Original Article

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Prevalence and factors associated with rheumatic heart disease among school-going children in Dhanusha district, southern Nepal: a cross-sectional echocardiographic screening study

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Abstract

Background and Aims: Rheumatic heart disease remains a leading preventable cause of cardiovascular morbidity and mortality in low-income countries, yet echocardiographic data from Nepal are scarce. We estimated echocardiographic rheumatic heart disease prevalence and associated factors among school-going children in Dhanusha district, southern Nepal.

Methods: A cross-sectional study was conducted across eight public schools in eight selected local levels of Dhanusha district between May 2023 and December 2024. Assenting school-going children aged 6–16 years underwent blinded cardiac auscultation and portable echocardiography by one cardiologist using 2012 World Heart Federation criteria; screen-positive or suspicious studies were re-read by a second blinded cardiologist, with third-cardiologist confirmation of disagreements. Mixed-effects logistic regression assessed associated factors.

Results: Out of 4,970 students, 4,536 eligible school-going children were screened. Eighty-five had rheumatic heart disease (18.7 per 1,000; 95% confidence interval 15.1–23.0): 54 borderline and 31 definite. Prevalence was higher in girls than boys (23.3 versus 13.6 per 1,000; p=0.02), peaking at 26.0 per 1,000 among girls aged 10–14 years. Fifty-five cases (64.7%) had no audible murmur (auscultation sensitivity 35.3%). Female sex was positively associated with rheumatic heart disease (adjusted odds ratio 1.62; 95% confidence interval 1.03–2.57), although this association was not significant when restricted to definite disease alone, whereas self-reported symptom history did not help identify affected children.

Conclusion: Rheumatic heart disease affected 18.7 per 1,000 school-going children in eight sampled public schools of Dhanusha district; most cases were silent and more common in girls. Echocardiographic screening may aid early detection, and this burden supports local secondary prophylaxis alongside longitudinal evaluation.

Keywords: Echocardiographic Screening; Nepal; Rheumatic Heart Disease; School-Going Children

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Introduction

Rheumatic heart disease (RHD) is the most common acquired heart disease among children and young adults in low- and middle-income countries, arising as an autoimmune sequel of group A streptococcal pharyngitis through episodes of acute rheumatic fever and progressive valvular damage.[1,2] Global Burden of Disease estimated 33.4 million people living with RHD and approximately 319,400 deaths each year, concentrated in South and Southeast Asia, sub-Saharan Africa, and Oceania.[3] Nepal has recognised RHD as a public health problem for decades, yet reliable echocardiographic prevalence data remain limited.[4]

Auscultation-based surveillance misses subclinical disease: echocardiographic screening detects five- to eight-fold more cases than clinical examination,[5,6] and auscultation sensitivity rarely exceeds 20–30%.[7] The 2012 World Heart Federation (WHF) echocardiographic criteria define borderline and definite disease, enabling treatment before irreversible valve damage occurs.[8] In Nepal, the only published school-based echocardiographic prevalence survey, conducted in Sunsari district, reported a prevalence of 10.2 per 1,000,[9] whereas auscultation-based surveys from the Kathmandu Valley, hilly districts, and central Nepal reported 0.9–7.2 per 1,000.[10–12] Dhanusha district, a densely populated and socioeconomically disadvantaged Terai district, has never been surveyed echocardiographically, and no Nepalese study has quantified between-school variation in RHD risk.

We conducted an echocardiographic screening study among school-going children attending eight sampled public schools in Dhanusha district with three objectives: to determine the prevalence of borderline and definite RHD using WHF 2012 criteria; to identify individual-level factors associated with RHD; and to estimate the between-school variance component relevant to the design of future surveillance studies.

Methods

Study type and design

A school-based cross-sectional screening study was conducted and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[13]

Place and duration of study

Field screening and data collection were carried out between May 2023 and December 2024 in eight public schools, one in each of eight selected local levels (municipalities) of Dhanusha district, Madhesh Province, in the southern Terai region of Nepal. Because the sample was large, each school required about five consecutive school days to complete; each school was screened once, schools were visited sequentially with one school completed before the next began, and the team travelled to the district several times. School closures for festivals (Dashain, Tihar, Chhath), examinations, and summer and monsoon holidays spread the overall screening period over approximately 20 months and across different seasons. The same team, portable ultrasound system, and diagnostic criteria remained unchanged throughout the screening period.

