiring hospitalization among children aged 1–59 months without HIV infection in seven countries in Africa and Asia. Ten pathogens accounted for most etiologically attributable cases; viruses were responsible for a substantial proportion of severe pneumonia, while bacterial pathogens also contributed importantly [9]. Respiratory syncytial virus was particularly important among young children. These findings demonstrate why the clinical presentation alone cannot reliably determine whether pneumonia is viral or bacterial.

Risk factors associated with increased occurrence or severity include undernutrition, lack of exclusive breastfeeding, indoor air pollution, crowding, low birth weight, incomplete immunization, and unfavorable socioeconomic conditions [3]. Underlying cardiopulmonary disease, immunodeficiency, neuromuscular disorders, and other chronic conditions can further increase the risk of severe disease.

Diagnostic approach

The diagnosis of childhood pneumonia begins with a careful clinical assessment. Respiratory rate should be measured while the child is calm, and assessment should include respiratory effort, chest indrawing, grunting, nasal flaring, mental status, hydration, ability to feed or drink, and oxygen saturation.

The absence of tachypnoea has historically been considered useful in reducing the likelihood of pneumonia, whereas the presence of tachypnoea is a sensitive but not highly specific indicator. Clinical prediction models have been studied, but many have limitations in specificity and have not replaced clinical judgment [8].

Pulse oximetry is an essential component of assessment in children with suspected severe pneumonia. Hypoxaemia is strongly associated with increased mortality risk. WHO evidence indicates that hypoxaemia may occur in approximately 13% of children with severe or very severe pneumonia, although prevalence varies according to disease severity and healthcare setting [10]. WHO recommends pulse oximetry to identify hypoxaemia and guide oxygen therapy where the equipment is available [10].

Laboratory investigations may be useful in selected patients but should not be interpreted as definitive tests for bacterial pneumonia. Leukocyte counts, C-reactive protein, and other inflammatory markers may support clinical assessment but cannot consistently distinguish bacterial from viral pneumonia [8]. Blood cultures are generally reserved for selected hospitalized or severely ill children because bacteremia is uncommon in uncomplicated outpatient pneumonia and culture yield is limited.

Chest radiography is not routinely necessary for every child with uncomplicated community-acquired pneumonia. International pediatric recommendations support radiography when the diagnosis is uncertain, when significant respiratory distress or

hypoxaemia is present, when there is suspected complication, or when the child fails to improve after appropriate initial treatment [6,8]. Radiographic patterns also cannot reliably identify the causative pathogen.

Lung ultrasound has become an increasingly important diagnostic technique. A 2024 systematic review and meta-analysis involving 26 studies and 3,401 children reported pooled sensitivity of 0.95 and specificity of 0.92 for lung ultrasound, compared with sensitivity of 0.92 and specificity of 0.93 for chest radiography [11]. These results indicate that lung ultrasound can provide diagnostic performance comparable to chest radiography in appropriate clinical settings while avoiding ionizing radiation. It may be particularly useful for identifying consolidation and pleural effusion.

Etiological considerations

The microbiological causes of childhood pneumonia vary according to age and setting. *Streptococcus pneumoniae* has historically been a major bacterial cause of childhood pneumonia, while *Haemophilus influenzae* type b has also been an important pathogen in populations with low vaccination coverage [3]. Vaccination has substantially changed the epidemiology of these infections.

The WHO position paper on pneumococcal conjugate vaccines summarizes evidence from randomized controlled trials involving more than 113,000 children. Pooled vaccine efficacy was 80% against vaccine-type invasive pneumococcal disease and 27% against WHO-defined radiographic pneumonia [12]. These findings support vaccination as a major component of pneumonia prevention.

Respiratory viruses are particularly important in young children. Global estimates for respiratory syncytial virus-associated acute lower respiratory infection demonstrate a substantial burden among children younger than five years, particularly in the first years of life [13]. Consequently, antimicrobial treatment should not automatically be initiated solely because a child has cough and fever.

