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Original Article

Prevalence and patterns of malnutrition in children with congenital heart disease: a cross-sectional study in a tertiary care hospital.

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Abstract

Background

Malnutrition frequently complicates congenital heart disease (CHD) during early childhood because of increased energy expenditure, feeding difficulty, recurrent respiratory illness, and delayed corrective treatment.

Objectives

To determine the prevalence and patterns of malnutrition among children aged 6 months to 5 years with echocardiographically confirmed CHD and to compare severe malnutrition between cyanotic and acyanotic lesions.

Methods

This hospital-based cross-sectional study included 257 children admitted to a tertiary care pediatric department in North Maharashtra over two years. Demographic and clinical data were recorded, cardiac lesions were classified by echocardiography, and weight, length/height, head circumference, and mid-upper arm circumference were assessed using standard procedures. Nutritional status was classified with World Health Organization and Indian Academy of Pediatrics growth references. Categorical variables were compared using the chi-square test.

Results

The mean age was 2.3 years; 176 children (68.5%) were male. Ventricular septal defect was the predominant lesion, affecting 138 (53.7%) children. Overall malnutrition was identified in 154 (59.9%) participants, including mild-to-moderate malnutrition in 89 (34.6%) and severe malnutrition in 65 (25.3%). Chronic malnutrition was documented in 174 (67.7%) children. Severe malnutrition was substantially more frequent in cyanotic CHD than in acyanotic CHD (60.5% versus 19.2%).

Conclusion

Malnutrition represents a major comorbidity among young children with CHD, with the greatest burden in cyanotic lesions.

Recommendations

Nutritional screening should be integrated into every pediatric cardiology encounter, followed by individualized energy-dense feeding, micronutrient support, close growth surveillance, and timely referral for definitive cardiac intervention.

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Introduction

Congenital heart disease (CHD) comprises structural abnormalities of the heart or great vessels that arise during fetal development and remain among the most frequent congenital disorders worldwide. Reported incidence varies with diagnostic intensity and case definition, although clinically important defects occur in approximately 6-10 per 1,000 live births.[1] In India, the large annual birth cohort, uneven access to pediatric cardiology, and delayed referral create a substantial burden of untreated or late-treated CHD, particularly among infants and preschool children.[2] Improvements in echocardiographic diagnosis and corrective procedures have increased survival, but growth failure continues to influence clinical stability, operative readiness, and long-term development.

Malnutrition in children with CHD has a multifactorial origin. Tachypnea, fatigue during feeding, poor suck-swallow-breathe coordination, early satiety, and recurrent respiratory infections reduce nutrient intake. At the same time, increased myocardial and respiratory work, neurohormonal activation, inflammation, malabsorption, and elevated resting energy expenditure raise nutritional requirements.[3,4] Chronic hypoxemia in cyanotic lesions can further suppress appetite, impair cellular metabolism, and limit linear growth. Infants with pulmonary overcirculation or heart failure often expend considerable energy during feeding while consuming smaller volumes, producing a persistent energy deficit.

The consequences extend beyond low weight. Undernutrition weakens immune function, delays wound healing, reduces respiratory muscle reserve, and is associated

with longer ventilation, infection, prolonged hospitalization, and adverse postoperative outcomes. Indian and international studies have documented marked variation in prevalence because populations differ in age, lesion complexity, timing of diagnosis, socioeconomic context, and anthropometric definitions.[3,5-8] A recent systematic review reported pooled preoperative estimates of approximately one-quarter for underweight, stunting, and wasting, while hospital-based studies from resource-constrained settings often report much higher rates.[8] Meta-analytic evidence also identifies heart failure, pulmonary hypertension, low oxygen saturation, anemia, inadequate dietary intake, and delayed surgery as important correlates of poor nutritional status.[9]

Routine growth assessment is therefore an essential component of pediatric cardiac care rather than an ancillary activity. Current guidance emphasizes repeated anthropometry, early identification of feeding problems, individualized energy and protein targets, and coordinated management by pediatricians, cardiologists, dietitians, nurses, and surgeons.[10] However, regional evidence from North Maharashtra remains limited, and local estimates are needed to support feasible screening and referral pathways. The objective of this study was to determine the prevalence and patterns of malnutrition among children aged 6 months to 5 years with echocardiographically confirmed CHD in a tertiary care hospital. A secondary objective was to describe the distribution of cardiac lesions and compare the frequency of severe malnutrition between cyanotic and acyanotic CHD.