Sample size and sampling method

Dhanusha district comprises 18 local levels (one sub-metropolitan city, 11 municipalities, and six rural municipalities); eight local levels were selected purposively to include different parts of the district and both urban and rural settings, and in each selected local level one public school teaching up to grade 10 was selected at random. All students on the rolls of the selected schools were invited (whole-school census). Of the 4,970 students enrolled, 434 were outside the eligible 6–16-year age range and all 4,536 eligible school-going children were enrolled and screened (Figure 1). Because local levels were selected purposively and private-school attendees and out-of-school children were not included, the estimates refer strictly to school-going children attending the eight sampled public schools rather than all children in Dhanusha district or Nepal. The final sample provided a precision of ±3.9 per 1,000 school-going children (half-width of the 95% confidence interval) for the overall prevalence estimate.

Methods of data collection

A trained research coordinator administered a pre-tested clinical-history questionnaire (available from the corresponding author) recording age, sex, household socioeconomic indicators, and 12-month self-reported symptom history (sore throat with fever, joint pain with fever, and involuntary jerky movements of the upper and lower extremities). A cardiologist performed and recorded cardiac auscultation before echocardiography, remaining unaware of echocardiographic results. Each school-going child was then scanned on-site by one experienced cardiologist (rather than two independent on-site examiners) using complete transthoracic echocardiography on a portable ultrasound system (M-Turbo, SonoSite, Inc., USA; 2.0–5.0 MHz phased-array transducer), regardless of auscultatory findings. Before fieldwork, participating cardiologists held a joint protocol review covering machine settings, standard views, and WHF 2012 diagnostic rules, without formal pre-study inter-observer kappa testing. Studies were classified using WHF 2012 criteria as normal, borderline RHD, or definite RHD.[8] All screen-positive or suspicious studies (every borderline, definite, or indeterminate scan) were digitally recorded and independently re-read by a second blinded senior cardiologist, whereas normal studies were not recorded or re-read; any diagnostic disagreement between the two readers was resolved by an independent third senior cardiologist. The 2012 WHF criteria were applied because the 2023 WHF guidelines were published after fieldwork began.

Ethical approval and patient consent

The protocol was approved by the Nepal Health Research Council (Protocol Registration No. 155/2023; approval date 13 April 2023) and was conducted in accordance with the Declaration of Helsinki and the NHRC National Ethical Guidelines for Health Research (2022). A written information notice was sent home with each school-going child one week before screening, and

study personnel explained the study in person to guardians on the screening day. Written informed consent was then obtained from all parents or legal guardians; for illiterate caregivers, thumbprint consent witnessed by an independent third party was accepted. Assent was obtained from school-going children aged 7 years or older (verbal assent at 7–11 years and written assent at 12–16 years); those aged 6 years were enrolled with parental consent, in line with the NHRC National Ethical Guidelines (2022).

Inclusion and exclusion criteria

School-going children aged 6–16 years enrolled in the selected public schools whose parents or legal guardians provided written informed consent were included. Students outside this age range, those without verified parental consent, and those with a previously documented history of congenital heart disease that could confound structural echocardiographic assessment were excluded.

Protocols followed

All school-going children with borderline or definite RHD were referred for secondary prophylaxis with benzathine penicillin G and annual echocardiographic reassessment at the Shahid Gangalal National Heart Centre branch hospital, Janakpur (currently Department of Cardiology, Madhesh Provincial Hospital), where care was provided free of cost. Follow-up of referred school-going children is was documented in a separate clinical programme and is not part of this analysis.

Statistical analysis

Categorical variables were summarised as frequencies and percentages and compared using chi-square or Fisher's exact tests; continuous variables were compared using Wilcoxon rank-sum or Student's t tests. Prevalence was expressed per 1,000 school-going children with exact binomial 95% confidence intervals (CIs). Associated factors were assessed across all 4,536 participants using mixed-effects logistic regression with a school-level random intercept and fixed effects for age, sex, and self-reported symptom history, reported as adjusted odds ratios (AORs) with 95% CIs. The random intercept accounted for within-school clustering rather than estimating individual school effects; self-reported symptom history served as an adjustment variable rather than a causal risk factor, and the unadjusted odds ratio for sex is also reported. Pre-specified sensitivity analyses added a quadratic age term, substituted categorical age groups, and restricted the outcome to definite RHD. Between-school variance and its likelihood-ratio test are shown in Supplementary Table S3. Analyses used Stata version 18 (StataCorp, College Station, TX, USA), with two-tailed $P<0.05$ considered statistically significant.

Results

Of the 4,970 students invited, 434 were outside the 6–16-year age range and were not eligible, and all 4,536 eligible school-going children (91.3% of school rolls) completed the questionnaire, cardiac auscultation, and echocardiographic assessment (Figure 1). The median age of enrolled school-going children was 13 years (interquartile range 10–15), 2,402 (53.0%) were girls (and 2,134 [47.0%] were boys), and 3,864 (85.2%) resided in rural areas; the largest ethnic groups were Dalit (15.2%), Muslim (11.8%), Yadav (11.0%), and Janajati (10.7%). The baseline characteristics of the cohort are presented in Table 1.

