



FACTORS ASSOCIATED WITH RHEUMATIC HEART DISEASE

Research report

2025

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LIST OF ABBREVIATIONS

ARF	Acute Rheumatic Fever
RHD	Rheumatic Heart Disease
GAS	Group A Streptococcus
UN	United Nations

FACTORS ASSOCIATED WITH RHEUMATIC HEART DISEASE

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1. INTRODUCTION

1.1. Background

Acute rheumatic fever (ARF) is a systemic inflammatory disease associated with an immune hypersensitivity reaction that develops late following infection with Group A streptococcus (GAS) (Seckeler & Hoke, 2011). The disease may involve the skin, joints, and central nervous system, and can also result in cardiac damage, with rheumatic heart disease (RHD) representing its most serious complication. RHD has a severe impact on human health, causing chronic damage to the heart valves and leading to loss of work capacity, deterioration in quality of life, and even death (Guan et al., 2023).

Globally, ARF and RHD create a substantial burden of morbidity and mortality; in 2015 alone, approximately 34 million people were diagnosed with RHD, and more than 319,400 deaths were reported (Watkins et al., 2017). In high-income countries, improvements in living conditions and the ability to diagnose and treat GAS pharyngitis early and completely with antibiotics have led to a marked decline in ARF and RHD, and in some countries these diseases are considered nearly eliminated (Baker et al., 2019). In contrast, in low- and middle-income countries, these diseases remain prevalent among children and adolescents and continue to place a considerable burden on health systems (Carapetis, 2007).

The pathogenesis of progression from ARF to RHD is most commonly related to recurrent episodes of ARF or to incomplete diagnosis and treatment of cardiac involvement at the time of initial diagnosis (Sika-Paotonu et al., 2017). Repeated inflammatory episodes lead to scarring of the heart valves and the development of chronic changes. In some cases, these changes present without clear clinical symptoms and are detectable only by echocardiography, resulting in a high risk of remaining undiagnosed and of interrupted follow-up.

GAS pharyngeal infection (pharyngitis) is the main cause of ARF and is thought to exert its effect both directly and indirectly (Cunningham, 2008). GAS pharyngeal infection is easily transmissible, and close contact and crowded living conditions increase the risk of transmission (Shaikh, Leonard, & Martin, 2010). In the prevention of ARF and RHD, primary health care plays a crucial role through timely diagnosis of streptococcal infection and appropriate antibiotic treatment (Michael A Gerber et al., 2009). In addition, for individuals diagnosed with ARF, secondary prevention—such as continuous long-term antibiotic prophylaxis—is the main strategy to prevent the development of valvular heart damage. However, in practice, limited access to health care services, interrupted follow-up, and poor adherence to treatment regimens remain key conditions leading to the development of RHD.

The factors influencing the development and course of ARF and RHD are not limited to infectious causes alone; they depend on the interaction of multiple factors, including environmental conditions, individual characteristics, immune responses, socioeconomic conditions, and the health care system (Baker et al., 2022). Socioeconomic factors related to poverty—such as cold, damp, poorly ventilated housing, overcrowded living conditions, and inadequate sanitation ("Rheumatic fever and rheumatic heart disease," 2004)—are considered to increase the risk of developing ARF.

Nevertheless, the magnitude and significance of the effects of these risk factors vary by region (Sharma & Toor, 2019), and research remains insufficient at the local level regarding the true prevalence of the disease, age- and sex-specific characteristics, frequency of recurrences, implementation of treatment and follow-up, and their relationship with socioeconomic conditions. Patterns of antibiotic use, timing of health care seeking, seasonal variation of infections, household and school environmental conditions, and differences in health education may vary by region and influence disease patterns, creating a need for systematic study of these factors.

Therefore, identifying the infectious, immunological, socioeconomic, environmental, and health care-related factors influencing ARF and RHD in accordance with the specific context of our country is of great importance for improving early detection, effective management, and policies and programs aimed at preventing complications.

Literature review

ARF and RHD remain highly prevalent worldwide, particularly among children and adolescents in low- and middle-income countries. Although these diseases are preventable, they place a substantial burden on health systems. Research findings indicate that while the prevalence of ARF and RHD has markedly declined in high-income countries, the disease burden remains highest in low- and middle-income countries (Carapetis, 2007).

Although disease prevalence showed a declining trend between 1990 and 2019, it remains high among socioeconomically vulnerable groups in Asia (Guan et al., 2023). This indicates that disease prevalence is strongly influenced not only by health services but also by socioeconomic inequality and living conditions.

In Mongolia, cardiovascular diseases have remained the leading cause of mortality and the third leading cause of morbidity over the past 30 years. Mongolia is among the countries with a high prevalence of ARF; however, research in this area is limited (Sukhbaatar et al., 2023). Another study evaluating diagnostic methods for ARF and RHD which was conducted in 2011, indicated that all patients diagnosed with polyarthritis and chorea require echocardiographic examination (Bolormaa & Tsogtochir, 2011).

According to statistical data from the Center for Health Development, a total of 1,494 children aged 0–18 have been diagnosed with ARF, and 810 children have been diagnosed with RHD as of 2024.

Table 1. Number of children diagnosed nationwide with acute rheumatic fever and rheumatic heart disease, by age group, as of 2024

	Diagnosis (icd-10)	0-5 yrs old	11-15 yrs old	6-10 yrs old	16+ yrs old	Total
ACUTE RHEUMATIC FEVER	I00	24	353	163	295	835
	I01	19	254	99	222	594
	I02	0	26	8	31	65
CHRONIC RHEUMATIC DISEASES	I05	23	146	118	125	412
	I06	2	3	2	2	9
	I07.9				1	1
	I08	0	0	2	4	6
	I09	1	96	11	274	382
	Total	69	878	403	954	2304

Over the past decade, an average of 9,200 cases of acute rheumatic fever have been reported. Although this constitutes a small proportion of overall cardiovascular disease, analysis by age group reveals substantial variation. In particular, acute rheumatic fever accounts for 40% of cardiovascular morbidity among children aged 10–19 years, representing the highest proportion within any age category.

During the same period, an average of 7,500 cases of rheumatic heart disease have been recorded, comprising 1.7% of all cardiovascular diseases, with an increasing trend observed in recent years. Among children aged 10–19 years, rheumatic heart disease represents 20% of cardiovascular morbidity, the highest share within this age group.

The United Nations Children’s Fund (UNICEF), with financial support from the Luxembourg government, has been implementing the project “Reducing and Preventing Rheumatic Heart Disease in Children” for the period 2022–2027. As part of this initiative, and in collaboration with the Government of Mongolia, rapid tests for the detection of streptococcal infection were incorporated into the national pediatric diagnostic package. The project also involved the training of 60 master trainers and 534 healthcare professionals working in primary healthcare facilities. As of June 1, 2025, Mongolia had 751,807 children aged 6–15 years, of whom 661,590 (88%) were screened for streptococcal infection using rapid diagnostic tests. Of those screened, 46,311 children (7.1%) tested positive, demonstrating a substantial risk for the development of acute rheumatic fever.

With respect to risk factors for acute rheumatic fever, although comprehensive evaluation remains limited, researchers suggest that as many as nine categories of risk factors may contribute, including environmental, socioeconomic, and healthcare-related factors (Mendoza et al., 2024). In addition, some studies have identified associations with hereditary factors, genetic characteristics of certain ethnic groups, and household size (Engel et al., 2011).

