University of Auckland Research Repository, ResearchSpace

Version

This is the Accepted Manuscript version. This version is defined in the NISO recommended practice RP-8-2008 http://www.niso.org/publications/rp/

Suggested Reference


Copyright

Items in ResearchSpace are protected by copyright, with all rights reserved, unless otherwise indicated. Previously published items are made available in accordance with the copyright policy of the publisher.

This is the peer reviewed version of the article above which has been published in final form at 10.1111/j.1440-1754.2012.02446.x

This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for self-archiving.

For more information, see General copyright, Publisher copyright, SHERPA/RoMEO.
Mortality and Hospitalisation Costs of Rheumatic Fever and Rheumatic Heart Disease in New Zealand

Original article

Richard J. Milne$^{1,2}$, Diana Lennon$^3$, Joanna Stewart$^1$, Stephen Vander Hoorn$^4$, Paul A. Scuffham$^5$

1 School of Population Health, University of Auckland
2 Health Outcomes Associates Ltd, Auckland
3 Department of Community Paediatrics, University of Auckland
4 Department of Statistics, University of Auckland*
5 School of Medicine, Griffith University, Brisbane, Australia

*Current address: University of Melbourne

Accepted by J. Pediatrics and Child Health, 2011

2593 words excluding abstract, tables, figures and references.

Running head: Mortality and costs of RHD

Corresponding author: Dr. Richard Milne, Section of Epidemiology and Biostatistics, School of Population Health, University of Auckland, Private Bag 92019, Auckland 1142

rj.milne@auckland.ac.nz

Telephone: +64 9 575-9137
Fax: +64 9 373-7503
What is already known on this topic:

1. Acute rheumatic fever (ARF) generally leads to rheumatic heart disease (RHD) and in some cases costly cardiac valve surgery in childhood or mid life.
2. ARF is preventable.
3. Mortality from rheumatic heart disease is low in children.

What this paper adds:

1. Age adjusted RHD mortality rates are 5-10 times higher for Māori and Pacific peoples compared to the rest of the population.
2. The mean age at death from RHD (2000-2007) was 58 years for Māori, 56 years for Pacific and 80 years for nonMāori/Pacific.
3. Most of the hospital admission costs of ARF/RHD occur for individuals >30 years of age, with 72% of the cost due to valve surgery.
Abstract
241 words

Aims
To estimate the annual mortality and the cost of hospital admissions for acute rheumatic fever (ARF) and rheumatic heart disease (RHD) for New Zealand residents.

Methods
Hospital admissions in 2000-2009 with a principal diagnosis of ARF or RHD (ICD9_AM 390-398; ICD10-AM I00-I099) and deaths in 2000-2007 with RHD as the underlying cause were obtained from routine statistics. The cost of each admission was estimated by multiplying its diagnosis related group cost weight by the national price for financial year 2009/2010.

Results
There were on average 159 RHD deaths each year with a mean annual mortality rate of 4.4 per 100,000 (95%CL 4.2, 4.7). Age adjusted mortality was 5 to 10-fold higher for Māori and Pacific peoples than for nonMāori/Pacific. The mean age at RHD death (male/female) was 56.4/58.4 for Māori; 50.9/59.8 for Pacific; and 78.2/80.6 for nonMāori, nonPacific men and women.

The average annual DRG-based cost of hospital admissions in 2000-2009 for ARF and RHD across all age groups was $12.0m (95% CL $11.1m, $12.8m). Heart valve surgery accounted for 28% of admissions and 71% of the cost. For children 5-14 years of age, valve surgery accounted for 7% of admissions and 27% of the cost. Two thirds of the cost occurs after the age of 30.
**Conclusions**

ARF and RHD comprise a burden of mortality and hospital cost concentrated largely in middle age. Māori and Pacific RHD mortality rates are substantially higher than those of non-Māori/Pacific.
Acute rheumatic fever (ARF) in most cases leads to a preventable chronic disease, rheumatic heart disease (RHD) (1). The conditions associated with chronic RHD viz. infective endocarditis (2, 3); atrial fibrillation (3, 4) which is also a risk factor for ischaemic stroke; mitral stenosis (3); and progression to left ventricular enlargement followed by compensated or (eventually) uncompensated heart failure (5) can all lead to premature mortality. In a companion paper we report that the incidence of ARF in children and young people in New Zealand (NZ) has increased since 1993 and there is a large and increasing disparity between incidence rates for indigenous Māori and immigrant Pacific peoples compared to nonMāori/Pacific (European, Asian and other categories) (6).