Eighty-five school-going children (56 girls [65.9%] and 29 boys [34.1%]) met WHF 2012 criteria for RHD, yielding an overall prevalence of 18.7 per 1,000 (95% CI 15.1–23.0), comprising 54 borderline (11.9 per 1,000; 95% CI 9.0–15.5) and 31 definite (6.8 per 1,000; 95% CI 4.7–9.7) cases (Table 2). Prevalence was higher in girls (56/2,402; 23.3 per 1,000; 95% CI 17.8–30.1) than in boys (29/2,134; 13.6 per 1,000; 95% CI 9.3–19.4; P=0.02). By sex and age group (Figure 2), prevalence among girls rose from 16.7 per 1,000 (7/418) at 6–9 years to a peak of 26.0 per 1,000 (37/1,421) at 10–14 years before declining to 21.3 per 1,000 (12/563) at 15–16 years, whereas among boys the corresponding values were 14.8 (4/270), 10.4 (12/1,159), and 18.4 (13/705) per 1,000. Fifty-five of 85 cases (64.7%) had no audible murmur, and the sensitivity of cardiac auscultation for WHF 2012-confirmed RHD was 35.3% (30/85) (Table 2). Valve involvement was isolated to the mitral valve in 76 of 85 cases (89.4%), isolated to the aortic valve in 8 (9.4%), and combined mitral and aortic in 1 (1.2%) (Table 2). Echocardiographic findings included pathological mitral regurgitation in 76 cases (89.4%), anterior mitral leaflet thickening of ≥3 mm in 36 (42.4%), and aortic regurgitation in 9 (10.6%) (Table 2, Figure 3). No clinical or echocardiographic parameter differed significantly between girls and boys with RHD (Supplementary Table S4). No individual item of self-reported symptom history was associated with RHD status (Supplementary Table S2); however, overall RHD prevalence was 24.1 per 1,000 (47/1,950; 2.4%) among school-going children reporting none of the three symptoms compared with 14.7 per 1,000 (38/2,586; 1.5%) among those reporting at least one symptom (P=0.03), and self-reported symptom history was treated as an adjustment variable rather than a protective factor.

Compared with school-going children without RHD, those with RHD were more often girls (65.9% [56/85] vs 52.7% [2,346/4,451]; P=0.02) and less often reported a positive 12-month symptom history (44.7% [38/85] vs 57.2% [2,548/4,451]; P=0.03); the school-grade distribution also differed between groups (P=0.04), whereas age, residence, household size, family economic status, family livelihood, and time to school did not (Table 1; Supplementary Table S1).

In multivariable mixed-effects logistic regression accounting for clustering of school-going children within schools (Table 3), girls had 62% higher adjusted odds of RHD than boys (AOR 1.62; 95% CI 1.03–2.57; P=0.038), consistent in direction with the unadjusted odds ratio (OR 1.73; 95% CI 1.10–2.72). Age showed no linear association with RHD (AOR 1.02 per 1-year increase; 95% CI 0.94–1.11; P=0.606), whereas a positive self-reported symptom history in the preceding 12 months was inversely associated with RHD (AOR 0.53; 95% CI 0.34–0.84; P=0.006), reflecting high background recall of non-specific symptoms among unaffected school-going children rather than a protective effect. In pre-specified sensitivity analyses (Table 4), the association with female sex remained consistent when adding a

quadratic age term (AOR 1.61; 95% CI 1.02–2.54; P=0.042) or replacing continuous age with categorical age groups (AOR 1.61; 95% CI 1.02–2.54; P=0.041), but attenuated and became non-significant when restricted to the 31 definite RHD cases (AOR 1.18; 95% CI 0.57–2.43; P=0.651), an analysis with limited statistical power. The school-level random intercept was statistically significant (variance ψ=0.78; intraclass correlation ρ=0.19, 95% CI 0.07–0.44; likelihood-ratio test P<0.001), indicating meaningful variation in RHD risk across schools, although with eight schools this cluster variance is estimated with wide uncertainty (Supplementary Table S3).

