Interim Evaluation of the Sore Throat Management Component of the New Zealand Rheumatic Fever Prevention Programme
Quantitative Findings

Final Technical Report of Quantitative Findings
October 2015

Whāia te iti kahurangi, ki te tuohu koe me maunga teitei
Pursue that which is precious, and do not be deterred by anything less than a lofty mountain

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### GLOSSARY

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<tbody>
<tr>
<td>Comparator</td>
<td>Usual primary care delivered by general practitioners and nursing staff</td>
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<tr>
<td>Co-payment</td>
<td>The cost to the patient of a consultation with a general practitioner</td>
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<tr>
<td>Incremental cost utility ratio (ICUR)</td>
<td>The ratio of the lifetime incremental costs of the intervention divided by the net benefits in QALYs</td>
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<tr>
<td>Decile (school)</td>
<td>Decile 1 schools are the 10 percent of schools with the highest proportion of students from low socio-economic communities. Decile 10 schools are the 10 percent of schools with the lowest proportion of these students.</td>
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<tr>
<td>Decile and Quintile (New Zealand Deprivation Index [NZDep])</td>
<td>Index of socioeconomic deprivation for small areas (mesh blocks) combining nine variables from the NZ Census reflecting eight areas of deprivation. Note: NZDep decile 10 (or quintile 5) is the most deprived and decile 1 (or quintile 1) is the least deprived (opposite to school deciles)</td>
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<tr>
<td>Discounting</td>
<td>A technical method for estimating the present value of future costs or benefits</td>
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<tr>
<td>PHARMAC</td>
<td>Pharmaceutical Management Agency</td>
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<tr>
<td>Quality adjusted life year (QALY)</td>
<td>A metric that combines mortality and morbidity over the lifetime of the patient</td>
</tr>
<tr>
<td>Study perspective</td>
<td>The point of view of the analysis; in particular which costs are included and excluded</td>
</tr>
<tr>
<td>Time horizon</td>
<td>The time period over which the costs and benefits of the intervention and the comparator are considered</td>
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## ABBREVIATIONS

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<thead>
<tr>
<th>Acronym/Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADHB</td>
<td>Auckland District Health Board</td>
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<tr>
<td>ARF</td>
<td>Acute Rheumatic Fever</td>
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<tr>
<td>BOP</td>
<td>Bay of Plenty</td>
</tr>
<tr>
<td>CAU</td>
<td>Census Area Unit</td>
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<tr>
<td>CCDHB</td>
<td>Capital and Coast District Health Board</td>
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<tr>
<td>CMDHB</td>
<td>Counties Manukau District Health Board</td>
</tr>
<tr>
<td>DHB</td>
<td>District Health Board</td>
</tr>
<tr>
<td>DOT</td>
<td>Directly Observed Therapy</td>
</tr>
<tr>
<td>DRG</td>
<td>Diagnosis-related Group</td>
</tr>
<tr>
<td>ECHO</td>
<td>Echocardiography</td>
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<tr>
<td>ESR</td>
<td>The Institute of Environmental Science and Research</td>
</tr>
<tr>
<td>GAS</td>
<td>Group A Streptococcus</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GP</td>
<td>General Practitioner</td>
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<tr>
<td>HOA Ltd</td>
<td>Health Outcomes Associates Ltd</td>
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<tr>
<td>HVDHB</td>
<td>Hutt Valley District Health Board</td>
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<tr>
<td>HUHC</td>
<td>High Use Health Card</td>
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<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
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<td>ICUR</td>
<td>Incremental Cost Utility Ratio</td>
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<tr>
<td>IM</td>
<td>Intra-muscular</td>
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<tr>
<td>INR</td>
<td>International Normalised Ratio of prothrombin time</td>
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<td>MoH</td>
<td>Ministry of Health</td>
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<td>NMDS</td>
<td>National Minimum Data Set</td>
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<tr>
<td>NZ</td>
<td>New Zealand</td>
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<tr>
<td>NZDep</td>
<td>New Zealand Deprivation Index</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>pcpa</td>
<td>Per Child Per Annum (year)</td>
</tr>
<tr>
<td>PHC</td>
<td>Primary Health Care</td>
</tr>
<tr>
<td>PHN</td>
<td>Public Health Nurse (Public Health Nursing service)</td>
</tr>
<tr>
<td>PN</td>
<td>Practice Nurse</td>
</tr>
<tr>
<td>QALY</td>
<td>Quality Adjusted Life Year</td>
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<tr>
<td>RFPP</td>
<td>Rheumatic Fever Prevention Programme</td>
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<tr>
<td>RHD</td>
<td>Rheumatic Heart Disease</td>
</tr>
<tr>
<td>VLCA</td>
<td>Very Low Cost Access</td>
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<tr>
<td>WDHB</td>
<td>Waitemata District Health Board</td>
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1. EXECUTIVE SUMMARY

Background
New Zealand has strikingly high rates of acute rheumatic fever (ARF) compared to other Organisation for Economic Co-operation and Development (OECD) countries. The distribution of ARF is markedly unequal, with this disease almost exclusively confined to Māori and Pacific children and young people aged 4–19 years living in lower socio-economic areas in the North Island (priority populations). The major sequela of ARF, rheumatic heart disease (RHD), correspondingly affects Māori and Pacific people in midlife and is a major cause of premature death in these populations.

Current understanding of the pathophysiology is that ARF is triggered by a throat infection with group A streptococcus (GAS) bacteria. A small proportion (0.3% to 3%) of untreated GAS pharyngitis activate an autoimmune reaction that results in ARF. It is thought that repeated episodes of GAS sore throat might be needed to cause ARF. About 30–45% of ARF cases have heart valves affected at the time of initial diagnosis – some only minimally, but some more severe and persistent, leading to RHD. Primary prevention of ARF is focused on detecting and treating GAS throat infections and the spread of GAS infections through timely management of sore throats. Primary prevention should be focused on high risk populations and include early diagnosis through throat swabbing those with sore throats, appropriate and timely antibiotic treatment for GAS positive sore throats, and ensuring a full course of antibiotics is completed to eradicate the GAS bacteria from the throat. In most highly developed countries, ARF has virtually disappeared as living conditions and access to good health care has improved. However, in some countries such as New Zealand and Australia, indigenous and Pacific populations continue to have high rates of ARF. The development of ARF is associated with environmental factors including poverty and household crowding.

In response to rising rates of ARF in New Zealand, the Rheumatic Fever Prevention Programme (RFPP) was set up by the Ministry of Health (MoH) and rolled out, initially to eight District Health Board (DHB) areas considered high-risk, in 2011. This was subsequently expanded to include a further three DHB areas when the reduction of ARF became a Better Public Service (BPS) government target in 2012. The BPS target aims to reduce the incidence of ARF by two-thirds from a baseline of 4.0 per 100,000 in 2009/10–2011/12, to 1.4 per 100,000 by 2017.

The MoH RFPP incorporates three main strategies to decrease ARF: 1) primordial strategies addressing social and environmental factors such as poor housing and household crowding; 2) primary prevention strategies such as the school-based sore throat management service and primary care rapid response clinics; and 3) health promotion to families and health professionals.
around the importance of ARF - what causes it and how to prevent it.

The largest component of the RFPP is the school-based sore throat management service, and that is the main focus of this evaluation. The implementation of rapid response clinics have been much more recent, and therefore their full potential impact could not be assessed in this interim evaluation. The housing initiatives and health promotion strategies of the RFPP were outside the scope of this interim evaluation.

The RFPP school-based sore throat management service was based on recommendations from the NZ National Heart Foundation, which in turn was based on the outcomes of a randomised controlled trial (RCT) of school-based sore throat management conducted in Auckland and a subsequent meta-analysis of school-based and community sore throat management interventions. The RCT was conducted from 1998–2001 where school-based sore throat management services were implemented in areas with high-risk children to reduce ARF. The Auckland trial found a 21%–28% reduction in the incidence of ARF that was not statistically significant, attributed to lack of power. A subsequent meta-analysis including the Auckland trial and other observational studies that were noted to be of poor quality, was conducted. The authors suggested that with ‘the best evidence available in an area with imperfect information’ ARF cases would reduce by about 60% using a school-based or community approach.
**Aims**

- To assess the overall effect of the sore throat management component of the RFPP on reducing the incidence of ARF in priority children and young people populations, focusing on the impact of the school-based sore throat management service.

- To assess the effect of the RFPP on the targeting of throat swabbing to children at high risk of developing ARF, based on the rates and distribution of swabbing and group A streptococcus (GAS) detection.

- To determine the extent to which first episode ARF hospitalisation cases are successfully identified and swabbed, either in primary health care or through a school-based service, during the period of their presumed acute pharyngitis.

- To evaluate the costs and cost effectiveness of the school-based sore throat management service in preventing ARF.

- To provide conclusions for future investment in sore throat management for priority populations.
Methods

Descriptive epidemiological analysis – we used hospitalisation data covering the 15 ½ year period from January 2000 to June 2015 to determine trends in ARF hospitalisations. In general, the three-year period 2009–11 provides a pre-programme baseline and 2012– June 2015 represents the intervention period.

We produced cumulative notification graphs from 2009 through to June 2015 using the most recent ARF notification data available by disease onset date.

