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Community-based prevalence study of rheumatic heart disease in rural Ethiopia

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Abstract

Background: Chronic Rheumatic Heart disease (RHD) continues to be a health problem in many low and middle income countries and especially in sub-Saharan Africa. Echocardiography has shown that the disease is far more widespread than may be detected by clinical assessment, but data are lacking on the prevalence and epidemiological features in rural Africa.
Design: Community-based prevalence survey
Methods: We used transthoracic echocardiography to carry out a population-based study of RHD in a rural area of Ethiopia. A total of 987 participants aged 6 to 25 were selected by cluster sampling. The prevalence of RHD was assessed by the current consensus World Heart Federation criteria.
Results: There were 37 definite cases of RHD and a further 19 borderline cases giving an overall prevalence of 37.5 cases per 1000 population (95% CI 26.9–51.8) rising to 56.7 (95% CI 43.9–73.5) if the borderline cases are included. The prevalence of definite disease rose to a peak of 60 cases per 1000 in those aged 16–20 years before falling to 11 cases per 1000 in subjects aged 21–25 years. Of the 37 with definite disease, 36 had evidence of mitral valve and seven evidence of aortic valve disease.
Conclusions: RHD has a high prevalence in rural Ethiopia. Although follow-up is needed to determine how the disease develops with advancing age, the data provide evidence that the disease is an important health problem in rural sub-Saharan Africa requiring urgent concerted action.

Keywords

Chronic rheumatic heart disease, echocardiography, rural communities, Ethiopia, prevalence

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Introduction

Although rheumatic heart disease (RHD) has virtually disappeared in most developed countries, it remains an important public health problem in low and middle income countries and is estimated to affect about 15 million people worldwide.[1] The disease is widespread in the Middle East and Asia, in the poor indigenous populations of some wealthy countries and is particularly prevalent in sub-Saharan Africa. In sub-Saharan Africa it is one of the most common causes of heart disease and carries a grim prognosis because of the lack of specialized centres and the availability of cardiac surgery.[2–5] Hospital-based studies in Africa report that RHD accounts for up to 34.0% of hospital admissions related to cardiovascular disease[6] and it is the most frequent cause of heart failure among children and young adults. One large study reported a 180-day mortality of 35.4%.[7] Although surveys based on auscultatory criteria have consistently indicated a high disease burden,[8] echocardiographic screening has shown that RHD is far more widespread than previously appreciated, with up to a 10-fold increase in sensitivity compared with clinical assessment.[9] Using consensus guidelines developed by the World Heart Federation (WHF), recent echocardiographic surveys of

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schoolchildren in a number of African counties have shown a prevalence of between 15 and 34 cases per 1000,[10–13] but they were largely based on urban or peri-urban communities and little is known about the prevalence of RHD in rural areas, where most of the population still live. Because RHD is linked with poverty,[14–16] surveys of schoolchildren will tend to underrepresent the disease prevalence as poor children are much less likely to attend school. We therefore carried out echocardiographic screening of RHD in a population-based study of children and young adults to obtain realistic estimates of the disease prevalence in rural Ethiopia.

Methods

Study area

Jimma Zone, southwest Oromia State is an administrative zone within Ethiopia (Figure 1) with an area of 15,568 km^2 and a population of nearly 2.5 million people (11% urban, 89% rural). The zone is divided into 17 *woredas* or districts and each of these is divided into a number of *kebeles* or neighbourhoods with an average population of about 5000 people. The majority of the population works in agriculture because the zone is one of the major coffee-growing areas, although typical incomes are very low (<US$500/year). Only 9% of the inhabitants of Jimma Zone have access to electricity; 57% of all eligible children are enrolled in primary school and 12% are enrolled in secondary schools.[17]

Sample selection

We used a multi-stage, cluster-sampling technique. In a sample of ten *woredas*, we randomly selected 33 of a total of 54 possible *kebeles*. Health extension workers maintained a numbered list of households within each *kebele*. We used a sequential sample of these households to obtain a list of about 40 households. If the household included someone in the 6–25 year old age group, its members were invited to attend for screening at the local health post. If there was more than one person in this age group in the household, we selected one person by simple random sampling; if there was no person in this age group, or the family was away, we selected the next household in the sequence. The Jimma University ethical review board approved the project and written informed consent was obtained from each participant.