Table 1. Baseline characteristics of screened school-going children in the eight sampled public schools according to rheumatic heart disease status (n=4,536)

Characteristic	Overall (n=4,536)	No RHD (n=4,451)	RHD (n=85)	P value*
Age, years, median (IQR)	13 (10–15)	13 (10–15)	13 (11–15)	0.76†
Sex				0.020
Girls	2,402 (53.0)	2,346 (52.7)	56 (65.9)	
Boys	2,134 (47.0)	2,105 (47.3)	29 (34.1)	
Age group, years				0.83
6–9	688 (15.2)	677 (15.2)	11 (12.9)	
10–14	2,580 (56.9)	2,531 (56.9)	49 (57.6)	
15–16	1,268 (27.9)	1,243 (27.9)	25 (29.4)	
School grade				0.04
Pre-primary (Bal class)	24 (0.5)	24 (0.5)	0 (0.0)	
Grades 1–5	1,365 (30.1)	1,334 (30.0)	31 (36.5)	
Grades 6–8	1,983 (43.7)	1,958 (44.0)	25 (29.4)	
Grades 9–10	1,164 (25.7)	1,135 (25.5)	29 (34.1)	
Residence				0.44
Rural or village	3,864 (85.2)	3,794 (85.2)	70 (82.4)	
Urban or bazar	672 (14.8)	657 (14.8)	15 (17.6)	
Household size, persons, mean (SD)	6.5 (3.0)	6.5 (3.0)	6.5 (2.9)	0.51†
Family economic status				0.85
Very low	489 (10.8)	481 (10.8)	8 (9.4)	
Low	2,169 (47.8)	2,126 (47.8)	43 (50.6)	
Medium	1,878 (41.4)	1,844 (41.4)	34 (40.0)	
Positive self-reported symptom history (past 12 months)‡	2,586 (57.0)	2,548 (57.2)	38 (44.7)	0.03

Data are n (%) unless otherwise stated. Percentages are column percentages within each RHD status group.

*P value from the chi-square test unless otherwise indicated; †Wilcoxon rank-sum test; ‡self-reported symptom history recalled over the preceding 12 months (sore throat or tonsillitis with fever, fever with joint pain, or involuntary jerky movements; unrecorded symptom items on field forms denoted absence of symptoms).

Table 1 presents unadjusted comparisons only; adjusted associations are presented in Table 3. IQR = interquartile range; SD = standard deviation; RHD = rheumatic heart disease classified by 2012 World Heart Federation echocardiographic criteria.

Table 2. Prevalence and echocardiographic and clinical characteristics of rheumatic heart disease (n=4,536 screened; 85 cases)

Characteristic	Value
School-going children screened	4,536
RHD cases (borderline or definite)	85
Overall prevalence per 1,000 (95% CI)*	18.7 (15.1–23.0)
Borderline RHD	54 (63.5)
Definite RHD	31 (36.5)
Clinical presentation	
No audible murmur	55 (64.7)
Audible murmur	30 (35.3)
Sensitivity of cardiac auscultation for any RHD, %	35.3
Valve involvement	
Mitral valve only	76 (89.4)
Aortic valve only	8 (9.4)
Combined mitral and aortic involvement	1 (1.2)
Echocardiographic findings	
Pathological mitral regurgitation	76 (89.4)
Aortic regurgitation	9 (10.6)
Anterior mitral leaflet thickening ≥3 mm	36 (42.4)

Data are n (%) of the 85 RHD cases unless otherwise stated. Valve involvement classifies the 85 cases by affected valve(s) (mitral only, aortic only, or both; total = 85), whereas individual echocardiographic findings may co-exist in the same child.

*Exact binomial 95% confidence interval. Borderline 11.9 per 1,000 (95% CI 9.0–15.5); definite 6.8 per 1,000 (95% CI 4.7–9.7). Prevalence by sex and age group is shown in Figure 2.

CI = confidence interval; RHD = rheumatic heart disease; WHF = World Heart Federation.

Table 3. Factors associated with rheumatic heart disease: mixed-effects logistic regression with a school-level random intercept (n=4,536)

Variable	Adjusted OR*	95% CI	P value
Female sex (girls vs boys)	1.62	1.03–2.57	0.038†
Age (per 1-year increase)	1.02	0.94–1.11	0.606
Positive self-reported symptom history (vs none)	0.53	0.34–0.84	0.006†

*Mixed-effects (random-effects) logistic regression with a school-level random intercept to account for the nesting of school-going children within schools across all 4,536 participants; female sex, age, and self-reported symptom history were included simultaneously. The unadjusted odds ratio for female sex was 1.73 (95% CI 1.10–2.72); self-reported symptom history was included as an adjustment variable rather than a causal risk factor.

†P < 0.05. OR = odds ratio; CI = confidence interval; RHD = rheumatic heart disease.

Table 4. Pre-specified sensitivity analyses of the association between female sex and rheumatic heart disease (n=4,536)

Model	Female OR	95% CI	P value
Primary mixed-effects model*	1.62	1.03–2.57	0.038†
Age-squared term added	1.61	1.02–2.54	0.042†
Categorical age groups	1.61	1.02–2.54	0.041†
Definite RHD only (n=31)‡	1.18	0.57–2.43	0.651

*Primary model adjusted for age, self-reported symptom history, and a school-level random intercept.