Moreover, nutritional status and micronutrient deficiencies may play a role in the development of acute rheumatic fever. The relationship between dental diseases, particularly dental caries, and acute rheumatic fever was already being examined in the 1930s. Although genetic influences are considered to be significant, specific gene variants associated with acute rheumatic fever have yet to be clearly identified.

Overall, existing evidence suggests that while acute rheumatic fever and rheumatic heart disease arise as complications following infection, their prevalence and progression are shaped by the interplay of multiple factors, including socioeconomic conditions, environmental exposures, access to healthcare, and individual characteristics. However, in Mongolia, studies that systematically evaluate these factors and their relationships with age, sex, environmental context, and socioeconomic status remain insufficient. Consequently, identifying context-specific determinants of acute rheumatic fever and rheumatic heart disease in Mongolia is essential for strengthening early detection, optimizing disease management, and enhancing preventive policies and programs.

1.2. Purpose

To identify the risk factors of acute rheumatic fever and rheumatic heart disease among children.

1.3. Objectives

1. To study the risk factors of acute rheumatic fever among children.
2. To study the risk factors of rheumatic heart disease among children.

2. MATERIALS AND METHODS

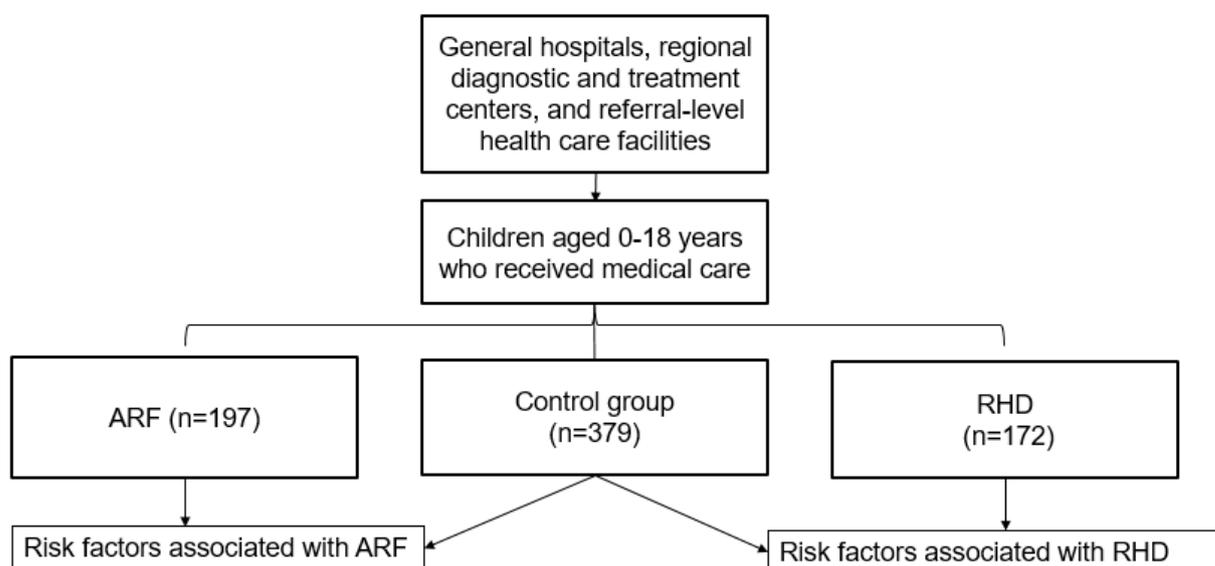
The study was carried out using a case–control design within the scope of each study objective.

2.1. Within the scope of Objective 1

2.1.1 Study design

The study employed a hospital-based case–control design. To investigate risk factors for acute rheumatic disease, children diagnosed with acute rheumatic disease between 2020 and 2025 in all 21 provinces of Mongolia and the 9 districts of Ulaanbaatar, in accordance with nationally approved clinical guideline criteria, were included as cases. Controls were selected from patients who presented to hospitals for other conditions and were matched to cases by age and sex. A 1:1 case-to-control ratio was applied (Figure 1).

Figure 1. Schematic overview of the study design



Case group: Cases included in the study were children diagnosed with acute rheumatic disease /acute rheumatic fever/ (ICD-10 codes I00–I02) in accordance with the national standard case definition of Mongolia (Minister of Health Order No. A/426, Appendix 2). Cases diagnosed exclusively with chorea or with indolent (slowly progressive) carditis were excluded. Eligible participants were identified from the national disease registration database using the diagnosis of acute rheumatic disease. Participants were then contacted by telephone and invited to participate in the study. For those who provided consent, data were collected through structured interviews conducted by telephone and, when feasible, using paper-based questionnaires.

Control group: The control group consisted of individuals who presented themselves to healthcare facilities for non-cardiac reasons and who agreed to participate in the study.

2.1.2. Sample size and sampling method

The sample size was calculated using the epiR software based on assumptions for a matched case–control study and informed by findings from previous studies. The case-to-control ratio was set at 1:2. The assumed probability of exposure among the control group was 0.099, the anticipated odds ratio was 2.5, statistical power was set at 80%, and the confidence level was

95%. Based on these calculations, a total of 197 children were required for the case group and 379 children for the control group (Figure 1).

The study population was selected using a non-probability purposive sampling method. Potential participants were identified from the disease registry list and contacted by telephone. Data were collected from consenting participants through telephone interviews and face-to-face interviews when feasible. The study sample was assembled in accordance with the predefined inclusion and exclusion criteria (Table 1).

Table 2. Inclusion and Exclusion Criteria for Objective 1

Study group	Inclusion criteria	Exclusion criteria
Case group	<ul style="list-style-type: none"> - Individuals with a confirmed diagnosis of Acute rheumatic fever (ARF) coded as ICD-10 I00–I02 - Diagnosis meeting the standard national case definition of Mongolia - Provision of informed consent of study participation - Available for data collection via telephone contact and structured interview 	<ul style="list-style-type: none"> - Clinical presentation inconsistent with ARF - Suspected or documented insidious-onset carditis - Diagnosis not verified or insufficient clinical information to confirm the diagnosis
Control group	<ul style="list-style-type: none"> - Individuals presenting for care due to non-cardiac conditions - Matched to cases by age and sex - No personal history of rheumatic fever and rheumatic heart disease - Provision of informed consent of study participation 	<ul style="list-style-type: none"> - Clinically documented history suggestive of rheumatic fever - Medical condition rendering the individual unable to participate in the study interview

2.2. Within the scope of Objective 2

2.2.1. Study design

The study was conducted using a hospital-based matched case–control design (Figure 1). Children who presented to healthcare facilities and were diagnosed between 2024 and 2025 in all 21 provinces of Mongolia and the 9 districts of Ulaanbaatar were included. The objective of the study is to identify risk and protective factors for rheumatic heart disease (RHD) in children.

Children in the case group diagnosed with rheumatic heart disease (ICD-10 codes I01, I02.0) were selected and enrolled in the study after obtaining informed consent from their caregivers. The control group included children matched by age and sex who attended healthcare facilities for non-cardiac reasons. Cases diagnosed with chorea or subacute/chronic carditis were excluded from the study.

Definition of cases and controls:

Cases: Children diagnosed with rheumatic heart disease (I01, I02.0) according to the clinical guidelines currently in force in Mongolia, and recorded in the clinical registry (Ministry of Health Order A/426, Annex 3).