Effectiveness analysis – we used a cohort study design to assess the association between exposure to the school-based sore throat management service and the risk of ARF using notification data to the end of 2014. Eligible children were all children aged 5–12 years attending decile 1–3 schools in the 10 DHBs with the school-based sore throat management service operating under the RFPP during the 2012 to 2014 period. We calculated person-days-exposed for those attending a school with a school-based service operating and those who did not (person-days–not-exposed). We used notified ARF cases (probable and confirmed, initial episodes) with an onset date between January 2012 and December 2014. We determined service effectiveness (SE) as SE = 1-relative risk. As few rapid response clinics were fully operating by the end of 2014, we were unable to determine their effectiveness.

Economic analysis – we estimated the cost effectiveness of the school-based sore throat management service using a lifetime cohort Markov model, incorporating ARF incidence rates, sore throat service effectiveness, hospital admissions, other costs and mortality. We estimated cost effectiveness in one DHB that was selected as a best-case base scenario due to high coverage of a well-functioning school-based service, a high incidence of ARF, and cost data availability. The analysis was adapted from a previous model of a school sore throat service that was reported to the MoH in 2011, but using empirically derived transition probabilities and costs.

Throat swab and microbiological analysis – we undertook a descriptive epidemiological analysis and linkage to ARF hospitalised cases to the end of 2014. We stratified swab sample data, incidence rates and percentage test positivity according to socio-demographic factors (source of swab, New Zealand Deprivation Index (NZDep) quintile, ethnicity and in Auckland, by DHB) to determine overall annual differences.

Root cause analysis – we used ARF notification data from July to December 2014 to assess putative school-based sore throat service improvements and their potential to increase RFPP effectiveness.
Key findings

1. ARF descriptive epidemiology

First episode ARF hospitalisation trends

National rates of ARF as measured by first episode ARF hospitalisation through to June 2015 have significantly declined compared to baseline rates (2009–2011). The decline began in 2014 (Figure 1 and Table 1).

![Figure 1. NZ first episode ARF hospitalisation rates per 100,000 population per year](image)

NB. This graph deliberately uses crude rates to be consistent with method used for specifying the ARF Better Public Services baseline and target rates (see Table 4 for age-standardised rates later in the report).

Table 1 presents first episode ARF hospitalisation rates for all NZ for the baseline years of the RFPP (2009–2011) compared to 2012, 2013, 2014 and to mid-2015. For all ages, there was a 27% statistically significant reduction in ARF rates per 100,000 by mid-2015 compared to baseline years (2009–11); for children 5–12 years there was a 32% statistically significant reduction; and for young people 13–19 years there was a 19% reduction that was not statistically significant, in ARF rates per 100,000 by mid-2015 compared to baseline years (2009–11) as calculated from Table 1 data.
Table 1. First episode ARF hospitalisation crude rates per 100,000 population for baseline years 2009–11 compared to 2012, 2013, 2014, and June 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>All New Zealand cases</th>
<th>Cases 5–12 years</th>
<th>Cases 13–19 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Population</td>
<td>Rate per 100,000</td>
</tr>
<tr>
<td>2009–11</td>
<td>162</td>
<td>4,345,767</td>
<td>3.72</td>
</tr>
<tr>
<td>2012</td>
<td>151</td>
<td>4,408,100</td>
<td>3.43</td>
</tr>
<tr>
<td>2013</td>
<td>191</td>
<td>4,442,100</td>
<td>4.30</td>
</tr>
<tr>
<td>2014</td>
<td>143</td>
<td>4,509,900</td>
<td>3.17</td>
</tr>
<tr>
<td>2015 to June</td>
<td>125</td>
<td>4,596,700</td>
<td>2.72</td>
</tr>
</tbody>
</table>

P value: two tailed z-test for comparing rates; *significant at 0.01; ** significant at 0.05
+ Note number of cases has been seasonally adjusted for 2015 to calculate an annual rate
Note: Numbers of cases and rates presented in this report differ slightly from those reported by the MoH. Although the same case definition was used (Appendix 1), these differences may be due to variations in time of data extraction; data exclusion rules; time periods analysed; and choice of population denominators.

The following graphs represent data only through to the end of 2014. Rates in the 5–12 years age group targeted by the school-based service of the RFPP had not declined significantly compared with baseline (Table 1, Figure 2) to the end of 2014, however there is a significant decline to mid-2015. In addition, ARF rates in this age group have not diverged from those observed in the 13–19 years age group, who are (largely) not covered by the school-based service (Table 1, Figure 2).

Figure 2. Total New Zealand first episode ARF hospitalisation rates by age groups 5–12 and 13–19 years

Error bars represent upper and lower 95% confidence interval (CI)

Trends in first episode ARF hospitalisation by ethnicity are seen in Figure 3 below. For Māori children in 2014 there was a decreasing trend compared to 2013, however over the whole time...
period there was no decline.

**Figure 3.** Annual rate of first episode ARF hospitalisation for children 5-14 years by prioritised ethnicity, 2000–2014

![Graph showing annual rate of first episode ARF hospitalisation for children 5-14 years by prioritised ethnicity, 2000–2014](image)

Error bars represent upper and lower 95% CI

Using three-year average age-standardised rate ratios highlights the increasing disparities for Māori and Pacific in developing ARF from 2000 through to 2014 (Figure 4, see Table 4 for confidence intervals).

**Figure 4.** First episode ARF hospitalisation age-standardised rate ratios by prioritised ethnicity 2000–2014, average by three-year periods

![Graph showing first episode ARF hospitalisation age-standardised rate ratios by prioritised ethnicity 2000–2014, average by three-year periods](image)

Cumulative ARF notifications

Figure 5 shows the cumulative number of ARF probable and confirmed notifications by disease onset date in the 10 DHBs where the school-based sore throat management service was, or is being, implemented for children and young people aged 4–19 years. The graphs show the baseline years of 2009–2011 for the RFPP, compared to 2013, 2014 and through to mid-2015. For
children and young people 4–19 years there was a 29% decline in notified cases by June 2015 relative to the baseline period (see Table 5), although it is uncertain if this is a sustained decline, if it is linked to the RFPP, or if it is due to other unknown (and possibly unmeasurable) reasons.

**Figure 5.** Cumulative ARF notifications in 4–19 year olds for the 10 RFPP DHBs with a school-based service, 2009–2015

To further review this recent trend we produced similar cumulative graphs for ARF notifications in children aged 5–12 years in the 10 DHBs where the school-based service was being implemented (Figure 6).

**Figure 6.** Cumulative ARF notifications in 5–12 year olds for the 10 RFPP DHBs with a school-based service, 2009–2015

The above graph show that for all 5–12 year old children there was a 26% decline in ARF notifications from baseline years 2009–11 compared to June 2015. (see Table 5). This decline could be partly due to the school-based service which targets this age group although it could also be partly due to a background decline in the incidence of ARF, for example due to other components of the RFPP, improved primary care management, or for other unknown reasons.
Additional months and years of data will be needed to confirm trends. In addition, for young people aged 13–19 years who are largely not targeted by the school-based service there was a decline of 40% by June 2015 compared to baseline years (Figure 7).

Figure 7. Cumulative ARF notifications in 13–19 year olds for the 10 RFPP DHBs with a school-based service, 2009–2015

![Cumulative ARF notifications graph](image)

2. School-based sore throat service implementation

As determined by MoH monitoring data, by December 2013, 83% of planned RFPP school-based sore throat management services were fully implemented. Ten DHBs implemented school-based services in decile 1–3 schools that had a high proportion of Māori and Pacific children, thereby targeting children at higher risk of developing ARF. The school-based service reached its maximum coverage at the start of 2014, with 251 schools implementing the service covering an estimated 53,998 children. By June 2014, 58 schools had stopped the service, leaving 193 schools operating at least through to the end of 2014, covering an estimated 45,656 children. Coverage for high-risk children attending decile 1–3 schools with a school-based sore throat management service varied among DHBs from 20%–100% (Figure 8).

Figure 8. Coverage (%) of children aged 5–12 years attending decile 1–3 schools with a school-based sore throat management service by the 10 implementing DHBs.
3. Effectiveness analysis of the school-based sore throat management service of the RFPP

The effectiveness analysis was generally a ‘before and after analysis’ of the school based service based on ARF confirmed and probable notifications for children aged 5–12 years attending a decile 1–3 school with a school-based sore throat management service through to the end of 2014. ARF cases not exposed to the school-based service were compared to cases exposed. Some schools ended the school-based service within the time period analysed and so children attending those schools were not exposed after the service ended.

- Overall in the 10 DHBs implementing school-based services there was a 17% reduction (non-statistically significant) in ARF cases (95% confidence interval (CI): -17% to 42%).
- In Counties Manukau DHB (CMDHB) there was a 31% reduction (non-statistically significant) in ARF cases (95% CI: -13% to 58%).

Table 2. Effectiveness analysis summary based on ARF confirmed and probable notifications

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of cases exposed/person-days exposed</th>
<th>Number of cases not-exposed/person-days not exposed</th>
<th>ARF decline (%)</th>
<th>Lower confidence limit (%)</th>
<th>Upper confidence limit (%)</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools with a sore throat service</td>
<td>79/34,798,158</td>
<td>52/18,960,113</td>
<td>17</td>
<td>-17</td>
<td>42</td>
<td>No</td>
</tr>
<tr>
<td>Schools in CMDHB with a sore throat service</td>
<td>33/15,273,980</td>
<td>31/9,945,963</td>
<td>31</td>
<td>-13</td>
<td>58</td>
<td>No</td>
</tr>
</tbody>
</table>

These results must be interpreted with caution, as although there was a decline, it was not statistically significant, so it is also consistent with the service having no effect on the incidence of...
ARF to the end of 2014. It is possible that another year of data may strengthen findings. Our analysis was suitably powered (85%) to detect a true effect size of 50% effectiveness on three years of data (approximately 18 months exposed to the service and 18 months not-exposed to the service).

