

ORIGINAL ARTICLE

High prevalence of rheumatic heart disease in schoolchildren detected by echocardiography screening in New Caledonia

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Aim: Despite the well-documented burden of rheumatic heart disease (RHD) in several Pacific countries, the disease is poorly understood in New Caledonia. The aim of this study was to assess the prevalence of RHD detected by echocardiographic screening in school children.

Methods: An annual RHD screening programme is conducted by the Health and Social Agency of New Caledonia for school-aged children in their fourth year of primary school. For the purpose of this study, we used data collected during this echocardiographic screening between 2008 and 2010.

Results: Of 12 728 children screened, 50.2% were male and the mean age was 9.6 ± 0.6 years. Between 2008 and 2010, 114 children had RHD, corresponding to a prevalence of 8.9 cases per 1000 (95% confidence interval (CI) (7.3–10.6)). Prevalence of RHD was higher on the main island outside Greater Noumea (13.7 per 1000; 95% CI (9.8–17.5)) and in the outlying island groups (14.6 per 1000; 95% CI (8.4–20.9)) than in Greater Noumea (5.8 per 1000; 95% CI (4.1–7.5)). RHD was more prevalent in Melanesian children (13.5 per 1000; 95% CI (10.9–16.1)) than in European (1.8 per 1000; 95% CI (0.4–3.1)).

Conclusion: This study documented a high prevalence of RHD in New Caledonia, particularly in districts located outside Noumea and in children of Melanesian heritage. These results uncover a hitherto unknown burden of disease in New Caledonia and underline the importance of delivering secondary prophylaxis to reduce the prevalence of RHD.

Key words: New Caledonia; rheumatic fever; rheumatic heart disease; schoolchildren; screening.

What is already known on this topic

- 1 Rheumatic fever is endemic in New Caledonia.
- 2 In the South Pacific, rheumatic heart disease affects indigenous groups in high-income countries as populations in low-income countries.
- 3 School echocardiographic screening allows detection of early cases of rheumatic heart disease.

What this paper adds

- 1 Prevalence of rheumatic heart disease in school-aged children is high in New Caledonia.
- 2 Prevalence of rheumatic heart disease is far higher in Melanesian children than in European children.
- 3 High-prevalence districts are located outside Greater Noumea and are scattered throughout the territory.

Rheumatic heart disease (RHD) is estimated to affect 15.6 million to 19.6 million people world-wide and causes between 233 000 and 492 000 deaths each year.^{1,2} RHD is the long-term damage to the heart valves that follows acute rheumatic fever (ARF). ARF, an autoimmune disease that follows infection with the bacterium *Streptococcus pyogenes*, predominantly affects children aged between 5 and 15 years, with the peak incidence of first episodes occurring at age 12 years.² RHD prevalence increases beyond the adolescent years, peaking in the third and

fourth decade of life, leading to premature death.² Three groups of factors are thought to be risk factors for ARF and RHD: host genetic susceptibility, virulence factors of the organism and environmental factors. These environmental factors include poverty, household overcrowding, low educational attainment, poor nutrition and reduced access to medical care.³

Despite a documented decrease in the incidence of ARF and a similar documented decrease in the prevalence of RHD in high-income countries during the past five decades, RHD remains a major public health problem throughout many low- and middle-income countries. RHD is a significant cause of cardiovascular disease and deaths in Africa and in Asia.⁴ Auscultatory screening with echocardiographic confirmation conducted in Mozambique and Cambodia found a prevalence of RHD of 21.5 cases per 1000 (95% confidence interval (CI) (16.8–26.2)) and 30.4 cases per 1000 (95% CI (23.2–37.6)), respectively, among children aged 6 to 17 years old.⁵

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ARF and RHD are important causes of morbidity and mortality in the Pacific region. The median prevalence of RHD in children aged five to 14 years in the Pacific has been estimated at 7.6 per 1000 (95% CI (2.5 to 13.5)).² Specific studies in the Pacific region, also with auscultation screening followed by echocardiographic confirmation, have found high prevalence around the region. For example, in Fiji, the prevalence of definite RHD among children aged 5–15 years was 4.1 per 1000 in 2006,⁶ and in Tonga the prevalence was 33.2 per 1000 in 2004.⁷ In specific communities in high-income countries in the Pacific, ARF and RHD are a health burden, particularly among Aboriginal Australians^{8,9} and among Maori and other Pacific Islanders in New Zealand.^{10,11} In northern Australia, the average annual incidence of ARF among Aboriginal children aged 5–14 years ranged from 156 to 350 per 100 000 in the years 2002–2008, and the prevalence of RHD (all ages) over the years 1997–2008 was 19.4 per 1000 (register-based data).⁸ In New Zealand, the average annual incidence of ARF among children aged 5–14 years was 14.9 per 100 000 from 1996 to 2005 (hospitalisation-based data).¹¹

