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Nutritional Status in Children with Cyanotic and Acyanotic Congenital Heart Disease: A Systematic Literature Review

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Abstract

Congenital heart disease (CHD) is frequently associated with impaired growth and malnutrition in children. However, whether nutritional status differs consistently between cyanotic and acyanotic CHD remains uncertain. This systematic literature review aimed to evaluate and compare the nutritional status of children with cyanotic and acyanotic CHD. The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework. Literature was identified through PubMed, Google Scholar, and Garuda, focusing on pediatric CHD and nutritional status assessed using standard anthropometric indicators and Z-scores. The included evidence showed a high prevalence of nutritional impairment among children with CHD, but comparative findings were heterogeneous. Several studies reported poorer nutritional outcomes among children with cyanotic CHD, whereas other studies found no significant difference or higher malnutrition prevalence among children with acyanotic CHD. Overall, nutritional status appears to be influenced not only by cyanotic status but also by hemodynamic severity, pulmonary hypertension, heart failure, age, and feeding-related factors. Routine nutritional assessment and early, individualized nutritional support should therefore be integrated into comprehensive pediatric CHD care.

Keywords: *Congenital Heart Disease, Nutritional Status, Cyanotic, Asianotic, Malnutrition*

Abstrak

Penyakit jantung bawaan (PJB) sering berkaitan dengan gangguan pertumbuhan dan malnutrisi pada anak. Namun, apakah status gizi berbeda secara konsisten antara PJB sianotik dan asianotik masih belum jelas. Tinjauan sistematis ini bertujuan mengevaluasi dan membandingkan status gizi anak dengan PJB sianotik dan asianotik. Tinjauan ini dilaporkan sesuai dengan kerangka Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020. Literatur diidentifikasi melalui PubMed, Google Scholar, dan Garuda dengan fokus pada PJB anak dan status gizi yang dinilai menggunakan indikator antropometri serta skor-Z standar. Bukti yang diperoleh menunjukkan prevalensi gangguan status gizi yang tinggi pada anak dengan PJB, tetapi hasil perbandingan antara kelompok sianotik dan asianotik bersifat heterogen. Beberapa penelitian melaporkan luaran gizi yang lebih buruk pada PJB sianotik, sedangkan penelitian lain tidak menemukan perbedaan bermakna atau justru menemukan prevalensi malnutrisi yang lebih tinggi pada PJB asianotik. Secara keseluruhan, status gizi tidak hanya dipengaruhi oleh status sianotik, tetapi juga oleh derajat gangguan hemodinamik, hipertensi pulmonal, gagal jantung, usia, dan faktor terkait pemberian makan. Oleh karena itu, penilaian status gizi secara rutin dan dukungan nutrisi dini yang individual perlu menjadi bagian dari tata laksana komprehensif anak dengan PJB.

Kata Kunci: Penyakit Jantung Bawaan, Status Gizi, Sianotik, Non-sianotik, Malnutrisi

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I. INTRODUCTION

Congenital Heart Disease (CHD) is a structural disorder of the heart and large blood vessels that occurs in the prenatal period due to abnormalities in embryological development that cause real and potential structural dysfunction (Thiene & Fedrigo, 2025). The severity of this disorder varies, ranging from the presence of pyrenees in the cardiac septum (a hole in the septum that separates the atrial and ventricular heart chambers) that can close without intervention to severe congenital abnormalities that require intervention with both catheterization and invasive procedures such as surgery (Singh & Rajaram Tawker, 2022). CHD is the most common form of non-infectious congenital disorder in the prenatal period with incidence rates in developed and developing countries ranging from 6 to 10 cases per 1,000 live births (Amelia et al., 2020). Globally, the incidence rate of CHD is around 9.4 cases per 1,000 live babies worldwide while in Indonesia, the incidence of this disorder is estimated to be around 8 cases per 1,000 live babies (Pertiwi & Berawi, 2024).

The clinical manifestations and hemodynamic impacts of CHD vary widely, but in general, these abnormalities are classified into two main types, cyanotic CHD and acyanotic CHD, which are differentiated based on the presence of pyrotechnics and systemic blood oxygen saturation levels (Yandika et al., 2025). Asiaanotic congenital heart disease includes Ventricular Septal Defect (DSV), Atrial Septal Defect (DSA), Patent Duct Arteriosus (DPA), aortic coarchtasis, and aortic stenosis. Meanwhile, cyanotic CHD includes Tetralogy of Fallot (ToF), Transposition of Great Arteries (TGA), Total Anomalous Pulmonary Venous Connection (TAPVC) (Umboh et al., 2022).

