Pneumonia in Children with Congenital Heart Disease: A Literature Review

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Abstract

Pneumonia is a leading cause of morbidity and mortality among children worldwide, particularly in those with Congenital Heart Disease (CHD). CHD causes hemodynamic disturbances and pulmonary congestion, which increase the risk of recurrent pneumonia and exacerbate the severity of infection. This literature review aims to systematically analyze current data on risk factors, clinical manifestations, mortality, morbidity, and clinical outcomes of pneumonia in children with CHD. A narrative review method was used, with literature searches conducted through PubMed and ScienceDirect databases using the keywords “pneumonia,” “congenital heart disease,” and “children” for publications between 2020–2025. Four relevant articles meeting the inclusion criteria were analyzed descriptively. The analysis revealed that the prevalence of CHD among children with pneumonia ranged from 12.5% to 21.3%, predominantly consisting of acyanotic defects such as Ventricular Septal Defect (VSD), Patent Ductus Arteriosus (PDA), and Atrial Septal Defect (ASD). Left to right shunt CHD contributes to chronic pulmonary overcirculation, leading to pulmonary edema, congestive heart failure, and a favorable environment for respiratory infections. Children with CHD have longer hospital stays (more than seven days), a higher risk of ICU admission, and a mortality rate twice as high as children without CHD. In conclusion, CHD is a significant risk factor for the increased incidence and severity of pneumonia in children. Early detection and cardiac screening, especially in recurrent pneumonia cases, are essential to prevent complications and reduce mortality through an appropriate multidisciplinary approach.

Keywords: Children, congenital heart disease, pneumonia

Pneumonia pada Anak dengan Penyakit Jantung Bawaan: Tinjauan Pustaka

Abstrak

Pneumonia merupakan penyebab utama morbiditas dan mortalitas anak di seluruh dunia, terutama pada anak dengan Penyakit Jantung Bawaan (PJB). PJB menyebabkan gangguan hemodinamik dan kongesti paru yang meningkatkan risiko terjadinya pneumonia berulang dan memperberat keparahan infeksi. Literatur ini bertujuan untuk menganalisis secara sistematis data terkini mengenai faktor risiko, manifestasi klinis, mortalitas, morbiditas, dan luaran klinis pneumonia pada anak dengan PJB. Metode yang digunakan adalah narrative review dengan pencarian literatur melalui database PubMed dan ScienceDirect menggunakan kata kunci “pneumonia”, “congenital heart disease”, dan “children” untuk publikasi tahun 2020–2025. Empat artikel yang memenuhi kriteria inklusi dianalisis secara deskriptif. Hasil analisis menunjukkan bahwa prevalensi PJB pada anak dengan pneumonia berkisar antara 12,5% hingga 21,3%, dengan dominasi jenis defek asianotik seperti Ventricular Septal Defect (VSD), Patent Ductus Arteriosus (PDA), dan Atrial Septal Defect (ASD). PJB tipe shunt kiri-ke-kanan berperan dalam meningkatkan sirkulasi paru secara kronis sehingga menimbulkan edema paru, gagal jantung kongestif, dan menciptakan kondisi ideal bagi infeksi saluran pernapasan. Anak dengan PJB memiliki lama rawat inap lebih dari tujuh hari, risiko masuk ICU lebih tinggi, serta angka mortalitas dua kali lipat dibandingkan anak tanpa PJB. Kesimpulannya, PJB merupakan faktor risiko signifikan terhadap peningkatan kejadian dan keparahan pneumonia pada anak. Deteksi dini dan skrining jantung pada kasus pneumonia, khususnya yang berulang, sangat diperlukan untuk mencegah komplikasi dan menurunkan angka kematian melalui pendekatan multidisiplin yang tepat.

Kata Kunci: Anak, penyakit jantung bawaan, pneumonia

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Introduction

Pneumonia is one of the leading causes of morbidity and mortality in children, particularly among those with congenital heart disease (CHD), which significantly increases the risk of lower respiratory tract infections[1]. Children with CHD experience hemodynamic disturbances and congestive complications that make them more susceptible to recurrent pneumonia and respiratory failure, resulting in a higher mortality rate compared with children without CHD[2]. Left to right shunt CHDs, such as ventricular septal defect (VSD) and patent ductus arteriosus (PDA), are major risk factors for recurrent pneumonia in

children[3]. These conditions increase cardiac workload and induce pulmonary circulatory changes that facilitate the development of pulmonary infections.

