

Clinical Profile, Echocardiographic Findings, and Management of Rheumatic Heart Disease in Children: *A Hospital-Based Longitudinal Study in Ethiopia*

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Research Article

Keywords: Rheumatic Heart Disease, Child Health, NCD, Ethiopia

Posted Date: September 9th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10478101/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Rheumatic heart disease (RHD) remains a major cause of morbidity and premature mortality among children and adolescents in low- and middle-income countries. Despite being preventable, it continues to impose a substantial burden on already strained health systems. Early detection, proper management, and secondary prophylaxis are essential for reducing disease progression and preventing complications. However, there is limited data on the clinical profile, echocardiographic characteristics, and management practices of RHD in Ethiopian children, which hinders the development of targeted prevention and treatment strategies. This study aimed to determine the clinical and echocardiographic features of RHD and its management practice.

Methods

A hospital-based prospective observational follow-up study was conducted from June 01, 2023 to May 2024 at the University of Gondar Comprehensive Specialized Hospital and Debre Tabor Comprehensive Specialized Hospital, Ethiopia. All children and adolescents clinically diagnosed with RHD who attended follow-up visits or were admitted for heart failure management were consecutively enrolled. Sociodemographic characteristics, clinical presentation, and management patterns were collected at admission and throughout 12 months follow-up visits by attending pediatricians using paper-based piloted structured questionnaires. Doppler echocardiography was performed by pediatric cardiologists to assess valvular lesions and ventricular function. Descriptive statistics were used for data analysis.

Results

A total of 151 children and adolescents with RHD were enrolled, with a mean $\pm$ SD age of 12 ± 3 years; 54.3% were female. Most participants (69.5%) resided in rural areas, and the majority came from families with low formal educational attainment and socioeconomic status. Polyarthralgia (80.5%) was the most common presenting complaint, and cardiac murmurs were clinically detected in 86.8% of patients. Echocardiography revealed predominantly regurgitant lesions: mitral regurgitation (87.0%), aortic regurgitation (AR) (52.7%), tricuspid regurgitation (TR) (28.2%), and pulmonary regurgitation (PR) (1.8%). Mitral stenosis (MS) was present in 47.0% of patients. Multiple-valve involvement was common, with frequent combinations including MR + AR (42.3%), MR + MS (42.4%), and MR + AR+TR (24.5%). Severe valvular lesions were frequent, particularly severe MR (30.9%) and severe AR 17.3%). Severe MS (mitral valve area [MVA] < 1.0 cm²) occurred in 7.9% of patients. Left ventricular systolic dysfunction (left ventricular ejection fraction [LVEF] $< 40\%$) was documented in 3.6% of patients, while 8.2% had mildly reduced ejection fraction. Nearly half of the patients (45.7%) had advanced functional impairment (Ross class III or IV). Overall, 68.9% of patients received monthly 10-day courses of amoxicillin as secondary prophylaxis, and diuretics were the most frequently prescribed medications.

Conclusion

Children and adolescents with RHD in these settings commonly present with advanced diseases characterized by multiple-valve involvement, predominantly regurgitant lesions, and significant functional impairment. The high prevalence of severe valvular pathology and late-stage presentation, coupled with suboptimal adherence to universally recommended secondary prophylaxis with benzathine penicillin G, underscore the urgent need for strengthened preventive strategies, early echocardiographic screening, and improved access to specialized cardiac care.

1. Introduction

Rheumatic heart disease (RHD) is one of the major causes of childhood morbidity and premature death in developing countries, imposing a significant burden on already constrained health systems. According to the World Health Organization (WHO), RHD is the most common acquired heart disease in children and young adults under 25 years of age, affecting an estimated 55 million people worldwide and claiming approximately 360,000 lives each year, the majority of whom live in low- and middle-income countries (LMICs)(1). Despite being a preventable disease, RHD remains a common childhood problem causing significant mortality and lifelong disability(2).

RHD results from damage to heart valves caused by one or several episodes of rheumatic fever (RF), an autoimmune inflammatory reaction to throat infection caused by group A streptococci (streptococcal pharyngitis) (3). This condition can be prevented or halted by early treatment and regular prophylaxis with benzathine penicillin G (1, 3). Risk factors for streptococcal infection include poverty, malnutrition, overcrowding, poor housing, and shortage of healthcare resources, factors that underscore the high prevalence of RHD in developing countries. Post-rheumatic valvular lesions remain the main cause of morbidity and mortality among children and young adults in these settings (3, 4).