Treatment principles

Treatment should be determined by disease severity, age, probable pathogen, ability to take oral medication, presence of hypoxaemia, and underlying conditions.

For non-severe bacterial pneumonia managed in the outpatient setting, oral amoxicillin remains a principal first-line treatment in international guidelines [1,6]. WHO guidance has specifically recommended oral amoxicillin for childhood pneumonia and injectable antibiotics for severe pneumonia requiring hospital-level care [14].

A systematic review by Lodha, Kabra, and Pandey included 29 randomized trials involving 14,188 children. In ambulatory treatment of WHO-defined non-severe pneumonia, amoxicillin and co-trimoxazole had similar treatment failure and cure rates in the analyzed trials. In children with severe pneumonia without hypoxaemia who were feeding adequately, oral antibiotics demonstrated outcomes comparable with injectable therapy in the evidence reviewed [15].

Antibiotic selection should nevertheless be individualized according to disease severity, age, local antimicrobial resistance patterns, previous antibiotic exposure, vaccination history, and suspected pathogen. Antibiotics are not indicated for every respiratory infection because a substantial proportion of childhood pneumonia is viral.

Supportive care is equally important. Children with hypoxaemia require oxygen therapy. WHO emphasizes that pulse oximetry should be used whenever available to identify hypoxaemia and guide oxygen administration [10]. Adequate hydration and nutrition should be maintained, but excessive intravenous fluid administration should be avoided in severe pneumonia because fluid overload may worsen respiratory function [5].

Children with respiratory failure or persistent hypoxaemia despite conventional oxygen therapy may require escalation of respiratory support in an appropriately equipped facility.

Management of complicated pneumonia

Complications include parapneumonic effusion, empyema, necrotizing pneumonia, lung abscess, pneumothorax, and respiratory failure. These conditions require more intensive diagnostic evaluation and management.

The 2026 IDSA/PIDS guideline update recommends chest ultrasound rather than CT or MRI for characterization of moderate-to-large parapneumonic effusions when imaging is required [7]. Small uncomplicated effusions may often be observed, whereas moderate effusions associated with respiratory distress, large effusions, or purulent effusions generally require drainage [7].

For children with empyema requiring drainage, the updated guideline suggests chest tube drainage combined with intrapleural fibrinolytic therapy rather than surgical debridement as first-line treatment in most cases. Video-assisted thoracoscopic surgery may be reserved for selected children with extensive loculation or disease that remains refractory to less invasive treatment [7].

Evaluation of Treatment Effectiveness

Evaluation of treatment effectiveness should be systematic and based primarily on clinical response rather than on isolated laboratory values.

The first major indicator is improvement in respiratory status. Effective treatment should be associated with reduced respiratory distress, decreasing respiratory rate, improvement in chest indrawing and grunting, and stabilization or improvement of oxygen saturation. In children receiving oxygen, the requirement for supplemental oxygen should progressively decrease as pulmonary function improves.

The second important indicator is improvement in general condition. Restoration of normal activity, improved appetite, ability to drink or breastfeed, reduction in lethargy, and normalization of mental status are clinically meaningful indicators of recovery.

Fever should gradually resolve in children whose pneumonia is responding appropriately. Persistence or recurrence of fever, worsening respiratory distress, increasing oxygen requirement, new chest pain, or deteriorating general condition should prompt reassessment for treatment failure, resistant infection, an alternative diagnosis, or complications.

Clinical response is particularly important during the first 48–72 hours after initiation of appropriate treatment. Lack of improvement during this period should lead to a systematic reassessment of the diagnosis, antimicrobial selection, adherence, complications, and possible non-bacterial causes [6,8].

Laboratory parameters can provide additional information in hospitalized patients but should not replace clinical assessment. Similarly, repeat chest radiography is generally

unnecessary in children who show uncomplicated clinical recovery. Imaging should instead be repeated selectively when symptoms persist, worsen, or complications are suspected [6].