For similar power with a true effect size of 30%, we estimate approximately eight years of data would be required (2008 to June 2016). For 85% power with a true effect size of 15%, we estimate approximately 32 years of data would be required. Power could be increased by having more schools in the service, or by using individual level data if available.

This analysis does not account for any changes in background incidence that may be seen in children attending a school without a school-based service. See Appendix 5 for further discussion.

ARF is an uncommon disease with a small number of cases each year. Few rapid response clinics were fully operating by the end of 2014 so this analysis largely reflects the effect of the school-based sore throat management service. We were not able to separate out and attribute any specific effects on the incidence of ARF due to the rapid response clinics, or usual primary care.

4. Targeting of throat swabbing to high-risk populations
Analysis of laboratory data generated by throat swabbing in both primary care and the school-based service clearly demonstrate a marked increase in the rate of throat swabbing after the school-based sore throat management service of the RFPP was introduced. Importantly, the swabbing rate was highest in populations at highest risk of ARF, namely Māori or Pacific children residing in areas of high socioeconomic deprivation. In this regard, the RFPP could be considered as providing effective targeting of throat swabbing to high-risk populations.

5. Economic analysis
The economic analysis is a ‘what if’ comparative analysis of one hypothetical cohort of high risk children in CMDHB who received the school-based sore throat management intervention versus an identical cohort without the intervention, as a test case for other DHBs. It considers one year’s funding of a school-based sore throat service and the progression from GAS throat infection to ARF to RHD to death from RHD over the lifetime of a cohort of children 10 years of age, as a proxy for children aged 5–12 years. For the base case analysis the model assumes 30% effectiveness of the school sore throat service (range 10% to 50%) and an expenditure of $200 per student per year (range $150 to $300). Under these assumptions, if a school-based sore throat service was made available for one year to 25,000 high risk children in CMDHB at a cost of $5m and the observed ARF incidence rate of 87.1 per 100,000 it would: prevent six or seven cases of ARF in that year; possibly avert one premature death from RHD over the lifetime of children covered by the school-based service; and provide 26.5 QALYs of lifetime health benefit. The cost per first episode ARF hospitalisation prevented in the base case is $0.37m and the (undiscounted) cost per RHD death prevented over the lifetime of the cohort is $2.39m. Accordingly, the service would
provide a cost per QALY of $90,043 which amounts to 11.1 QALYs per million dollars invested in health care. A ‘what if’ cost per QALY analysis is presented using varying annual costs per child and effectiveness to demonstrate the range of cost per case averted, cost per RHD death averted and cost per QALY gained outcomes.
Table 3. Estimated additional cost per case averted, per RHD death averted and per QALY gained by the school-based sore throat management service in CMDHB, over a range of annual cost per student and service effectiveness

<table>
<thead>
<tr>
<th>Annual cost per child</th>
<th>Assumed effectiveness of school-based service</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost per case prevented</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td></td>
<td>$761,013</td>
<td>$335,128</td>
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<td>$250</td>
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<td>$284,649</td>
</tr>
<tr>
<td>$300</td>
<td></td>
<td>$2,427,447</td>
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<td>$751,659</td>
<td>$525,462</td>
<td>$400,912</td>
</tr>
<tr>
<td></td>
<td>Cost per RHD death averted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td></td>
<td>$3,424,560</td>
<td>$1,899,057</td>
<td>$1,136,306</td>
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<td>$10,923,511</td>
<td>$6,898,358</td>
<td>$4,885,781</td>
<td>$3,678,235</td>
<td>$2,873,205</td>
</tr>
<tr>
<td></td>
<td>Cost per QALY gained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td></td>
<td>$195,689</td>
<td>$81,388</td>
<td>$42,879</td>
<td>$24,066</td>
<td>$12,735</td>
</tr>
<tr>
<td>$200</td>
<td></td>
<td>$338,526</td>
<td>$152,807</td>
<td>$90,043</td>
<td>$59,522</td>
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<td>$250</td>
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<td>$69,545</td>
</tr>
<tr>
<td>$300</td>
<td></td>
<td>$624,201</td>
<td>$295,644</td>
<td>$184,369</td>
<td>$130,434</td>
<td>$97,950</td>
</tr>
</tbody>
</table>

Note: ARF incidence rate of 87.1 per 100,000 for high-risk children in CMDHB
Pink shading indicates less than one GDP per capita (‘very cost effective’ by WHO standards); bold font is the base case; GDP per capita = $52,735 in FY 2013/14. QALY = quality adjusted life year.
As the effectiveness of the school-based service approaches zero, the cost effectiveness ratio approaches infinity, and is not shown.

For any given level of funding, the cost effectiveness depends on the baseline incidence rate of ARF and the effectiveness of the school-based service. Figure 9 displays the range of cost per QALY by varying incidence rates of ARF with dotted lines indicating cost effectiveness according to WHO criteria as described below.

Figure 9. Cost per QALY as a function of ARF incidence rate and effectiveness at a cost of $200 per child per year
GDP per capita = $52,735 in FY 2013/14

PHARMAC uses a relative approach that compares new interventions within a fixed budget where the ‘value for money’ depends on what interventions are available. The cost per QALY in the base case analysis is higher than the range that PHARMAC generally considers cost-effective compared to other pharmaceuticals under consideration in a given financial year (FY). In FY2013/14, new pharmaceuticals and/or line extensions or new indications funded by PHARMAC provided a minimum weighted average of 28 QALYs per million dollars ($35,714 per QALY). Therefore by current local criteria, the school-based intervention might not be considered cost effective compared with usual primary care, at current costs and the assumed value of effectiveness. However, PHARMAC operates with a mandated capped budget and it funds new pharmaceuticals with a wide range of cost effectiveness ratios, so it does not provide a good guide to funding of public health interventions.

New Zealand has no formal benchmark ICUR (‘willingness to pay’) for health care interventions. The WHO Commission on Macroeconomics and Health recommends using gross domestic product (GDP) as a readily available indicator to derive the following three categories of cost-effectiveness: ‘highly cost-effective’ (less than GDP per capita); ‘cost-effective’ (between one and three times GDP per capita); and ‘not cost-effective’ (more than three times GDP per capita). GDP was reported as $52,735 at the end of March 2015 (March 2015, Statistics New Zealand).

If DHBs were to adopt the WHO criterion (one GDP per capita, or $1,000,000/$52,735 = 19.0 QALYs per million dollar expenditure), assuming that the school sore throat service is 30% effective and costs $200 per child per year, its continuance could be justified by its benefits in reducing the incidence of ARF because the cost per QALY is between one and three times GDP.

Another possible comparison would be the infant rotavirus vaccination programme which was funded recently with an ICUR of $46,092, or the school based human papillomavirus vaccination programme ($US33,000 per QALY). Both of these interventions are more cost-effective than the school sore throat service.

The current analysis is conservative because it includes only a restricted range of direct medical costs, which introduces a slight bias against the intervention. Consistent with the healthcare perspective of the analysis, the model excludes indirect costs such as loss of income and costs to carers. It also excludes co-benefits of the school service, such as education of children and families and treatment of skin infections and other health issues that could potentially be diagnosed in the school setting.

6. Sore throat management approach to reduce rheumatic fever

Targeting the treatment of GAS pharyngitis as a strategy to reduce the incidence of ARF has shortcomings. More than a third of ARF cases do not recall having had a sore throat in the four
weeks prior to admission or diagnosis. Distinguishing viral pharyngitis from GAS pharyngitis, and viral pharyngitis with concurrent GAS carriage are notable challenges. Optimal swabbing, antimicrobial prescribing and adherence also need strengthening in the school-based sore throat service. Furthermore, implementing the school-based sore throat management service in primary and intermediate schools would only reach approximately two-thirds of the children and young people at risk of developing ARF in New Zealand. Therefore, the school-based service alone will not be adequate to meet the BPS target for reducing ARF incidence in NZ.

In 2014, when the school-based service of the RFPP could be expected to be functioning at maximum impact, we found that the majority of children with ARF aged 5–14 years had not had a throat swab taken prior to hospitalisation (62% in Northland DHB, 77% in Auckland and 75% in Capital and Coast DHB - see section 6, pages 53–54). These findings are in keeping with the root cause analysis (see section 8, Table 17, page 116) which found that for notified ARF cases aged 5–12 years in the 11 DHBs implementing the RFPP in 2014, the proportion of ARF cases who had a sore throat and had a throat swab taken (in school or primary care) was only 28% (9/32).
Limitations
This interim evaluation has several important limitations.