The global burden of RHD is substantial. Up to 1% of school children in Africa, Asia, the Eastern Mediterranean region, and Latin America exhibit signs of RHD. Globally, there are approximately two million individuals with RHD who require frequent hospitalization, and one million who are likely to need cardiac surgery. However, these estimates are based on conservative assumptions, and the actual disease burden is likely much higher(5). Regional disparities are striking: in sub-Saharan Africa, the prevalence of RHD is substantially higher than in North Africa and economically developed countries (6).

In East Africa, studies have reported considerable prevalence of RHD among school children. In Ethiopia specifically, meta-analyses have indicated a substantial disease burden, with pooled prevalence estimates ranging from approximately 2% to 3% (6–8). A historical study conducted at Ethio-Swedish Children's Hospital between 1981 and 1988 found that mitral valve involvement occurred in a significant proportion of pediatric RHD cases, with isolated mitral stenosis (MS) observed in a smaller subset of patients(9).

International studies have documented varying patterns of valvular involvement in RHD. A community-based study conducted in Yemen between 1999 and 2003, which included participants across a wide age range with children constituting approximately one-third of the study population, found that isolated mitral valve lesions were the most common presentation, followed by mixed valve lesions, while isolated aortic valve lesions were less frequent. Gender-specific patterns showed that mitral regurgitation (MR) and MS affected both males and females at comparable rates, while aortic regurgitation (AR) showed some gender variation, and aortic stenosis was relatively uncommon in both groups (10).

Effective control of RHD relies predominantly on primary and secondary prevention strategies, which constitute the most reliable and cost-effective approaches for reducing associated morbidity and mortality. Primary prevention involves prompt diagnosis and treatment of streptococcal pharyngitis to prevent initial episodes of RF. Secondary prevention consists of long-term antibiotic prophylaxis with benzathine penicillin G to prevent recurrent RF episodes and progression of valvular damage in individuals with a history of RF or established RHD (1, 3)

Despite global recognition of the importance of prevention and early detection, there is limited data on the clinical profile, echocardiographic characteristics, and management practices of RHD in Ethiopian children and adolescents. Understanding the patterns and severity of valvular involvement, clinical presentation, and current treatment practices is essential for developing targeted prevention strategies, improving early detection programs, and optimizing clinical care in resource-limited settings. Therefore, the objective of this study was to determine the clinical and echocardiographic features of RHD and its management practice in children and adolescents attending the University of Gondar Comprehensive Specialized Hospital (UGCSH) and Debre Tabor Comprehensive Specialized Hospital, Ethiopia (DTCSH).

2. Method

Study Design and Setting

A hospital-based prospective observational follow-up study was conducted at the UGCSH and DTCSH, Ethiopia, from June 01, 2023 to May 2024. The hospitals serve as a major referral center for Northwest Ethiopia.

Study Population

All children and adolescents diagnosed with RHD who attended the pediatric cardiology follow-up clinics or were admitted for heart failure management during the study period were eligible for inclusion.

Sample Size Determination and Sampling

The sample size was calculated using a single population proportion formula with the following assumptions: a 95% confidence level ($Z = 1.96$), an expected prevalence (p) of 55.1% based on a study conducted in Yemen in 2007, and a margin of error (d) of 0.05.

$$n_0 = \frac{(1.96)^2 \times 0.551 \times 0.449}{(0.05)^2}$$

$$n_0 = \frac{3.8416 \times 0.551 \times 0.449}{0.0025}$$

$$n_0 = \frac{0.951}{0.0025} \approx 380.4$$

The initial calculated sample size was subsequently adjusted using the finite population correction (FPC) to account for the small and known number of eligible patients in the sampling frame. After incorporating a 10% allowance for non-response, the final required sample size was 145. Participants were recruited consecutively using a convenience sampling technique as they presented to the follow-up clinic or pediatric wards during the study period.

Data Collection

A structured, pre-tested questionnaire was used to collect sociodemographic and clinical data. Except for the echocardiographic data collection tool, which was adapted from other studies, all other questionnaires were developed specifically for this study based on a review of the relevant literature.(11) Clinical data, including detailed medical history and physical examination findings, were obtained by attending pediatricians. Data were collected at baseline and subsequently at monthly follow-up visits for 12 months, yielding a total of 12 assessment points for each participant. Transthoracic Doppler echocardiography was performed by pediatric cardiologists to evaluate valvular morphology, characterize the type and severity of valvular lesions, and assess ventricular function.

