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Incidence of Acute Rheumatic Fever in New Zealand Children and Youth

Original article

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What is already known on this topic:

Acute rheumatic fever (ARF) in New Zealand is concentrated by age group (5 to 14-year-olds), ethnicity (Māori and Pacific children) and geographical area (upper North Island).

What this paper adds:

1. ARF incidence rates for Māori and Pacific 5-14 year olds have increased substantially since 1993 while nonMāori/Pacific rates have declined.
2. ARF is highly correlated with socioeconomic deprivation: 70% of school aged ARF occurred in the most deprived quintile.
3. Māori and Pacific children carry 95% of ARF cases, making ARF very uncommon in the South Island.

Abstract [244 words]

Aim

To estimate acute rheumatic fever (ARF) incidence rates for New Zealand children and youth by ethnicity, socioeconomic deprivation and region.

Methods

National hospital admissions with a principal diagnosis of ARF (ICD9_AM 390-392; ICD10-AM I00-I02) were obtained from routine statistics and stratified by age, ethnicity, socioeconomic deprivation index (NZDep2006) and District Health Board (DHB).

Results

The mean incidence rate for ARF in 2000-2009 peaked at 9 to 12 years of age. Incidence rates for children 5 to 14 years of age for Māori were 40.2 (95%CI 36.8, 43.8), Pacific 81.2 (73.4, 89.6), nonMāori/Pacific 2.1 (1.6, 2.6) and all children 17.2 (16.1, 18.3) per 100,000. Māori and Pacific incidence rates increased by 79% and 73% in 1993-2009 while nonMāori/Pacific rates declined by 71%. Overall rates increased by 59%.

In 2000-2009, Māori and Pacific children comprised 30% of children 5-14 years of age but accounted for 95% of new cases. Almost 90% of index cases of ARF were in the highest 5 deciles of socioeconomic deprivation and 70% were in the most deprived quintile. A child living in the most deprived decile has about 1 in 150 risk of being admitted to hospital for ARF by 15 years of age. Ten DHBs containing 76% of the population 5 to 14 years of age accounted for 94% of index cases of ARF.

Conclusions

ARF with its attendant RHD is an increasing public health issue for disadvantaged North Island communities with high concentrations of Māori and/or Pacific families.

Key words

Rheumatic fever; incidence; ethnicity; socioeconomic status; New Zealand; District Health Board

Acute rheumatic fever (ARF) is an inflammatory disease which can develop after a sore throat with pharyngitis caused by group A *streptococcus* bacteria (GAS; *Streptococcus pyogenes*). The severe sequel, rheumatic heart disease (RHD), is a preventable chronic disease (1, 2). Chronic RHD can lead to infective endocarditis (3, 4); atrial fibrillation (4, 5) which is a risk factor for ischaemic stroke; mitral stenosis in adult life (4); and progression to left ventricular enlargement followed by heart failure (6). All these conditions are potentially fatal. ARF has largely disappeared from the developed world (1).

Secondary prevention of ARF recurrences has been largely successful in New Zealand since initiatives in the 1980s (7, 8) but new cases of ARF continue to occur. Current incidence rates for Māori and Pacific children are comparable to rates for non Māori in the 1920s (9).

Primary prevention of rheumatic fever has been reviewed as part of the development of evidence-based best practice guidelines (10, 11) and a school intervention has been trialled as an alternative method of primary care delivery (12). The guidelines recommend primary prevention for primary and intermediate school children with annual ARF incidence rates >50 per 100,000.

Several vaccine candidates against GAS infection are in varying stages of preclinical and clinical development but only one has entered clinical trials in the last 30 years. There remains an urgent need to institute available public health control measures against GAS diseases (13). This will require targetting.

A recent study reported that ARF is intensely concentrated by age group (5 to 14-year-olds), ethnicity (indigenous Māori and immigrant Pacific peoples) and geographical area (upper North

Island). Males and females are almost equally affected. (14) Dependence on socioeconomic status was not reported.

The purpose of this study was to estimate ARF incidence rates in more detail, with a focus on primary and intermediate school age children (about 5 to 14 years of age), in order to inform targetting of a primary community intervention for school age children such as sore throat clinics and/or an immunisation programme.