- The major outcome, ARF, can be difficult to diagnose in some cases. Diagnostic behaviour may have changed over time, particularly with increasing awareness and interest in this disease. Additionally, there is no established national ARF register, so it was necessary to use ESR notifications or hospitalisations to track this disease over time. Even with an agreed set of decision rules for analysing these data, there are inevitably some potential errors in using these data sources in measuring the incidence of ARF.
- ARF is an uncommon disease so a change in incidence will need to be large to be statistically significant.
- Monitoring of the sore throat component of the RFPP was not standardised and reporting on deliverables and indicators was inadequate until more recently. Children consenting to participate in a school-based sore throat service did not have National Health Index (NHI) numbers routinely recorded. Evaluating the sore throat component of the RFPP therefore has been extremely challenging with the preferred and more robust approach of undertaking individual level analysis through linking data by NHI not possible. Throat swabs taken from the school-based service are clearly identified in laboratory data, however throat swabs taken in rapid response clinics are not currently identified. Consequently, the contribution of rapid response clinics as differentiated from usual primary care has not been possible.
- This interim evaluation has shown that the nature of the intervention also varies considerably across DHB regions in terms of coverage of throat swabbing and management in priority populations, frequency of throat swabbing offered, support for adherence to antimicrobial treatment, and additional elements such as management of skin infections.
- Some of the surveillance data used here require careful interpretation. It is important to note that the root cause analysis, by definition, only applies to intervention failures i.e. those who have developed ARF despite the RFPP, and it was based on six months of data with small numbers. Findings therefore cannot be generalised to estimate these measures for the entire population of children aged 5–19 years.
- Obtaining complete, consistent data on the costs of the RFPP has been difficult and the data used in the current model are likely to be questioned by some users of this report. As with the RFPP itself, there is considerable regional diversity in the costs of the programme. Partly for this reason, the economic analysis has focused on a single DHB, considered to be a best performer and thus more likely to demonstrate any benefit it there is one.
- This interim evaluation focused on quantitative effectiveness and cost-effectiveness of the school-based sore throat management service of the RFPP to the end of 2014. A qualitative
study of parents/whānau service users and suppliers is being carried out separately, and the findings will be available later in 2015.

- Some potential benefits are not being measured, such as additional health benefits from operating school-based health services, particularly for deprived populations who may have poor access to primary care services. Some potential harms are also not being measured by this interim evaluation, notably the potential negative impact of increased antibiotic use on resistance has not been assessed here, although this question is being addressed separately.

- This interim evaluation was conducted over a very short time period and largely relied on existing routine data sources, the quality of which can vary across time and region. This may have limited the ability of this interim evaluation to assess the true effectiveness and cost-effectiveness of the sore throat management services. More time would have allowed the researchers the opportunity to check and validate some of these data more fully.

- Rapid response clinics and services aimed at reducing household crowding were being implemented during 2014 with increasing coverage in 2015. Findings from this interim evaluation therefore largely do not reflect any significant impact from those particular interventions.
**Strengths**

This interim evaluation has several important strengths:

- Despite the limitations of ARF surveillance, New Zealand does have two long established national sources of ARF surveillance data: hospitalisations and notifications. After considerable work, these data sources are showing a high level of concordance, particularly over the last five years (2010–2014).

- Laboratory data provide a complete and fairly unambiguous measure of the extent and results of throat swab testing across populations.

- The unique patient identifier (NHI) allows additional data quality improvements and, in particular, linking of multiple surveillance data sources, notably laboratory and cases data.

- Surveillance systems have been refined to provide additional insights, notably school attended (which allows us to identify if a child was attending a school which is providing the sore throat management service). Also, the more recent addition of root cause analysis data collection to the ARF notification system allows a comprehensive analysis of modifiable factors contributing to the ARF cases occurring.

The timing of this evaluation seems particularly useful as the RFPP is still operating, providing opportunities for the MoH to act on the findings in terms of decisions to continue and/or modify this component. This is the earliest that such an evaluation could be conducted. The school-based sore throat management service has operated at maximum intensity for an entire year (2014). The rationale for the sore throat management component of the RFPP is that by detecting and treating presumed GAS pharyngitis, the development of ARF will be prevented. The lag time for ARF following GAS throat infection is estimated at three weeks, on average. We would therefore expect to see a rapid reduction in ARF rates in those populations exposed to the sore throat management component of the RFPP, if such a programme was effective and delivered effectively. There is no reason why the effectiveness of the component should necessarily increase further with time, unless this occurs through some other completely different mechanism (such as a reduction in circulating GAS caused by the widespread use of antibiotics in the programme, although supporting evidence for this theory is extremely limited).
Conclusions

- This interim evaluation was conducted just over half-way through a planned six year programme of work that aims to decrease the incidence of ARF by two-thirds by 2017.

- National rates of ARF, as measured by first episode hospitalisations, show a statistically significant decline following implementation of the RFPP by June 2015 compared to baseline years (2009–2011).

- The cumulative number of ARF notifications in children and young people aged 4–19 years also show a statistically significant decline through to June 2015 compared to 2009–2011, both overall (28%), and in the ten DHBs implementing the school-based sore throat management service (29%). Notification data suggest that the incidence of ARF began to decline with a downward 'trajectory' sometime between August 2014 (in CMDHB but not other Auckland DHBs) and November 2014 (other North Island DHBs) and continued during the first 6 months of 2015.

- In the 10 DHBs that implemented a school-based service, for 5-12 year old children regardless of exposure to the school-based service, there was a decline in ARF notifications of 26% to June 2015 compared to June 2009–2011. There was also a decline of 40% in young people 13–19 years who are largely not covered by the school-based service. Consequently, it is difficult to attribute this decline solely to exposure to the school-based service of the RFPP. If this decline persists, then it would be useful to consider whether it can be linked to other aspects of the RFPP, such as the general increasing emphasis on sore throat treatment in primary care or the emphasis on primordial prevention (social and environmental e.g. improved housing), or for other unknown reasons.

- The effectiveness analysis shows that to the end of 2014, attending a school with a school-based sore throat management service was associated with a modest but non-statistically significant decline in ARF notifications (17%). There was a larger decrease in ARF notifications associated with the school-based sore throat management service in CMDHB (31%) but again this was not statistically significant. It is possible that an additional year of data may help determine if these recent downward trends are sustained and become statistically significant.

- In order for New Zealand to be able to meet the BPS target of reducing the incidence of ARF hospitalisations by two-thirds (67%) by 2017, the school-based service alone will not be adequate.

- The school-based sore throat management service of the RFPP appears effective at targeting throat swabbing to high-risk populations attending schools with a school-based service with a marked increase in the rate of throat swabbing after implementation of the RFPP. There was also a smaller increase in throat swabbing in high-risk and low-risk children in primary care.

- The overall coverage of the school-based service for high-risk children to the end of 2014 is...
relatively low in several DHBs.

- The economic analysis is a ‘what if’ assessment noting that the effectiveness of the sore throat service of the RFPP to date is modest and not statistically significant. For CMDHB with a high incidence of ARF, good programme coverage, at a cost of $200 per child per year and an assumed effectiveness of 30%, the school based service would not be considered cost effective by current PHARMAC criteria. However it is cost effective by WHO criteria, although not highly cost effective. For other areas with a lower incidence of ARF, lower coverage of high risk children and more modest effectiveness, the school-based service would not be considered cost effective. However, a high cost may be acceptable in ongoing attempts to reduce marked ethnic and socioeconomic disparities in ARF.

- It was not possible, using existing data, to separate out the effectiveness of the school-based service from rapid response clinics, or rapid response clinics from routine primary care management of sore throats.

- Several aspects of the school-based sore throat service could be strengthened including encouraging all children with sore throats to have throat swabs taken, timely initiation of antimicrobial treatment, and supporting antimicrobial adherence. However, there is insufficient information at this stage to know if these changes would in fact improve the effectiveness of the school-based service.

- The school-based service of the RFPP was not adequately designed to be systematically and comprehensively evaluated. A further evaluation, incorporating at least an additional year of data, and/or using individual level data, could be considered to provide more certainty around the conclusions contained in this report. However, it is important to note that based on data from 2012 to 2014 the effectiveness analysis does have adequate power to determine a 50% reduction in ARF incidence, had that been seen according to the expected effectiveness of such a service as per the meta-analysis and National Heart Foundation recommendations. More modest reductions would require many years of data with the service fully implemented to gain sufficient power to demonstrate statistical significance.

- It would be important to repeat the main analyses in this report once complete 2015 data are available to provide a more definitive assessment of the effectiveness of the RFPP. Further updated analyses are likely to be useful in future years to support decisions about the optimum development of the RFPP.

- Further assessment of the RFPP could be strengthened by the inclusion of additional data which were not available for this interim evaluation. For example:
  - establishing a laboratory administrative marker for throat swabs and a record of who attends rapid response clinics (with NHIs) may allow contribution to any effect to be differentiated between the school-based service, rapid response clinics and usual primary care;
recording NHIs of all children consenting to be part of the school-based service would allow more robust individual-level analysis to be conducted. Tracking would need to document important details such as the timing of participation;

good quality monitoring data for both the school-based service and rapid response clinics including: children and young people swabbed, repeated swabs on the same child or young person, prescriptions given, family members swabbed, and referral to housing initiatives from RFPP programmes, would allow a better assessment of implementation issues;

consistent reporting of RFPP costs could support a more extensive economic analysis of the programme;

as noted, a more complete assessment of the RFPP would include potential co-benefits from operating school-based health services as well as the potential harms of increased antibiotic use on resistance;

investigate the ability to track antibiotic dispensing at an individual level, linked to NHI, in order to monitor the safe and judicious use of antibiotics;

assessment of alternative methods of delivery including the current quality of and access to sore throat management in primary care for high-risk populations;

establishing a national ARF register would allow improved monitoring of ARF incidence throughout New Zealand, including a more consistent application of the ARF case definition and root cause analysis.
2. BACKGROUND

New Zealand has strikingly high rates of acute rheumatic fever (ARF) and rheumatic heart disease (RHD) compared to other Organisation for Economic Co-operation and Development (OECD) countries. The distribution of ARF is markedly unequal, with this disease almost exclusively confined to Māori and Pacific children and young people aged 4–19 years living in lower socio-economic areas in the North Island (priority populations). The 2012/13 first episode ARF hospitalisation rates per 100,000 were 12.7 for Māori and 25.9 for Pacific peoples compared to 4.0 for the total New Zealand (NZ) population. The incidence rate for first episode ARF hospitalisations steadily increased in NZ from 2.8 in 2001 to 4.0 per 100,000 in 2011. There was a corresponding increase in first episode ARF hospitalisations for Māori from 1.0 to 16.5 per 100,000 over the same time period. The average incidence rates between 1993 and 2009 for children 5–14 years of age were 81.2 per 100,000 for Pacific, 40.2 per 100,000 for Māori and 2.1 per 100,000 for non-Māori non-Pacific children. These disparities are similar in District Health Boards (DHBs) where ARF occurs. Depending on the year analysed, the Pacific incidence rates for ARF are about 40-fold higher, and for Māori about 20-fold higher than non-Māori/Pacific children.