Controls: Children with non-cardiac diagnoses who presented to healthcare facilities and were matched to cases by age and sex.

2.2.2. Sample size and sampling method

The sample size was calculated using the epiR software based on a matched case–control study design and the following parameters:

- Prevalence of exposure among controls (p_0): 15%
- Expected odds ratio (OR): 2.2
- Statistical power: 80%
- Confidence level: 95%
- Case-to-control ratio= 1 : 2

Based on these calculations::

- **Case group:** 174 children
- **Control group:** 344 children

The study population was selected using a non-probability purposive sampling method, in accordance with predefined inclusion and exclusion criteria (Table 2).

Table 3. Inclusion and exclusion criteria within the scope of objective 2

Group	Inclusion criteria	Exclusion criteria
Case group	<ul style="list-style-type: none"> – Children diagnosed at healthcare facilities in all 21 provinces of Mongolia and the districts of Ulaanbaatar between 2020 and 2025 – Diagnosed with rheumatic heart disease (ICD-10 codes I05.0–I09.0) – Diagnoses made in accordance with national clinical guidelines currently in force in Mongolia – Voluntary informed consent provided for participation in the study 	<ul style="list-style-type: none"> – Diagnosed with rheumatic chorea – Diagnosed with indolent (subclinical) carditis – Did not provide informed consent or could not be contacted – Diagnosis was unclear or not confirmed
Control group	<ul style="list-style-type: none"> – Children who presented to healthcare facilities for non-cardiac reasons – Matched to cases by age and sex – With no history of rheumatic disease 	<ul style="list-style-type: none"> – History of rheumatic disease – Physical or mental condition not suitable for participation in the study (e.g., cognitive impairment) – Did not provide voluntary informed consent

2.3 Data collection methods

Study participants were identified from the medical record and disease history databases. Members of the research team contacted eligible participants, provide information about the study, and invite them to participate. Written informed consent was obtained using an informed consent form from those who agree to participate, after which study data was collected using a pre-designed structured questionnaire. The duration of data collection is expected to be approximately 15–25 minutes per participant. The questionnaire was pre-tested to assess its preliminary validity prior to data collection.

Participants in both the case and control groups (or parents/legal guardians in the case of participants under 16 years of age) took part in interviews and provide the required information.

The data collection questionnaire was developed based on a review of international literature and national clinical guidelines (Appendix 1).

Risk and protective factors in the study were identified through a comprehensive literature review. Based on these findings, hypotheses regarding causal relationships influencing acute rheumatic disease were developed. The identified factors were categorized and included in data collection and analysis as follows:

- Environmental factors (e.g., housing conditions, living environment)
- Access to healthcare services (e.g., utilization of healthcare services, barriers to access, health education)
- Health status (e.g., general health, oral health, nutritional status)
- Social determinants (e.g., household and caregiver socioeconomic status)
- Genetic and demographic factors (e.g., family history of disease, age, sex, ethnicity)
- Infectious agents

2.4. Statistical analysis

Statistical analysis was performed using RStudio version 4.3.6. Appropriate statistical tests were selected based on the type and distribution of the study variables. According to the sample size calculation, most continuous variables were assumed to follow a normal distribution; therefore, the statistical analysis methods are presented in Table 3.

Table 4. Statistical Methods and Analytical Plan

Type of analysis	Objective 1 – risk factor for ARF	Objective 2 – Risk factor for RHD
1. Descriptive statistics	Age, sex, residence, family characteristics, nutritional status, living conditions	Age, sex, pulmonary diagnosis, durations from symptom onset to healthcare seeking, vaccination status, lifestyle factors
2. Hypothesis testing	Chi-square test, Fisher’s exact test, Independent two-sample T test, Mann-Whitney U test	Chi-square test, Fisher’s exact test, Independent two-sample T test, Mann-Whitney U test
3. Regression analysis	Univariable and multivariable logistic regression models (Adjusted OR, 95% CI)	Univariable and multivariable logistic regression models (Adjusted OR, 95% CI)

2.5 Outcomes:

- This study represented the first evidence-based research conducted in Mongolia in this field, as no previous studies have been carried out to date.
- Identification of risk factors contributed to the prevention of acute rheumatic fever and, consequently, to the reduction of rheumatic heart disease.
- The study provided decision-makers with evidence-based information necessary to identify key risk factors influencing the development of acute rheumatic fever and rheumatic heart disease and to implement appropriate preventive measures.
- The findings served as evidence for the development of prevention guidelines and manuals targeting the major risk factors associated with acute rheumatic fever and rheumatic heart disease.

3. RESULTS

A total of 750 children were enrolled in the study, including those diagnosed with rheumatic heart disease (RHD), acute rheumatic fever (ARF), and a control group.

With respect to anthropometric characteristics, mean body weight was significantly greater in the ARF group than in both the RHD group and the control group. Conversely, no significant intergroup differences were observed in mean height, household size, or age of the children ($p > 0.05$).

Socioeconomic analysis revealed that the average monthly household income was significantly lower among children with ARF compared to the other groups ($p = 0.011$).

Enrollment in preschool education was similar across groups ($p > 0.05$). In contrast, caregiver educational attainment differed significantly between groups ($p = 0.0001$), with caregivers in the ARF group more frequently having secondary-level education, whereas tertiary education was more prevalent among caregivers of children in the RHD and control groups.

No statistically significant differences were identified among the groups regarding caregivers' marital status ($p > 0.05$).

Table 1. General characteristics of participants

Variable	Study groups						p value
	Rheumatic heart disease		Acute rheumatic fever		Control group		
	n	%	n	%	n	%	
Sex							na
Female	110	63.2%	106	53.8	220	58.0%	
Male	64	36.8%	91	46.2	159	42.0%	
	mean	SD	mean	SD	mean	SD	
Height (cm)	140.60	24.65	146.27	26.19	141.01	25.80	na
Weight (kg)	37.27	16.79	44.89	18.02	39.86	16.80	0.003
Household size	4.81	1.15	4.81	1.20	4.75	1.29	na
Child age (years)	9.89	4.15	11.97	4.70	10.61	4.66	0.067
Monthly household income (MNT)	2,965,833	2,169,849	2,364,565	1,593,429	2,961,046	1,986,314	0.011
	n	%	n	%	n	%	
Attendance at school/kindergarten							na
No	11	6.4%	10	5.2%	27	7.2%	
Yes	161	93.6%	184	94.8%	348	92.8%	
Caregiver's educational attainment							0.0001
No formal education/Primary	2	1.1%	5	2.5%	7	1.8%	
Secondary	74	42.5%	100	50.8%	124	32.7%	
Vocational/Technical	5	2.9%	12	6.1%	28	7.4%	

Higher education	93	53.4%	80	40.6%	220	58.0%
Caregiver's marital status						
Unmarried	6	3.4%	12	6.1%	15	4.0%
Married/Cohabiting	154	88.5%	174	88.3%	345	91.0%
Single parent	14	8.0%	11	5.6%	19	5.0%

In the groups with rheumatic heart disease (A) and acute rheumatic fever (B), symptoms of shortness of breath, palpitations, and fatigue were observed at a significantly higher frequency compared with the control group (A–C, B–C; $p < 0.001$) (Table 2).