The epidemiology of RHD in New Caledonia has not been well documented. A first study in 1986 based on 76 patients with acute rheumatic fever (Jones criteria) showed that ARF preferentially affected younger subjects of both sexes and was more common among Melanesians (72.4%) and Polynesians (22.4%) in New Caledonia.¹² Other diseases caused by *S. pyogenes* have also been studied. A study conducted in 2006 estimated the annual incidence of invasive *S. pyogenes* infections in New Caledonia to be 38 cases per 100 000 inhabitants, a rate that is some 10 times higher than in Europe and the United States. Infections mainly occurred among Melanesian children under 15 years old, reflecting the high burden of streptococcal disease in this group.¹³

Tackling the problem of ARF and RHD requires effective primary prevention and a well-organised secondary prevention programme. The effectiveness of secondary prevention can be bolstered by early case detection.

The aim of this study was to assess the prevalence of RHD in schoolchildren between 2008 and 2010 in New Caledonia.

Methods

Study population

New Caledonia (249 000 inhabitants; Census 2009, New Caledonian Institute for Statistics and Economics (ISEE)) is an archipelago in the South Pacific located approximately 1200 kilometers east of Australia and 1500 kilometers northwest of New Zealand. It comprises a main island (Grande Terre), the Loyalty Islands, the Isle of Pines and several smaller islands. Fifty-two per cent of the population lives in Noumea and its suburbs, 35% in other districts on the main island and 13% on other islands. Half of the population is aged less than 30 years and 25% is aged less than 15 years. Forty per cent of the population is indigenous Melanesian ('Kanak'), 30% European, 13% Polynesian and 2% Asian.

In 2009, 36 600 children were in nursery school or primary school in New Caledonia, and 42 595 children were aged between 3 and 12 years (ISEE, 2009). Thus, schooling rate for nursery school and primary school was estimated at 86%.

Organisation of the RHD screening in New Caledonia

The Health and Social Agency (Agence Sanitaire et Sociale de la Nouvelle-Calédonie; ASS-NC) is a public agency in New Caledonia responsible for disease prevention and health promotion, including prevention of ARF and RHD. A school-based echocardiographic RHD screening programme was initiated in 2007 by ASS-NC. The major aim of this programme has been to identify children with RHD early in the natural history of the illness to prevent progression of the RHD and recurrence of ARF. Every year, ASS-NC conducts a RHD screening for all children in their fourth year of primary school. ASS-NC collects details about children to avoid double counting. Children are examined at school by a physician expert in echocardiography. Each child undergoes an abbreviated and focused echocardiographic assessment using a portable echocardiography machine (Vivid I, General Electric, Fairfield, CT, USA). Children suspected of having RHD (any mitral or aortic valve regurgitation or mitral valve stenosis) or another cardiac anomaly on this screening echocardiogram are referred to a cardiologist for a second echocardiography to confirm RHD using diagnostic criteria defined *a priori* (Table 1). The echocardiographic criteria are agreed on by cardiologists experienced in the diagnosis of RHD in New Caledonia.

Prophylactic antibiotic therapy and regular medical surveillance are initiated by the child's general practitioner.

Study design

This observational study assessed the annual and period prevalences of RHD in schoolchildren, as well as prevalences with reference to sex, ethnicity and school location, between 2008 and 2010 in New Caledonia. For this purpose, we analysed data collected during the echocardiographic screening of schoolchildren in their fourth year of primary school in New Caledonia (usual age 9–10 years).

Statistical methods

Annual and period RHD prevalence were calculated as the number of children screened with a confirmation of RHD at a specified period of time divided by the number of children who underwent echocardiography at school for the same period. We analysed a number of variables and their effect on the distribution of cases of RHD, including sex, age, community, school district and public or private status of school. Comparative analyses were performed using the Student or Wilcoxon test for continuous variables and the chi-squared or Fisher exact test for categorical variables where appropriate. The 95% CIs of prevalence were determined by use of robust standard errors. A *P*-value less than 0.05 was considered to denote statistical significance. Data were analysed with STATA software version 11.0 (Stata Corporation, College Station, TX, USA).