An accurate and contemporary assessment of the disease burden of a potentially preventable disease such as ARF/RHD (7) is important for informing decisions on the use of scarce resources. Mortality rates for ARF in children have been estimated from incidence rates and case fatality ratios for 4 countries (8) but these exclude the major mortality burden of RHD, which occurs in middle age. Surprisingly, RHD mortality appears not to have been reported in detail in any country.

In NZ, public hospitals fully funded by the Government deliver most of the health care associated with ARF and its sequelae. An early study estimated the annual cost to Auckland hospitals at $NZ2.6m (1991 dollars). Almost half of this cost was for non surgical admissions for unspecified ‘RHD related conditions’ (9).

The aim of this study was to estimate the annual mortality and the costs to the NZ Government of hospital admissions for acute rheumatic fever (ARF) and rheumatic heart disease (RHD).
**Methods**

**Admissions and deaths**

Hospital admissions with a principal diagnosis of ARF or RHD (ICD9_AM 390-398; ICD10-AM I00-I099) for the period January 2000 to December 2009 were obtained from the National Minimum Data Set (NMDS). Admissions were stratified by primary diagnosis, 5-year age group and prioritised ethnicity. The NMDS records up to 3 ethnic groups for each patient. Multiple ethnic groups were prioritised using the following hierarchy: Māori, Pacific, nonMāori/Pacific. Admissions for non residents (domicile code 9999), including children from Pacific islands who were referred to New Zealand for treatment, were excluded from the analysis.

Deaths with an underlying cause (‘diagnosis D’) of RHD for the period January 2000 to December 2007 were obtained from the National Mortality Collection. Population denominators were taken from the NZ Census. There were no deaths coded as ARF.

Age specific RHD mortality rates using prioritised ethnicity were calculated using RHD deaths as the numerator and 1996, 2001 and 2006 census data with prioritised ethnicity (Statistics New Zealand) as the denominator, with linear interpolation to estimate denominators in the non census years. For comparison across international studies, average mortality rates for the period 2000-2007 were age adjusted to the WHO and SEGI standard populations (10) using the direct method (11). Age adjustment was also performed with the Māori and nonMāori/Pacific 2001 census populations as the standards, to facilitate comparisons within New Zealand (12).

**Admission costs**

Diagnosis related group (DRG)-based cost weights for all hospital admissions were obtained from the NMDS. The cost of each admission with a principal diagnosis of ARF or RHD in the
period 2000 to 2009 was estimated by multiplying its DRG cost weight by the national price for FY2009/2010 ($4318.48; NZHIS), bringing all costs to 2009/2010 values. Cases that were admitted to 2 hospitals on the same day (1.5% of all admissions) were costed as a single admission at the second hospital, because these are probably transfers between hospitals; however, multiple admissions for the same individual on different days at the same or different hospitals were costed separately. For admissions that spanned 2 calendar years, the cost was attributed to the year of admission.

Data analysis

Confidence intervals on mortality rates were estimated using Fisher’s exact method, and secular trends in mortality were tested using Poisson regression with population as offset. Epidemiological and statistical analyses were conducted using SAS version 9.2 (SAS Institute Inc, USA; www.sas.com).

Results

RHD mortality

There were no statistically significant changes in RHD mortality rates for any ethnic group in the period 2000-2007. There were 159 deaths on average each year coded with RHD as the underlying cause over the same period, with a mean mortality rate of 4.4 per 100,000 (Table 1). Over all age groups, although there were more nonMāori/Pacific RHD deaths, unadjusted (crude) mortality rates for Māori and Pacific people were almost double those of nonMāori/Pacific categories (Table 1).
Only 4 of these deaths were children and young people (age<20y) but RHD mortality increased in mid life, reaching 27.5 per 100,000 for Māori and 18.1 per 100,000 for Pacific peoples compared to 1.1 per 100,000 for nonMāori/Pacific categories at age 50-59 years (Figure 1). The mean age at death coded as RHD was substantially lower than life expectancy for Māori but not for nonMāori/Pacific peoples (Table 2).