Methods

Data sources, coding and prioritised ethnicity

Hospital admissions with a principal diagnosis of ARF (ICD9_AM 390-392; ICD10-AM I00-I02) for January 1993 to December 2009 were obtained from the National Minimum Data Set (NMDS). Admissions were stratified by primary diagnosis, 5-year age group, prioritised ethnicity and District Health Board (DHB). The NMDS records up to 3 ethnic groups for each patient. Multiple ethnic groups were prioritised using the following hierarchy: Māori, Pacific, nonMāori/Pacific (comprising European, Asian and other categories). Population denominators were obtained from Statistics NZ.

Admissions for nonresidents including children from Pacific Islands who were referred to New Zealand for treatment (16/1792 = 0.9% of index admissions), were excluded from the analysis.

NZDep index and school decile rating

The NZDep index (15) is a small geographical area-based index of socioeconomic deprivation calculated from each five-yearly census based on the following variables: income, employment,

communication, transportation support, educational and other qualifications, home ownership and household crowding. It is arranged in deciles, with '1' representing the least disadvantaged and '10' representing the most disadvantaged. Individuals were assigned a domicile code based on their home address at the time of admission, which was then mapped to the index for 2006 (NZDep2006).

Incidence rates and risk

Age specific ARF incidence rates were calculated using index admissions by principal diagnosis (ICD9-AM 390-392 or ICD10-AM I00-I02) as the numerator and 1996, 2001 and 2006 census data with prioritised ethnicity as the denominator, with linear interpolation to estimate denominators in the non census years.

Admissions for individuals with a prior admission for ARF or RHD in the period January 1, 1988 (when use of a unique National Health Index became universal) to December 31, 1992 were excluded to reduce the risk of counting a recurrent admission as an index admission. First ARF admissions that were preceded by an admission for RHD were also excluded from incidence rates because these are likely to be recurrent admissions following a prior episode of ARF that either was not reported as ARF or occurred prior to 1993. Cumulative risk of ARF is defined as the probability of having had an attack of rheumatic fever by a certain age, expressed as a decimal (e.g. 0.01) or its reciprocal (1 in 100). The cumulative risk was estimated in 5-year age groups from the incidence rates (16).

Data analysis

A Poisson regression model was applied to the incidence data, including ethnicity, age, and year to establish secular trends. Confidence limits on incidence rates and rate ratios were estimated assuming Poisson distributions (16). Epidemiological and statistical analyses were conducted using SAS version 9.2 (SAS Institute Inc, USA; www.sas.com/).

Results

Secular trends in incidence rates, by ethnic group

Most index ARF cases occur in children 5 to 14 years of age (14). In the period 1993-2009 there were 1552 index admissions for ARF (ICD9-AM 390-392; ICD10-AM I00-I029) in this age group. Annual index cases for Māori and Pacific children increased over this period while index cases for NonMāori/Pacific children declined (Figure 1A). Accordingly, incidence rates increased by 79% and 73% for Māori and Pacific children respectively and declined by 71% for NonMāori/Pacific categories, with an overall increase of 59% (Figure 1B). Secular trends in incidence rates were all statistically significant ($p < 0.0001$) and there was a substantial variation between ethnic groups in these secular trends ($p < 0.0001$) but an interaction between ethnicity and age was not statistically significant ($p = 0.49$).

[Figure 1 near here]

During 1993-2009 the ethnic disparity for Māori and Pacific children compared to NonMāori/Pacific children widened both in relative terms (the ratio of incidence rates) and in absolute terms (the difference in incidence rates)[Table 1].

[Table 1 near here]

Impact of age and ethnicity on incidence rates

In the last decade there were 1225 index admissions for ARF for individuals less than 25 years of age including 1007 admissions for children 5 to 14 years of age (Figure 2A). The mean incidence rate for ARF peaked at 9 to 12 years of age and was relatively low for preschool children and older adolescents (Figure 2B). Incidence rates in 2000-2009 for children 5 to 14 years of age were about 20-fold higher for Māori children and 40-fold higher for Pacific children in this age group compared to nonMāori/Pacific categories (Table 2).