Congenital heart disease is the most common major birth defect globally, affecting approximately 1% of all live births worldwide, with an estimated prevalence ranging from 8 to 12 per 1,000 live births, and Asia reporting the highest rates[4]. CHD is also a significant risk factor that exacerbates acute respiratory infections, with global studies indicating that CHD is present in 25.6% to 54.5% of pediatric pneumonia cases requiring hospitalization, highlighting the high risk of poor outcomes such as mortality and the need for intensive care[5]. In Indonesia, although national CHD registry data remain limited, the incidence is estimated at 8 to 10 per 1,000 live births, equivalent to 40,000 to 50,000 infants born with CHD each year[4,6]. Acyanotic CHD types, such as VSD and PDA, are the most frequently encountered[5,7]. A study at Dr. Sardjito General Hospital in Yogyakarta also confirmed the association between CHD and pneumonia, reporting that 16.74% of children with pneumonia had CHD, accompanied by a substantially increased rate of admission to the Pediatric Intensive Care Unit (PICU), reaching 31.94% among CHD pneumonia cases[8].

Given the high global and national prevalence of CHD, and its role as a major risk factor that worsens the clinical outcomes of pneumonia, a comprehensive understanding of the interaction between these two conditions is essential[9]. Children with CHD are not only more susceptible to pneumonia but also face a substantially higher risk of mortality due to complications such as respiratory failure, worsening heart failure, and poor nutritional status or anemia, all of which aggravate prognosis[10]. Since pneumonia markedly influences morbidity and mortality outcomes in children with CHD, identifying additional risk factors contributing to pneumonia in this population is crucial. The findings of this review are expected to provide a strong scientific foundation for clinicians and healthcare professionals in developing effective strategies for prevention, early diagnosis, and management, ultimately improving quality of life and reducing mortality in this vulnerable patient group.

Methods

This literature review employed a narrative review approach with the aim of systematically analyzing current data regarding risk factors, clinical manifestations, mortality, morbidity, and clinical outcomes of pneumonia in children with CHD. To enhance transparency and minimize publication bias, a systematic search was conducted across PubMed and ScienceDirect databases for publications from 2020 to 2025. The search used the Boolean operator “AND” with the keywords “pneumonia,” “congenital heart disease,” and “children”. From an initial identification of 289 articles, 45 duplicates were removed, and 244 titles/abstracts were screened, resulting in four final articles for deep analysis.

Inclusion criteria consisted of studies involving pediatric populations (0–18 years) with pneumonia and/or congenital heart disease, English-language articles, full-text availability, original research studies, observational studies, cohort studies, cross-sectional studies, or randomized controlled trials (RCTs) when available, and publications between 2020 and 2025. Exclusion criteria included studies involving patients with other congenital anomalies beyond CHD, studies lacking separate data specific to children (0–18 years), studies on severely immunocompromised patients, patients undergoing immunosuppressive therapy, and animal experimental studies. This review is limited by the small number of databases accessed and the absence of a formal risk of bias analysis, which may affect the generalizability of the clinical conclusions. Furthermore, potential publication bias exists as studies with negative results may not have been captured.

Discussion

Congenital heart disease (CHD) is a structural abnormality of the heart present at birth that disrupts blood flow and cardiac function[1,11]. CHD may include ventricular septal defect (VSD), patent ductus arteriosus (PDA), and atrial septal defect (ASD), all of which result in abnormal blood shunting and hemodynamic

burden on the lungs[1,3]. CHD is classified into two main types: cyanotic and acyanotic. Cyanotic CHD is characterized by right to left shunting or circulatory disturbances that reduce blood oxygen saturation, leading to cyanosis or bluish discoloration of the skin and mucous membranes. In contrast, acyanotic CHD typically involves left to right shunting without cyanosis, resulting in volume overload in the pulmonary circulation[1,12].

Pneumonia is an acute lower respiratory tract infection that causes inflammation and consolidation of lung tissue, manifesting with common symptoms such as fever, cough, and dyspnea[3,13]. It is a leading cause of mortality in children under five, particularly in developing countries, and this risk is significantly higher in children with both cyanotic and acyanotic CHD due to associated hemodynamic and immunologic impairments[1,14].

The mechanism of pneumonia in CHD patients is closely related to left to right shunting, which leads to pulmonary overcirculation, excessive pulmonary blood volume, and increased pressure, ultimately causing pulmonary edema and congestive heart failure (CHF). Pulmonary congestion creates an environment conducive to colonization and infection of the respiratory tract by pathogens[1,11]. In cyanotic CHD, hypoxemia and cyanosis further increase susceptibility to infectious complications, although through slightly different mechanisms. Impaired pulmonary function and immune dysregulation in both CHD types heighten vulnerability to pneumonia, necessitating appropriate evaluation and management to reduce morbidity and mortality[11,15].