An estimated 42% to 60% of people diagnosed with ARF develop RHD unless they are treated appropriately with monthly intramuscular antimicrobials. For NZ Māori and Pacific populations with RHD the mean age of death is (male/female) 56.4/58.4 years and 50.9/59.8 years respectively. RHD is also associated with considerable cost. This compares to the current Māori life expectancy of 73/77.1 years; Pacific life expectancy of 74.5/78.7 years; and total NZ population life expectancy of 79.5/83.2 years. Preventing ARF, and therefore RHD, has become a government priority to contribute towards protecting health, reducing ethnic disparities, and reducing the burden of RF related disease and cost.

The baseline option for assessing the sore throat management component of the RFPP is ‘usual care’, which is that provided by New Zealand’s primary care system. Since 1996 this system has included Government funded (‘free’) general practitioner (GP) care for children up to the age of six years, which was expanded to include ‘free’ after hours care from 2011 for the same age group. While ARF does occur in children under six years old it is rare, so this initiative was unlikely to impact the incidence of ARF. The extension of ‘free’ GP care up to the age of 13 years was not implemented until mid-2015.

The Rheumatic Fever Prevention Programme (RFPP) has been operating since July 2011 and the school-based service reached its maximum coverage at the start of 2014. It therefore seems reasonable to expect that quantitative outcome measures (such as ARF rates and root cause analysis of ARF cases) and intermediate process indicators (such as coverage as measured by laboratory throat swabbing data) will have good validity as indicators of how the sore throat
management component of the RFPP is operating. In addition, many qualitative aspects of the RFPP have already been systematically evaluated, notably by the formative evaluation of the RFPP. The stated rationale for the sore throat management component of the RFPP is that detecting and treating presumed GAS pharyngitis will prevent the development of ARF. The lag time between a GAS throat infection and the development of ARF is estimated at three weeks on average. Following this sore throat management logic, we would therefore expect to see a rapid reduction in ARF rates in those populations sufficiently exposed to the sore throat management component of the RFPP, if such a component was effective and delivered effectively. These direct effects should be most apparent in populations exposed to the more intense school-based sore throat management service, i.e. 5–12 year old Māori and Pacific children in high risk areas attending a school with a school-based sore throat management service. We would also expect rates in this group to start to diverge (downwards) from rates in older children not covered by the school service. We note that the overall RFPP has a strong health promotion messaging component that children and young people at high risk but not attending a school with a school-based service may be exposed to. They may then seek appropriate care and treatment for sore throats through rapid response or usual primary care clinics which may reduce ARF rates.

**Rheumatic Fever Prevention Programme Description**

Although some DHBs had already developed programmes to prevent ARF, the NZ MoH RFPP was launched in 2011 after recognising the lack of decline in the incidence of ARF. The programme was initially launched in eight high incidence DHBs. In 2012 the RFPP was expanded to three further DHBs when the NZ Government made the reduction of ARF one of its 10 Better Public Services (BPS) targets. The target aimed to reduce the incidence of ARF (as measured by first episode ARF hospitalisations) by two-thirds, from 4.0 per 100,000 at 2009/10–2011/12 baseline to 1.4 cases per 100,000 population by June 2017.

The RFPP is currently operating in the 11 DHB areas with the highest incidence of ARF hospital admissions namely: Northland; Auckland; Counties Manukau; Waitemata; Waikato; Bay of Plenty; Tairāwhiti; Lakes; Hawke’s Bay; Hutt Valley; and Capital & Coast. High incidence DHBs were defined by the MoH as those with a three-year average baseline (2009/10 to 2011/12) incidence rate of ARF higher than 1.5 initial hospitalisations per 100,000 total population, and a three-year average of four or more cases per annum.

The RFPP has three key strategies to reduce ARF following the MoH programme logic (Figure 10):

- improve access to timely diagnosis and treatment for group A streptococcus (GAS) throat infections among priority populations (Māori, Pacific, low decile schools (more deprived), children and young people aged 4–19 years);
- increase community awareness of ARF, what causes it and how to prevent it in priority populations;
- reduce household crowding and therefore reduce household transmission of GAS.

![Diagram of MoH programme logic for RFPP](image-url)

**Sore Throat Management Component of RFPP**

![Diagram of MoH sore throat component of RFPP](image-url)
Note: Programme funding by the MoH has now been extended to June 2016.

1. School Based Sore Throat Management Service

The MoH officially launched the RFPP in 2011 and funding was allocated to providers to set up sore throat management services in low decile primary and intermediate schools (Year 1–8). These services were initially within eight high incidence DHB areas based on cluster analysis of ARF incidence for 5–14 year old children. These initial eight DHBs were: Northland, Counties Manukau, Waikato, Bay of Plenty, Lakes, Tairāwhiti, Hawke’s Bay, and Capital & Coast. In 2012, the RFPP was extended to include a further three DHBs, namely, Auckland and Waitemata and Hutt Valley. Hutt Valley only implemented rapid response clinics (starting in 2014), whereas the other 10 DHBs implemented both the school-based service and more recently (from 2014), rapid response clinics. The RFPP therefore covered all North Island DHBs, except for Taranaki, Whanganui, MidCentral, and Wairarapa. It did not include any of the five South Island DHBs, so effectively covered 11 of New Zealand’s 20 DHBs, with 10 DHBs implementing a school-based sore throat management service of the RFPP.

The DHBs selected which schools would implement a sore throat management service. Most DHBs followed the NZ Rheumatic Fever Guidelines 2009, that recommended if an area had an age-specific ARF rate for children aged 5–14 years of 50 per 100,000 or higher, they should consider implementing a school-based sore throat service15. Some DHBs, for example Counties Manukau, selected schools based on a school scoring system using four risk factors including: ARF rate in the census area unit (CAU) where the school was located; school case density; school decile; and proportion of the school roll that is Māori or Pacific. Waitemata and Auckland followed a similar system. Other DHBs selected schools based on low decile, and with a high proportion of children who were of Māori or Pacific ethnicity. DHBs used data that was available at the time of planning the school-based service. Three DHBs initiated a school-based sore throat service prior to the start of the RFPP: Northland began a school-based sore throat service in 2002; Bay of Plenty in 2009; and Hawke’s Bay in 2010.

A variety of contracting approaches were used over time to implement the school-based sore throat service including contracting with DHBs who then subcontracted to service providers, or direct contracting between MoH and local service providers including Māori and Pacific health provider organisations. As specified in the contracts, the overall service objective for providers was to reduce the incidence of ARF hospitalisations by:

- providing throat swabbing and referral services in the school, home or other settings as appropriate for school children aged 5–14 years who present with sore throats in high-risk areas, and eligible whānau/family members living with these children;
- increasing awareness of rheumatic fever risk factors among children and their whānau/families in the key geographical areas;
• developing and maintaining relationships with other health and social service providers
  (including Whānau Ora providers) to facilitate referral and support, as appropriate.

The RFPP funding 2011–14 was to be used as ‘seed funding’ that DHBs or other local
organisations could add to for related activities in preventing ARF. The cost of throat swabs and
laboratory testing was borne by the DHBs. DHBs also financially contributed considerably to the
rolling out of the RFPP in their areas including investments in the school-based service and rapid
response clinics. Some DHBs such as Counties Manukau through their implementing agency,
Mana Kidz, took a broader approach and included the assessment and management of
uncomplicated skin infections.

The roll-out of the MoH RFPP funded programme occurred progressively from the end of 2011
through to 2014 (Figure 12) with a maximum coverage of the selected schools by the first half of
2014. As noted, a school-based sore throat management service was already in place from 2002
in Northland, 2009 in Lakes, and 2010 in Hawke’s Bay but are not represented in Figure 12. Each
line represents a school where a school-based sore throat service has been implemented, so the
height of the DHB block represents the number of participating schools. The top horizontal timeline
is divided into six-month blocks by year. Where a blue block commences indicates when the
school-based service was first implemented. Similarly, if the blue block ends this indicates the
school no longer operates a sore throat service. These data were obtained from the MoH and were
not verified by individual DHBs.