[Figure 2 near here]

[Table 2 near here]

Heart involvement

Admissions for acute rheumatic fever are reported 'with heart involvement' (ICD9 391 or 392.0; ICD10 I01 or I020) or 'without mention of heart involvement' (ICD9 390 or 392.9; ICD10 I00, I029). Although the incidence of ARF for those recorded as 'without mention of heart involvement' remained stable over the period 1993 to 2009, the incidence rate for those recorded as 'ARF with heart involvement' increased over the same period and the proportion of index admissions with known heart involvement increased from 32% to 54% (Figure 3).

[Figure 3 near here]

Impact of socioeconomic deprivation on incidence rates

Māori and Pacific children 5-14 years of age accounted for 92% of new cases of ARF in the period 2000-2009 and comprised 30% of children in the 2006 census. Pacific and Māori children 5 to 14 years of age jointly comprised 71% of same-age children in areas with the most socioeconomic deprivation (decile 10) but only 8.4% of same-age children in areas with the lowest socioeconomic deprivation (decile 1).

Over 2000-2009, incidence rates for ARF increased steeply with the degree of socioeconomic deprivation, with most index admissions occurring in NZDep2006 deciles 8 to 10 across all age groups of children and youth (Figure 4A). Incidence rates for Māori and Pacific children 5-14 years of age were greater than 50 per 100,000 for decile 10 and deciles 7-10 respectively and rates for Pacific children ranged from 50 per 100,000 upwards across deciles 7 to 10, reaching 109 per 100,000 (>1 per 1000) in decile 10 (Figure 4B).

[Figure 4 near here]

Almost 90% of index cases of ARF for children 5 to 14 years of age in the period 2000-2009 were in the highest five NZDep2006 deciles and 48% were in decile 10. Deciles 9 and 10 regions together accounted for 70% of index admissions in this age group, at a mean incidence rate of 51 per 100,000, which is about that recommended as a primary prevention threshold by the NZARF guidelines (17). This group comprised just 23% of the population in this age group, showing that cases of ARF are concentrated in areas of high socioeconomic deprivation.

For decile 10 Pacific children the annual incidence rate reached 109 per 100,000 (> 1 per 1000). For deciles 9/10 Māori and Pacific children 5 to 14 years of age the incidence rates were 64.9 and 96.0 respectively, or 75.6 per 100,000 combined.

The cumulative risk (16) of ARF reaches 0.0035 for decile 9 children and 0.0066 for decile 10 children (1 in 287 and 1 in 152 respectively) by 15 years of age then increases slightly (Table 3). Therefore a child who lives in a region of high socioeconomic disadvantage (NZDep2006 decile 10) has about 1 in 150 risk of being admitted to hospital for ARF by 15 years of age.

[Table 3 near here]

ARF incidence by District Health Board and ethnicity

The incidence of ARF depends on the region and on ethnicity (Table 4). In 2000-2009 Counties Manukau DHB in south Auckland, which has a high concentration of Māori and Pacific families, had the highest mean annual incidence rate (93.9 per 100,000) and contributed 298/700 cases (43%). Five DHBs had incidence rates that were over the recommended treatment threshold of 50 per 100,000 (10, 17). Ten 10 North Island DHBs containing 76% of the NZ population 5 to 14 years of age accounted for 94% of index cases of ARF in this age group. . Māori and Pacific children jointly accounted for 95% of all cases. In the DHB with the highest incidence (Counties Manukau), 99% of index cases were of Māori or Pacific ethnicity.

Discussion

This study shows that the incidence of ARF in New Zealand, as determined from hospital admissions in 2000-2009, peaked at 9 to 12 years of age. Incidence rates for Māori and Pacific children were about 20-fold and 40-fold higher than those for nonMāori/Pacific children, although Māori and Pacific children comprise 30% of NZ's 5-14 year olds. For this age group, the average annual incidence rate across all ethnic groups over the period 2000-2009 was 17.2 per 100,000 (95%CI 16.1, 18.2). Mean rates in 2000-2009 were greater than the suggested NZ Guidelines threshold for intervention (50 per 100,000) for Pacific children in deprivation deciles 7 to 10 regions and for Māori children in decile 10 regions.