Table 1. Literature Search Results[1,3,11,13]

Author	Title	Study Design	Population	Results	Conclusion
Rahayuningsih, S. E. et al. (2021)	Left to right shunt congenital heart disease as a risk factor of recurrent pneumonia in under five-year-old children: a single centre experience in Bandung Indonesia	Retrospective study	1,258 children aged >5 years who were hospitalized at Dr. Hasan Sadikin General Hospital, Bandung, during 2015–2018.	1. A total of 144 children (62%) under 1 year of age had a higher incidence of CHD compared with those aged 1–5 years. 2. Among patients with CHD, 232 children (18.4%) experienced recurrent pneumonia. 3. Male children accounted for 119 cases (51.3%). 4. A total of 91.8% of CHD patients with recurrent pneumonia had left to right shunt lesions. 5. Isolated VSD and malnutrition were significant risk factors for recurrent pneumonia (OR: 1.551 and 2.591, respectively). 6. Recurrent pneumonia occurred more frequently in children with left to right shunt CHD and in those younger than 1 year.	Left to right shunt congenital heart disease is one of the most common causes of recurrent pneumonia, with VSD having a significant influence on its higher prevalence.

Author	Title	Study Design	Population	Results	Conclusion
Jat, N. K. et al. (2022)	Assessment of the prevalence of congenital heart disease in children with pneumonia in tertiary care hospital	Observational Cross-Sectional Study	Pediatric patients under 5 years of age with pneumonia (N = 160).	1. The prevalence of CHD among pneumonia cases was 12.5%, and congestive heart failure occurred in 27.5% of patients. 2. The most common CHD was VSD (8.8%), followed by PDA (2.5%), ASD (1.9%), and TGA (0.6%). 3. Pneumonia episodes: recurrent (20.6%) and persistent (7.5%). 4. Mortality was 10% in CHD patients and 3.75% in non-CHD patients. 5. Length of hospital stay: 95% of CHD patients were hospitalized for more than 7 days, whereas 75.7% of non-CHD patients were hospitalized for fewer than 7 days. 6. A significant association was found between CHD and the occurrence of CCF.	Recurrent ALRTI frequently occurs in children with a history of CHD and is also associated with the development of congestive heart failure. Children with CHD are more susceptible to recurrent respiratory tract infections.
Ullah, M. A. et al. (2023)	Prevalence of Congenital Heart Disease in Children with Recurrent Respiratory Tract Infection	Observational study	Fifty children with recurrent lower respiratory tract infections (Recurrent LRTI).	1. Male (54.5%) and female (45.5%) patients. 2. The most common CHD was VSD (40%), followed by ASD (30%) and PDA (15%). 3. The findings indicate that CHD is a major cause of recurrent LRTI.	CHD is a major cause of recurrent LRTI in children; therefore, screening for CHD is essential in all children presenting with recurrent LRTI.
Talukder, D. et al. (2024)	Prevalence of Congenital Heart Diseases in Children with Pneumonia: Observations from the Pediatric Respiratory ICU of a Tertiary Care Hospital	Prospective observational study	A total of 258 children aged 2–12 months diagnosed with pneumonia and admitted to the PICU (N = 258).	1. The prevalence of CHD among children with pneumonia was 21.32% (n = 55). 2. Mean age: 7.2 ± 3.1 months. 3. Sex distribution: males (58.91%), females (41.09%). 4. Types of pneumonia: acute (8.33%), recurrent (44.74%), persistent (34.21%).	CHD shows a significant prevalence among children with pneumonia, particularly in recurrent and persistent cases, and is associated with adverse outcomes such CCF.

Author	Title	Study Design	Population	Results	Conclusion
				5. The most common CHD was ASD (41.81%), followed by PDA (21.82%) and VSD (18.18%). 6. The prevalence of CHD was higher in recurrent (44.74%) and persistent (34.21%) pneumonia cases. 7. 52.73% of children with CHD developed CCF.	