By December 2013, 83% of planned RFPP school-based sore throat services were fully
implemented. The school-based service reached its maximum coverage at the start of 2014, with
251 schools implementing the service, covering an estimated 53,998 children. By June 2014, 58
schools had stopped the service, leaving 193 schools operating at least through to the end of
2014, covering an estimated 45,656 children.
The implementation of a school-based sore throat service was variable among the DHBs in terms of coverage of high-risk children, frequency of swabbing, scope of service, and model of delivery. For the school-based service there was an overall estimated average coverage of just over 50% for children aged 5–12 years attending a decile 1–3 school with a school-based service in 2012 and 2013. Two DHBs ceased implementing a school-based service in 2014 (Tairāwhiti and Lakes).
leaving an overall coverage of 36%, or 46% coverage for the remaining eight DHBs still implementing the school-based service. Coverage of children aged 5–12 years attending decile 1–3 schools ranged from 20% in Waitemata to over 100% in Tairāwhiti (Figure 13).

![Figure 13. Coverage (%) of children aged 5–12 years attending decile 1–3 schools with a school-based sore throat management service by the 10 implementing DHBs](image)

Note: Due to denominator issues, possibly relating to the accuracy of school roll numbers, Tairāwhiti has a coverage of over 100%.

The frequency of sore throat swabbing services by the various providers during the school year ranged from ‘as requested’, to three days per week, to five days per week. No services were provided through the school-based service during weekends or school holidays. As noted, some providers such as Mana Kidz in CMDHB expanded the scope of services to include wider child health services with a focus on the management of uncomplicated skin infections in addition to swabbing and managing sore throats.

Provider personnel ranged from trained nursing staff such as public health nurses or other registered nurses, to trained non-nursing staff collectively known as kaiāwhina (community support workers and whānau [family] support workers), or a combination. At least earlier in the school-based service roll-out, there were quality issues noted in the taking of throat swabs. The provision of antibiotics for children with a positive GAS throat swab was generally through the use of standing orders. [A standing order is a written instruction issued by a medical practitioner that authorises a specified person or class of people (e.g., registered nurses) who does not have prescribing rights to administer and/or supply specified medicines and some controlled drugs. A standing order does not allow a person to generate a prescription and provide it to a patient to take to a pharmacy to be dispensed (with the prescription signed later by the issuer of the standing order) (Ministry of Health 2012).] Antibiotics (or prescriptions for antibiotics) were either collected...
by parents/caregivers or delivered to their home, in some places with an extra home visit or phone call to check and encourage antimicrobial understanding and adherence.

Many of the RFPP’s planned monitoring and evaluation and surveillance activities to support the roll-out of the school-based sore throat service were delayed. Monitoring systems were not initially standardised. Local data recording, collection and reporting to the MoH has been incomplete and of variable quality. Of note, the National Health Index numbers (NHIs) of consented children participating in the RFPP have not been systematically recorded (although NHIs are recorded for those having a throat swab). Children who have moved out of schools through progression to high school, or those who have moved away from the area have not been systematically recorded. Therefore exposure to the school-based sore throat service for individual children could not be ascertained accurately over time.

2. Rapid Response Clinics for Sore Throat Management

Recognising that a coverage through the school-based service of around 50% of high-risk children in 2012 and 2013, and a service only operating for 40 weeks of the year was unlikely to have a large enough impact in reducing ARF, towards the end of 2013 the MoH expanded the sore throat management component to set up rapid response sore throat management clinics. These were commenced in several high-risk DHB regions at the end of 2013, expanding to other high-risk areas through 2014. The aim was to enable 80% of target populations (children and young people aged 4–19 years, Māori, Pacific, or NZDep quintile 5) as ascertained by Primary Health Organisations based on enrolled populations, to have free and open access to school-based services, nurse-led primary or community care sore throat assessment and treatment. Of note, patients presenting with a sore throat do not need to be enrolled in a practice to access the free service.

DHBs were encouraged to provide these services in a variety of settings including general practices, pharmacies, high-need secondary schools, or other venues such as youth health services. Separate funding was allocated specifically for these services and was not to be used to enhance existing school-based services. The aim was to provide free (no cost to the patient, and no GMS claim made for non-enrolled patients), accessible, walk-in service not requiring an appointment for high-risk children and young people who did not attend a school with a school-based service, or who did not attend school. It was envisaged that these services be available out of school hours including school holidays.

Those eligible to receive free sore throat assessment and treatment are the priority population i.e. Māori and Pacific children and young people aged 4–19 years and those living in NZDep quintile 5 areas and their household contacts aged 3–35 years who have a sore throat. Children or young people presenting to these rapid response clinics with a sore throat were to have a throat swab taken and treated, or treated empirically with no swab taken - as per the MoH guidelines for rapid response clinics [MoH, personal communication].
As the rapid response clinics are currently being rolled out, and by the end of 2014 were not fully implemented, this evaluation was not able to evaluate their specific impact on ARF incidence. Some DHBs are transitioning to scaling up rapid response clinics and decreasing the school-based service e.g. Tairāwhiti.

Figure 14 illustrates the roll-out of the rapid response clinics through to the end of 2014. Similar to the school-based service figure, each line represents a sore throat rapid response clinic that has been implemented, so the height of the DHB block represents the number of rapid response clinics to the end of 2014. The top horizontal timeline is divided into three-month blocks by year. Where a blue line commences is when the rapid response clinic was first implemented.

**Figure 14. Progressive roll out of rapid response sore throat clinics by quarters in DHBs**

These clinics were only operating in 5 out of the 11 DHBs that were providing a school-based service by the end of 2014, although this has expanded considerably since then. By the end of 2014, there was an overlap of the school-based service and rapid response sore throat clinics with 37% of areas (census area units) with a rapid response clinic also having a school-based service operating.
In addition to school-based and rapid response clinics, priority populations can access their usual primary care practice for sore throat management. Some primary care general practices elect to be Very Low Cost Access (VLCA) Primary Care Practices where consultation fees are kept to an agreed low maximum amount. Eligibility for the VLCA scheme is limited to Primary Healthcare Organisations and contracted general practices meeting the eligibility criteria of 50% or more of their enrolled population being high needs (defined as Māori, Pacific, or NZDep quintile 5).

Figure 15. Example of the location of school-based, rapid response clinics, and Very Low Cost Access Primary Care Practices in an area of Auckland (March 2015)
3. BACKGROUND TO THE SORE THROAT COMPONENT OF THE RFPP INTERIM EVALUATION

Interim Evaluation Goals

Goals of interim evaluation

- Process and interim outcome evaluation
- Focus on the sore throat management component of the RFPP
- Include a value for money review of the sore throat component
- Provide conclusions for future investment in sore throat management

Ethics

Ethical approval for this interim evaluation was provided by the Otago University Human Research Ethics Committee (HD15/009) after being validated by the New Zealand Health and Disability Ethics Committee (15/NTB/63) as not being within the scope of Health and Disability Ethics Committee review. In addition, the interim evaluation protocol was assessed by the Ngāi Tahu Research Consultation Committee which considered the research to be of importance to Māori health, encouraged ethnicity data to be collected, and suggested dissemination of the research findings to Māori health organisations and the National Heart Foundation.

Background to evaluation methods

1. Notification systems for ARF in New Zealand

In NZ there are three major systems used for the surveillance of RF: national hospitalisation data\textsuperscript{16}; national notification data (based on notifications to Medical Officers of Health)\textsuperscript{17}; and regional patient registers\textsuperscript{18}. Both first episodes of ARF and recurrences have been notifiable in NZ since 1986. RHD in children and young adults aged less than 20 years has also been included in the case definition for ARF notifications, until recently\textsuperscript{19}. Under-reporting has been documented in ARF notification data\textsuperscript{20-22} and ARF register data\textsuperscript{21,23} in some regions. Miscoding and misdiagnoses affect hospitalisation data, which may over count cases by 25%-33\%\textsuperscript{24}. In more recent years, ARF notifications and first episode ARF hospitalisations have become more closely aligned (Figure 16).

Rheumatic fever became a notifiable disease in 1986, however due to under-notification and delays in notifications, first episode ARF hospitalisations have been used by the MoH to monitor the incidence of initial episodes since 2010. The MoH requested that this interim evaluation estimate the effectiveness of the sore throat swabbing component of the RFPP based on the incidence of first episode ARF hospitalisations which we have used for the majority of the
descriptive epidemiological section. For methodological reasons we have used notifications of probable and confirmed ARF cases to estimate effectiveness of the school-based sore throat management service, and to construct cumulative notified case curves including data from the first 6 months of 2015.

ARF hospitalisations were determined using the MoH’s first episode ARF hospitalisation criteria for data definition, June 2013 (see Appendix 1). The National Minimum Data Set (NMDS) de-identified hospitalisation data from 2000 to June 2015 for ARF and RHD were obtained from the MoH.

Since 2010, the number of ARF cases as determined by first episode hospitalisation or by notification have matched (Figure 16). We are therefore confident in using either data source for analysis in this interim evaluation.

![Figure 16. Comparison of ARF notifications and hospitalisations, by year, 2000-2014](image)

Data Source: NMDS (hospitalisations); ESR (notifications by onset date; probable and confirmed).
Note: Some of the increase in incidence reflects use of count data rather than rates.