Data collection

A questionnaire was verbally administered in *Oromifa* (the local language). Participants (and/or a family member) were asked about school attendance, their parents' level of education and occupation. They were

Figure 1. Map of Ethiopia showing the location of Jimma.

also asked about their birthplace, their timing of birth (wet or dry season) and whether a parent had died. Details of their housing were recorded, including the number of rooms, the number of people living in the house, the type of construction of the house, whether animals lived in the same house as the occupants and the source of their drinking water (piped or river).

A brief medical history was recorded and a clinical examination was carried out to define symptoms and signs suggestive of rheumatic fever or cardiac valvular disease. A transthoracic echocardiogram was obtained with the use of a portable, battery-operated echocardiographic system (Esoate MyLab30 gold) with M-mode, two-dimensional and Doppler imaging. The views obtained included the parasternal long axis, the parasternal short axis and apical four- and five-chamber views, noting the valve morphology on cross-sectional two-dimensional imaging and the presence of mitral and aortic regurgitation using colour flow Doppler. Doppler interrogation of the regurgitant jets was used to assess the velocity, spectral envelope and duration.

Diagnosis and classification of RHD

The participants were classified as having definite or borderline RHD on the basis of the 2012 WHF criteria.[10] The criteria for definite RHD included the combination of pathological regurgitation and at least two morphological features of RHD: mitral stenosis with a mean gradient $\geq$4 mmHg or borderline disease of both the aortic and mitral valve. Doppler criteria for regurgitation included a regurgitant jet seen in two planes with a jet length $\geq$2 cm for the mitral and $\geq$1 cm for the aortic valve in at least one plane, a peak velocity $\geq$3 m/s for one complete envelope and the jet persisting through systole for the mitral valve and diastole for the aortic valve. Morphological features of RHD for the mitral valve were anterior mitral leaflet or chordal thickening, restricted leaflet motion or excessive leaflet tip motion during systole; for the aortic valve the features were irregular or focal thickening, a coaptation defect, restricted leaflet motion or prolapse. Borderline disease was defined as having either (a) at least two morphological features of RHD of the mitral valve without regurgitation or stenosis or (b) pathological mitral or aortic regurgitation. The positive and borderline images and 10% of the negative scans were reviewed by an experienced cardiologist.

Statistical methods

For practical and logistic reasons, we opted for a multistage, cluster-sampling approach with each cluster consisting of 35 participants. Anticipating a prevalence of RHD of about 5% and a modest design effect of 1.5, we estimated that 29 clusters would be needed to enable us to estimate the prevalence with a standard error of 1.0%. Subsequent post hoc analyses showed that the design effect was negligible. Contingency tables were used to compare the prevalence of borderline and definite cases as determined by different observers and the κ statistic was computed to assess the inter-observer reliability. The data are presented as cross-tabulations or mean $\pm$ SD values and comparisons between groups were carried out using χ^2 tests or Fisher's exact test where the cell counts were small.

Results

We carried out a total of 987 transthoracic echocardiograms, achieving a response rate of 82%. The mean $\pm$ SD age of the screened population was 13.2 $\pm$ 4.7 years and 454 (46.0%) of the participants were male. Table 1 shows the comparison between the original field diagnosis and the diagnosis after expert review (the scans were not available for three participants). There was a high level of agreement ($\kappa = 0.65$, $p < 0.001$). The marginal totals were very similar and 83% of categorizations were in complete agreement, while a further 18% differed by only one category. There was only one completely discordant assessment. Where there were discrepancies, the categorization by the expert cardiologist was used in the analysis.

There were 37 definite cases of RHD and a further 19 borderline cases, giving an overall prevalence of 37.5 cases per 1000 population (95% CI 26.9–51.8), increasing to 56.7 (95% CI 43.9–73.5) if the borderline cases were included. The prevalence did not differ by sex (overall prevalence 61.8 per 1000 in men and 52.5 per 1000 in women). The prevalence of definite disease increased progressively from 24 cases per 1000 among participants aged 6–10 years to a peak of 60 cases per 1000 in those aged 16–20 years, before falling to 11 cases per 1000 in participants aged between 21 and 25

Table 1. Comparison between the original screening diagnosis and the diagnosis following expert review among borderline and definite cases and a 10% sample of the negative scans. (scans for three definite or borderline cases were not available for review).