Because Māori and Pacific populations have much higher proportions of younger people than nonMāori/Pacific categories, mortality was adjusted for the age structure (age standardised) by referencing each ethnic group to a standard population. The choice of standard population influences the standardised mortality ratio (SMR). (13) Therefore SMRs were calculated using the WHO standard population and the older SEGI standard population for comparisons with other countries (http://www.who.int/healthinfo/paper31.pdf) and also the Māori and the nonMāori/Pacific population as standards for comparisons within New Zealand (13).(Table 2). After adjusting for differences in age structures, Māori and Pacific people had 5 to 10-fold higher mortality from RHD than nonMāori/Pacific categories.

**Cost of admissions for ARF and RHD**

ARF can be costly, especially for children who immediately or subsequently require cardiac valve repair or replacement. However, most hospital admissions ensuing from childhood ARF occur after the age of 30, as cardiac valves deteriorate progressively over time and symptoms develop.

There were 7404 admissions in the period 2000-2009 with a principal diagnosis of ARF/RHD, with a peak for children 10 to 14 years of age and a smaller plateau from 45 to 79 years of age.
(Figure 2A). These admissions were roughly equally distributed across non surgical admissions, valve surgery and ‘other surgery or procedures’ (including 860 admissions for echocardiography; ICD9-AM procedure code 8872, mostly as day cases). Annual ARF/RHD admission rates were highest for school age children and the elderly. The average length of stay in different age groups varied from about 4 to 14 days for non surgical admissions and 8 to 30 days for valve surgery (not shown), plus day cases.

Most (71%) of the cost occurred for individuals 30 or more years of age. The estimated annual cost of hospital admissions with a principal diagnosis of ARF or RHD in the period 2000-2009 was $12.0m (95% CL $11.1m, $12.8m) in 2009/10 dollars (Figure 2B). Hospital admissions and the corresponding annual costs to the Government were highest in the age group 5 to 14 years and non surgical admissions accounted for well over half of this cost. Valve surgery comprised 7.1% of admissions and 28% of the cost for children 5-14 years of age but 27% of admissions and 72% of the cost across all age groups.

Discussion

To the best of our knowledge, this is the first country-wide report of the mortality and the cost burden of ARF and RHD. Most of the cost burden and nearly all the deaths from RHD occur after 30 years of age, when RHD has progressed and cardiac valve surgery is indicated.

For all age groups, mortality in the period 2000-2007 was considerably higher for both Māori and Pacific peoples than for nonMāori/Pacific (e.g. 24-fold higher for Pacific and 16-fold higher for Māori at age 50-59 years). After adjusting for differences in age structures, Māori and Pacific
peoples had 5 to 10-fold higher overall RHD mortality rates than the nonMāori/Pacific population.

The current pattern of RHD mortality and costs in mid life probably results from acute rheumatic fever occurring in childhood, whether or not it was diagnosed as such. In contrast to earlier reports (14, 15), ARF has almost completely disappeared from the nonMāori/Pacific population of New Zealand. Progression of RHD has been strongly associated with recurrences of ARF (1, 16), which have been reduced to low levels by a secondary prophylaxis programme that was introduced to NZ in the 1980s (1, 17, 18). High mortality and costs in middle age are likely to be the legacy of high ARF incidence rates in childhood (6) and absence of a secondary prophylaxis programme prior to 1980, both for indigenous Māori children and for Pacific children who immigrated to New Zealand in the 1970s and 1980s. Provided the existing programme of secondary prophylaxis is continued, the prevalence of rheumatic heart disease and its costs and mortality burden could be lower in the future than shown by the present analysis. On the other hand, some deaths from ischaemic stroke secondary to atrial fibrillation following rheumatic valvular disease could have been coded as stroke rather than RHD, leading to undercounting of deaths attributable to RHD. Rheumatic valvular disease was present in 45% of cardioembolic strokes recorded on a stroke registry in Iran (19). Some deaths coded as heart failure could also have been secondary to undiagnosed rheumatic valvular disease. A detailed analysis of medical records and death certificates would be required to estimate the impact of childhood ARF on mortality rates in more depth.

RHD mortality in middle age depends on the management of severe chronic RHD, in particular local policies on referral to mitral and/or aortic valve surgery. Many studies document early and late mortality after cardiac valve surgery (20-22) but most of these are not specific to RHD aetiology and there is little published information on mortality for patients with RHD who are not referred to surgery. The mortality rate in our study reflects management of chronic RHD in
earlier decades when echocardiography was unavailable and surgery was undertaken relatively late in the course of the disease, with a poorer prognosis. It may therefore overstate mortality in the future to an unknown extent.