Notes: CHD, Congenital Heart Disease; ALRTI, Acute Lower Respiratory Tract Infections ; LRTI, Lower Respiratory Tract Infections ; CCF, Congestive Cardiac Failure; OR, Odds Ratio; VSD, Ventricular Septal Defect; PDA, Patent Ductus Arteriosus; ASD, Atrial Septal Defect ; TGA, Transposition of the Great Arteries

Based on the search results from two database sources, a total of 289 articles were identified and screened by title and abstract. Four articles were deemed relevant and selected for full-text comparison and analysis. Pneumonia and congenital heart disease (CHD) are major contributors to childhood morbidity and mortality globally, particularly in developing countries[2]. CHD has long been recognized as an important risk factor among children with acute and severe respiratory infections. Studies by Jat et al. (2022) and Talukder et al. (2024) reported the prevalence of CHD among children with pneumonia to range from 12.5% to 21.32%, which is significantly higher than in the general population[1,11].

The prevalence of pneumonia in children with CHD is dominated by those under five years of age[1]. A study by Rahayuningsih et al. (2021) found that children under one year of age (62%) were significantly more likely to have CHD than those aged 1–5 years. However, Talukder et al. (2024) reported the mean age of patients with CHD to be 7.2 months. Regarding sex distribution, studies on children with recurrent lower respiratory tract infections (recurrent LRTI) associated with CHD showed male predominance (30 out of 50 cases)[13]. Similar findings were reported by Rahayuningsih et al. (2021), where 119 children (51.3%) were male.

The underlying mechanism for these findings is the presence of acyanotic CHD defects such as ventricular septal defect (VSD), patent ductus arteriosus (PDA), and atrial septal defect (ASD), which result in left to right shunts[1]. These shunts lead to chronic pulmonary overcirculation, causing pulmonary edema and congestive cardiac failure (CCF). Persistent pulmonary congestion creates an ideal environment for respiratory infections, increasing susceptibility to pneumonia[1].

The most frequently identified cardiac defects among children with pneumonia are VSD, PDA, and ASD. Jat et al. (2022) identified VSD as the most common defect (8.8%), whereas Talukder et al. (2024) reported ASD as the most prevalent (41.81%)[1,11]. The importance of VSD as a risk factor was further confirmed by Rahayuningsih et al. (2021), who demonstrated that VSD was an independent risk factor for recurrent pneumonia with an odds ratio of 1.551[3]. Larger left to right shunts tend to cause massive pulmonary circulation overload, maintaining chronic pulmonary congestion and heart failure key predisposing factors for recurrent lower respiratory tract infections. Non-cardiac risk factors such as malnutrition also played a significant role, increasing the risk of recurrent pneumonia by 2.591 times[3].

The clinical diagnosis of pneumonia in children with CHD is based on clinical symptoms, physical findings, and chest radiographic evidence. The most common symptoms include fever (100%), difficulty breathing (96.3%), and cough or cold (95%)[1].

The hallmark clinical finding with high sensitivity is tachypnea, observed in all cases. This increased respiratory rate represents a compensatory response to reduced pulmonary compliance from congestion and edema due to pneumonia or heart failure, and from increased metabolic demand during fever[1,11]. Common clinical findings in children with CHD include hyperactive precordium (90%) and cardiac murmurs (85%), followed by cardiomegaly (50%) and increased bronchovascular markings (35%)[1].

Morbidity is significantly worsened by cardiac complications. The prevalence of congestive cardiac failure (CCF) among patients with CHD and pneumonia is markedly higher (52.73%) than among those without CHD (16.75%)[11]. Common clinical manifestations of CCF include difficulty breathing (84%), hepatomegaly (81%), feeding difficulties (79.4%), excessive sweating (50%), and weight loss (3.2%)[1].

CHD significantly increases morbidity and disease severity in pneumonia. Talukder et al. (2024) reported a considerably higher prevalence of CHD in recurrent pneumonia cases (44.74%) than in persistent cases (34.21%)[11]. Clinically, pneumonia in children with CHD tends to be more severe and often requires more intensive management. These patients demonstrate longer hospital stays, higher ICU admission rates, and greater need for mechanical ventilation. These increased ICU requirements stem from complications such as CCF and pulmonary hypertension, which further impair respiratory status[11].

Regarding length of hospital stay, CHD contributes markedly to prolonged hospitalization among children with pneumonia. Approximately 95% of children with CHD required hospitalization for more than 7 days, reflecting disease severity and the need for extended management[1]. In contrast, 75.7% of children without CHD were hospitalized for fewer than 7 days[1]. Prolonged hospitalization in CHD cases results from interactions between the underlying heart condition and acute infection, often accompanied by heart failure that is difficult to control and requires intensive monitoring.