In the rheumatic heart disease group, shortness of breath (48.9%), palpitations (51.1%), and fatigue (31.6%) were observed at relatively high frequencies. Similarly, in the acute rheumatic fever group, the prevalence of these symptoms was also high, with shortness of breath reported in 39.6%, palpitations in 31.0%, and fatigue in 32.5% of patients.

Cyanosis of the nasolabial triangle was observed in 21.3% of the rheumatic heart disease group and 12.2% of the acute rheumatic fever group, and this prevalence were significantly higher compared with the control group ($p < 0.001$).

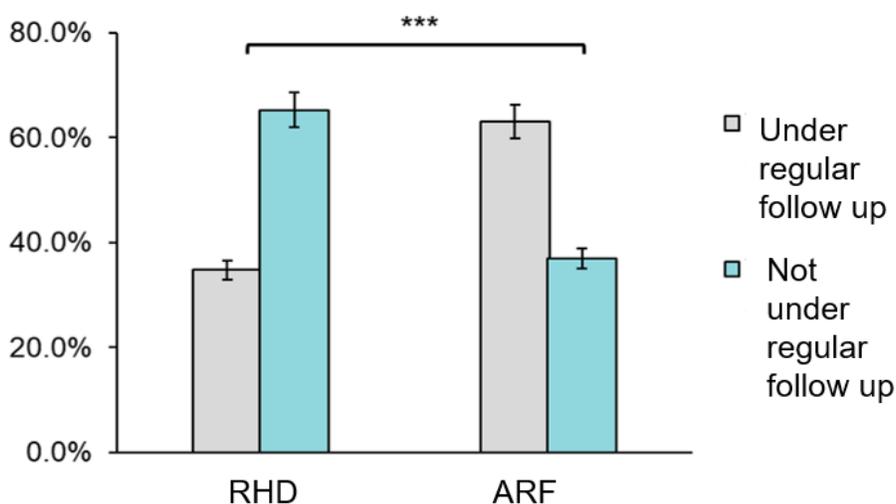
Peripheral edema was infrequently observed in both the rheumatic heart disease group (4.6%) and the acute rheumatic fever group (5.1%); however, compared with the control group, a statistically significant difference was observed in the rheumatic heart disease group ($p = 0.001$).

Table 2. Clinical features and symptoms of rheumatic heart disease and acute rheumatic fever

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
Shortness of breath							0.000	0.000
No		51.1%	119	60.41%	355	93.67%		
Yes		48.9%	78	39.59%	24	6.33%		
Palpitations							0.000	0.000
No		48.9%	136	69.04%	354	93.40%		
Yes		51.1%	61	30.96%	25	6.60%		
Cyanosis of the nasolabial triangle							0.000	0.000
No		78.7%	173	87.82%	378	99.74%		
Yes		21.3%	24	12.18%	1	0.26%		
Fatigue							0.000	0.000
No	119	68.4%	133	67.51%	360	94.99%		
Yes	55	31.6%	64	32.49%	19	5.01%		
Lower extremity edema (leg swelling)							0.001	0.000
No	166	95.4%	187	94.92%	377	99.47%		
Yes	8	4.6%	10	5.08%	2	0.53%		

As shown in Figure 1, there is a clear difference in the follow-up status of clinical symptoms and manifestations between rheumatic heart disease (RHD) and acute rheumatic fever (ARF). Among children diagnosed with RHD, 65.3% were not enrolled in regular clinical follow-up, whereas the proportion of children with ARF who were receiving regular follow-up care was relatively higher. This difference was statistically significant ($p < 0.001$).

Figure 1. Clinical manifestations and symptoms of acute rheumatic fever and rheumatic heart disease



Regarding long-term symptoms observed after treatment, the rheumatic heart disease group exhibited a higher frequency of persistent symptoms compared with the other groups (A–C, B–C; $p = 0.0001$).

In both the rheumatic heart disease and acute rheumatic fever groups, shortness of breath was observed more frequently compared with the control group, and these differences were statistically significant (A–C $p = 0.01$, B–C $p = 0.013$).

Fatigue/weakness was observed at a significantly higher frequency in both the rheumatic heart disease (4.0%) and acute rheumatic fever (4.6%) groups compared with the control group (1.1%) (A–C $p = 0.042$, B–C $p = 0.014$).

Elevated blood pressure was reported more frequently in the rheumatic heart disease group compared with the control group, and this difference was statistically significant (A–C $p = 0.036$).

Palpitations were observed at a markedly higher frequency in the rheumatic heart disease group (10.3%) compared with the control group (0.26%), and this difference was statistically significant (A–C $p = 0.0001$). In contrast, no statistically significant difference in the prevalence of palpitations was observed between the acute rheumatic fever group and the control group ($p > 0.05$).

With respect to edema and cyanosis of the nasolabial triangle, no statistically significant differences were observed between the groups ($p > 0.05$).

Table 3. Long-term quality of life in children

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
Long-term symptoms after treatment							0.0001	0.0001
No	139	79.9%	183	92.89%	374	98.68%		
Yes	35	20.1%	14	7.11%	5	1.32%		
Cyanosis of the nasolabial triangle							0.031	0.117
No	171	98.3%	195	98.98%	379	100.00%		
Yes	3	1.7%	2	1.02%	0	0.00%		
Difficulty breathing							0.01	0.013
No	170	97.7%	193	97.97%	379	100.00%		
Yes	4	2.3%	4	2.03%	0	0.00%		
Fatigue / weakness							0.042	0.014
No	167	96.0%	188	95.43%	375	98.94%		
Yes	7	4.0%	9	4.57%	4	1.06%		
Elevated blood pressure							0.036	0.471
No	170	97.7%	197	100.00%	378	99.74%		
Yes	4	2.3%	0	0.00%	1	0.26%		
Palpitations							0.0001	0.637
No	156	89.7%	196	99.49%	378	99.74%		
Yes	18	10.3%	1	0.51%	1	0.26%		
Edema							0.234	0.471
No	172	98.9%	197	100.00%	378	99.74%		
Yes	2	1.1%	0	0.00%	1	0.26%		

Among children who experienced sore throat with clinical symptoms during the preceding 12 months, the prevalence of streptococcal infection was significantly higher ($p < 0.001$).

The occurrence of skin rash during the preceding 12 months was significantly associated with rheumatic heart disease ($p = 0.002$), whereas no significant association was observed with acute rheumatic fever ($p > 0.05$).

At the household level, a history of streptococcal infection diagnosed among family members within the past year was significantly associated with the occurrence of rheumatic heart disease ($p = 0.017$). In contrast, the frequency of sore throat among family members and other household-related factors did not show statistically significant differences.

Furthermore, the occurrence of sore throat and fever in the child during the past month was not significantly associated with either acute rheumatic fever or rheumatic heart disease ($p > 0.05$).