Methodology

Study design

A hospital-based cross-sectional study was conducted in the Department of Pediatrics at SMBT Institute of Medical Sciences & Research Centre, Dhamangaon (Nandi Hills), Nashik District, Maharashtra, India, from May 2023 to May 2025. The study was designed to estimate the prevalence and describe the patterns of malnutrition among children with congenital heart disease (CHD).

Study setting

SMBT Hospital is the teaching hospital attached to SMBT Institute of Medical Sciences & Research Centre and is located at Dhamangaon (Nandi Hills), Taluka Igatpuri, in North Maharashtra. It is a 1,200-bed charitable tertiary-care hospital situated in a hilly and tribal catchment area and functions as a referral centre for surrounding rural, semi-rural, and tribal communities. The hospital provides multidisciplinary outpatient, inpatient, emergency, diagnostic, and specialist referral services. The Department of Pediatrics provides inpatient and outpatient care for infants and children with acute and chronic illnesses, including growth and nutritional assessment, and has access to diagnostic imaging and specialty consultation. For the present study, children with suspected structural heart disease underwent two-dimensional echocardiography with Doppler assessment for confirmation and physiological classification of CHD.

Study participants

Potential participants were children aged 6 months to 5 years admitted to the Department of Pediatrics during the study period. Children were screened consecutively against prespecified eligibility criteria, and eligible participants were enrolled until the required sample size was achieved.

Eligibility criteria - Inclusion criteria

Children were included if they were 6 months to 5 years of age, of either sex, admitted during the study period, and had CHD confirmed by two-dimensional echocardiography with Doppler assessment. Written informed consent from a parent or legally authorised guardian was required before enrolment.

Eligibility criteria - Exclusion criteria

Children were excluded if they had undergone previous corrective or palliative cardiac surgery; had a chromosomal abnormality or major extracardiac congenital malformation; had tuberculosis, human immunodeficiency virus infection, chronic kidney disease, or another serious systemic illness likely to affect growth independently; or required immediate intensive resuscitation at the time scheduled for anthropometric assessment.

Sample size

The sample size was calculated using the single-proportion formula $n = Z^2PQ/d^2$. An anticipated malnutrition prevalence of 60% was used, with Q = 40%, a 95% confidence level, and an absolute precision of 6%, corresponding to 10% of the anticipated prevalence. The calculated value was 256.1 and was rounded to 257 participants.

Data collection and clinical classification

A structured case-record form captured age, sex, socioeconomic details, consanguinity, family history, presenting symptoms, relevant illnesses, and clinical findings. Breathlessness, fatigue during activity or feeding, feeding difficulty, and wheeze were recorded from caregiver history and examination. Cardiac diagnosis was obtained from echocardiographic reports. Lesions were grouped as acyanotic CHD—ventricular septal defect, atrial septal defect, combined ventricular and atrial septal defects, and patent ductus arteriosus—or cyanotic CHD—tetralogy of Fallot, truncus arteriosus, and total anomalous pulmonary venous connection.

Anthropometric assessment and outcome definitions

Weight, recumbent length or standing height, head circumference, and mid-upper arm circumference were measured using standard pediatric anthropometric procedures. Weight-for-age, height-for-age, and weight-for-height indices were interpreted with World Health Organization child-growth standards and age-appropriate Indian Academy of Pediatrics references. Consistent with published CHD nutrition studies, a z score below -2 standard deviations indicated malnutrition.[5,8] Values from -2 to -3 standard deviations were categorized as mild-to-moderate malnutrition, while values below -3 standard deviations denoted severe malnutrition. Chronic malnutrition was defined by height-for-age below -2 standard deviations. The primary outcome was overall malnutrition prevalence; secondary outcomes included severity, chronic malnutrition, lesion distribution, and severe malnutrition by cyanotic status.