Ethical considerations

Ethical clearance was obtained from the Public Health and Social Agency of New Caledonia. Written informed consent was obtained from the parent or guardian of each participant before screening was performed.

Table 1 Echocardiographic criteria for confirmation of rheumatic heart disease, New Caledonia, 2008–2010

Criteria for rheumatic mitral valvular damage

(i) *Mitral valve stenosis*

OR

(ii) *Two of Doppler-detected signs:*

- Regurgitation identified in at least two planes
- Regurgitant jet greater than 2 cm
- Pansystolic regurgitation
- Mosaic colour jet with peak velocity greater than 2.5 m/s

AND one of the following signs:

- Valvular thickening >5 mm in time motion mesodiastolic
- Abnormal mobility of valve leaflets
- Abnormal subvalvular thickening
- Thickened 'dog leg' anterior mitral valve leaflet

Criteria for rheumatic aortic valvular damage

(iii) *All of Doppler-detected signs:*

- Regurgitant jet greater than 1 cm
- Pandiastolic regurgitation
- Mosaic colour jet with peak velocity greater than 2.5 m/s

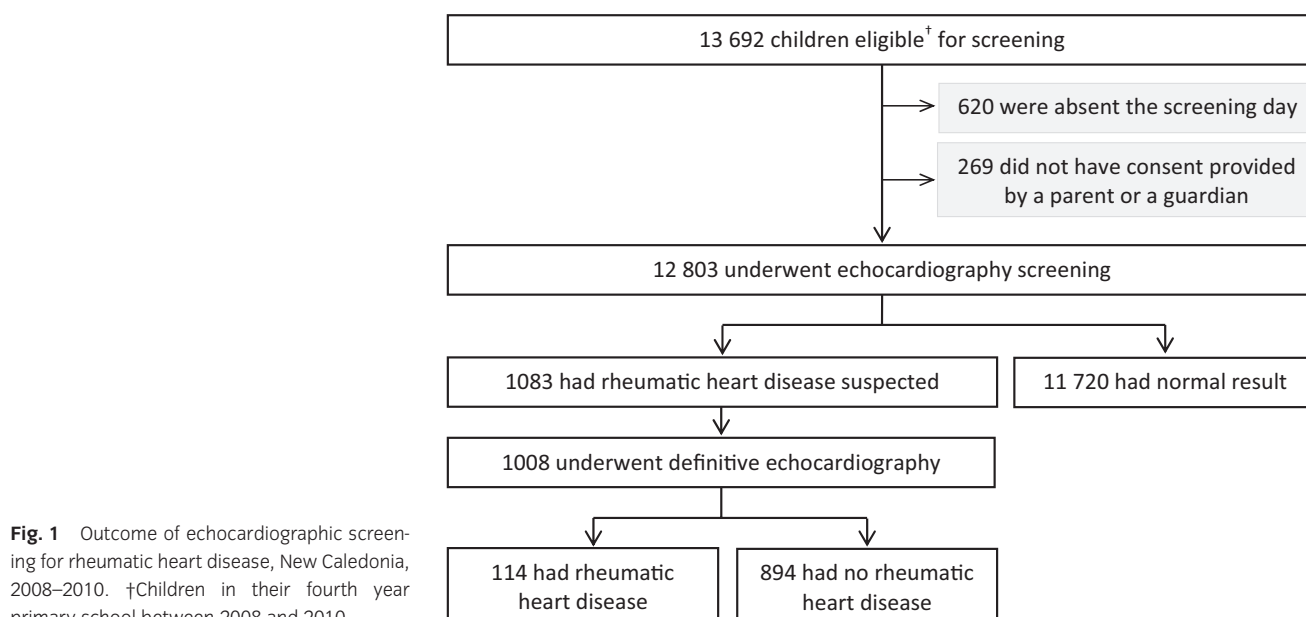


Fig. 1 Outcome of echocardiographic screening for rheumatic heart disease, New Caledonia, 2008–2010. †Children in their fourth year primary school between 2008 and 2010.