Incidence rates for Pacific and Māori children 5 to 14 years of age have increased by more than 70% since 1993 while rates have declined by about 70% for nonMāori/Pacific children. A previous study reported an increase in age adjusted incidence rates for Māori and a decline for nonMāori/Pacific in the period 1995-2006 (14). This study also reported a 10-fold incidence rate ratio for Māori and a 21-fold ratio for Pacific peoples compared to nonMāori/Pacific. These ratios are about half those observed in our study, implying that the ethnic disparity is diluted at higher ages. Another earlier study of rheumatic fever registers in NZ in 1995-2000 reported incidence rates for children 5-14 years of age that were about 20% lower than we observed for Pacific and Māori children (64.5 and 31.9 per 100,000 respectively). This is consistent with an increase in Pacific and Māori rates since 1993. Historically (1918-1927) ARF rates of the predominantly non Māori school population of Auckland city were similar (65/100,000) to rates reported in this report for Māori and Pacific school children into the 21st century (9).

ARF index cases are distributed unevenly around the country. The North Island, with 78% of the population 5 to 14 years of age, where high concentrations of Māori and Pacific children reside, carries 98% of ARF cases. In addition, almost 90% of index cases of ARF in the current study were in the highest 5 deciles of socioeconomic deprivation and almost half were in the most deprived decile. A child living in one of the poorest regions (NZDep2006 decile 10) has about 1 in 150 risk of being admitted to hospital for ARF by 15 years of age. Currently therefore, ARF and RHD are increasing public health issues for poorer North Island communities with high proportions of Māori and/or Pacific families.

The finding of increasing proportions of carditis in this hospitalized population might have been due partly to increased availability and/or evolving interpretation of echocardiography. In particular, children who present with chorea and especially polyarthritis who fulfill the Jones criteria but who do not have an audible heart murmur are considered by clinicians to be able to be more confidently diagnosed with ARF if they have characteristic echocardiographic evidence

of cardiac mitral or aortic regurgitation. In NZ, in the presence of raised streptococcal titres, inflammatory markers and other conventional criteria used by Jones and colleagues, carditis detected only by echocardiography is now eligible as a major criterion (17). However, this cannot explain our finding because in the NZ school study, with independent scrutiny of consecutive ARF cases, carditis as a major criterion detected solely by echocardiography was necessary for diagnosis in only 5% of cases (12). In addition, hospitalisation for ARF requires recognition of symptoms by family and GP, access to primary care, and an understanding by the GP that a case of ARF needs hospitalisation for diagnosis. These factors could have changed over the study period.

Lack of progress since 1993 in the control of ARF for Māori and Pacific peoples appears to be linked to socioeconomic disparity. The NZDep score (15) is a proxy for socioeconomic status, made up of variables including income, access to telephone and transport, and housing status. Household crowding was a major risk factor for epidemic serogroup B meningococcal disease in New Zealand during the 1990s (18). An ecological study based on first hospital admissions for ARF for the 10-year period 1996 to 2005 reported that ARF incidence rates in New Zealand are associated with household crowding at the neighbourhood level. The incidence of ARF at Census Area Unit level was significantly associated with the proportion of crowded households, even after controlling for age, ethnicity, household income and the density of children in the area (19). A recent NZ paper evaluating improved social housing demonstrated a 27% reduction in hospitalisations related to housing in 5-34 year olds (20). This includes ARF, which is preceded by untreated or inadequately treated group A streptococcal pharyngitis. Access to health care for Māori and Pacific has been documented many times as inadequate (11).

NZ schools are rated by decile, with the lowest decile schools representing the most disadvantaged communities. Based on an Auckland Register of ARF cases, which (unlike the NMDS) contains information about school attended, there is a strong correlation between the

numbers of incident cases in regions of high socioeconomic deprivation and incident cases in schools with low decile ratings (personal communication, Catherine Jackson). This finding suggests that interventions targetted to decile 1 and 2 schools have the potential to prevent most of the ARF cases.

Rheumatic fever with its attendant RHD has for many decades been considered a preventable disease (21-23). Other countries much poorer than NZ, including those in the French Caribbean and Costa Rica, have controlled ARF and RHD (11). A randomised clinical trial of sore throat clinics in high risk schools was conducted in Auckland from February 1998 to December 2001 (12). When combined into a meta-analysis of community interventions, the findings were highly supportive of a school/community intervention with a relative risk of 0.41 (95% CI 0.23 - 0.70) suggesting potentially a 60% reduction in ARF. In this meta-analysis the study from Baltimore USA showed a 60% reduction with the instigation of community clinics for primary care. There was no particular initiative for secondary penicillin prophylaxis to prevent recurrent attacks (24). The model most advanced in NZ is a school-based clinic approach targetted to children of primary and intermediate age (12) (25).