Table 4. Baseline risk factors: exposure to streptococcal infection and family history

History of infection and genetic predisposition

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
History of fever within the past 12 months							0.000	0.000
No	32	21.6%	58	30.2%	186	51.7%		
Yes	116	78.4%	134	69.8%	174	48.3%		
History of sore throat within the past 12 months							0.000	0.000
No	16	11.1%	39	20.2%	122	35.0%		
Yes	128	88.9%	154	79.8%	227	65.0%		
History of skin ulcers or purulent skin lesions within the past 12 months							0.998	0.002
No	149	96.8%	175	90.7%	357	96.7%		
Yes	5	3.2%	18	9.3%	12	3.3%		
Antibiotic prescription for the child following a medical consultation within the past 12 months							0.331	0.331
No	28	18.4%	57	30.0%	153	42.4%		
Yes	124	81.6%	133	70.0%	208	57.6%		
If prescribed, completion of the full course of antibiotics							0.247	0.387
No	18	14.5%	18	13.5%	22	10.5%		
Yes	105	85.5%	115	86.5%	186	89.4%		
Presence of household members with recurrent sore throat							0.000	0.305
No	58	40.3%	93	54.4%	204	59.1%		
Yes	86	59.7%	78	45.6%	141	40.9%		
Presence of a household member (child or adult) who experienced sore throat and sought medical care within the past 12 months							0.166	0.302
No	72	48.0%	115	59.3%	197	54.7%		
Yes	78	52.0%	79	40.7%	163	45.3%		
Presence of a household member diagnosed with streptococcal infection within the past 12 months							0.057	0.017
No	141	94.0%	180	93.3%	344	97.5%		
Yes	9	6.0%	13	6.7%	9	2.5%		
Presence of classmates with sore throat and fever within the past month							0.633	0.331
No	34	47.2%	63	56.3%	100	50.5%		
Yes	38	52.8%	49	43.8%	98	49.5%		

Oral health indicators, specifically tooth brushing frequency, showed a statistically significant difference between the rheumatic heart disease group and the control group ($p = 0.024$). In contrast, no significant difference was observed when compared with the acute rheumatic fever group ($p = 0.586$) (Table 5).

The frequency of dental check-ups during the preceding 12 months did not differ significantly among the three groups ($p > 0.05$). However, the prevalence of dental diseases (including dental caries and filled teeth) was significantly higher in the acute rheumatic fever group compared with the control group ($p = 0.019$), with a higher proportion observed in the affected group. This indicator did not show a statistically significant difference when compared with the rheumatic heart disease group ($p = 0.329$).

The prevalence of gingivitis also did not show statistically significant differences among the three groups ($p > 0.05$).

Table 5. Oral health

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control (C)		A*C	B*C
	n	%	n	%	n	%		
Frequency of tooth brushing per day	1.9	0.5	2.0	0.4	2.0	0.6	0.024	0.586
Annual frequency of dental (oral) examinations	1.6	1.6	1.7	1.5	1.9	1.7	0.114	0.144
History of dental caries (decayed teeth)							0.329	0.019
No	47	28.0%	43	22.63%	114	32.20%		
Yes	121	72.0%	147	77.37%	240	67.80%		
Gingivitis							0.104	0.779
No	125	81.2%	140	85.89%	296	86.80%		
Yes	29	18.8%	23	14.11%	45	13.20%		

When comparing the frequency of sugar-sweetened beverage consumption among the three groups, no statistically significant differences were observed (A–C $p = 0.322$, B–C $p = 0.351$). Consumption of sugar-sweetened beverages 1–2 times per week was the most common pattern across all groups, whereas the proportion of daily consumption was relatively low (Table 6).

The frequency of sweet food consumption also did not differ significantly among the three groups (A–C $p = 0.135$, B–C $p = 0.624$). Consumption of sweet foods 1–2 times per week and 3–4 times per week was predominant among the study participants.

In contrast, a statistically significant difference was observed between the acute rheumatic fever group and the control group in terms of eating outside/fast food consumption during the past 7 days (B–C $p = 0.0001$). Specifically, the proportion of children who ate outside fewer than two times per week was lower in the acute rheumatic fever group compared with the control group. Conversely, no statistically significant difference was found for this indicator between the rheumatic heart disease group and the control group (A–C $p = 0.691$).

Table 6. Consumption of sweet foods and fast food

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
Consumption of sugar-sweetened beverages (sweetened tea, coffee, soft drinks)							0.322	0.351
Daily	15	8.62%	12	6.42%	26	7.14%		
5-6 days per week	11	6.32%	13	6.95%	28	7.69%		
3-4 days per week	38	21.84%	52	27.81%	96	26.37%		
1-2 days per week	62	35.63%	66	35.29%	133	36.54%		
1-3 times per month	29	16.67%	40	21.39%	60	16.48%		
Less than once per month	19	10.92%	4	2.14%	21	5.77%		
Consumption of sugary foods/sweets							0.135	0.624
Daily	10	5.75%	18	9.18%	34	9.32%		
5-6 days per week	23	13.22%	13	6.63%	32	8.77%		
3-4 days per week	39	22.41%	53	27.04%	105	28.77%		
1-2 days per week	57	32.76%	64	32.65%	115	31.51%		
1-3 times per month	29	16.67%	41	20.92%	59	16.16%		
Less than once per month	16	9.20%	7	3.57%	20	5.48%		
Eating out / fast food consumption in the past 7 days							0.691	0.0001
Daily	0	0.00%	9	4.59%	3	0.82%		
3-4 days per week	15	8.62%	23	11.73%	32	8.79%		
Less than twice per month	159	91.38%	164	83.67%	329	90.38%		

When comparing living environment conditions across the groups, statistically significant differences were observed for certain indicators. With regard to housing type, the proportion of children living in ger was relatively higher in the acute rheumatic fever group, and this difference was statistically significant compared with the control group (B–C $p = 0.0001$).

The housing floor area of children in the control group was larger, and a statistically significant difference was observed between the groups (B–C $p = 0.000$). In contrast, no significant difference was found among the groups with respect to the number of household members living in the dwelling ($p > 0.05$).

A statistically significant difference in the duration of residence at the current home (years) was observed between the rheumatic heart disease group and the control group (A–C $p = 0.001$). In contrast, no significant difference was found when compared with the acute rheumatic fever group (B–C $p = 0.941$).

The presence of mold or fungal growth on walls and ceilings showed a statistically significant difference between the acute rheumatic fever group and the control group (B–C $p = 0.049$). In contrast, no statistically significant difference was observed for this indicator in the rheumatic heart disease group.

When assessing whether the home was cold during the winter and whether, during the past month, the family had to sleep together on an uncomfortable and damp bed to keep warm, the latter indicator was significantly more frequent in both disease groups compared with the control group (A–C $p = 0.010$, B–C $p = 0.0001$).

Table 7. Living environment factors

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
What type of housing does your household live in?							0.153	0.0001
House	53	30.46%	51	25.89%	116	30.61%		
Apartment	86	49.43%	75	38.07%	208	54.88%		
Shared/communal housing	0	0.00%	4	2.03%	2	0.53%		
Ger	34	19.54%	66	33.50%	47	12.40%		
Other	1	0.57%	1	0.51%	6	1.58%		
Dwelling floor area (m ²)	56.90	29.43	50.88	23.27	61.90	31.30	0.087	0.000
Number of people living in the dwelling	4.72	1.18	4.72	1.27	4.68	1.23	0.701	0.656
How many years has your household lived in this dwelling?	8.99	4.95	7.47	5.20	7.50	4.90	0.001	0.941
Presence of mold/mildew on walls or ceiling of the dwelling							0.142	0.049
No	158	91.86%	186	97.89%	341	94.46%		
Always	0	0.00%	1	0.53%	3	0.83%		
Often	4	2.33%	2	1.05%	2	0.55%		
Sometimes	10	5.81%	1	0.53%	15	4.16%		
In winter, is your home cold?							0.794	0.526
No	0	0.00%	0	0.00%	0	0.00%		
Always	8	4.62%	10	5.15%	14	3.72%		
Often	30	17.34%	42	21.65%	72	19.15%		
Sometimes	135	78.03%	142	73.20%	290	77.13%		
During the past 1 month, did you need to sleep together in one room (despite discomfort) in order to stay warm?							0.010	0.0001
No	141	81.03%	145	75.13%	336	89.12%		
Yes	33	18.97%	48	24.87%	41	10.88%		

When comparing access to health care services across the three groups, significant differences were observed for certain indicators. The proportion of children who were unable to consult a physician within 24 hours when needed was significantly higher in the acute rheumatic fever group compared with the control group (B–C $p = 0.012$). In contrast, no significant difference was observed for this indicator in the rheumatic heart disease group compared with the control group (A–C $p = 0.191$).