2. Planned individual-level analysis

Initially we planned to assess the effectiveness by an individual-level analysis of ARF risk in relation to exposure to specific components of the RFPP, namely children attending a school with a sore throat service, or accessing a rapid response sore throat clinic. This analysis would have depended on the MoH providing the researchers with unique identifiers (encrypted NHIs for all children in the high risk population (estimated 234,067) and those children exposed to sore throat management component of the RFPP, including the school-based service (estimated 52,028 children participating in 2014), and rapid response clinics (estimated coverage of 88,000 children and young people) and the duration they were exposed for. [All number estimates noted here were given by the MoH].
Retrospective analysis would assess the change in individual risk of first episode ARF hospitalisations for those high-risk children associated with exposure to the sore throat management component of the RFPP compared to high-risk children not exposed to the component at the same time period. This individualised analysis would reduce area-based or school-based confounding and have a much greater power than the area- or school-based analysis.

Unfortunately this method was not possible as service providers have not consistently or fully collected NHIs of all consented children in the sore throat management component regardless of whether they received a throat swab or not. Some providers had hand written lists of consented children, or incomplete electronic records. Due to the time constraints of the interim evaluation it was not deemed feasible for this information to be collected retrospectively. In addition, it was not clear that providers had sufficient records to document when individual students entered and exited their service. For this reason it may never be possible to accurately assess the impact of this component retrospectively (although there is potential to improve data collection prospectively to support improved evaluation in the future).

3. Descriptive epidemiology methods

As described earlier, ARF hospitalisations were determined using the first episode ARF hospitalisation criteria for data definition, June 2013 (see Appendix 1). The NMDS de-identified hospitalisation data from 2000 to 2014 for ARF and RHD was obtained from the MoH. Total NZ first episode ARF hospitalisation data for January to June 2015 was also obtained later in the evaluation. Added to the NMDS is the New Zealand Deprivation (NZDep2013) score which is an area-based measure of deprivation from 1 (low deprivation) to 10 (high deprivation). Ethnicity was assigned using prioritised ethnicity where each respondent is allocated to a single ethnic group using the priority system (Māori, Pacific peoples, Asian, other groups except European, and European). This output type is the one most frequently used in MoH statistics and is also widely used in the health and disability sector. Its advantage is that it produces data that are easy to work with as each individual appears only once so the sum of the ethnic group populations will add up to the total NZ population.

Most hospitalisation rates are given using the raw population numbers, however where age-standardised rates are given, the rates provided use the 2013 census usually resident population as the referent population.

Notifications for probable and confirmed ARF cases with onset dates from 2009 to June 2015 were used to construct cumulative graphs.
4. DESCRIPTIVE EPIDEMIOLOGY OF FIRST EPISODE ARF HOSPITALISATIONS

First episode ARF hospitalisation incidence

The following figure shows the incidence rate of ARF in NZ, based on first episode ARF hospitalisations, by year from 2000 to June 2015. This illustrates the key defined outcome of the RFPP.

Starting from a baseline rate of 4.0 per 100,000 (for the three year period 2009/10–2011/12) the BPS target is for a two-thirds reduction to 1.4 cases per 100,000 population, by June 2017.

There was a statistically significant decline in first episode ARF hospitalisations by June 2015 compared to the RFPP baseline years as noted earlier in Table 1 (page 6).

Figure 17. Total New Zealand first episode ARF hospitalisation rates per 100,000 population, crude annual rate by year, 2000-June 2015
1. First episode ARF hospitalisations age and gender distribution

The following graphs only include data through to the end of 2014. From 2009 to 2014, for children and young people aged 4–19 years, the median age of initial ARF hospitalisation was 12 years with an interquartile range of 9–16 years. The most common age of initial hospitalisation was 10 years.

The risk of ARF is shown to have a fairly symmetrical bell-curve distribution for those aged 4–19 years (Figure 18). The distribution of cases by year of age was fairly consistent across the baseline (2009–2011) period and the subsequent three years.

Figure 18. Distribution of total New Zealand first episode ARF hospitalisations for 4–19 year olds 2009–2011 average, 2012, 2013 and 2014

Highest incidences of first episode ARF hospitalisations in New Zealand are in children and young people (Figure 19), with the highest incidence in the 5–12 years age group, followed by young people aged 13–19 years (Figure 20). First episode ARF hospitalisations rarely occur in young children under the age of 5 years or adults over the age of 20 years.
Figure 19. Total New Zealand overall first episode ARF hospitalisation rates by age group

First episode ARF hospitalisation rates in the 5–12 years age group targeted by the school-based service of the RFPP had not declined significantly compared with baseline rates by the end of 2014 (Figure 20). In addition, ARF rates in this age group had not diverged from those observed in the 13–19 years age group which are (largely) not covered by the school-based service (Figure 20).

Figure 20. Total New Zealand overall first episode ARF hospitalisation rates by age groups, 5–12 and 13–19 years
New Zealand consistently has a higher incidence of first episode ARF hospitalisations in males (Figure 21). The reasons for this have not been determined.

**Figure 21. Total New Zealand overall first episode ARF hospitalisation rates by gender**

First episode ARF hospitalisations have a well-documented association with socio-economic status with the highest incidence observed among those living in the most deprived NZDep deciles in New Zealand (Figure 22).

**Figure 22. Total New Zealand overall first episode ARF hospitalisation rates by NZDep**

3. First episode ARF hospitalisations distribution by ethnicity

Māori and Pacific populations have a much higher incidence of first episode ARF hospitalisations compared to non-Māori, non-Pacific populations (Figure 23). In recent years (2013–14) the incidence of ARF among Māori and Pacific children appears to have diverged with a decreasing trend in Māori, whereas among Pacific children the incidence appears to have risen.
The RFPP also aims to reduce ethnic inequalities in ARF incidence. The following table (Table 4) shows the age-standardised rate ratio for Māori and Pacific compared with European/Other, averaged by three-year periods from 2000 to 2014.

Since 2000–2002 the age-standardised rate ratios have generally increased for both Māori and Pacific, with a widening of inequalities in developing ARF compared to European/Other. Strikingly, between 2000 and 2014 the rate ratios for Māori have increased from 9.4 to 27.4 times higher than that of European/Other, and for Pacific an increase from 25.2 to 62.9 times higher.
Table 4. First episode ARF hospitalisations age-standardised* rates and rate ratios by prioritised ethnicity 2000-2014, by three-year periods

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<td>2.88</td>
<td>2.58</td>
<td>3.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003–2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European/Other</td>
<td>43</td>
<td>0.47</td>
<td>0.33</td>
<td>0.61</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>191</td>
<td>7.48</td>
<td>6.37</td>
<td>8.60</td>
<td>15.94</td>
<td>13.56</td>
<td>18.75</td>
</tr>
<tr>
<td>Pacific</td>
<td>148</td>
<td>15.66</td>
<td>13.04</td>
<td>18.28</td>
<td>33.38</td>
<td>28.27</td>
<td>39.41</td>
</tr>
<tr>
<td>Total</td>
<td>382</td>
<td>3.02</td>
<td>2.71</td>
<td>3.32</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2006–2008</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>European/Other</td>
<td>41</td>
<td>0.44</td>
<td>0.31</td>
<td>0.58</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>226</td>
<td>8.82</td>
<td>7.61</td>
<td>10.03</td>
<td>19.96</td>
<td>16.96</td>
<td>23.49</td>
</tr>
<tr>
<td>Total</td>
<td>404</td>
<td>3.14</td>
<td>2.84</td>
<td>3.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009–2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European/Other</td>
<td>41</td>
<td>0.44</td>
<td>0.30</td>
<td>0.57</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>262</td>
<td>10.66</td>
<td>9.30</td>
<td>12.02</td>
<td>24.41</td>
<td>20.78</td>
<td>28.69</td>
</tr>
<tr>
<td>Pacific</td>
<td>182</td>
<td>18.42</td>
<td>15.65</td>
<td>21.20</td>
<td>42.19</td>
<td>35.75</td>
<td>49.80</td>
</tr>
<tr>
<td>Total</td>
<td>485</td>
<td>3.80</td>
<td>3.46</td>
<td>4.13</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2012–2014</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European/Other</td>
<td>34</td>
<td>0.35</td>
<td>0.23</td>
<td>0.47</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>235</td>
<td>9.65</td>
<td>8.35</td>
<td>10.95</td>
<td>27.44</td>
<td>23.01</td>
<td>32.73</td>
</tr>
<tr>
<td>Pacific</td>
<td>215</td>
<td>22.11</td>
<td>19.05</td>
<td>25.18</td>
<td>62.88</td>
<td>52.68</td>
<td>75.05</td>
</tr>
<tr>
<td>Total</td>
<td>484</td>
<td>3.80</td>
<td>3.46</td>
<td>4.14</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Age standardised to age distribution in 2013 Census usually resident population.
Māori

Similar to overall New Zealand, the highest incidence of first episode ARF hospitalisation for Māori is among children aged 5–12 years. This is also the age group that is targeted in the school-based sore throat service and where there appears to be a trend in decreasing incidence since 2011. However, there is no clear trend for the next highest incidence group of young people aged 13–19 years (Figure 24).

![Figure 24. Māori first episode ARF hospitalisation rates by age](image)

Similar to overall NZ there is a strong socio-economic status gradient in the incidence of first episode ARF hospitalisation amongst Māori, with those living in the most deprived NZDep quintile having the highest incidence (Figure 25). However, those in the three next most deprived quintiles also have incidence rates higher than the NZ total, and higher than non-Māori non-Pacific populations. Only those in the least deprived NZDep quintile amongst Māori have incidence rates similar to non-Māori, non-Pacific, in the most recent years.