Data Analysis Approach

This study utilized descriptive statistics (means, standard deviations, frequencies, and percentages) to analyze the data. Although inferential statistical methods were considered, the limited sample size and number of dependent variables were insufficient to support robust inferential analyses. Consequently, findings are descriptive in nature and limited to the study sample.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the University of Gondar. Permission to conduct the study was subsequently secured from the University of Gondar Comprehensive Specialized Hospital administration. Written informed consent was obtained from the

parents or legal guardians of all participating children, while written assent was obtained from children aged 7 years and older before enrollment, in accordance with ethical guidelines. Participants' privacy and confidentiality were strictly maintained throughout the study by using anonymize data and restricting access to study information to authorized personnel only.

The study involved non-invasive clinical assessments and did not require the collection of biological specimens or expose participants to additional risks beyond routine clinical care. All study procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

3. Result

3.1 Sociodemographic and Clinical Characteristics

Among 151 enrolled children with RHD 45.7% were males, and 69.5% lived in rural areas. The mean $\pm$ SD age was 12 ± 3 years. Approximately 41.1% lived in families with more than 5 members, while 43.1% lived in families with 3 to 5 members. The majority of mothers had low educational attainment, with 66.9% unable to read or write, and 66.8% were housewives. Nearly half of fathers (48.3%) were also unable to read or write. Most children (90.7%) attended elementary school (Table 1).

Table 1
Demographic findings of their parents and children with RHD (N = 151)

Demography	N (%)
Mother	
<i>Married</i>	116(76.8)
<i>Divorced</i>	18(11.9)
<i>Widowed</i>	7(4.6)
<i>Died</i>	4(2.7)
<i>Not married</i>	6(4.0)
Maternal Occupation	
<i>House wife</i>	105(69.5)
<i>Employed</i>	11(7.3)
<i>Daily laborer</i>	6(4.0)
<i>Farmer</i>	23(15.2)
<i>Merchant</i>	6(4.0)
Sex	
<i>Male</i>	69(45.7)
<i>Female</i>	82(54.3)
Residential area	
<i>Urban</i>	46(30.5)
<i>Rural</i>	105(69.5)
Maternal education	
<i>unable to read and write</i>	101(66.9)
<i>able to read and write</i>	12(7.9)
<i>primary education 1–8</i>	18(11.9)
<i>secondary education 9–12</i>	14(9.3)
<i>tertiary above 12</i>	4(2.7)
Paternal education	
<i>unable to read and write</i>	73(48.3)

Demography	N (%)
<i>able to read and write</i>	27(17.9)
<i>primary education 1–8</i>	29(19.2)
<i>secondary education 9–12</i>	13(8.6)
<i>tertiary above 12</i>	9(6.0)
Educational status of child	
<i>Can't read and write</i>	14(9.3)
<i>Elementary school 1–8</i>	137(90.7)
Family size	
<i>Less than or equal to 3</i>	24(15.9)
<i>Less than or equal to 5</i>	65(43.0)
<i>Above 5</i>	62(41.0)
Duration of illness before seeking medical advice	
<i>Less than or equal to 6 month</i>	53(35.1)
<i>Greater than 6 month</i>	98(64.9)

Polyarthralgia was the most frequent presenting symptom (80.5%), followed by palpitations, edema (19.2%), dyspnea (18.6%), and cough (11.4%). On physical examination, a murmur was detected in 86.8% of cases, shifted apical impulse in 54.3%, hyperactive precordium in 37.8%, bulging of the precordium in 28.4%, and accentuated P2 in 10.5%. Nearly half of the children presented with advanced functional limitation (Ross class III or IV), while 37.7% were in Ross class I (Table 2).