Bias and quality-control measures

Several measures were used to reduce potential bias. Consecutive recruitment of eligible children was used to limit investigator-driven selection, and eligibility criteria were defined before enrolment. Diagnostic misclassification was reduced by requiring echocardiographic confirmation of CHD and by applying prespecified cyanotic and acyanotic categories. Information bias was minimized through use of a structured case-record form. Anthropometric measurement bias was addressed by following standard pediatric measurement procedures and interpreting growth indices using established World Health Organization and Indian Academy of Pediatrics references. The same operational definitions for malnutrition severity were applied to all participants. Because the study was conducted among hospitalized children at a tertiary referral centre, referral and spectrum bias could not be eliminated completely; this limitation was considered when interpreting prevalence and generalizability.

Statistical analysis

Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were summarized using mean and standard deviation when available; categorical variables were reported as frequencies and percentages. Prevalence estimates were presented with 95% confidence intervals where appropriate. The chi-square test compared severe malnutrition between cyanotic and acyanotic groups. A two-sided p value below 0.05 was considered statistically significant.

Ethical considerations

The study was conducted after approval by the Institutional Ethics Committee (IEC), SMBT Institute of Medical Sciences & Research Centre, Dhamangaon, Nashik, Maharashtra, India. Written informed consent was obtained from the parent or legally authorised guardian of each child before enrolment. Participation was voluntary, and refusal to participate did not affect clinical care. Confidentiality was maintained by assigning unique study identification codes and limiting access to study records to authorised research personnel. The study procedures were observational and did not alter the clinical management prescribed by the treating pediatric team.

Results

Participant flow

Children aged 6 months to 5 years admitted to the Department of Pediatrics between May 2023 and May 2025 were screened against the prespecified eligibility criteria. The final analytic cohort comprised 257 children with echocardiographically confirmed CHD. The supplied manuscript does not report the total number initially screened or the numerical distribution of pre-enrolment exclusions; these values should be completed from the original screening log before resubmission. No post-enrolment exclusions were reported in the manuscript, and all 257 enrolled participants were included in the final analysis (Figure 1).

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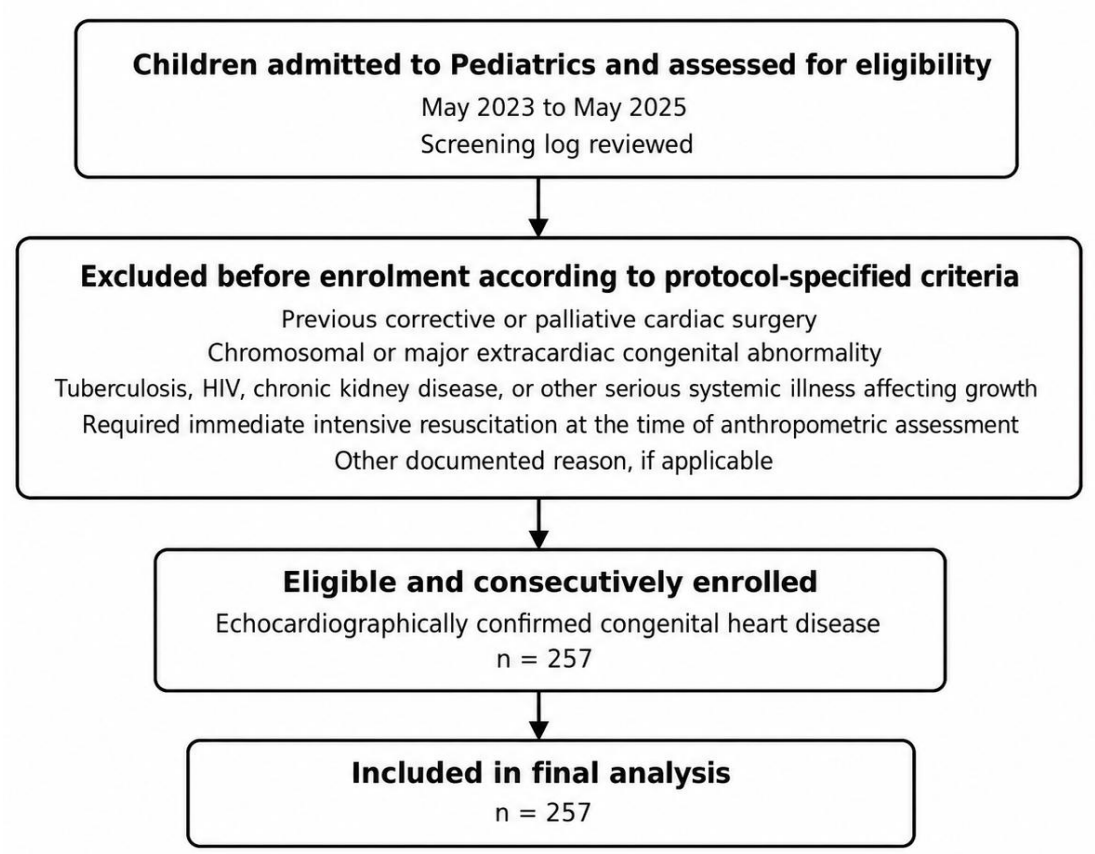