Mortality rates in pneumonia with CHD exceed those without CHD, reaching 10% compared to 3.75% in non-CHD cases[11]. Ullah et al. (2024) reported that CHD accounted for approximately 261,247 global deaths in 2017[13]. Most CHD-related deaths (69%) occurred in infants under one year of age. Increased mortality in children with CHD and pneumonia is primarily driven by systemic failure exacerbated by infection, worsening heart failure, and pulmonary hypertension, which further compromises cardiopulmonary function[11].

Patient outcomes were evaluated based on pneumonia incidence and CHD status. Follow-up data from Jat et al. (2022) showed that the majority of CHD patients (60%) continued conservative management, 20% underwent corrective surgery, and 5% died. Long-term outcomes depend heavily on early cardiac intervention and timely pneumonia detection. Appropriate treatment of CHD can prevent severe complications such as progressive pulmonary hypertension and Eisenmenger syndrome[13]. Early prevention and intervention are crucial, as untreated CHD may lead to irreversible pulmonary vascular damage that worsens long-term prognosis.

Clinical implications vary significantly between community-acquired pneumonia (CAP) and nosocomial pneumonia in children with CHD, though they are often analyzed collectively. Acyanotic CHD with left-to-right shunts, such as VSD and ASD, poses a higher risk of recurrent CAP due to chronic pulmonary congestion and edema[1,11]. Conversely, cyanotic CHD is more closely associated with prolonged nosocomial infections and hypoxemia-driven complications. A cross-study synthesis of numerical outcomes reveals that CHD status doubles the mortality risk to 10%, compared to 3.75% in children without heart defects[11]. Furthermore, morbidity is significantly higher in the CHD group, with 95% of patients requiring hospitalization for more than 7 days and 52.73% developing congestive cardiac failure (CCF), compared to only 16.75% in non-CHD cases[11]. These integrated findings demonstrate that the synergy between hemodynamic instability and malnutrition drives the severe clinical outcomes observed, necessitating targeted management

for each pneumonia type and CHD classification[3].

Given the high prevalence and risk, a multidisciplinary approach is strongly recommended to prevent respiratory complications in children with CHD. A key clinical implication is the need for proactive screening. Jat et al. (2022) recommend that all children presenting with pneumonia should be screened for CHD during their first episode. Cardiac evaluation is mandatory in all recurrent pneumonia cases or in children with failure to thrive to identify underlying CHD[1]. These strategies aim to enable early detection and timely cardiac intervention to improve clinical outcomes.

Summary

CHD is a structural heart defect present at birth that disrupts blood flow and cardiac function. Common defects such as VSD, PDA, and ASD cause abnormal left to right shunts and increased hemodynamic load on the lungs[1,3,11,12]. CHD is classified into cyanotic (right to left shunt) and acyanotic (left to right shunt) types, each affecting oxygenation and pulmonary circulation differently. Pneumonia a major cause of under-five mortality occurs more frequently in children with CHD due to impaired hemodynamics and immune function. Studies show CHD prevalence among children with pneumonia ranges from 12.5% to 21.3%, with most affected children being under five and predominantly male. VSD, ASD, and PDA are the most common defects predisposing patients to pneumonia due to pulmonary congestion and chronic heart failure. Children with CHD and pneumonia have higher morbidity, complications, and mortality (up to 10%) than those without CHD. Therefore, multidisciplinary management and early cardiac screening, especially in recurrent pneumonia, are essential to reduce complications and improve outcomes.

Conclusion

Pneumonia and congenital heart disease (CHD) represent major causes of pediatric morbidity and mortality worldwide. Children with CHD, particularly acyanotic types such as VSD, PDA, and ASD, face a higher risk of severe and recurrent pneumonia due to chronic pulmonary overcirculation and congestive cardiac failure (CCF). To improve clinical outcomes, healthcare providers must implement concrete operational steps: first, mandatory cardiac screening using echocardiography is essential for all children with recurrent pneumonia or failure to thrive to detect underlying defects early. Second, clinical monitoring must prioritize the early identification of CCF signs, such as hepatomegaly, feeding difficulties, and excessive sweating, which are present in over 50% of CHD-pneumonia cases. Third, aggressive nutritional management is required since malnutrition increases the risk of recurrence by more than 2.5 times. Finally, a multidisciplinary approach focusing on timely cardiac intervention is crucial to prevent prolonged hospital stays which exceed seven days for 95% of these patients and to reduce a mortality rate that is twice as high as that of children without heart defects.

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