†P < 0.05; ‡restricted analysis with limited statistical power (31 definite RHD cases).

OR = odds ratio; CI = confidence interval; RHD = rheumatic heart disease.

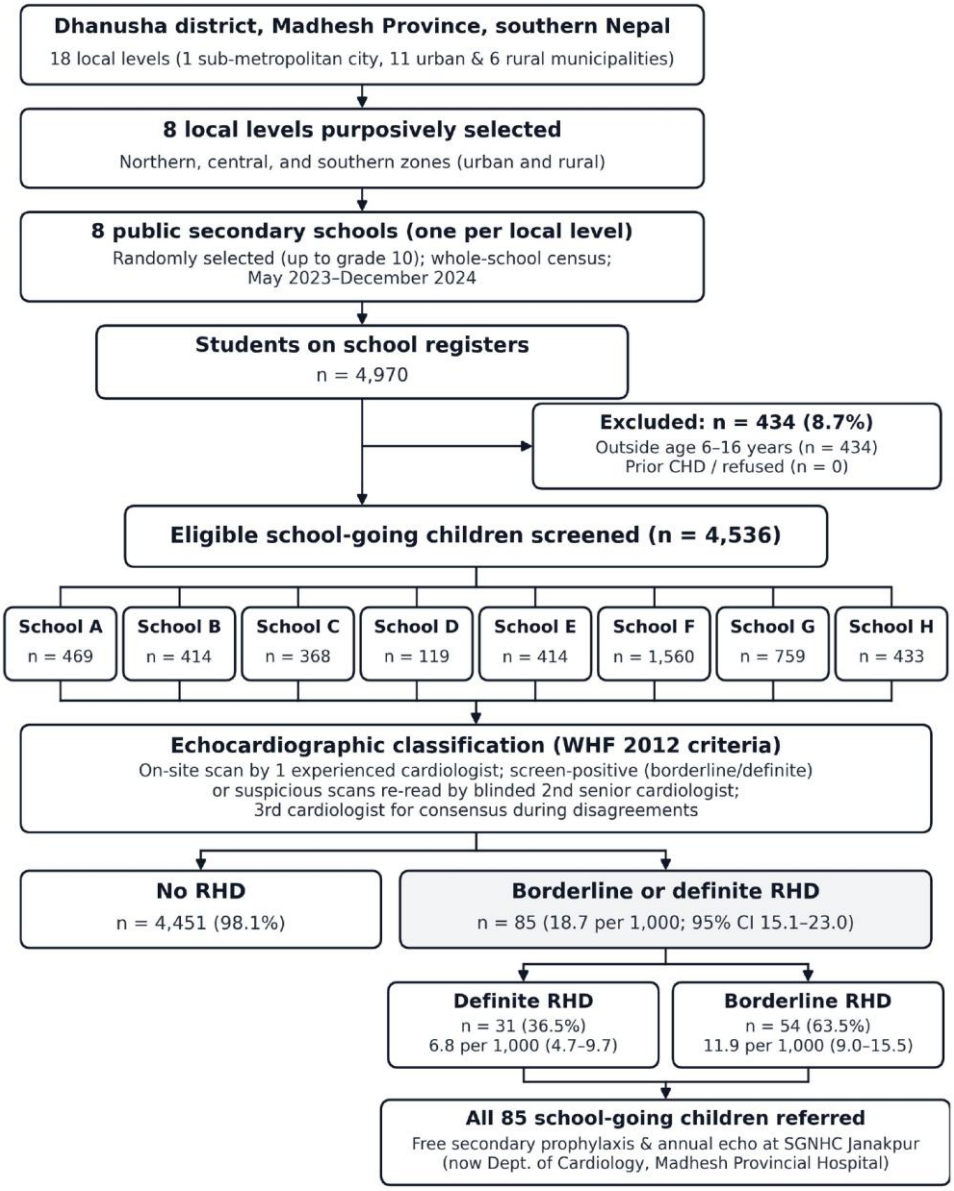


Figure 1: *Flow of participant screening and detection of rheumatic heart disease (RHD) among school-going children in eight sampled public schools of Dhanusha district (n=4,536). Schools are anonymised as A–H. CHD = congenital heart disease; CI = confidence interval; RHD = rheumatic heart disease; SGNHC = Shahid Gangalal National Heart Centre; WHF = World Heart Federation.*