Worsening child well-being as measured by the UNICEF index has been linked by some authors to increasing income inequalities (26). Rheumatic fever in NZ seems to be an important indicator of total well-being, particularly as it is a carefully diagnosed and reported entity with accurate data over time (27). In conclusion, rheumatic fever is an increasing public health issue for NZ with the burden falling on disadvantaged North Island communities with high concentrations of Māori and/or Pacific families.

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Chris Lewis and Simon Ross at NZ Health Information Services provided searches of hospital admissions (the National Minimum Dataset) and deaths from the National Mortality Collection. Trish Morant at Statistics NZ provided demographic information and Andrew Wooding at Auckland City Hospital provided advice on coding. The authors thank Catherine Jackson for information relating school deciles to socioeconomic deprivation and Ross Nicholson and Michael Baker for helpful discussion.

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Figure legends

Figure 1. Annual index cases and incidence rates for acute rheumatic fever in 1993-2009 for children 5 to 14 years of age.

Figure 2. National ARF index cases 2000-2009 (A) and mean incidence rates with 95% confidence intervals by age group (B).

Figure 3. ARF incidence rates by known heart involvement for children 5-14y of age.

Figure 4. ARF incidence rates by socioeconomic deprivation and age (A) and for children 5-14 years of age, by ethnicity (B) [mean of 2000-2009].

Table 1. Changes in ethnic disparity over time for children 5 to 14 years of age during the period 1993-2009^a

	Incidence rate ratio ^b		Incidence rate difference per 100,000 per year ^c	
	1993	2009	1993	2009
Māori	5.8	36.3	21.2	44.5
Pacific	11.7	72.0	47.0	89.7

^a Based on linear regression of incidence rates on year

^b Incidence rate of Māori or Pacific children divided by that for NonMāori/Pacific children

^c Difference in incidence rates between Māori or Pacific compared to NonMāori/Pacific

Table 2. ARF incidence rates for New Zealand children 5 to 14 years of age (2000-2009)

	Māori	Pacific	NonMāori/Pacific	Total	Rate ratio ^a	
					Māori	Pacific
Mean	40.2	81.2	2.1	17.2	19.5	39.3
-95%CI	36.8	73.4	1.6	16.1	15.5	31.3
+95%CI	43.8	89.6	2.5	18.2	24.5	49.8

^a Compared to nonMāori/Pacific

Table 3. Incidence and cumulative risk of ARF for children and young people living in regions of high socioeconomic deprivation

Age group (y)	Mean annual incidence rate per 100,000		Cumulative risk	
	NZDep2006 decile		NZDep2006 decile	
	Decile 9	Decile 10	Decile 9	Decile 10
<5	1.3	1.9	0.0001	0.0001
5-9	29.0	52.9	0.0015	0.0027
10-14	39.5	77.2	0.0035	0.0066
15-19	6.5	14.9	0.0038	0.0073
20-24	1.9	3.9	0.0039	0.0075
5-14	34.3	65.0	Na	Na

Na = not applicable

Table 4. Index ARF cases and incidence rates for deciles 9 &10 children aged 5-14y, by District Health Board

DHB ^a	Index ARF cases in 2000-2009				Mean annual incidence per 100,000			
	Māori	Pacific	Non Māori/ Pacific	Total	Māori	Pacific	Non Māori/ Pacific	Total
Counties Manukau	111	183	4	298	115.8	121.6	5.6	93.9
Northland	62	1	4	67	99.7	48.3	13.6	71.5
Capital and Coast	9	23	3	35	50.9	102.2	16.1	59.5
Auckland ^b	13	49	5	67	58.3	86.8	12.1	55.7
Bay of Plenty	39	3	5	47	63.7	147.1	17.8	51.5
Tairāwhiti	19	1	1	21	60.5	85.5	11.7	51.0
Hawke's Bay	27	7	3	37	60.9	107.5	12.2	49.0
Lakes	19	5	1	25	50.5	196.1	6.6	45.2
Waikato	43	3	4	50	60.4	36.6	7.3	37.2
Midcentral	10	2	0	12	43.2	51.7	0.0	22.7
Remaining 11 ^c	20	14	7	41	18.8	29.6	3.9	12.4
Total	372	291	37	700	64.9	96.0	7.5	51.0
Top 10 DHBs	332	278	28	638	75.1	104.1	8.7	61.9
% total cases ^d	95%	95%	81%	94%	Na	Na	Na	Na
% population ^e	81%	84%	64%	76%	Na	Na	Na	Na