Figure 1. Participant flow through the study

A total of 257 children with echocardiographically confirmed CHD were included in the analysis. The mean age was 2.3 years. Most participants were aged 1-3 years (140, 54.5%), followed by those younger than 1 year (62, 24.1%) and those aged 4-5 years (55, 21.4%). There was a clear male predominance, with 176 boys (68.5%) and 81 girls (31.5%). Breathlessness was the leading presenting symptom, reported in 201 (78.2%) children; fatigue and wheeze were documented in 157 (61.1%) and 120 (46.7%), respectively (Table 1).

Table 1: Demographic and clinical characteristics of the study participants (N = 257)

Characteristic	Category	n	%
Age group	<1 year	62	24.1
	1-3 years	140	54.5
	4-5 years	55	21.4
Sex	Male	176	68.5
	Female	81	31.5
Presenting symptom	Breathlessness	201	78.2
	Fatigue	157	61.1
	Wheeze	120	46.7

Note. Symptoms were not mutually exclusive; therefore, their percentages do not sum to 100%.

Acyanotic CHD accounted for 219 (85.2%) cases, while 38 (14.8%) children had cyanotic CHD. Ventricular septal defect was the most common lesion, affecting 138 (53.7%) participants. Atrial septal defect occurred in 38 (14.8%), combined ventricular and atrial septal defects in 22 (8.6%), and patent ductus arteriosus in 21 (8.2%). Among cyanotic lesions, tetralogy of Fallot was most frequent, followed by truncus arteriosus and total anomalous pulmonary venous connection (Table 2).

Table 2: Distribution of congenital heart disease lesions

CHD category	Specific lesion	n	%
Acyanotic	Ventricular septal defect	138	53.7
	Atrial septal defect	38	14.8
	Ventricular + atrial septal defects	22	8.6
	Patent ductus arteriosus	21	8.2
Cyanotic	Tetralogy of Fallot	22	8.6
	Truncus arteriosus	12	4.7
	Total anomalous pulmonary venous connection	4	1.6

Overall malnutrition was present in 154 children, corresponding to a prevalence of 59.9% (95% confidence interval, 53.9%-65.9%). Mild-to-moderate malnutrition affected 89 (34.6%) children, while 65 (25.3%) had severe malnutrition. The remaining 103 (40.1%) children were classified as nutritionally normal. Height-for-age assessment identified chronic malnutrition in 174 (67.7%) participants (Table 3).