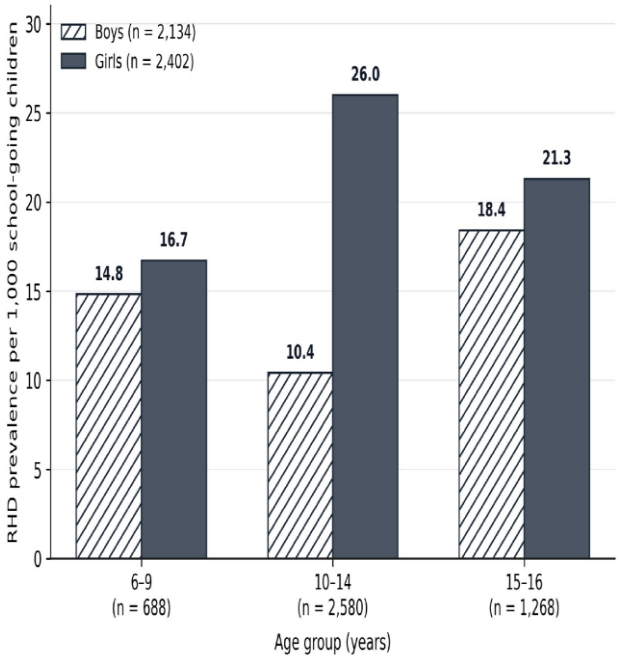


Figure 2: *Prevalence of borderline or definite RHD per 1,000 school-going children by age group and sex (n=4,536). Hatched bars show boys and solid bars girls across the three age groups (6–9, 10–14 and 15–16 years). Values above bars indicate prevalence per 1,000 school-going children. See Table 2 for exact 95% confidence intervals. RHD = rheumatic heart disease.*

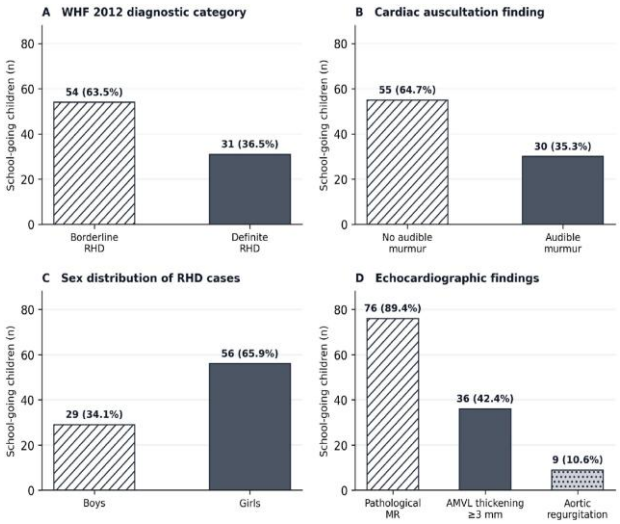


Figure 3: *Summary of echocardiographic and clinical findings among the 85 school-going children with rheumatic heart disease, Dhanusha district, Nepal (May 2023–December 2024). Panel A: RHD category (borderline RHD n=54; definite RHD n=31). Panel B: auscultation finding (no audible murmur n=55; audible murmur n=30). Panel C: sex distribution of RHD cases (boys n=29; girls n=56). Panel D: echocardiographic findings (pathological mitral regurgitation n=76; anterior mitral valve leaflet thickening ≥3 mm n=36; aortic regurgitation n=9). AMVL = anterior mitral valve leaflet; MR = mitral regurgitation; RHD = rheumatic heart disease; WHF = World Heart Federation.*

Supplementary Materials

Supplementary Table S1. Family livelihood and time to school of screened school-going children by rheumatic heart disease status (n=4,536)

Characteristic	Overall (n=4,536)	No RHD (n=4,451)	RHD (n=85)	P value*
Family livelihood				0.58
Farming or daily wages	1,972 (43.5)	1,937 (43.5)	35 (41.2)	
Employment abroad	1,081 (23.8)	1,056 (23.7)	25 (29.4)	
Government or private employment	1,301 (28.7)	1,280 (28.8)	21 (24.7)	
Other or unclassified	182 (4.0)	178 (4.0)	4 (4.7)	
Time to school, minutes, mean (SD)	16 (12)	16 (12)	17 (13)	0.58‡

Data are n (%) unless otherwise stated. *Chi-square test; ‡Student's t test.

SD = standard deviation; RHD = rheumatic heart disease.

Supplementary Table S2. Individual items of 12-month self-reported symptom history among school-going children by echocardiographic RHD status (n=4,536)

Self-reported symptom history (past 12 months)	Overall (n=4,536)	No RHD (n=4,451)	RHD (n=85)	P value*
Throat pain or tonsillitis with fever	1,995 (44.0)	1,965 (44.1)	30 (35.3)	0.10
Fever with joint pain	1,176 (25.9)	1,156 (26.0)	20 (23.5)	0.71
Involuntary jerky movements	965 (21.3)	948 (21.3)	17 (20.0)	0.89
Positive self-reported symptom history (≥1 item)	2,586 (57.0)	2,548 (57.2)	38 (44.7)	0.03†
All three symptoms	449 (9.9)	440 (9.9)	9 (10.6)	0.85

Data are n (%). Self-reported symptom history covered the preceding 12 months (unrecorded items denoted absence of symptoms).