		Original diagnosis			
		Normal	Borderline	Definite	Total
Diagnosis after expert review	Normal	84	7	0	91
	Borderline	9	6	3	18
	Definite	1	4	30	35
	Total	94	17	33	144

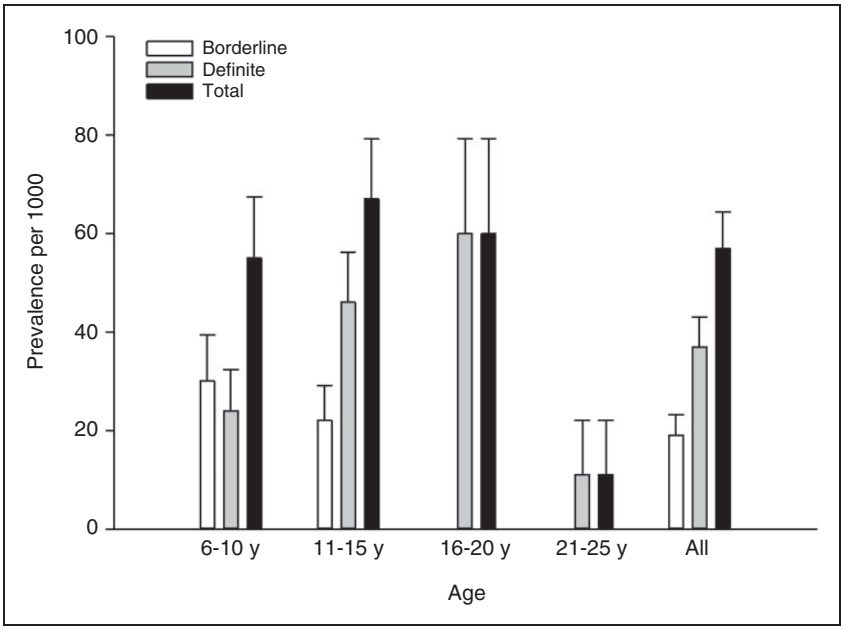

Figure 2. Age specific prevalence of echocardiographic RHD in the 987 screened participants (Error bars show SEM).

Table 2. Type of valvular disease detected in the participants classified as having borderline or definite RHD.

	Doppler abnormality detected	
Finding	Borderline ($n = 19$)	Definite ($n = 37$)
Mild MR	11	30
Significant MR	0	6
Mild AR	0	5
Significant AR	0	2

years (Figure 2). Borderline disease was observed in the youngest two age groups (30 and 22 cases per 1000, respectively), but was not found in participants over the age of 16 years. Of the 37 participants with definite disease, 36 had evidence of mitral valve involvement and seven had evidence of aortic valve disease (Table 2). Eight of the participants diagnosed with definite disease had significant aortic or mitral regurgitation; the others had mild valve disease. The participants did not report any symptoms related to heart failure. None gave a convincing history of preceding rheumatic fever. Only one of the participants with definite disease reported taking monthly prophylactic penicillin.

Table 3 shows that the population had a low level of education and a high level of unemployment. One-third reported that they were not attending school. Parental illiteracy was high and >70% were subsistence farmers or labourers. One-quarter of households had thatched roofs, in almost one-half animals shared the space with the family and one-third reported that their water supply was unprotected. None of these measures, nor the measurements of crowding such as family size, persons per room or number sleeping together, differed between participants with RHD and the healthy, unaffected population. Table 3 also shows the data on medical and family history. The only significant difference between participants with definite disease and the unaffected population was a history of scabies (16.2 vs. 5.4%, $p = 0.02$). Most cases of scabies were reported as being infected.