Results

Between 2008 and 2010, 12 803 children underwent echocardiographic screening for RHD, which represented 93.5% of children in their fourth year of primary school in New Caledonia (Fig. 1). The proportions in Greater Noumea, the main island outside Greater Noumea and outlying island groups were, respectively, 92.6%, 94.8% and 98.7% ($P < 0.001$). The mean age of screened children was 9.6 ± 0.6 years (range 7.0–13.6), and 50.2% were male. Melanesians comprised 58.1% and Europeans 30.8%. Overall, 61% were schooled on Greater Noumea, 27.7% on the main island outside Greater Noumea and 11.3% in the outlying island groups.

Of the 12 803 children screened at school, 1083 (8.5%) were suspected of having RHD or another cardiac anomaly. Among

this group, 114 were confirmed to have RHD by the second echocardiogram, corresponding to a period prevalence of 8.9 cases per 1000 (95% CI (7.3–10.6)) between 2008 and 2010. The prevalence was higher in Melanesian children (13.5 per 1000; 95% CI (10.9–16.1)) than in European (1.8 per 1000; 95% CI (0.4–3.1)) (Table 2). Prevalence by other demographic factors is presented in Table 2.

Highest prevalences by district were observed (i) in the north of the main island outside Greater Noumea (Poum, 54.8 per 1000; Kaala-Gomen, 52.6 per 1000; Touho, 33.3 per 1000); (ii) in the south of the main island outside Greater Noumea (Canala, 45.9 per 1000; Boulouparis, 18.7 per 1000); and (iii) in the outlying island groups (Mare, 28.1 per 1000) (Fig. 2).

Among children with RHD, the mitral valve was predominantly affected in 70.2% of cases.

Table 2 Prevalence of rheumatic heart disease detected by echocardiographic screening among children in their fourth year of primary school, New Caledonia, 2008–2010

	Children with RHD (<i>n</i> = 114)	Children without RHD (<i>n</i> = 12 614)	P-value†	Prevalence of RHD per 1000 (95% CI)
Age (Year)			NA‡	NA
Mean ± SD	9.7 ± 0.6	9.6 ± 0.6		
Range	8.4–11.8	7.0–13.6		
Class age			NA‡	
7–8 years	9 (8.0%)	1746 (14.0%)		NA
9–10 years	100 (89.3%)	10 485 (83.9%)		NA
11–14 years	3 (2.7%)	267 (2.1%)		NA
Sex			0.1800	
Female	64 (56.1%)	6282 (49.8%)		10.0 [7.6–12.5]
Male	50 (43.9%)	6325 (50.2%)		7.8 [5.7–10.0]
School location			<0.0001	
Greater Noumea	45 (39.5%)	7743 (61.4%)		5.8 [4.1–7.5]
Main island outside Greater Noumea	48 (42.1%)	4871 (27.4%)		13.7 [9.8–17.5]
Loyalty and Pines islands	21 (18.4%)	1412 (11.2%)		14.6 [8.4–20.9]
Ethnicity			<0.0001	
Melanesian	100 (87.8%)	7275 (57.7%)		13.5 [10.9–16.1]
Polynesian or Asian	7 (6.1%)	1402 (11.1%)		5.0 [1.3–8.6]
European	7 (6.1%)	3936 (31.2%)		1.8 [0.4–3.1]
School status			0.5480	
Public school	82 (71.9%)	9377 (74.3%)		8.7 [6.8–10.5]
Private school	32 (28.1%)	3227 (25.7%)		9.8 [6.4–13.2]
Screening year			0.3490	
2008	37 (32.4%)	3989 (31.6%)		9.2 [6.2–12.1]
2009	32 (28.1%)	4299 (34.1%)		7.4 [4.8–9.9]
2010	45 (39.5%)	4326 (34.3%)		10.3 [7.3–13.3]
Total 2008–2010	114 (100.0%)	12 614 (100.0%)		8.9 [7.3–10.6]

†Chi-square test. ‡P-value is not given because the study population was selected by age. CI, confidence interval; NA, not applicable; RHD, rheumatic heart disease; SD, standard deviation.

Discussion

Prevalence of RHD found using systematic echocardiographic screening was 8.9 cases per 1000 schoolchildren in their fourth year of primary school between 2008 and 2010 in New Caledonia. This result indicates that there is a high burden of RHD in New Caledonia; however, this prevalence of RHD cannot be extrapolated to the remainder of the population.