*Chi-square test; †P < 0.05. School-going children reporting none of the three symptoms had a higher RHD prevalence (24.1 per 1,000 [47/1,950; 2.4%]) than those reporting at least one (14.7 per 1,000 [38/2,586; 1.5%]). RHD = rheumatic heart disease.

Supplementary Table S3. School-level variance component of the primary mixed-effects logistic regression model (n=4,536)

Parameter	Estimate
School (random intercept) variance, ψ	0.78
Intraclass correlation coefficient (ρ)*	0.19
95% CI of ρ	0.07–0.44
Likelihood-ratio test for ρ=0	P < 0.001

*Latent-variable method: $\rho = \psi/(\psi + \pi^2/3)$, estimated from the primary model (Table 3) adjusted for sex, age, and self-reported symptom history. CI = confidence interval. This supplementary table presents the full between-school variance component estimated across the eight sampled public schools.

Supplementary Table S4. Clinical presentation of RHD-positive school-going children by sex (n=85)

Clinical presentation	Boys (n=29)	Girls (n=56)	P value*
Subclinical (no audible murmur)	16 (55.2)	39 (69.6)	0.23
Clinically manifest (audible murmur)	13 (44.8)	17 (30.4)	0.23

Data are n (%) within each sex column. *Fisher's exact test.

Sex-stratified counts for the individual echocardiographic variables (pathological mitral regurgitation and its jet characteristics, anterior mitral leaflet thickening, and aortic regurgitation) were also compared between sexes and none differed significantly (all P > 0.05); detailed counts are available from the corresponding author on request. RHD = rheumatic heart disease.

Discussion

This echocardiographic survey of 4,536 school-going children across eight sampled public schools in Dhanusha district addressed objectives. It identified an RHD prevalence of 18.7 per 1,000 in the sampled public schools, showed that nearly two-thirds of affected school-going children had no audible murmur, found a higher prevalence of RHD in girls, and demonstrated variation between the sampled schools that must be interpreted with caution.

The prevalence of 18.7 per 1,000 in these eight public schools exceeds the 10.2 per 1,000 reported in Sunsari-the only published school-based echocardiographic survey in Nepal, which sampled both public and private schools[9], and is far above the 2.2 per 1,000 in the Nepal Heart Foundation screening database.[14] It falls within the range reported in other endemic settings—India (20.4 per 1,000),[15] Uganda (14.8 per 1,000),[16] South Africa (20.2 per 1,000) and Ethiopia (30.5 per 1,000),[17] Nicaraguan children (48.0 per 1,000),[18] and Egypt (31.0 per 1,000)[19]—and closely matches the pooled South Asian echocardiographic prevalence of 18.3 per 1,000 (95% CI 11.6–26.4).[20] Earlier auscultation-based Nepalese surveys reported only 0.9–7.3 per 1,000,[10,14,21] highlighting how strongly detected burden depends on screening methodology.[22] Socioeconomic disadvantage, household crowding, limited primary care access, and genetic susceptibility remain unmeasured hypotheses, whereas the household socioeconomic indicators collected here were not associated with RHD.[23–28]

Unlike the steady age-related rise observed in Sunsari[9,29] and Senegal,[30] overall RHD prevalence in our sample was already 16.0 per 1,000 at 6–9 years and varied little across older overall age brackets (19.0 and 19.7 per 1,000), although sex-specific patterns diverged in mid-childhood-peaking at 10–14 years among girls (26.0 per 1,000) while dipping among boys (10.4 per 1,000)—broadly consistent with high-burden patterns reported in several sub-Saharan African and Oceanian cohorts.[5,6,16,31] Because a cross-sectional survey cannot separate early disease acquisition from spontaneous regression of borderline lesions, longitudinal follow-up studies across school ages are needed before recommending any age-specific or routine screening policy.

Isolated mitral valve involvement predominated among RHD cases (89.4%), with isolated aortic involvement in 9.4% and combined mitral and aortic involvement in only 1.2% of cases, consistent with school-based screening studies elsewhere;[5,15] however, because lesion duration could not be determined cross-sectionally, disease stage cannot be inferred from valve distribution alone. Higher RHD prevalence in girls (AOR 1.62), who accounted for nearly two-thirds of RHD cases in this cohort (65.9%), agrees with findings from Sunsari (OR 1.86),[9] Senegal,[30] India,[15] and a meta-analysis of 58 echocardiographic screening studies.[32] Potential explanations proposed in the literature such as sex differences in post-streptococcal immune responses, household exposure, or care-seeking were not examined in this study and remain hypotheses requiring further investigation.[33,34] Similarly, although clinical registries note that established rheumatic valve disease can contribute to maternal complications later in reproductive life,[35,36] maternal or adult outcomes were not assessed in this paediatric survey.