Table 2
Clinical findings at initial presentation of
children with RHD (N = 151)

Clinical Feature	n (%)
Murmur	
Yes	131(86.8%)
No	20(13.2%)
Precordium	
<i>Quite</i>	23(15.2%)
<i>Active</i>	71(47.0%)
<i>Hyperactive</i>	57(37.7%)
Bulged precordium	
Yes	40(28.4%)
No	111(71.6%)
Shifted apical impulse	
Yes	82(54.3%)
No	69(45.7%)
Accentuated P2	
Yes	14(10.5)
No	134(89.6)
<i>Ross Classification</i>	
<i>Class I</i>	57(37.7%)
<i>Class II</i>	25(16.6%)
<i>Class III</i>	40(26.5%)
<i>Class IV</i>	29(19.2%)

3.2 Echocardiographic Findings

Valvular Involvement Pattern

Regurgitant lesions predominated, with mitral valve lesions 100 (87.0%) and aortic regurgitation (AR) 60 (52.7%) being the most common. Mitral stenosis (MS) was present in 54(47.0%) of patients. Isolated MR was the most common single-valve lesion, occurring in 27.3% of patients, whereas combined MR, AR, and TR involvement was identified in 24.5% of cases. (Table 3).

Table 3
Pattern and severity of valvular lesions,
ventricular function in children with RHD based
on echocardiography (N = 151)

Echocardiographic Findings	Frequency (%)
Valvular Involvement Pattern	
MR	100(87.0%)
AR	60(52.7%)
TR	31(28.2%)
PR	2(1.8%)
Isolated AR	3(2.7%)
Isolated MR	30(27.3%)
Isolated MR & MS	5(4.0%)
MR, AR & TR	27(24.5%)
MS	54(47.0%)
MR and AR	52(42.3%)
Severity of Valvular Lesions	
Severe MR	34(30.9%)
Severe AR	19(17.3%)
Severe TR	12(10.9%)
Severe MS	12(10.4%)
Severe MR + AR + TR	45 (40.9%)
Ventricular Function	
LVEF	
Normal (55–65%)	91(82.7%)
HFpEF ($\geq 50\%$)	6(5.5%)
HFmrEF (41–49%)	9(8.2%)
HFrEF($\leq 40\%$)	4(3.6%)
Fractional Shortening (FS)	
Normal (28–42%)	92(83.6%)
Reduced ($< 28\%$)	18(16.4%)

Severity of Valvular Lesions

Severe forms of valvular lesions were commonly observed across all valve types. Severe MR was most prevalent (30.9%), followed by severe AR (17.3%), severe TR (10.9%), and severe MS (10.4%) (Table 3). The mean mitral valve area was 5.2 ± 4.4 cm². Among patients with mitral stenosis, 40.2% had normal valve area, while 7.9% had severe stenosis (MVA < 1 cm²).

Ventricular Function

Left ventricular systolic dysfunction was uncommon but clinically significant. The majority (82.7%) had normal left ventricular ejection fraction (55–65%). However, 3.6% had heart failure with reduced ejection fraction (LVEF ≤ 40%), and 16.4% had fractional shortening below 28% (Table 3).

3.3 Treatment and Prophylaxis

The majority of children (68.9%) were receiving monthly oral amoxicillin for secondary prophylaxis, while 31.1% received benzathine penicillin G. Diuretics were the most commonly prescribed medications (78.6%), either alone or in combination with other agents. ACE inhibitors were used in combination with diuretics in 9.4% of cases (Table 4). Over the 12-month follow-up period, only 2.6% patients on monthly amoxicillin prophylaxis had a recurrence of rheumatic fever.

Table 4
Pattern of treatment and prophylaxis in children with RHD

Medical Management	Frequency (%)
Secondary Prophylaxis (N = 151)	
<i>Amoxicillin</i>	104(68.8%)
<i>Penicillin G</i>	47(31.1%)
Medical Treatment(N = 106)	
<i>Diuretic</i>	78(78.6%)
<i>Diuretics and ACE Inhibitor</i>	10(9.4%)
<i>ACE inhibitor</i>	2(1.9%)
<i>Diuretics, ACEI with Dioxin</i>	4(3.8%)
<i>Phenobarbitone</i>	10(9.4%)
<i>B-blocker</i>	1(0.9%)
<i>B-blocker with Lasix</i>	1(0.9%)

4. Discussion

The objective of this study was to characterize the clinical presentation, echocardiographic findings, and disease severity in children diagnosed with RHD at a tertiary referral center. The major findings reveal that pediatric RHD in this population is characterized by advanced diseases at presentation, with extensive multivalvular involvement (isolated lesions were seen in 27.3% of cases), severe regurgitant lesions in 40.9% patients, and significant functional impairment (45.7% in Ross class III or IV).