Some previous studies using echocardiographic screening have found higher prevalence of RHD among school-age children, including studies in Mozambique (21.5 per 1000), Cambodia (30.4 per 1000),⁵ Tonga (33.2 per 1000)⁷ and Kenya (27.0 per 1000).¹⁴ Prevalence of RHD in New Caledonia is probably lower because of a better health care system in New Caledonia than in other countries listed. Moreover, the fact that all children in their fourth year of primary school were considered probably reduced bias in this study as compared with the others. Finally, echocardiographic criteria used for this screening were more stringent than the World Health Organization criteria usually used in other studies.¹⁵ Our definition of RHD may have led to fewer cases being diagnosed as RHD and to a lower measured prevalence of RHD.

Between 2008 and 2010, the prevalence of RHD was higher in areas outside Greater Noumea: 13.7 per 1000 in districts on the main island outside Greater Noumea, and 14.6 per 1000 in the outlying island groups. However, we observed an uneven distribution of RHD throughout the territory (Fig. 2). To better understand this geographic distribution, we need further information on the population's knowledge about the illness, on ethnicity breakdown by district and on environmental factors affecting children with RHD, such as overcrowding, socio-economic status, urbanisation, distance between home and health centre and access to medical services.

In the Pacific, RHD affects indigenous groups in high-income countries in a similar fashion to populations in low-income countries.¹⁶ RHD continues to be a major health problem in New Zealand, particularly among Maori and Pacific Islander peoples;¹¹ in Australia, particularly among Indigenous Australians;⁸ and in the Fiji Islands.¹⁷ In New Caledonia, there was an uneven distribution of RHD among ethnic groups, with a higher prevalence in Melanesian children. Ethnicity is therefore probably an important risk factor associated with RHD. Previous studies have also found disparate rates in indigenous populations. A descriptive study in New Zealand showed that 83% of ARF cases

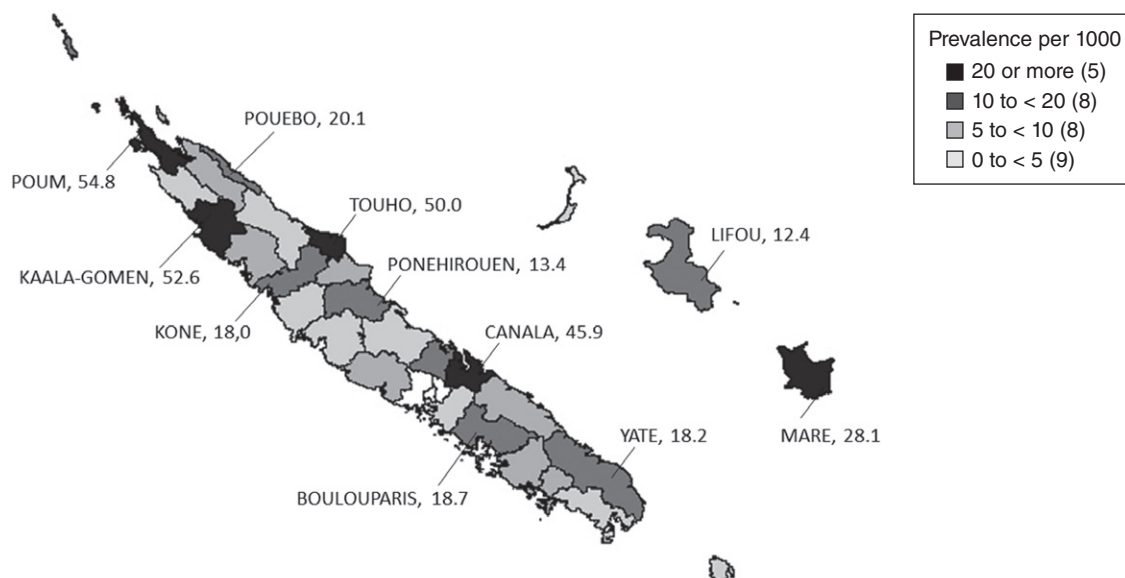


Fig. 2 Prevalence per 1000 of rheumatic heart disease detected by echocardiographic screening in school children by school district between 2008 and 2010, New Caledonia. No data available for the 3 districts in white because no school. Map made with PopGis New Caledonia software version 1.0 developed by Secretariat of the Pacific Community.