Table 3: Nutritional status of children with congenital heart disease

Nutritional indicator	Category	n	%
Overall nutritional status	Normal	103	40.1
	Mild-to-moderate malnutrition	89	34.6
	Severe malnutrition	65	25.3
	Any malnutrition	154	59.9
Height-for-age pattern	Chronic malnutrition present	174	67.7
	Chronic malnutrition absent	83	32.3

Note. Overall nutritional categories were mutually exclusive. Chronic malnutrition was assessed separately using height-for-age below -2 standard deviations.

The burden of severe malnutrition differed significantly by physiological category. Severe malnutrition was recorded in 23 of 38 children with cyanotic CHD (60.5%) compared with 42 of 219 children with acyanotic CHD (19.2%). The association between cyanotic status and severe malnutrition was statistically significant (chi-square = 29.30, $p < 0.001$) (Table 4).

Table 4: Association between congenital heart disease category and severe malnutrition

CHD category	Severe malnutrition, n (%)	No severe malnutrition, n (%)	Total
Acyanotic CHD	42 (19.2)	177 (80.8)	219
Cyanotic CHD	23 (60.5)	15 (39.5)	38
Total	65 (25.3)	192 (74.7)	257

Note. Pearson chi-square = 29.30; $p < 0.001$. CHD = congenital heart disease.

Discussion

This study identified a substantial nutritional burden among children aged 6 months to 5 years with congenital heart disease. Nearly three in five participants had malnutrition, one-quarter met criteria for severe malnutrition, and more than two-thirds showed chronic growth impairment. Ventricular septal defect was the dominant lesion, reflecting the usual predominance of left-to-right shunt lesions in pediatric cardiac practice. The markedly higher frequency of severe malnutrition in cyanotic CHD indicates that lesion physiology contributes meaningfully to nutritional risk beyond the background effects of poverty, illness, and suboptimal feeding.

The overall prevalence of 59.9% closely resembles the 59% underweight burden reported by Vaidyanathan and colleagues among Indian children presenting for corrective intervention.[3] It is lower than the 90.4% prevalence reported in a Nigerian case-control study and the 92% reported from another Nigerian tertiary center, where delayed presentation, symptomatic disease, and restricted access to definitive treatment were prominent.[5,6] Conversely, the present estimate exceeds the pooled preoperative prevalence reported by Diao et al., who found underweight, stunting, and wasting in roughly one-quarter of children across heterogeneous international studies.[8] Ethiopian data showing underweight in 43.1%, wasting in 38.6%, and stunting in 35.9% further illustrate the influence of case mix, age distribution, and health-system access.[7]

Severe malnutrition was more than threefold as frequent in cyanotic lesions as in acyanotic lesions. Chronic hypoxemia, polycythemia-related hyperviscosity, reduced appetite, recurrent illness, and increased cardiorespiratory work provide biologically plausible explanations. Earlier studies also demonstrated that cyanosis, heart failure, pulmonary hypertension, anemia, and prolonged uncorrected disease are associated with impaired weight gain and linear growth.[4,5,9] The high proportion of chronic malnutrition in this cohort suggests sustained nutritional deprivation rather than a transient response to acute hospitalization. Height-for-age assessment is therefore important because weight alone can underestimate long-standing growth failure.

These findings support nutritional care beginning at diagnosis and continuing through referral, surgery, and follow-up. Repeated anthropometry should trigger assessment of feeding endurance, meal duration, dietary energy density, micronutrient adequacy, respiratory symptoms, heart failure, and oxygen saturation. Perioperative literature links poor nutritional status with longer ventilation, greater morbidity, and less favorable recovery, while structured nutritional support and timely cardiac intervention facilitate catch-up growth.[11-14] Multidisciplinary protocols should combine caregiver counseling, energy-dense feeds, appropriate protein targets, micronutrient correction, and escalation to enteral support when oral intake remains inadequate. Current guideline reviews also emphasize standardized screening and implementation tools, although the evidence base remains uneven.[10]

The magnitude of malnutrition observed in this study should also be interpreted in relation to the recruitment setting. Participants were hospitalized children referred to a tertiary-care centre, which may preferentially capture symptomatic patients, children with delayed diagnosis, and those with more advanced hemodynamic consequences. Consecutive enrolment reduced discretionary selection within the hospital population, but it could not remove referral or spectrum bias. Accordingly, the prevalence estimate is most informative for comparable tertiary pediatric populations rather than for all children with CHD in the community. This setting-related interpretation is important when comparing the present findings with community-based cohorts or centres where definitive cardiac treatment is available earlier.