The medical treatment of CHD, both cyanotic and asianotic, often revolves around the correction of cardiac anatomical abnormalities only, while the nutritional status of the patient is an equally crucial parameter to determine the success of treatment results in children with CHD. The high morbidity and mortality rates in the CHD patient group are known to be greatly influenced by a progressive decline in nutritional status (Murni et al., 2023). The phenomenon of chronic malnutrition in children with CHD can occur in the form of underweight, wasting, or stunting. This occurs as a result of chronic energy imbalances triggered by multifactorial combinations such as inadequate food intake due to difficulty consuming food, impaired absorption of nutrients in the digestive tract, and increased metabolic needs (hypermetabolism) to support heavier cardiopulmonary and circulatory compensation work (Pertiwi & Berawi, 2024). This growth disorder is generally more severe in patients with cyanotic CHD due to the presence of chronic tissue hypoxia that interferes with systemic cellular metabolism (Umboh et al., 2022).

A comprehensive evaluation of the nutritional status of children with congenital heart defects is a very important clinical action. Strict monitoring of anthropometric indicators is not just a supportive step, but an essential preventive measure to prevent long-term growth disruptions that are at risk of becoming permanent. Improving and optimizing a child's nutritional status prior to definitive surgery has been clinically proven to reduce the risk of postoperative complications, shorten the length of hospitalization, and improve clinical outcomes and overall quality of life (Murni et al., 2023). By comparatively mapping the impact of cyanotic and asianotic CHD on nutritional status, it is hoped that earlier, more rigorous, and specific nutritional intervention strategies can be integrated into pediatric medical care protocols.

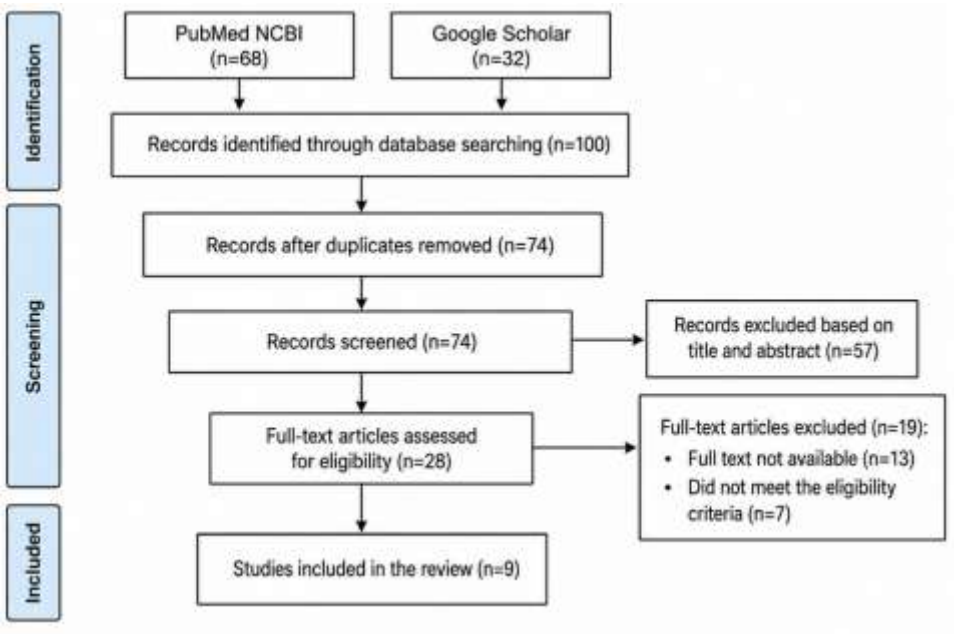
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II. METHODS

This study was designed as a Systematic Literature Review (SLR) to identify, evaluate, and synthesize evidence regarding nutritional status among children with cyanotic and acyanotic congenital heart disease (CHD). The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The search strategy was structured around three concepts: CHD, cyanotic/acyanotic phenotype, and nutritional status. The core Boolean strategy was: ("congenital heart disease" OR "congenital heart defect*" OR CHD) AND (cyanotic OR acyanotic) AND ("nutritional status" OR malnutrition OR undernutrition OR stunting OR wasting OR underweight OR "growth failure" OR anthropometr*). The search was conducted in PubMed, Google Scholar, and Garuda.