were among Maori and Pacific ethnicity in the years 1996–2002, rising to 91% in the years 2003–2005.¹¹ The exact mechanism underlying this disparity is not clear and is worthy of further study. While environmental factors, including social factors, likely play a central role, genetic factors may also be important in the interplay between rheumatogenic bacteria and the host immune system that leads to the aberrant autoimmune response.¹⁸ The basis of this susceptibility has yet to be clarified, and studies are needed to elucidate genetic markers for ARF/RHD.^{19,20} A case control study in New Caledonia is currently underway to identify cultural, social, economic and environmental risk factors for RHD.

Echocardiographic screening of individuals appears to detect more cases of RHD than auscultation for murmurs.²¹ According to a study in Cambodia and Mozambique, approximately 90% of RHD cases detected by echocardiographic screening were clinically silent, without audible murmurs.⁵ Echocardiographic screening can therefore detect approximately 10 times as many cases as clinical screening in school-age children. However, the high sensitivity of echocardiography needs to be balanced against the uncertainty around its specificity – that is, there is currently no evidence base that allows us to be certain whether very subtle changes in the echocardiogram truly represent pathology.²² There is a need for standardisation of echocardiography readings to ensure consistency. To determine echocardiographic diagnostic criteria for RHD, collaboration between cardiologists, public health professionals and epidemiologists is needed; this would improve diagnosis and therefore enable us to more accurately estimate the burden of RHD. A Web-based interface allowing cardiologists to share screening echocardiograms and compare interpretations with the aim of making echo reading as objective as possible could expedite standardisation of the diagnostic criteria.²⁰ To this end, in March 2011, an inter-

national panel of experts from 19 high-RHD prevalence countries developed evidence-based standardised criteria for the diagnosis of RHD by echocardiogram.^{23,24}

Detecting early RHD by echocardiographic screening, combined with register-based delivery of secondary penicillin prophylaxis, has the potential to reduce the prevalence of RHD. In New Caledonia, few data are available on the proportion of scheduled penicillin injections that are actually delivered, and the determinants of adherence are not documented. Moreover, this major challenge of adherence requires a focus on education and especially support at the primary care level to ensure high levels of adherence to prophylaxis.

Our study provides important baseline data for both New Caledonia and the Pacific region, and adds to the growing evidence base worldwide that has shown that RHD is an important cause of morbidity and mortality in tropical countries.^{1,4} There are other important potential data sources that can be used to add to the epidemiologic picture in New Caledonia. RHD register data in New Caledonia may be used for further studies to track the mortality, morbidity and severity of ARF and RHD.²⁰ In addition to register-based data, hospital and mortality data may be useful in better understanding the extent of the problem. This study also highlights issues for further research, which should closely monitor the ethnic differences and examine possible causes for these disparities.

Clearly, a local (and indeed Pacific regional) strategy is paramount in efforts to control RHD, and this strategy should include a register-based secondary prevention programme, school-based RHD screening and the capacity for further research. Since 2007, efforts in New Caledonia have grown. Collaboration in research programmes between Pacific countries is essential to help bring about a regional solution to the disease. We believe that control of ARF and RHD should be a social and public health priority.

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Participation of Authors

Designed, conducted and performed the screening: BR, BH, JMM, AG. Analysed the data: NB, BR, EDO. Wrote the paper: NB, EDO. Reviewed the manuscript: NB, EDO, BR, BH, AG, JMM.