No statistically significant differences were observed among the groups with respect to whether, during the preceding 12 months, children were unable to visit a doctor due to the absence of someone to care for other children ($p > 0.05$). Likewise, the inability to obtain prescribed medications or injections due to financial constraints did not differ significantly across the three groups ($p > 0.05$).

In contrast, the total expenditure on medications and injections during the preceding 12 months was highest in the rheumatic heart disease group (MNT 508,735), followed by the acute rheumatic fever group (MNT 392,127), and lowest in the control group (MNT 245,511). Statistically significant differences were observed between the rheumatic heart disease and control groups (A–C $p = 0.003$), as well as between the acute rheumatic fever and control groups (B–C $p = 0.05$).

Table 8. Access to health care services

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
Whether there were instances of being unable to consult a physician within 24 hours when medical care was needed							0.191	0.012
No	164	94.25%	162	83.94%	344	91.01%		
Yes	10	5.75%	31	16.06%	34	8.99%		
Were there any instances during the past 12 months when you were unable to take the child to a doctor due to the lack of someone to care for other children?							0.122	0.701
No	169	97.69%	180	93.75%	357	94.69%		
Yes	4	2.31%	12	6.25%	20	5.31%		
During the past 12 months, were there any instances in which the child was unable to obtain prescribed medications or injections due to financial constraints?							0.164	0.546
No	156	90.17%	177	92.19%	348	93.55%		
Yes	17	9.83%	15	7.81%	24	6.45%		
Expenditure on medications and injections during the past 12 months	508,735	119,107	392,127	90,157	245,511	73,868	0.003	0.05

When assessing participants' knowledge of the association between sore throat and acute rheumatic fever, the proportion of those who were aware of this relationship was statistically significantly higher in both the rheumatic heart disease and acute rheumatic fever groups compared with the control group (A–C $p < 0.001$, B–C $p < 0.001$).

Knowledge that acute rheumatic fever can damage the heart was significantly higher in the rheumatic heart disease group compared with the control group (A–C $p < 0.001$). In contrast, no significant difference was observed when compared with the acute rheumatic fever group (B–C $p = 0.314$).

Clear differences were observed among the three groups in terms of the frequency of seeking medical care for sore throat. Children in the rheumatic heart disease group showed a significantly higher tendency to seek medical care regularly compared with the control group (A–C $p < 0.001$). In contrast, no significant difference was observed between the acute rheumatic fever group and the control group (B–C $p = 0.090$).

When examining the time interval between the onset of sore throat and seeking medical care, a higher proportion of children in the rheumatic heart disease group sought care within 24–48 hours, and this proportion was significantly higher compared with the control group (A–C $p < 0.001$). In contrast, the difference in the B–C comparison was of borderline statistical significance ($p = 0.051$).

Regarding actions taken when a child develops a sore throat, the tendency to seek medical care immediately was more prevalent in the rheumatic heart disease group, and statistically significant differences were observed between the groups (A–C $p < 0.001$, B–C $p = 0.006$). In contrast, the proportions of those who self-medicated, used traditional remedies, or took no action were relatively higher in the control group.

Table 9. Knowledge and attitudes regarding the disease

Variable	Study groups						P value	
	Rheumatic heart disease (A)		Acute rheumatic fever (B)		Control group (C)		A*C	B*C
	n	%	n	%	n	%		
Can sore throat cause rheumatic fever?							0.000	0.000
No	38	25.00%	34	21.52%	144	61.02%		
Yes	114	75.00%	124	78.48%	92	38.98%		
Can rheumatic fever damage the heart?							0.000	0.314
No	59	34.50%	105	56.15%	223	60.93%		
Yes	112	65.50%	82	43.85%	143	39.07%		
Do you seek medical care when you have a sore throat?							0.000	0.090
Always	62	35.84%	54	27.84%	80	21.86%		
Mostly	57	32.95%	65	33.51%	104	28.42%		
Sometimes	39	22.54%	39	20.10%	79	21.58%		
Rarely	9	5.20%	19	9.79%	49	13.39%		
Never	6	3.47%	17	8.76%	54	14.75%		
How many days after the onset of a sore throat do you seek medical care?							0.000	0.051
No visit	8	4.62%	22	11.34%	61	16.53%		
Within 24 hours	87	50.29%	75	38.66%	103	27.91%		
Within 48 hours	63	36.42%	67	34.54%	144	39.02%		
Within 72 hours	15	8.67%	30	15.46%	61	16.53%		
What actions are taken when a child has a sore throat?							0.000	0.006
Seek medical care immediately	101	58.38%	79	40.72%	123	33.42%		
Purchase medication from pharmacy	43	24.86%	77	39.69%	174	47.28%		

Use traditional remedies	27	15.61%	37	19.07%	53	14.40%
No action taken	2	1.16%	1	0.52%	18	4.89%

The majority of children included in the study washed their hands before meals. The highest proportion was observed in the acute rheumatic fever group (88.78%), followed by the rheumatic heart disease group (79.31%) and the control group (80.16%). The differences among the groups were statistically significant ($p = 0.01$).

Table 10. Handwashing practices

Variable	Study groups						P value
	Rheumatic heart disease		Acute rheumatic fever		Control group		
	n	%	n	%	n	%	
Whether the child washes hands before meals							0.01
No	36	20.69%	22	11.22%	75	19.84%	
Yes	138	79.31%	174	88.78%	303	80.16%	

According to the multivariable logistic regression analysis presented in Table 11, several factors were significantly associated with the development of rheumatic heart disease. A prior history of acute rheumatic fever in the child was identified as the strongest risk factor, increasing the likelihood of developing rheumatic heart disease by 34.69 times (OR = 34.69; 95% CI: 12.28–98.21; $p < 0.001$).

Living in an environment exposed to tobacco smoke increased the risk of developing rheumatic heart disease by 1.71 times (OR = 1.71; 95% CI: 1.18–2.48; $p = 0.004$). In addition, the marital status of the caregiver (married/living with a partner) was also significantly associated with the occurrence of rheumatic heart disease (OR = 1.32; 95% CI: 1.07–2.36; $p = 0.035$).

A history of fever and sore throat during the past 12 months, as well as seeking medical care when experiencing a sore throat, were each associated with a 3–4-fold increase in the risk of developing rheumatic heart disease ($p < 0.001$). In addition, children who did not complete the full course of antibiotic treatment had a 1.48-fold higher risk of developing rheumatic heart disease (OR = 1.48; 95% CI: 1.06–2.88; $p = 0.025$).

Having a family member who experiences sore throat increased the risk by 2.15 times (OR = 2.15; 95% CI: 1.44–3.19; $p < 0.001$). In contrast, a history of diagnosed streptococcal infection among family members did not reach statistical significance ($p = 0.064$).