Primary observational studies (cross-sectional, cohort, or case-control) involving children aged 0–18 years with confirmed cyanotic or acyanotic CHD were eligible when they reported nutritional status using standard anthropometric indicators or Z-scores (e.g., weight-for-age, height/length-for-age, weight-for-height/length, or BMI-for-age). Studies published in Indonesian or English were considered. Case reports, editorials, studies without accessible full text, and studies in which major non-cardiac congenital disorders were likely to dominate growth failure were excluded. Secondary reviews identified during the search were retained only as contextual references and were not treated as primary observational evidence in the comparative synthesis. Because the available study summaries in the source manuscript did not contain sufficient methodological detail to perform a reproducible formal risk-of-bias appraisal, no formal risk-of-bias score was assigned; this limitation was considered when interpreting the findings. Given the heterogeneity of study populations, CHD lesions, nutritional indicators, and study designs, findings were synthesized narratively rather than pooled quantitatively.



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Figure 1. PRISMA Flow Diagram

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III. RESULT AND DISCUSSION

1. Result

Table 1 Article Data Mapping Results

Author (Year)	Research Design and Location	Sample Characteristics (Number & Age)	Measured Nutritional Parameters	Key Findings
Amelia et al. (2020)	Primary observational; cross-sectional (Medan, Indonesia)	58 children; mean age 57 months	Nutritional status; stunting; wasting	Malnutrition 70.7%; significant association with CHD type (p=0.015); cyanotic group had lower malnutrition risk than acyanotic group.
Sathio et al. (2024)	Primary observational; cross-sectional (Pakistan)	250 children (Age < 5 years)	W/A, H/A, W/H (WHO Z-score)	Malnutrition 79.6%; cyanotic CHD with pulmonary hypertension had particularly severe growth failure.
Pertiwi & Berawi (2024)	Secondary review; contextual evidence (Indonesia)	Review of studies in toddlers	W/A, H/A, W/H	Reports a higher nutritional risk in cyanotic CHD; used as contextual evidence rather than primary comparative evidence.
Zhang et al. (2024)	Systematic Review & Meta-analysis (Global)	13 studies (total number of 8,031 children with CHD, age <18 years)	WHO Growth Standard Z-score (Z < -2)	Pulmonary hypertension, low birth weight, and parental height were associated with growth impairment; pulmonary hypertension OR=3.81.
Agarwal et al. (2025)	Primary observational; cross-sectional (Jaipur, India)	85 children (Ages 1-12, majority 1-5 years)	WAZ, HAZ, WHZ	Underweight 74.1%, stunting 64.7%, wasting 70.6%; cyanotic lesions showed a tendency toward more growth disorders.
Vazzana et al. (2025)	Secondary narrative review; contextual evidence (global)	Literature Review to 2025	WAZ, HAZ, WHZ, BMI, MUAC, skinfold	Reports substantial nutritional impairment across CHD populations, particularly in younger children and those with greater disease burden
Yandika et al. (2025)	Primary observational; retrospective descriptive (Padang, Indonesia)	36 children (Ages 0-18 years, majority <1 year)	WAZ and HAZ	69.4% of the sample was malnourished (47.2% malnourished) and 63.9% had a stunting stature. The group of children with Asianotic PJD was almost half short and the group of children with Cyanotic PJB was half very short.

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Weningtyas et al. (2026)	Observasional Analysis – Cross-sectional (Bogor, Indonesia)	62 children (31 Cyanotic, 31 Asianotic) (Age 0-5 years)	WFL or WHZ (WHO Z-score)	Malnutrition was higher in acyanotic CHD (64.5%) than cyanotic CHD (25.8%); p=0.009.
Nurhakiki et al. (2026)	Primary observational; descriptive-exploratory (Jakarta, Indonesia)	94 children with left-to-right shunts; median age 35 months	WAZ, HAZ, WHZ/BAZ (WHO Z-score)	High malnutrition: 33% wasting and 35.1% stunting, large defect size and pulmonary hypertension are associated with worse nutritional manifestations

2. Discussion

The included evidence demonstrates that nutritional impairment is common among children with CHD. Across the primary studies summarized in this review, reported prevalence varied substantially, including 70.7% malnutrition in the study by Amelia et al. (2020), 79.6% in the study by Sathio et al. (2024), 74.1% underweight, 64.7% stunting, and 70.6% wasting in Agarwal et al. (2025), and 69.4% malnutrition with 63.9% stunting in Yandika et al. (2025). The meta-analysis by Zhang et al. (2024), used as contextual secondary evidence, similarly identified pulmonary hypertension, low birth weight, and parental height as factors associated with growth impairment. These findings support the conclusion that nutritional problems are common in CHD, but they do not establish that cyanotic physiology consistently confers greater nutritional risk.