Discussion

There is very little population-based data on the prevalence of RHD in rural sub-Saharan Africa and this is the first study based on the current WHF definition of echocardiographic disease. Our prevalence of 37.5/1000, increasing to 56.7/1000 if borderline cases are included, is among the highest reported rates in the world and almost twice as high as the rates reported from urban/peri-urban populations of schoolchildren in Lilongwe in Malawi,[11] Jimma in Ethiopia,[12] Cape Town in South Africa[12] and Kampala in Uganda.[13] These surveys, which used the same diagnostic criteria as the current study, reported prevalence rates ranging from 7 to 17 per 1000 for definite and 20 to 34 per 1000 for total disease occurrence. These rates are, in turn, about ten times higher than previously published prevalence rates in Ethiopian schoolchildren based on clinical criteria.[18,19] The findings suggest that rural Ethiopia and probably therefore other rural areas of sub-Saharan Africa have a high and largely

Table 3. Socioeconomic, housing and medical characteristics of the RHD cases and the healthy population.

	RHD diagnostic category			
	Normal	Borderline	Definite	*p*-value
Attending school/education (%)				
Yes	604 (64.9)	13 (68.4)	21 (58.3)	0.68
No	326 (35.1)	6 (31.6)	15 (41.7)	
Parental education (%)				
Illiterate	572 (61.6)	11 (57.9)	26 (72.2)	0.41
Primary or more	356 (38.4)	8 (42.1)	10 (27.8)	
Occupation of parent (%)				
Farmer/Labourer	682 (73.3)	15 (78.9)	26 (70.3)	0.79
Other	249 (26.7)	4 (21.1)	11 (29.7)	
Mean family size (SD)	5.87 (1.9)	5.95 (1.3)	5.43 (2.0)	0.40
Mean persons per room (SD)	3.0 (2.1)	2.7 (2.1)	2.8 (2.0)	0.78
Mean number sleeping together (SD)	2.6 (0.96)	2.7 (1.1)	2.6 (0.92)	0.91
Animals share house (%)				
Yes	404 (44.5)	10 (52.6)	17 (50.0)	0.65
No	504 (55.5)	9 (47.4)	17 (50.0)	
House roof (%)				
Thatched	249 (27.5)	5 (26.3)	9 (26.5)	0.99
Corrugated	656 (72.5)	14 (73.7)	25 (73.5)	
Water supply (%)				
Piped	344 (37.8)	8 (42.1)	7 (20.6)	0.11
River	565 (62.2)	11 (57.9)	27 (79.4)	
Birth season (%)				
Dry season	63 (7.0)	3 (15.8)	4 (12.1)	0.19
Wet season	841 (93.0)	16 (84.2)	29 (87.9)	
Place of birth (%)				
Rural	834 (92.3)	16 (84.2)	30 (88.2)	0.32
Urban	70 (7.7)	3 (15.8)	4 (11.8)	
Loss of mother (%)	42 (4.6)	1 (5.3)	4 (11.8)	0.17
Loss of father (%)	129 (14.2)	0	5 (14.7)	0.21
History of scabies (%)				
Yes	49 (5.4)	1 (5.6)	6 (16.2)	0.02
No	859 (94.6)	17 (94.4)	31 (83.8)	
Infected scabies	37/49	1/1	5/6	

undiagnosed prevalence of this disease. Our data may be directly compared with the prevalence of echocardiographic RHD using the same WHF criteria in Jimma, Ethiopia and in Cape Town, South Africa. Our study suggests a prevalence rate almost twice as high as in the previous Ethiopian study, which was based on a survey of schoolchildren in a mixed urban/rural community and which reported a rate of 16.5 per 1000, increasing to 30.5 per 1000 if borderline cases were included.[12] The prevalence rate in the largely urban South African population was much lower at 4.8 per 1000 for definite and 20.2 per 1000 for total cases.[12]

The current study was based on screening of a population-based sample and as the response rate (82%) was high, we believe our study to be representative of the rural population. This community, in turn, is typical of many rural areas of sub-Saharan Africa with a high prevalence of subsistence farming and low levels of literacy (Table 3). Medical care is very poor and only one of our definite cases was taking penicillin prophylaxis. We used the current WHF criteria for diagnosing RHD and the diagnoses made in the field were verified by a senior cardiologist. Our findings show that echocardiographic screening of schoolchildren, and particularly

urban children, greatly underestimates the true prevalence (rural and urban) of this disease in countries such as Ethiopia. The likely reason for this is that the poverty-related major risk factors for the disease are more prevalent and thus more important in rural areas and are linked with poor school attendance.