Among clinical symptoms, shortness of breath, palpitations, and cyanosis of the nasolabial triangle were strongly associated with the presence of rheumatic heart disease ($p < 0.001$). In contrast, fatigue and lower-limb edema were not statistically significant.

Regarding oral health and household factors, a higher daily tooth brushing frequency had a protective effect against the development of rheumatic heart disease (OR = 0.69; $p = 0.025$), whereas dental disease was not statistically significant. In addition, longer duration of residence at the current home and having to sleep together in one place to keep warm during the past month were associated with an increased risk of developing rheumatic heart disease (OR = 1.06; $p = 0.001$; OR = 1.92; $p = 0.010$).

In addition, higher expenditures on medications and injections, greater consumption of sweet foods, and a larger number of students in the child's classroom were all significantly associated with the presence of rheumatic heart disease ($p < 0.05$).

Table 11. Factors associated with the development of rheumatic heart disease

Variable	OR	95% CI		P value
		Lower	Upper	
History of acute rheumatic fever				
No	1			
Yes	34.69	12.26	98.21	0.000
The child is exposed to secondhand smoke				
No	1			
Yes	1.71	1.18	2.48	0.004
Marital status of the caregiver				
Married / living with a partner	1			
Unmarried / single-parent household	1.32	1.07	2.36	0.035
Have there been any episodes of fever during the past 12 months?				
No	1			
Yes	3.87	2.49	6.03	0.000
Have there been any episodes of sore throat during the past 12 months?				
No	1			
Yes	4.30	2.45	7.56	0.000
Did you seek medical care when experiencing a sore throat?				
Yes	1			
No	2.62	1.72	3.99	0.000
Whether the child completed the full course of antibiotics prescribed by a physician				
No	1			
Yes	1.48	1.06	2.88	0.025
Whether there is a family member who experiences sore throat				
No	1			
Yes	2.15	1.44	3.19	0.000
Was there a child or family member who had a sore throat and sought medical care during the past year?				
No	1			
Yes	1.31	0.89	1.92	0.166
Whether there is a family member diagnosed with streptococcal infection				
No	1			
Yes	2.44	0.95	6.27	0.064
Clinical symptoms				
None	1			
Shortness of breath	3.99	2.07	7.70	0.000
Palpitations	5.16	2.73	9.77	0.000
Cyanosis of the nasolabial triangle	44.60	5.74	346.52	0.000

Fatigue	1.69	0.79	3.59	0.173
Leg edema	2.02	0.36	11.21	0.423
Number of times the child brushes teeth per day	0.69	0.50	0.95	0.025
Dental disease in the child (carious and filled teeth)				
No	1			
Yes	1.22	0.82	1.83	0.329
Housing area (m ²)	0.99	0.99	1.00	0.090
Duration of residence at the current home (years)	1.06	1.02	1.10	0.001
Need for family members to sleep together to keep warm				
No	1			
Yes	1.92	1.16	3.16	0.010
Amount spent on medications and injections during the past 12 months	0.91	0.92	1.00	0.025
Consumption of sweet foods				
Low	1			
High	2.28	1.46	3.56	0.000
Number of children in the same classroom at school/kindergarten	1.03	1.01	1.05	0.015

According to the multivariable logistic regression analysis, several factors were associated with the development of acute rheumatic fever. Child's weight and age showed statistically significant associations with acute rheumatic fever, with the risk increasing as weight (OR = 1.017; 95% CI: 1.007–1.027; $p = 0.001$) and age (OR = 1.065; 95% CI: 1.026–1.106; $p = 0.001$) increased.

The risk of developing acute rheumatic fever varied according to the educational level of the caregiver, with a higher risk observed among those with complete secondary education (OR = 2.218; 95% CI: 1.536–3.202; $p < 0.001$). In addition, a decrease in average monthly household income was associated with an increased risk of acute rheumatic fever (OR = 0.971; 95% CI: 0.801–1.000; $p = 0.001$).

Living in an environment exposed to tobacco smoke increased the risk of developing acute rheumatic fever by 1.48 times (OR = 1.484; 95% CI: 1.038–2.122; $p = 0.030$). In addition, having a history of a diagnosed chronic disease in the child was associated with a 2.6-fold increase in the risk of acute rheumatic fever (OR = 2.607; 95% CI: 1.122–6.058; $p = 0.026$).

Children who experienced fever, sore throat, or skin rash during the preceding 12 months had a significantly higher risk of developing acute rheumatic fever (OR = 2.470; $p < 0.001$; OR = 2.122; $p < 0.001$; OR = 3.060; $p = 0.004$, respectively). Consistent with this, being prescribed antibiotics when seeking medical care was significantly associated with acute rheumatic fever (OR = 1.716; 95% CI: 1.181–2.495; $p = 0.005$).

Table 12. Factors associated with the development of acute rheumatic fever

Variable	OR	95% CI		P value
		Lower	Upper	
Child's weight	1.017	1.007	1.027	0.001
Child's age / age at illness onset	1.065	1.026	1.106	0.001
Caregiver's educational level				
Higher education	1			
College	1.964	0.606	6.366	0.260
Complete secondary	2.218	1.536	3.202	0.000
Primary	1.179	0.572	2.429	0.656

Average monthly household income	0.971	0.801	1.000	0.001
Secondhand smoke exposure				
No	1			
Yes	1.484	1.038	2.122	0.030
Whether the child has a diagnosed chronic disease				
No	1.000			
Yes	2.607	1.122	6.058	0.026
Have there been any episodes of fever during the past 12 months?				
No	1.000			
Yes	2.470	1.704	3.579	0.000
Have there been any episodes of sore throat during the past 12 months?				
No	1.000			
Yes	2.122	1.402	3.212	0.000
Whether the child had skin ulcers or purulent rash during the past 12 months				
No	1.000			
Yes	3.060	1.442	6.494	0.004
If medical care was sought during the past 12 months, was the child prescribed antibiotics?				
No	1.000			
Yes	1.716	1.181	2.495	0.005
Was there a household member diagnosed with streptococcal infection in your family during the past year?				
No	1.000			
Yes	2.760	1.158	6.581	0.022
Dental disease in the child (carious and filled teeth)				
No				
Yes	1.624	1.082	2.438	0.019
Type of housing				
House				
Apartment	2.638	0.310	22.476	0.375
Dormitory	2.163	0.256	18.267	0.478
Family housing	12.000	0.796	180.974	0.073
Other	8.426	0.982	72.318	0.052
Housing area	0.983	0.974	0.991	0.000
Mold or fungal growth on home walls				
No				
Yes	0.122	0.016	0.933	0.043
During the past month, was there a need for everyone to sleep together in one room, even if it was uncomfortable, in order to keep warm?				
No				
Yes	2.713	1.712	4.298	0.000
Whether the child washes hands before meals				
Yes	1.000			
No	1.958	1.175	3.262	0.010
During the past 12 months, were there any instances when the child was unable to see a doctor within 24 hours when medical care was needed?				
Yes	1.000			
No	1.936	1.150	3.261	0.013
Whether sweet food consumption was reduced after treatment				
Yes	1.000			
No	1.507	1.007	2.255	0.046
Whether preventive measures against sore throat are routinely practiced (e.g., wearing a mask, gargling, etc.)				
Yes	1.000			
No	1.837	1.242	2.717	0.002

Having a family member diagnosed with streptococcal infection during the past year increased the risk of developing acute rheumatic fever by 2.76 times (OR = 2.760; 95% CI: 1.158–6.581; $p = 0.022$). In addition, the presence of dental disease in the child (caries) was significantly associated with the development of acute rheumatic fever (OR = 1.624; 95% CI: 1.082–2.438; $p = 0.019$).