Treatment safety must also be evaluated. Adverse effects of antibiotics, including gastrointestinal symptoms, allergic reactions, and other drug-related complications, should be documented. Avoidance of unnecessary broad-spectrum antibiotic use is an important component of antimicrobial stewardship.

Analysis and Discussion

The evidence demonstrates that childhood pneumonia should be approached as a clinical syndrome rather than as a disease that can be diagnosed solely by a single laboratory or imaging test. The most effective diagnostic strategy combines clinical examination with measurement of respiratory rate, assessment of respiratory effort, evaluation of general danger signs, and pulse oximetry.

The importance of hypoxaemia deserves particular emphasis. Hypoxaemia is a physiological marker of severe pulmonary disease and is associated with a markedly increased risk of death. WHO reports that pneumonia-associated hypoxaemia can increase the risk of death by up to fivefold [10]. Consequently, failure to measure oxygen saturation may result in under-recognition of severe disease.

At the same time, overuse of diagnostic testing should be avoided. Routine chest radiography does not reliably differentiate viral from bacterial pneumonia and is unnecessary for many clinically uncomplicated outpatient cases [6,8]. Lung ultrasound provides a valuable radiation-free alternative, particularly where trained personnel and appropriate equipment are available [11].

The etiological evidence also has direct implications for antibiotic stewardship. The PERCH study demonstrated that viral pathogens contribute substantially to severe childhood pneumonia [9]. Therefore, fever, cough, and radiographic infiltrates should not automatically be interpreted as evidence of bacterial disease. Antibiotic decisions should incorporate clinical severity and epidemiological context.

Where bacterial pneumonia is suspected, timely administration of an appropriate antibiotic remains essential. Evidence supports amoxicillin as an effective first-line option for many children with non-severe community-acquired pneumonia [1,15]. However, treatment must be adapted to local resistance patterns and individual clinical circumstances.

Treatment effectiveness is best assessed dynamically. A child who demonstrates improved oxygenation, reduced respiratory effort, improved oral intake, declining fever, and restoration of normal activity is generally showing a favorable response. Conversely, persistent hypoxaemia, worsening respiratory distress, prolonged fever, inability to feed, or new pleural findings should trigger immediate reassessment.

Vaccination remains a fundamental preventive strategy. Pneumococcal and Hib vaccination has reduced the burden of vaccine-preventable pneumonia, while broader childhood immunization programs contribute to prevention of respiratory infections [12,16]. Prevention should therefore be integrated with clinical management.

An important limitation of the current evidence is that diagnostic and therapeutic recommendations are not equally applicable to all settings. WHO recommendations are particularly relevant to low- and middle-income countries where access to imaging, laboratory testing, pulse oximetry, and oxygen may be limited. Conversely, the 2026 IDSA/PIDS guideline

on complicated pneumonia specifically excludes low-resource settings because diagnostic and management approaches differ according to available resources [7]. Clinical protocols should therefore be adapted to local healthcare capacity while maintaining evidence-based principles.

Conclusion

Childhood pneumonia remains a major cause of preventable morbidity and mortality. Its clinical course ranges from uncomplicated respiratory infection to severe disease characterized by hypoxaemia, respiratory failure, sepsis, or pleural complications. Early identification of tachypnoea, increased work of breathing, danger signs, and hypoxaemia is essential for appropriate triage.

Clinical assessment remains the foundation of diagnosis. Pulse oximetry is particularly important because hypoxaemia is a major predictor of poor outcome. Chest radiography should be used selectively, while lung ultrasound is increasingly supported as an accurate radiation-free diagnostic method. Laboratory markers may provide supplementary information but cannot reliably distinguish bacterial from viral pneumonia in isolation.