CCDHB = Capital and Coast DHB; CMDHB = Counties Manukau DHB; DHB = District Health Board; Na = not applicable

^a Sorted by total incidence rate

^b Waitemata patients were also hospitalised at Auckland hospital (ADHB)

^c Includes 5 North Island and all 6 South Island DHBs

^d Percentage of all index cases occurring in the top10 DHBs

^e Percentage of NZ population 5-14 years of age

Figure 1. Annual index cases and incidence rates for acute rheumatic fever in 1993-2009 for children 5 to 14 years of age.

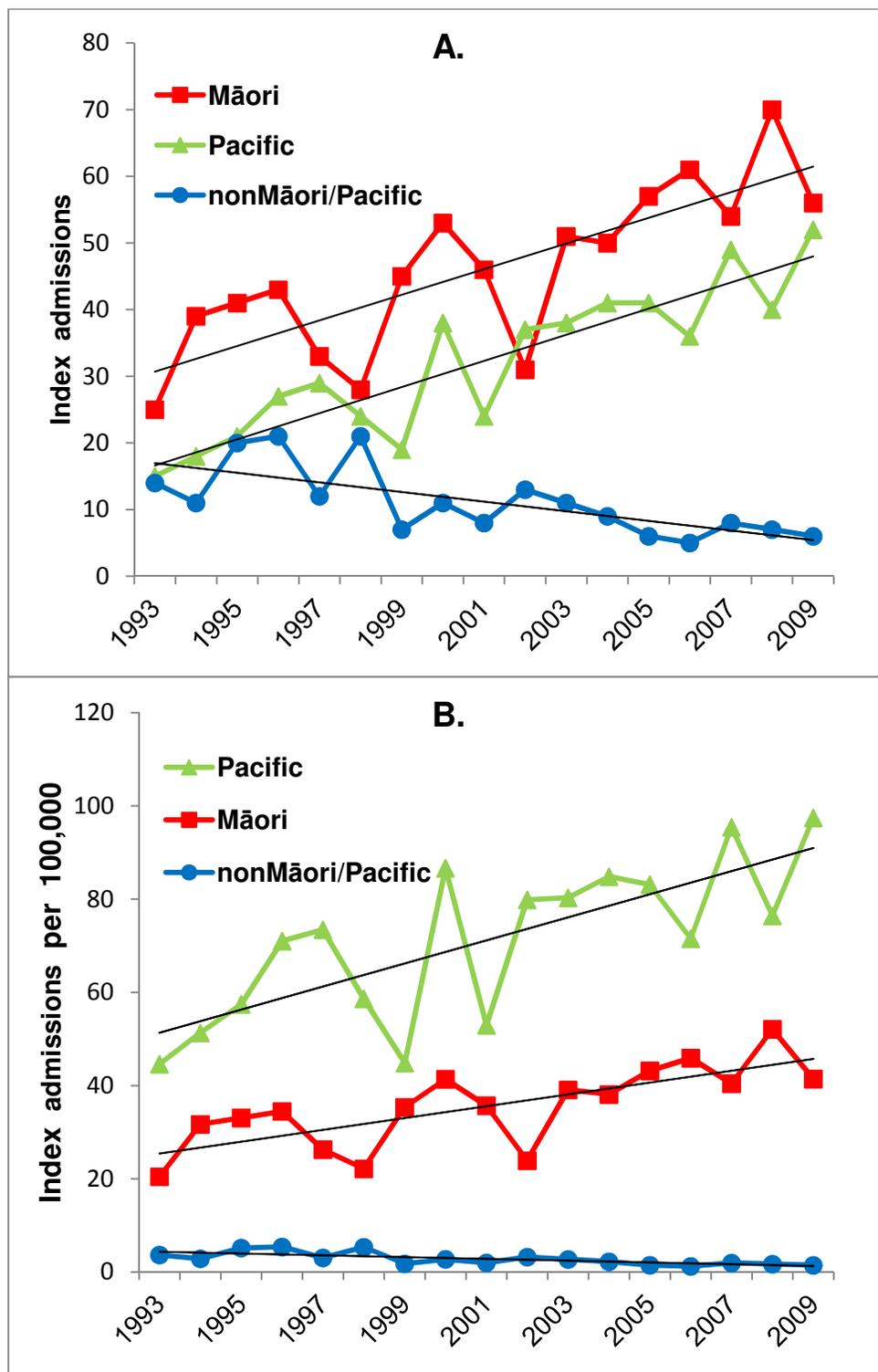


Figure 2. National ARF index cases 2000-2009 (A) and mean incidence rates with 95% confidence intervals by age group (B).

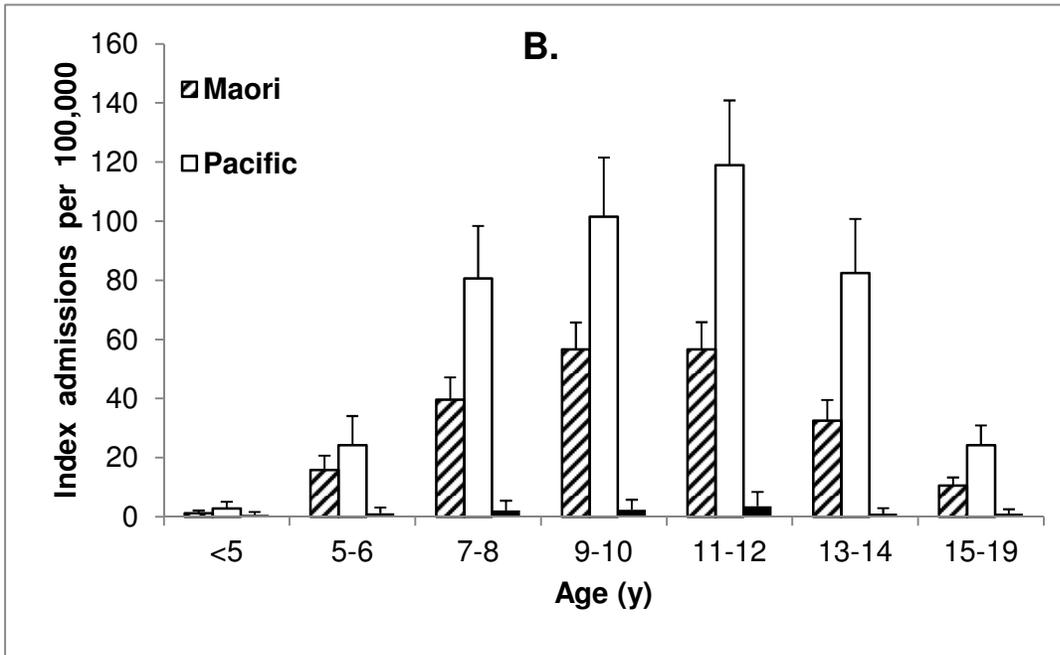
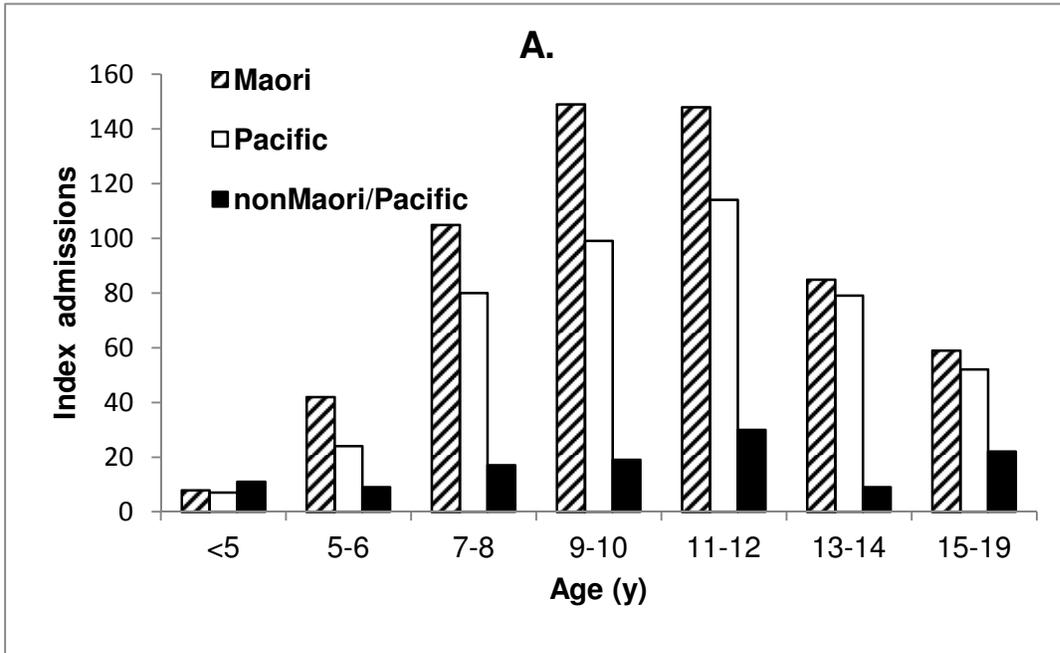