Polyarthralgia emerged as the predominant presenting complaint at the time of RHD diagnosis, reported in 80.5% of cases. This high frequency reflects the inflammatory nature of acute rheumatic fever and may indicate that many children are initially diagnosed during or shortly after an acute episode. Other symptoms were notably less frequent: palpitations (22.7%), edema (19.2%), dyspnea (18.6%), and cough (11.4%). With the exception of polyarthralgia, the proportion of patients presenting with cardiac symptoms in our study was lower than that reported in multiple regional and international studies (6, 12). This discrepancy may reflect several factors, including differences in disease acuity at presentation and variations in health-seeking behavior among families. The lower frequency of heart failure symptoms could also suggest that symptomatic cardiac decompensation had not yet developed in the majority of patients at initial presentation.

The echocardiographic findings revealed a pattern of extensive and complex valvular pathology. The predominant lesions identified were mitral regurgitation (87.0%), aortic regurgitation (52.7%), and tricuspid regurgitation (28.2%). The high prevalence of mitral and aortic valve involvement, as well as the greater disease burden among females, align with findings from other regional and international studies (12–14). Importantly, the overall magnitude and proportion of valvular involvement in our cohort exceeded those reported in a retrospective study from Saudi Arabia (10, 15, 16). This difference may be attributable to variations in study populations, as the Saudi study focused exclusively on patients with acute rheumatic fever rather than established RHD, likely capturing an earlier stage of disease with less cumulative valvular damage.

A particularly striking finding was the high prevalence of multivalvular involvement and severe regurgitant lesions, consistent with observations from Sudan (17). Combined lesions were prominent, including MR with AR (42.3%), MR with MS (42.4%), and the triad of MR, AR, and TR (24.5%). The overall burden and complexity of valvular pathology were greater than those documented in studies from Yemen, which included both children and adults (10), and Nigeria (18). These discrepancies likely reflect variations in study design, patient age distribution, healthcare infrastructure, and the stage of disease at which patients enter clinical care.

The mean mitral valve area (MVA) in this study was $5.2 \pm 4.4 \text{ cm}^2$ with 7.9% of patients demonstrating severe mitral stenosis ($\text{MVA} < 1.0 \text{ cm}^2$). These findings are consistent with reports from Yemen and Hiwot Fana Specialized Hospital in Ethiopia, which demonstrated comparable distributions of mitral valve narrowing (10, 19). The presence of severe stenosis in a notable minority of children highlights the chronicity and progressive nature of the disease in some patients, suggesting that delayed or missed opportunities for earlier intervention may have occurred.

Overall, 40.9% of children in the present study exhibited severe valvular lesions, a proportion similar to findings from Cameroon and Sudan (17, 20). This concordance with regional data suggests a shared pattern of delayed presentation and advanced disease at diagnosis across sub-Saharan Africa, likely reflecting common systemic barriers including limited healthcare access, inadequate early detection systems, poor adherence to secondary prophylaxis, and insufficient community awareness of rheumatic fever and its sequelae.

Functional impairment was substantial: 45.7% of pediatric patients were classified as Ross class III or IV, indicating moderate to severe limitation in daily activities, while 37.7% were in class I. These findings are comparable to studies conducted in Egypt and Sudan (17, 21) but represent a higher burden of functional impairment than reported in studies from SPHMMC, Ethiopia, and The Gambia (13, 22). The discrepancy with the Gambian study may be partially explained by differences in study populations, as the Gambian cohort included both children and adults, potentially diluting the pediatric-specific disease severity profile.

Left ventricular systolic dysfunction was present but relatively uncommon. Nearly four percent of children had heart failure with reduced ejection fraction (HF_rEF; LVEF < 40%), and 8.2% had mildly reduced ejection fraction (HF_{mr}EF; LVEF 41–49%), findings consistent with a study from Sudan (17). While the majority of children maintained preserved systolic function, the presence of severe valvular regurgitation and stenosis in the absence of reduced ejection fraction suggests that many are in a compensated state that may deteriorate over time without surgical intervention.

The high proportion of children presenting with severe, multivalvular disease and advanced functional impairment underscores critical gaps in the continuum of care for RHD prevention and management. These findings highlight delayed diagnosis, suboptimal implementation of primary and secondary prevention strategies, and limited access to timely echocardiographic evaluation. From a public health perspective, our results reinforce the urgent need for strengthened primary prevention through improved access to healthcare for streptococcal pharyngitis, community education on the importance of treating sore throats, and environmental improvements in overcrowded living conditions. Enhanced adherence to secondary prophylaxis with benzathine penicillin G or oral antibiotics, supported by patient education, reminder systems, and community health worker engagement, is essential. Expansion of echocardiographic screening programs, particularly in high-risk populations and regions with known RHD endemicity, would enable earlier detection and intervention before irreversible valvular damage occurs. Finally, integration of RHD care into existing maternal and child health platforms could improve longitudinal follow-up and multidisciplinary management.