The annual cost of admissions for ARF and RHD across all age groups is estimated conservatively at $NZ12.0m (95% CL $11.1m, $12.8m) [about $US10.4m]. This is similar to the annual cost of acute hospital admissions for paediatric pneumococcal disease including pneumococcal pneumonia plus pneumococcal and NTH/otitis media for the under 20 age group, which has been estimated recently at $NZ9.95m (in 2006/7 dollars) (23) and which translates to $13.6m at present value.

Although costs of ARF and RHD are high for school age children with severe RHD, two-thirds of the mean lifetime cost occurs after the age of 30 as cardiac valves degenerate and require surgical repair or replacement. Across all age groups, heart valve surgery accounted for 28% of admissions and 72% of the cost. For children 5 to 14 years of age, valve surgery accounted for 7% of admissions and 27% of the cost.

Children and young people (age <20 years) account for $2.87m (24%) of the annual cost of hospital admissions for ARF and RHD. For comparison, paediatric rotavirus gastroenteritis, which is less serious but far more prevalent than either rheumatic fever or pneumococcal disease, is estimated to cost the New Zealand Government about the same in hospital admissions each year ($2.89m in 2009 dollars). However, in contrast to ARF, the cost of rotavirus gastroenteritis is accrued largely by care of pre-school children (24) and there are few or no life-long sequelae.

The only other NZ study of the cost of ARF/RHD estimated the annual cost to Auckland hospitals at $2.6m (1991 dollars), using a top-down approach based on admissions in 1987. Almost half of the cost was for undefined non-surgical admissions for ‘RHD related conditions’
having a primary or secondary code of RHD (9). This is a more inclusive but less specific coding than in our study. It is difficult to compare the two studies because of the differences in coding, timing and specification of relevant costs in the previous study and the different populations. Also the mean length of stay for ARF in the previous study was much longer (47 days) and ARF recurrence rates were much higher than currently, therefore it is less relevant to today.

The main limitation of the present study is that the cost analysis was restricted to hospital admissions with a principal diagnosis of ARF or RHD. In adult patients, complications of RHD may be coded as the principal diagnosis; for example heart failure, stroke, atrial fibrillation or endocarditis. However, adjustment of medication, additional diagnostic procedures or changes in clinical care protocols because of comorbid RHD are not given a principal diagnosis code of RHD and were therefore excluded. In addition, some surgical procedures require a different level of care for children or adults with RHD (e.g. antibiotic prophylaxis). Also, most patients with dental caries and RHD are treated in hospital rather than the community; likewise, most antenatal care for women with RHD is obtained from a specialist obstetrician rather than a midwife. The extent to which admissions with a secondary code of ARF or RHD contribute to the cost burden of ARF or RHD is a case by case judgment call. Further research is needed to identify and quantify the indirect impact of RHD on other admissions, which could be considerable. Future research should also include outpatient clinic appointments; general practitioner consultations related to ARF/RHD; secondary prevention; community pharmaceuticals; costs to the family; and potential loss of income from premature death. It could also include nonresident children with RHD who are referred from Pacific islands.

For the reasons given above, our study is conservative in most respects. On the other hand, if more than one valve is documented as diseased in some way (stenosis, incompetence or regurgitation) and the cause is unspecified, RHD of multiple valves is coded by default, leading to possible overestimation of the cost of RHD (personal communication, Andrew Wooding).
DRG-based costings have intrinsic limitations. Although DRG cost weights are used nationally in research and policy making because they are applied reasonably uniformly across the country and across diagnoses, they are conservative because they exclude the costs of adjusters paid to DHBs for complexity of services; rural location; diseconomies of scale; Māori health; capital adjustment; acute demand; and blood. The costs reported in our study therefore should be used only as indicative costs for policy development.

ARF and RHD comprise a high burden of mortality in middle age, with striking ethnic disparities. The loss of young and middle age human potential becomes increasingly important as NZ society ages. Māori and Pacific individuals currently comprise 30% of the under 20s age group. The healthcare costs demonstrated across all age groups, particularly for Māori and Pacific New Zealanders, are avoidable as demonstrated by the changes in incidence rates over time for non-Māori/Pacific. Health literacy, health care access, housing and other factors are likely to be responsible for these striking differences (7). First attacks of ARF are preventable (7). School-based programmes are strongly supported and slowly being implemented (25). In addition, the role and cost effectiveness of echocardiographic screening for previously undetected RHD to avert more serious and costly RHD needs to be assessed, taking into account the currently unknown natural history of less severe echocardiographically diagnosed valve changes and the sensitivity, specificity and reproducibility of the screening test.