References

- Carapetis JR, Steer AC, Mulholland EK, Weber M. The global burden of group A streptococcal diseases. *Lancet Infect. Dis.* 2005; **5**: 685–94.
- World Health Organization. *The Current Evidence for the Burden of Group A Streptococcal Diseases*. Geneva, Switzerland: World Health Organization, 2005. WHO/FCH/CAH/05.07; WHO/IVB/05.12.
- Steer AC, Carapetis JR, Nolan TM, Shann F. Systematic review of rheumatic heart disease prevalence in children in developing countries: The role of environmental factors. *J. Paediatr. Child Health.* 2002; **38**: 229–34.
- Seckeler MD, Hoke TR. The worldwide epidemiology of acute rheumatic fever and rheumatic heart disease. *Clin. Epidemiol.* 2011; **3**: 67–84.
- Marijon E, Ou P, Celermajer DS *et al.* Prevalence of rheumatic heart disease detected by echocardiographic screening. *N. Engl. J. Med.* 2007; **357**: 470–6.
- Steer AC, Kado J, Wilson N *et al.* High prevalence of rheumatic heart disease by clinical and echocardiographic screening among children in Fiji. *J. Heart Valve Dis.* 2009; **18**: 327–35, discussion 36.
- Carapetis JR, Hardy M, Fakakovikaetau T *et al.* Evaluation of a screening protocol using auscultation and portable echocardiography to detect asymptomatic rheumatic heart disease in Tongan schoolchildren. *Nat. Clin. Pract. Cardiovasc. Med.* 2008; **5**: 411–7.
- Parnaby MG, Carapetis JR. Rheumatic fever in indigenous Australian children. *J. Paediatr. Child Health.* 2010; **46**: 527–33.
- Reeves BM, Kado J, Brook M. High prevalence of rheumatic heart disease in Fiji detected by echocardiography screening. *J. Paediatr. Child Health.* 2011; **47**: 473–8.
- White H, Walsh W, Brown A *et al.* Rheumatic heart disease in indigenous populations. *Heart Lung Circ.* 2010; **19**: 273–81.
- Jaine R, Baker M, Venugopal K. Epidemiology of acute rheumatic fever in New Zealand 1996–2005. *J. Paediatr. Child Health.* 2008; **44**: 564–71.
- Garraud O, Ribiere O, Dussarat GV, Plassart H, Moreau JP, Bach JF. Acute rheumatic fever in New Caledonia. Clinical and epidemiological aspects. *Presse Med.* 1986; **15**: 2047–50.
- Le Hello S, Doloy A, Baumann F *et al.* Clinical and microbial characteristics of invasive *Streptococcus pyogenes* disease in New Caledonia, a region in Oceania with a high incidence of acute rheumatic fever. *J. Clin. Microbiol.* 2010; **48**: 526–30.
- Anabwani GM, Bonhoeffer P. Prevalence of heart disease in school children in rural Kenya using colour-flow echocardiography. *East Afr. Med. J.* 1996; **73**: 215–7.
- World Health Organization. *Rheumatic Fever and Rheumatic Heart Disease: Report of a WHO Expert Consultation, Geneva, 29 October–1 November 2001*. Geneva, Switzerland: World Health Organization, 2004.
- Colquhoun SM, Carapetis JR, Kado JH, Steer AC. Rheumatic heart disease and its control in the Pacific. *Expert Rev. Cardiovasc. Ther.* 2009; **7**: 1517–24.
- Steer AC, Kado J, Jenney AW *et al.* Acute rheumatic fever and rheumatic heart disease in Fiji: Prospective surveillance, 2005–2007. *Med. J. Aust.* 2009; **190**: 133–5.
- Bryant PA, Robins-Browne R, Carapetis JR, Curtis N. Some of the people, some of the time: Susceptibility to acute rheumatic fever. *Circulation* 2009; **119**: 742–53.
- Stollerman GH. Rheumatic fever in the 21st century. *Clin. Infect. Dis.* 2001; **33**: 806–14.
- Carapetis JR, Zuhlke LJ. Global research priorities in rheumatic fever and rheumatic heart disease. *Ann. Pediatr. Cardiol.* 2011; **4**: 4–12.
- Barnes SS, Sim J, Marrone JR *et al.* Echocardiographic screening of schoolchildren in American Samoa to detect rheumatic heart disease: A feasibility study. *Pediatr. Health Med. Ther.* 2011; **2**: 21–3.
- Webb R, Wilson NJ, Lennon D. Rheumatic heart disease detected by echocardiographic screening. *N. Engl. J. Med.* 2007; **357**: 2088, author reply 9.
- World Heart Federation. *Consensus Reached on Diagnosis of RHD in Developing Countries*. 2011. Available from: <http://www.world-heart-federation.org/press/news/detail/article/consensus-reached-on-diagnosis-of-rhd-in-developing-countries> [accessed 5 January 2012].
- Remenyi B, Wilson N, Steer A *et al.* World Heart Federation criteria for echocardiographic diagnosis of rheumatic heart disease – An evidence-based guideline. *Nat. Rev. Cardiol.* 2012; **9**: 297–309.