While inferential statistical techniques were initially considered for this analysis, they were ultimately not implemented due to methodological constraints. Specifically, the sample size (N = 151) was insufficient to meet the assumptions and power requirements necessary for robust inferential testing. Additionally, the limited number of dependent variables, RF recurrence, examined did not provide adequate scope for meaningful multivariable or longitudinal inferential analysis. Therefore, the findings presented are based

solely on descriptive statistics and should be interpreted as exploratory observations of the study sample rather than generalizable inferences to a broader population. Further limitations include the reliance on clinical records, which may be subject to incomplete documentation. Prospective, multi-center studies with larger sample sizes are needed to confirm these findings and explore predictors of disease progression and treatment outcomes.

5. Conclusion and Recommendation

Children and adolescents with RHD in Gondar and Debre Tabor commonly present with advanced disease characterized by multiple-valve involvement, predominantly regurgitant lesions, and significant functional impairment. The high prevalence of severe valvular pathology and late-stage presentation, coupled with suboptimal adherence to universally recommended secondary prophylaxis with benzathine penicillin G, underscores the urgent need for strengthened preventive strategies, early echocardiographic screening, and improved access to specialized cardiac care.

Addressing these gaps through integrated interventions is essential to reducing the burden of RHD in resource-limited settings. Further multi-center studies are recommended to evaluate barriers to prophylaxis adherence and assess the effectiveness of comprehensive prevention and treatment strategies in the Ethiopian context.

Abbreviations

ACE Angiotensin-Converting Enzyme

ACEI Angiotensin-Converting Enzyme Inhibitor

AR Aortic Regurgitation

ANOVA Analysis of Variance

cm² Square Centimeters

DTCSH Debre Tabor Comprehensive Specialized Hospital

FS Fractional Shortening

GAS Group A Streptococcus

HFmrEF Heart Failure with Mildly Reduced Ejection Fraction

HFpEF Heart Failure with Preserved Ejection Fraction

HFrfEF Heart Failure with Reduced Ejection Fraction

LVEF Left Ventricular Ejection Fraction

MR Mitral Regurgitation

MS Mitral Stenosis

MVA Mitral Valve Area

P2 Pulmonic Component of Second Heart Sound

PR Pulmonary Regurgitation

RHD Rheumatic Heart Disease

SPHMMC St. Paul's Hospital Millennium Medical College

TR Tricuspid Regurgitation

UGCSH University of Gondar Comprehensive Specialized Hospital

Declarations

Declaration of AI use

Claude 4.5 Sonnet (Anthropic) was used for language editing and improving manuscript readability. The authors retain full responsibility for all content and scientific integrity.

Declaration of competing interests

None

Clinical trial registration number

not applicable. This study was a hospital based observational study and was not a clinical trial requiring trial registration.

Funding

This work was supported by the University of Gondar, Mega Research Projects.

Author Contribution

Z.T. conceptualized and designed the study, interpreted the findings, contributed to the study design, supervised data collection, critically revised the manuscript, provided overall supervision and interpreted the echocardiographic findings. Y.H. performed the statistical analysis, interpreted the findings, and

drafted the original manuscript. contributed to data interpretation, critically reviewed the manuscript, and approved the final version. H.T. supervised data collection, reviewed and edited the manuscript, and approved the final version. A.T. supervised data collection, reviewed and edited the manuscript, and approved the final version. W.B supervised the project, reviewed and edited the manuscript, and approved the final version. T.A. interpreted the findings, contributed to the study design, supervised data collection, reviewed and edited the manuscript, and approved the final version. K.A. supervised data collection, reviewed and edited the manuscript, and approved the final version. A.SH. supervised data collection, reviewed and edited the manuscript, and approved the final version. A.T. conceptualized and designed the study, interpreted the findings, contributed to the study design, supervised data collection, critically revised the manuscript, and provided overall supervision. AA. All authors read and approved the final manuscript.

Acknowledgement

We would like to thank the University of Gondar for providing financial support for the data collection phase of this research.

Data Availability

The author confirms that all data generated or analysed during this study are included in this published article

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