Figure 3. ARF incidence rates by known heart involvement for children 5-14y of age.

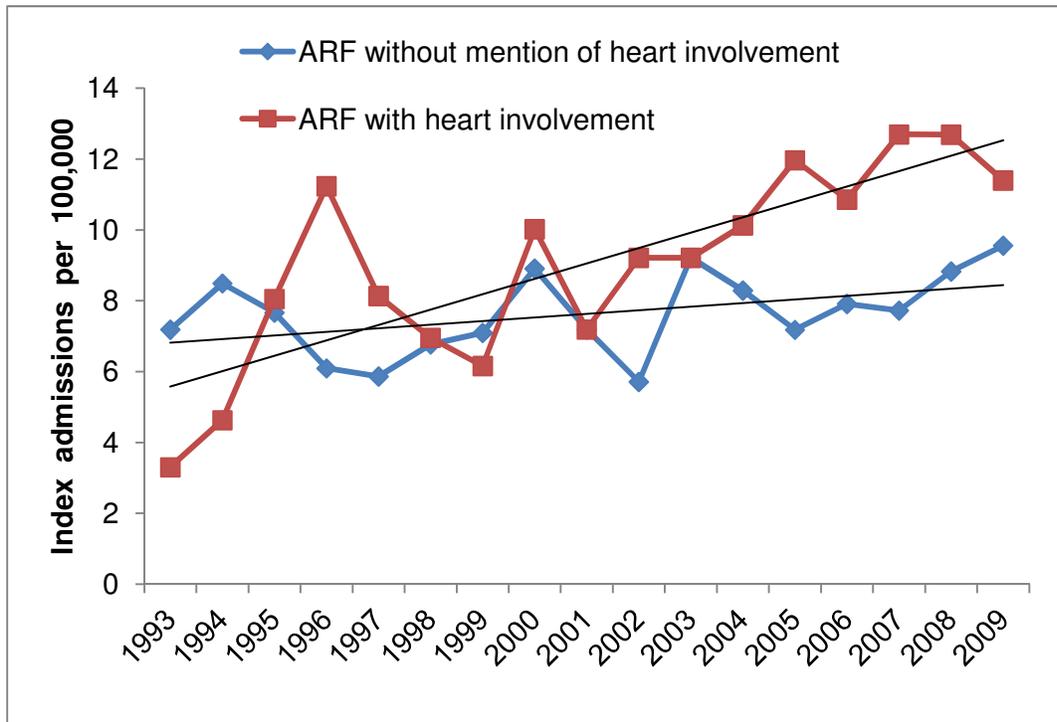


Figure 4. ARF incidence rates by socioeconomic deprivation and age (A) and for children 5-14 years of age, by ethnicity (B) [mean of 2000-2009].