Prevalence rates were similar in boys and girls, which agrees with previous studies.[9,11,12] In our study, we included young adults up to the age of 25 year – a difference from most other studies, which only included children under the age of 16 year. We found that the prevalence was fairly high in all age groups studied, with some evidence of a decrease in rates among the 21–25 year age group, although this was not significant. All but one of the definite cases detected had evidence of mitral regurgitation and 7/37 (19%) had additional evidence of aortic regurgitation (Table 2). None had valvular stenosis. As noted in the previous study from Jimma, Ethiopia,[12] we found a much higher ratio of definite to borderline disease than has been observed elsewhere in Africa. In our study the ratio of definite to borderline disease was 1.5 compared with 1.2 in the previous Jimma study, both of which are much higher than the ratios observed in Malawi (0.3) Uganda (0.35) or Cape Town (0.3).[11,12,20] The higher proportion of definite disease may be a consequence of a more aggressive disease pattern and higher prevalence in the Ethiopian population, but this clearly merits further investigation.

The relationship between poverty and RHD may well explain the remarkable persistence of the disease in resource-poor countries. Yet, we found no significant differences in our measures of socioeconomic background between the cases of the disease and the healthy population (Table 3). The main evidence for the role of socioeconomic factors in RHD derives from observations of high prevalence in disadvantaged, geographically defined populations, as observed historically in the UK and USA,[14] in meta-analyses of prevalence data,[8] as well as currently in sub-Saharan Africa.[16,21] Individual-level studies, however, have produced conflicting results and have largely failed to demonstrate convincing associations with either poverty or overcrowding,[15,22,23] which is surprising in view of the strength of the population associations.[14] There are a number of possible reasons for this, but it is likely to be explained by the low degree of heterogeneity of populations living in rural Africa, where the environments of RHD cases and those unaffected tend to be rather similar, or simply a failure to measure adequately the appropriate risk factor or factors related to RHD susceptibility.

We found that 16% of the RHD cases (Table 3) reported a history of scabies infection compared with 5% of the healthy population. Almost all cases also reported that their scabies had been infected. Although this needs to be replicated, this finding is of interest as it has been suggested that the infection of scabies lesions by group A streptococci could lead to RHD and may explain the high disease prevalence in Australian Aborigines, among whom scabies is very common.[24]

Our results showed a high prevalence of subclinical RHD in a rural community in Ethiopia. Rural Ethiopia is, in many ways, a good model for other rural areas of sub-Saharan Africa because its rural population (81% in 2014) and rate of urbanization are comparable with other countries in the region, as are the indices of rural poverty, education and maternal/child health.[25] Although follow-up is needed to assess how the disease develops with advancing age, the data provide evidence that RHD is an important and underestimated health problem in rural sub-Saharan Africa. There is a need for studies evaluating the prevalence elsewhere in rural communities in Africa, together with the development of effective strategies for the control and eradication of RHD.[26] This will require improved methods of detection and diagnosis, a programme for training rural nurses and health extension workers, as well as ensuring that adequate supplies of benzyl penicillin are available at the primary care level. Nevertheless, the difficulties of access and the geographical remoteness of many of these rural communities present a formidable challenge to achieving these goals. For those with advanced disease, access to specialist surgical facilities is much needed.[5]

Our studies also highlight the neglected research agenda in RHD; there is a pressing need to explain the persistence of this disease and investigate its association with poverty, an important feature of the disease in so many African countries. The identification of novel risk factors, such as domestic air pollution[27] or other early life influences,[28,29] offer potentially important clues that could lead to improved preventive strategies, but these will need proper evaluation. The recent Addis Ababa Communiqué has stressed the importance of a concerted and multi-sectoral partnership between governments, health ministries, international agencies and academia in addressing this problem.[30] Organizations such as the European Society of Cardiology have an important part to play in promoting awareness of the problem, stimulating research and encouraging the involvement of cardiologists within the constituent national cardiac societies.

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Author contribution

EHOP, DIWP and MHY conceived the study and its design, TG carried out the fieldwork; TG, EHOP, HM, DIWP and MHY carried out the analysis and drafted the manuscript; all

authors gave final approval and agreed to be accountable for all aspects of the work and ensuring its integrity and accuracy.

Declaration of conflicting interests

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