Treatment should be guided by disease severity and probable etiology. Amoxicillin remains an important first-line antibiotic for many children with non-severe bacterial community-acquired pneumonia, whereas severe pneumonia requires hospital-level management, appropriate parenteral antimicrobial therapy when indicated, oxygen for hypoxaemia, and careful supportive care. Complicated pneumonia requires specialized evaluation and may require pleural drainage.

The effectiveness of treatment should be evaluated through serial clinical assessment, particularly changes in respiratory distress, respiratory rate, oxygen saturation, fever, oral intake, activity, and general condition. Failure to improve within approximately 48–72 hours should prompt reassessment for diagnostic error, inappropriate antimicrobial therapy, resistant pathogens, or complications. Rational antibiotic use, reliable oxygen assessment, timely escalation of care, and vaccination are essential components of an evidence-based strategy for reducing the burden of pneumonia in children.

References:

1. World Health Organization. Guideline on the Management of Pneumonia and Diarrhoea in Children up to 10 Years of Age. Geneva: World Health Organization; 2025. pp. 1–65.
2. World Health Organization. Pocket Book of Hospital Care for Children: Guidelines for the Management of Common Childhood Illnesses. 2nd ed. Geneva: World Health Organization; 2013. pp. 1–438.
3. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. Bulletin of the World Health Organization. 2008;86(5):408–416.
4. World Health Organization. Pneumonia in children. Geneva: World Health Organization; 2022. pp. 1–4.
5. World Health Organization. Paediatric Emergency Triage, Assessment and Treatment: Care of Critically-Ill Children. Geneva: World Health Organization; 2016. pp. 1–74.
6. Bradley JS, Byington CL, Shah SS, et al. The management of community-acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. Clinical Infectious Diseases. 2011;53(7):e25–e76.

7. St. Peter SD, Ampofo K, Brogan T, et al. Clinical Practice Guideline by the Infectious Diseases Society of America and the Pediatric Infectious Diseases Society: 2026 Guideline Update on the Management of Community-Acquired Pneumonia in Infants and Children Older than 3 Months of Age. 2026. pp. 1–6.
8. Smith DK, Kuckel DP, Recidoro AM. Community-acquired pneumonia in children: rapid evidence review. *American Family Physician*. 2021;104(6):618–625.
9. The Pneumonia Etiology Research for Child Health (PERCH) Study Group. Causes of severe pneumonia requiring hospital admission in children without HIV infection from Africa and Asia: the PERCH multi-country case-control study. *The Lancet*. 2019;394(10200):757–779.
10. World Health Organization. *Oxygen Therapy for Children: A Manual for Health Workers*. Geneva: World Health Organization; 2016. pp. 1–66.
11. Yang Y, Wu Y, Zhao W. Comparison of lung ultrasound and chest radiography for detecting pneumonia in children: a systematic review and meta-analysis. *Italian Journal of Pediatrics*. 2024;50:12. pp. 1–13.
12. World Health Organization. WHO position paper: pneumococcal conjugate vaccines in infants and children under 5 years of age. *Weekly Epidemiological Record*. 2019;94(8):85–104.
13. Li Y, Wang X, Blau DM, et al. Global, regional, and national disease burden estimates of acute lower respiratory infections due to respiratory syncytial virus in children younger than 5 years in 2019: a systematic analysis. *The Lancet*. 2022;399(10340):2047–2064.
14. World Health Organization. *Revised WHO Classification and Treatment of Childhood Pneumonia at Health Facilities: Evidence Summaries*. Geneva: World Health Organization; 2014. pp. 1–30.
15. Lodha R, Kabra SK, Pandey RM. Antibiotics for community-acquired pneumonia in children. *Cochrane Database of Systematic Reviews*. 2013;(6):CD004874. pp. 1–102.
16. World Health Organization. *Haemophilus influenzae type b vaccination position paper*. *Weekly Epidemiological Record*. 2013;88(39):413–426.