Comparative findings between cyanotic and acyanotic CHD were heterogeneous. In the study by Sathio et al. (2024), malnutrition and growth failure were particularly pronounced among children with cyanotic CHD accompanied by pulmonary hypertension. Similarly, Agarwal et al. (2025) reported a high prevalence of underweight, stunting, and wasting and observed a tendency toward more growth disorders among cyanotic lesions. These findings are biologically plausible because chronic hypoxemia may increase cardiopulmonary workload and energy requirements, while feeding may be limited by tachypnea, dyspnea, or fatigue. However, these mechanisms should be interpreted as contributing pathways rather than proof that cyanotic status alone determines nutritional outcome.

Conversely, the evidence also demonstrates that acyanotic CHD can be associated with substantial nutritional impairment. Amelia et al. (2020) found a significant association between CHD type and nutritional status (p=0.015), with a lower prevalence of malnutrition among cyanotic patients than among acyanotic patients. Weningtyas et al. (2026) likewise reported significantly higher malnutrition prevalence in the acyanotic group (64.5%) than in the cyanotic group (25.8%; p=0.009). These findings highlight that acyanotic physiology should not be equated with low nutritional risk. Large left-to-right shunts may produce pulmonary overcirculation, increased respiratory work, heart failure, and feeding difficulties, all of which can compromise energy balance. Accordingly, the nutritional consequences of CHD are better understood in relation to hemodynamic burden than to cyanotic classification alone.

The heterogeneity across studies may reflect differences in age, specific cardiac lesions, pulmonary hypertension, heart failure, birth weight, parental stature, feeding practices, socioeconomic factors, and the anthropometric indicators used to define malnutrition. For example, Zhang et al. (2024) identified pulmonary hypertension as an important factor associated with growth retardation, with an odds ratio of 3.81, while Nurhakiki et al. (2026) reported worse nutritional manifestations among children with larger defects and pulmonary hypertension. These findings suggest that disease severity and hemodynamic

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consequences may be more informative determinants of nutritional status than the cyanotic/acyanotic label alone.

Clinically, the high prevalence of nutritional impairment supports routine nutritional assessment as part of comprehensive CHD care. Anthropometric measurements should be monitored longitudinally, and children at nutritional risk should receive individualized dietary assessment and intervention. Screening tools such as STRONGkids or PYMS may be considered where validated for the local pediatric setting, but screening should complement rather than replace direct anthropometric assessment and clinical evaluation. Specific calorie or protein targets should be individualized according to age, nutritional status, cardiac physiology, fluid restriction, and clinical condition rather than applied as a universal prescription. Management of contributory conditions such as heart failure, pulmonary hypertension, anemia, and feeding difficulty should be integrated with nutritional care.

This review has several limitations. First, the included primary studies were heterogeneous in age range, CHD phenotype, disease severity, nutritional indicators, and study design, limiting direct comparison. Second, most primary studies were observational and therefore cannot establish a causal relationship between CHD phenotype and nutritional status. Third, residual confounding from factors such as pulmonary hypertension, heart failure, feeding practices, birth weight, and socioeconomic conditions may have influenced the observed associations. Finally, the review was limited to PubMed, Google Scholar, and Garuda and to English- or Indonesian-language publications, which may have reduced the completeness of the evidence base.

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IV. CONCLUSION

Nutritional impairment is common among children with both cyanotic and acyanotic CHD. However, the available evidence does not demonstrate a consistent difference in nutritional status between the two groups: some studies report poorer outcomes in cyanotic CHD, whereas others report no significant difference or higher malnutrition prevalence in acyanotic CHD. Therefore, cyanotic status should not be considered an isolated determinant of nutritional status. Assessment should also account for hemodynamic severity, pulmonary hypertension, heart failure, age, feeding difficulty, and other clinical and social factors. Routine longitudinal anthropometric monitoring and early individualized nutritional intervention are recommended as components of comprehensive pediatric CHD management. The authors would like to express their deepest gratitude to the academic advisory team for all their guidance, constructive criticism, and valuable suggestions in refining this study. The authors also extend their highest appreciation to the experts and previous researchers whose scholarly works served as the primary literature foundation for this systematic literature review. Last but not least, the authors would like to thank the educational institution and colleagues for the supportive facilities and constructive scholarly discussions they have provided. Finally, the authors extend sincere thanks to their parents and loved ones for their prayers, love, and unceasing moral and material support, which made the successful completion of this research possible.

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