Nearly two-thirds of RHD cases (64.7%) had no audible murmur and cardiac auscultation detected only 35.3%, higher than the 17% sensitivity reported in Sunsari,[9] and closely comparable to high-risk Indigenous Australian school-going children, in whom echocardiographic RHD prevalence was 25.3 per 1,000 (versus 4.7 per 1,000 in low-risk urban peers)[37] and physician auscultation detected only 38.2% of echocardiographic abnormalities (20.6% for pathological murmurs), missing over three-fifths of cases.[38] Even in high-burden settings, most affected school-going children would remain undiagnosed by auscultation alone, and global registry data likewise highlight frequent late clinical presentation and severe surgical capacity gaps in low-income countries.[39]

The statistically significant school-level random intercept indicates that a meaningful share of the variation in RHD risk lies between the sampled schools, although with one school per selected local level this variation may reflect differences between catchment populations (socioeconomic conditions, environment, or access to health care) rather than characteristics of the schools themselves; these factors were not measured and remain hypotheses.[40,41] This variance component (Supplementary Table S3) should be incorporated into sample-size calculations for future surveys, which should enrol substantially more schools than the eight studied here.

Strengths include complete screening of eligible school-going children across eight public schools in a previously unsurveyed district, blinded pre-echocardiography auscultation, uniform WHF 2012 grading with blinded second-cardiologist review of screen-positive or suspicious studies and third-cardiologist confirmation of disagreements, and multilevel modelling. Several limitations merit note. First, eight of 18 local levels were selected purposively, one public school was sampled per local level without weights, and private-school and out-of-school children were excluded; findings therefore apply strictly to the eight sampled public schools and cannot be generalised to all children in Dhanusha district or Nepal. Second, on-site scanning was performed by a single cardiologist, normal scans were not recorded or re-read, and formal pre-study kappa calibration was not performed; any missed borderline lesions would likely bias prevalence slightly downwards. Third, having eight schools widens the confidence interval around the between-school variance, and WHF 2012 criteria were used because WHF 2023 guidelines appeared after fieldwork began. Finally, 12-month symptom recall, cross-sectional design, and unmeasured household or community factors limit causal and longitudinal inference.

Positive self-reported symptom history was common: 57.0% of school-going children reported at least one symptom, and 21.3% reported involuntary jerky movements, far exceeding plausible Sydenham chorea. Recall-based questions therefore had low specificity, and children with recent febrile symptoms may also have received antibiotics. Self-reported symptom history cannot identify school-going children with RHD on screening, reinforcing the limitations of symptom- or murmur-based case finding.

Portable echocardiography within school health programmes could be explored in high-burden settings, but this cross-sectional survey alone does not justify routine population-wide screening: feasibility at scale, long-term benefit, and cost-effectiveness in Nepal remain unestablished, and a Nepalese cluster randomised trial of systematic screening was inconclusive.[29] Identified cases were referred to a separate clinical follow-up and secondary prophylaxis programme at Janakpur; longitudinal outcomes from that cohort and formal cost-effectiveness evaluation of screening strategies[42] remain priorities.

Conclusion

In this cross-sectional survey of eight sampled public schools in Dhanusha district, southern Nepal, RHD affected 18.7 per 1,000 school-going children aged 6–16 years. Most cases were clinically silent and more common in girls, while prevalence varied across the sampled schools and self-reported symptom history did not identify cases. Because local levels were purposively selected and private-school and out-of-school children were excluded, these findings apply strictly to the sampled public schools rather than all children in Dhanusha district or Nepal. Echocardiographic screening may aid early detection of silent RHD, and the high burden observed in these schools supports local prevention focused on secondary prophylaxis—which may help prevent progression to advanced disease—alongside longitudinal follow-up and cost-effectiveness evaluation.

Declarations Contributors

PRR and ST conceptualised the study, designed the protocol, and interpreted the analyses. US, SNS, RKS, RS, PRB, and AT, as co-investigators, contributed equally to operational project execution, clinical data acquisition, and echocardiographic screening across all participating sites. PRR drafted the manuscript. All authors critically reviewed and revised the drafts, approved the final version, and accept accountability for the integrity of the work. PRR is the guarantor.

Conflicts of Interest

None declared.

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Data availability statement

Data are available from the corresponding author upon reasonable request.

Transparency declaration

The corresponding author (PRR) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, and that no important aspects of the study have been omitted.

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