Regarding household conditions, a smaller housing area was associated with an increased risk of developing acute rheumatic fever (OR = 0.983; 95% CI: 0.974–0.991; $p < 0.001$). In addition, children who had to sleep together as a family on an uncomfortable and damp bed to keep warm during the past month had a significantly higher risk of acute rheumatic fever (OR = 2.713; 95% CI: 1.712–4.298; $p < 0.001$).

With regard to health care access, being unable to consult a physician within 24 hours when medical care was needed was significantly associated with acute rheumatic fever (OR = 1.958; 95% CI: 1.175–3.262; $p = 0.010$). In addition, not reducing the consumption of sweet foods after treatment and not routinely practicing preventive measures against sore throat were both associated with an increased risk of developing acute rheumatic fever ($p < 0.05$).

DISCUSSION

This study identified multiple factors influencing the development and distribution of acute rheumatic fever (ARF) and rheumatic heart disease (RHD), and the findings are consistent with results reported in previous international studies. In particular, a prior history of ARF emerged as the strongest risk factor for the development of RHD, increasing the risk by 34.69 times. This finding supports the widely accepted consensus that recurrent streptococcal infections lead to cumulative damage of the cardiac valves, ultimately resulting in rheumatic heart disease. These results are fully aligned with international evidence demonstrating that ARF constitutes the fundamental precursor condition for the development of RHD, as reported in earlier studies (Carapetis et al., 2016; Marijon et al., 2012).

Living in an environment exposed to tobacco smoke significantly increased the risk of both rheumatic heart disease and acute rheumatic fever in children. This association may be related to the fact that secondhand smoke weakens immune function and increases susceptibility to respiratory and streptococcal infections. These findings are consistent with previous studies demonstrating that secondhand smoke exposure in children is associated with a higher frequency of respiratory infections and inflammatory conditions (Flouris et al., 2010).

In addition, socioeconomic factors—including caregiver marital status, educational level, and household income—were significantly associated with both acute rheumatic fever and rheumatic heart disease. Previous studies have shown that children from households with lower educational attainment and lower income often have limited access to health care services and a higher risk of infectious diseases, and the findings of the present study further support this evidence (Ayorinde et al., 2023; Coffey, Ralph, & Krause, 2018).

Clinical symptoms such as fever, sore throat, and skin rash during the past 12 months were associated with a 2–4-fold increase in the risk of developing acute rheumatic fever, and subsequently rheumatic heart disease. These findings indicate that post-streptococcal immune responses play a key role in the development of acute rheumatic fever and that, when treatment

is delayed or incomplete, progression to cardiac involvement may occur. As noted by Gerber and colleagues, complete antibiotic treatment of streptococcal pharyngitis remains the primary strategy for preventing both acute rheumatic fever and rheumatic heart disease (M. A. Gerber et al., 2009).

In our study, children who did not complete the prescribed course of antibiotic therapy had a higher risk of developing rheumatic heart disease, indicating that treatment adherence plays a critical role in the course and outcomes of rheumatic disease. Similarly, international studies have concluded that incomplete antibiotic treatment increases the risk of recurrent acute rheumatic fever and subsequent cardiac valve damage (Zühlke & Karthikeyan, 2013).

With respect to the family and household environment, living with a family member who frequently experiences sore throat, sleeping together in crowded conditions, and long-term residence in the same home were factors that facilitated infection transmission, thereby increasing the risk of both acute rheumatic fever and rheumatic heart disease. These findings are consistent with previous studies indicating that streptococcal infections are more prevalent in densely populated settings and in households with poorer living conditions (Lau et al., 2004).

Regarding oral hygiene, an increased frequency of daily tooth brushing showed a protective effect against rheumatic heart disease, which may be attributable to the reduction of oral infections and their positive influence on overall immune function. This finding is consistent with international evidence suggesting that improvements in oral hygiene may reduce systemic inflammation, thereby contributing to better cardiovascular and overall health outcomes (Petersen et al., 2005).

In addition, the risk of acute rheumatic fever increased with advancing age and higher body weight in children, which may be related to maturation of the immune system, greater physiological burden, and a higher prevalence of chronic conditions. The finding that children with chronic diseases had a higher risk of developing acute rheumatic fever is also consistent with previous studies suggesting that immune compromise and altered responses to infection contribute to increased susceptibility (Zimmermann & Curtis, 2019).

4. CONCLUSION

This study demonstrates that the development of acute rheumatic fever (ARF) and the subsequent progression to rheumatic heart disease (RHD) are primarily influenced by recurrent streptococcal pharyngitis, a prior history of ARF, incomplete antibiotic treatment, and unfavorable family and household conditions. A history of ARF was identified as the strongest risk factor for the development of RHD. Limited access to health care services and the inability to seek timely medical attention during acute illness increased the risk of disease complications. Furthermore, caregivers' knowledge of the disease and their health-seeking behaviors played a critical role in early diagnosis and the quality of treatment. Accordingly, the study highlights that early detection and complete treatment of streptococcal pharyngitis, improved public health education, and strengthened access to primary health care are essential strategies for the prevention of rheumatic diseases.

5. RECOMMENDATIONS

1. At the level of health care services

It is necessary to strengthen systems within primary health care facilities for the early detection, diagnosis, and complete standard-based treatment of streptococcal pharyngitis. In particular, increasing the opportunity for children to see a doctor within 24 hours when they have fever and sore throat, ensuring rapid streptococcal testing is conducted at all levels of health care, and maintaining continuity and full completion of antibiotic treatment are of critical importance for the prevention of acute rheumatic fever.

2. Preventive and Surveillance Measures

Children with a history of acute rheumatic fever should be placed under active follow-up, and systems for the early detection of recurrent sore throat infections and related symptoms should be strengthened. Such measures can reduce the risk of progression to rheumatic heart disease. In addition, when streptococcal infection is identified among family members, the routine implementation of contact tracing, monitoring, and counseling is recommended.

3. Health education and behavioral change

Health education programs for caregivers and parents should be strengthened to emphasize the importance of early diagnosis of streptococcal pharyngitis, completing a full 10-day course of antibiotic treatment, and preventing structural heart abnormalities caused by rheumatic fever. It is also crucial to convey the importance of timely medical consultation and adherence to the full antibiotic regimen. Furthermore, efforts should focus on reducing self-medication, incomplete treatment, and reliance on traditional remedies, while promoting appropriate health-seeking behaviors.

4. Improving household and socioeconomic conditions

Considering that the study identified unfavorable household conditions—including overcrowding, damp and cold housing, and sleeping together in shared spaces—as being associated with disease occurrence, it is important to improve housing hygiene and living conditions, particularly through the implementation of targeted support policies for vulnerable households.

5. In school and kindergarten settings

In school and kindergarten settings, it is important to institutionalize early detection and surveillance of streptococcal pharyngitis and to promote hygienic practices, including handwashing and oral health. Strengthening collaboration among teachers, school health staff, and parents is necessary to reduce the risk of infection transmission within classrooms and peer groups.

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