In conclusion, ARF and RHD comprise a high burden of mortality in middle age and a modest healthcare cost across all age groups, with striking inequalities between ethnic groups.

Acknowledgements

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.

This analysis was funded by the National Meningitis Trust and Rheumatic Fever Trust of New Zealand, the Lion Foundation, Health Outcomes Associates Ltd and the Ministry of Health. The authors thank Shirley Maihi for administering the Rheumatic Fever Trust and Richard Handley and Henare Mason for respectively setting up and administering the National Meningitis Trust and Rheumatic Fever Trust of New Zealand.
References


Figure legends

Figure 1. RHD deaths (A) and mean annual mortality rates (B) in 2000-2007 (with 95% confidence limits).

Figure 2. Estimated annual admissions (A) and cost to Government (B) for admissions for ARF or RHD (mean of 2000-2009)
Table 1. Mean annual deaths from rheumatic heart disease and unadjusted annual mortality rates, 2000-2007

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Mean</th>
<th>Lower 95% CL</th>
<th>Upper 95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual deaths</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>40</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>Pacific</td>
<td>15</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>nonMāori/Pacific</td>
<td>104</td>
<td>97</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>159</td>
<td>150</td>
<td>168</td>
</tr>
<tr>
<td><strong>Annual crude mortality rate (deaths per 100,000)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>7.3</td>
<td>6.5</td>
<td>8.1</td>
</tr>
<tr>
<td>Pacific</td>
<td>7.0</td>
<td>5.8</td>
<td>8.4</td>
</tr>
<tr>
<td>nonMāori/Pacific</td>
<td>3.7</td>
<td>3.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Total</td>
<td>4.4</td>
<td>4.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Table 2. Mean age at death from rheumatic heart disease for the 3 main ethnic groupings in New Zealand (2000-2007)

<table>
<thead>
<tr>
<th></th>
<th>Māori</th>
<th>Pacific</th>
<th>nonMāori/Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>No. of deaths</td>
<td>127</td>
<td>192</td>
<td>319</td>
</tr>
<tr>
<td>Mean age at death</td>
<td>56.4</td>
<td>58.4</td>
<td>57.6</td>
</tr>
<tr>
<td>Lower 95% CL</td>
<td>53.9</td>
<td>56.6</td>
<td>56.1</td>
</tr>
<tr>
<td>Upper 95% CL</td>
<td>59.0</td>
<td>60.3</td>
<td>59.1</td>
</tr>
<tr>
<td>Life expectancya</td>
<td>70.4</td>
<td>75.0</td>
<td>Na</td>
</tr>
</tbody>
</table>

Na= not available
a 2005-07 (Statistics NZ)
Table 3. Standardised mortality ratios (mean ± 95%CL) for Māori and Pacific peoples compared to nonMāori/Pacific categories

<table>
<thead>
<tr>
<th>Standard population</th>
<th>Māori</th>
<th>Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Māori</td>
<td>10.3 (8.7, 12.3)</td>
<td>9.5 (7.9, 11.3)</td>
</tr>
<tr>
<td>nonMāori/Pacific</td>
<td>4.9 (4.7, 5.1)</td>
<td>4.8 (4.6, 5.0)</td>
</tr>
<tr>
<td>SEGI’s*</td>
<td>7.9 (7.3, 8.7)</td>
<td>7.2 (6.6, 7.8)</td>
</tr>
<tr>
<td>WHO*</td>
<td>6.8 (6.3, 7.4)</td>
<td>6.3 (5.9, 6.9)</td>
</tr>
</tbody>
</table>

* [www.who.int/healthinfo/paper31.pdf](http://www.who.int/healthinfo/paper31.pdf)
Figure 1. RHD deaths (A) and mean annual mortality rates (B) in 2000-2007 (with 95% confidence limits).
Figure 2. Estimated annual admissions (A) and cost to Government (B) for admissions for ARF or RHD (mean of 2000-2009)

A.
- Other surgery and diagnostic procedures
- Valve surgery
- Non surgical

B.
- Other surgery and diagnostic procedures
- Valve surgery
- Non surgical

Admissions
- Age (y)
- Cost ($m)

Age (y)