Generalizability

The findings are most applicable to hospitalized children aged 6 months to 5 years with unoperated CHD who receive care in tertiary hospitals serving resource-constrained populations. The lesion distribution and high nutritional burden are relevant to similar referral centers in India, but

prevalence could differ in community samples, private cardiac programs, regions with earlier diagnosis, or populations with broader surgical access. Multicenter studies using uniform z-score definitions would provide stronger regional estimates and improve external validity.

Conclusion

Malnutrition was highly prevalent among children aged 6 months to 5 years with congenital heart disease in this tertiary care cohort. Nearly 60% had malnutrition, one-fourth had severe nutritional impairment, and chronic growth failure affected more than two-thirds. Cyanotic defects carried a distinctly greater burden of severe malnutrition than acyanotic lesions, supporting the role of hypoxemia and disease severity in impaired growth. Nutritional evaluation should therefore be treated as a core clinical measure from the time of diagnosis. Early feeding support, regular anthropometric monitoring, management of heart failure and infection, and timely definitive cardiac intervention are essential to improve operative readiness, recovery, growth, and developmental outcomes in this vulnerable population.

Limitations

The cross-sectional design prevented assessment of temporal relationships, postoperative catch-up growth, and causal determinants of malnutrition. Recruitment from a single tertiary hospital introduced referral bias and limited representation of children managed in community settings. Dietary intake, feeding duration, micronutrient status, heart-failure severity, pulmonary hypertension, oxygen saturation, socioeconomic gradients, and inflammatory markers were not analyzed. Residual confounding therefore remains relevant when interpreting lesion-specific differences.

Recommendations

All children with congenital heart disease should undergo nutritional screening at diagnosis and at every follow-up visit using weight-for-age, height-for-age, weight-for-height, and mid-upper arm circumference. Children with cyanosis, heart failure, feeding fatigue, recurrent respiratory infection, or declining growth trajectories require early dietitian referral. Management should include caregiver counseling, energy-dense age-appropriate feeds, adequate protein, correction of micronutrient deficiencies, and structured monitoring of tolerance and growth. Hospitals should establish joint pediatric cardiology-nutrition pathways and prioritize timely surgical assessment. Future multicenter prospective studies should evaluate dietary intake, lesion severity, biochemical deficiencies, perioperative outcomes, and post-intervention catch-up growth across diverse Indian health-care settings nationally.

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Abbreviations

ASD, atrial septal defect; CHD, congenital heart disease; CI, confidence interval; IAP, Indian Academy of Pediatrics; MUAC, mid-upper arm circumference; PDA, patent ductus arteriosus; SD, standard deviation; SPSS, Statistical Package for the Social Sciences; TAPVC, total anomalous pulmonary venous connection; TOF, tetralogy of Fallot; VSD, ventricular septal defect; WHO, World Health Organization.

Consent to participate

Written informed consent was obtained from a parent or legally authorized guardian of each participant.

Funding

No external funding was received for this study.

Conflict of interest

The authors declare no conflict of interest.

Data availability

De-identified study data are available from the corresponding author

Author contributions

Dr. Vaibhav Gode: conceptualization, study design, methodology, supervision, project administration, clinical oversight, data interpretation, and critical revision of the manuscript. Dr. Priyanka Halde: participant recruitment, clinical assessment, anthropometric measurements, data collection, data curation, literature review, and preparation of the initial manuscript draft. Both authors contributed to interpretation of the findings, reviewed the manuscript for important intellectual content, approved the final version, and accept responsibility for the integrity and accuracy of the work.

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