![Figure 25. Māori first episode ARF hospitalisation rates by NZDep](image)
Pacific

The highest incidence of first episode ARF hospitalisation among Pacific children is in the same age groups of 5–12 years, followed by 13–19 years. There appears to be an increasing trend in the incidence of ARF hospitalisation in children 5–12 years in the past three years to the end of 2014 although more time will be needed to see if this trend continues (Figure 26).

**Figure 26. Pacific first episode ARF hospitalisation rates by age**

![Graph showing the incidence of ARF hospitalisation rates by age among Pacific children]

Similar to New Zealand overall and Māori children and young people, there is a steep socio-economic gradient with Pacific populations living in the most deprived NZDep quintile having the highest incidence of first episode ARF hospitalisation. The next two quintiles also clearly have a high incidence, but small numbers make it difficult to interpret the less deprived NZDep quintiles pattern among the Pacific population (Figure 27).

**Figure 27. Pacific first episode ARF hospitalisation rates by NZDep**

![Graph showing the incidence of ARF hospitalisation rates by NZDep quintile among Pacific children]
5. CUMULATIVE NOTIFICATIONS OF PROBABLE AND CONFIRMED ARF CASES

Using notification data of probable and confirmed cases from January 2009 through to June 2015 we produced cumulative graphs to present temporal trends for ARF notifications for children and young people aged 4–19 years. Please note that due to variability in the completeness of notification data over time, particularly earlier in this time period, these findings are not directly comparable with temporal trends using ARF first episode hospitalisation data and should be treated with caution.

Figure 28 shows the cumulative number of ARF notifications for children and young people aged 4–19 years in NZ in total. There has been a statistically significant 28% decrease in notifications to June 2015 compared with June in the baseline 2009–2011 period.

Figure 28. Cumulative ARF notifications in 4–19 year olds for all New Zealand, 2009–June 2015

Figure 29 shows the cumulative incidence of ARF in the 10 DHBs where the school-based sore throat management service was or is being implemented. There has been a statistically significant 29% decline in notifications to June 2015 relative to June 2009–2011 period.

Figure 29. Cumulative ARF notifications in 4–19 year olds for the 10 DHBs with a school-based service, 2009–June 2015
To further explore these temporal trends we produced graphs for children aged 5–12 years (Figure 30) and young people aged 13–19 years (Figure 31) in the 10 DHBs where the school-based service was being implemented.

For all children aged 5–12 years there was a 26% reduction in ARF notifications by June 2015 compared to baseline years (Figure 30). This decline could be partly due to the school-based service which targets this age group although it may also be partly due to a background decline in the incidence of ARF. The RFPP messaging, improved primary care management, or for other unknown reasons may have contributed to the decline. Additional months and years of data will be needed to confirm trends.

![Figure 30. Cumulative ARF notifications in 5–12 year olds for the 10 DHBs with a school-based service, 2009–June 2015](image)

For young people aged 13–19 years there was a 40% reduction in ARF notifications by June 2015 compared to baseline years (Figure 31). These young people are not in the age group targeted by the school-based service and therefore the decline is unlikely to be related to the implementation of that service.

![Figure 31. Cumulative ARF notifications in 13–19 year olds for the 10 DHBs with a school-based service, 2009–June 2015](image)
The following figures show the cumulative incidence of ARF for various combinations of DHBs. There are the three Auckland DHBs combined (Figure 32), then CMDHB (Figure 33), Auckland and Waitemata DHBs combined (Figure 34), followed by the seven other DHBs outside Auckland which are implementing a school-based service (Figure 35).

These graphs highlight that the decrease in notifications can mostly be attributed to CMDHB (Figure 33), although there may be some decrease in incidence in the seven other DHBs in 2015 (Figure 35). By comparison, there is no apparent decline in ARF notifications in the other two Auckland DHBs (Auckland and Waitemata DHBs) (Figure 34), although based on very small numbers.

CMDHB has implemented the school-based sore throat management service in 61 primary and intermediate schools, with coverage of decile 1–3 school children aged 5–12 years of over 80% in their district. A decline in notifications can be noted from mid-2014, which has continued during the first six months of 2015. This matches the time period when the school-based service was fully operating in all the selected schools in CMDHB.

Figure 32. Cumulative ARF notifications in 4–19 year olds for Auckland, Waitemata and Counties Manukau DHBs, 2009–June 2015

Figure 33. Cumulative ARF notifications in 4–19 year olds for CMDHB, 2009–June 2015
Figure 34. Cumulative ARF notifications in 4–19 year olds for Auckland and Waitemata DHBs, 2009–June 2015

Figure 35. Cumulative ARF notifications in 4–19 year olds for the seven other DHBs with a school-based service, 2009–June 2015
Summary table of cumulative ARF notifications

Table 5. Percentage changes in annual incidence relative to the 2010–2012 baseline period

<table>
<thead>
<tr>
<th>ARF incidence</th>
<th>Baseline 2009–2011</th>
<th>2014</th>
<th>% decline 2014 compared to baseline</th>
<th>P value</th>
<th>Baseline 2009–2011 first six months</th>
<th>2015 first six months</th>
<th>% decline 2015 compared to first 6 months of baseline</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All New Zealand, 4–19 years</td>
<td>136</td>
<td>124</td>
<td>9%</td>
<td>0.22</td>
<td>75</td>
<td>54</td>
<td>28%</td>
<td>0.004</td>
</tr>
<tr>
<td>10 DHBs with a school-based service, 4–19 years</td>
<td>121</td>
<td>119</td>
<td>2%</td>
<td>0.42</td>
<td>68</td>
<td>48</td>
<td>29%</td>
<td>0.004</td>
</tr>
<tr>
<td>Auckland DHBs, 4–19 years</td>
<td>67</td>
<td>59</td>
<td>5%</td>
<td>0.37</td>
<td>39</td>
<td>28</td>
<td>28%</td>
<td>0.03</td>
</tr>
<tr>
<td>7 other North Island DHBs with a school-based service, 4–19 years</td>
<td>58</td>
<td>60</td>
<td>3% increase</td>
<td>N/A</td>
<td>30</td>
<td>20</td>
<td>33%</td>
<td>0.02</td>
</tr>
<tr>
<td>Counties Manukau DHB, 4–19 years</td>
<td>45</td>
<td>41</td>
<td>9%</td>
<td>0.31</td>
<td>30</td>
<td>17</td>
<td>43%</td>
<td>0.003</td>
</tr>
<tr>
<td>Other Auckland DHBs (Auckland and Waitemata), 4–19 years</td>
<td>17</td>
<td>18</td>
<td>6% increase</td>
<td>N/A</td>
<td>8</td>
<td>11</td>
<td>38% increase</td>
<td>N/A</td>
</tr>
<tr>
<td>Children 5–12 years (10 DHBs with a school-based service)</td>
<td>85</td>
<td>81</td>
<td>5%</td>
<td>0.31</td>
<td>47</td>
<td>35</td>
<td>26%</td>
<td>0.02</td>
</tr>
<tr>
<td>Young people 13–19 years (10 DHBs with a school-based service)</td>
<td>36</td>
<td>38</td>
<td>6% increase</td>
<td>N/A</td>
<td>20</td>
<td>12</td>
<td>40%</td>
<td>0.03</td>
</tr>
</tbody>
</table>

P value one-sided t test for a decrease compared to baseline.

The recent decline in ARF incidence (particularly for the first 6 months of 2015) appears to be widely distributed across populations of children who are vulnerable to the disease (4–19 year olds). For children 5–12 years old in the 10 DHBs which are implementing a school-based service, there was an overall 26% decline by mid-2015. However, this was for all children – both attending a school with and without a school-based sore throat service.
These graphs again show that ARF is a relatively uncommon disease and numbers vary from year to year for reasons that are not fully understood. For example, 2013 was a high incidence year across all geographic areas and age groupings. More months and years of data will help determine if downward trends seen mainly in 2015 are definite.

Looking at these graphs visually, and noting the limitation above, it appears that the incidence of ARF began a downward ‘trajectory’ sometime between August (CMDHB, but not other Auckland DHBs) and November 2014 (other North Island DHBs) and this decline has continued during the first six months of 2015. This decline was also observed among all children aged 5–12 years, not only those participating in the school-based service, and young people aged 13–19 years not targeted for the school service, suggesting that it may be driven by factors other than exposure to the school-based service. If this decline persists, then it would be useful to consider whether it can be linked to aspects of the RFPP such as the generally increasing emphasis on sore throat management in primary care or rapid response clinics, or the emphasis on primordial prevention – such as improved housing, or due to other unknown factors.
6. Effectiveness of the Sore Throat Component of the RFPP

Methods for the statistical analysis to determine the effectiveness of the sore throat component of the RFPP

The full effectiveness analysis was conducted using a cohort study design of all children aged 5–12 years in decile 1–3 schools in the 10 DHBs with the school-based service operating up to the end of 2014. We also performed a series of sub-analyses resulting in four analyses in total:

a) full analysis of 10 DHBs
b) restricted to children living in CMDHB
c) restricted to children attending schools with a sore throat service operating at any time during 2012–2014
d) restricted to children attending schools with a sore throat service operating at any time during 2012–2014 in CMDHB only.

Because the school-based service was progressively rolled out in decile 1–3 schools in 10 DHBs in the North Island, analyses (c) and (d) were effectively ‘before and after’ analyses, although some school-based services ended before the end of 2014. Methods and results for analyses (a) and (b) are reported in Appendix 5.

Methods restricted to children attending schools with a school-based service [(c) and (d)]

The aim of this cohort study was to estimate the school-based sore throat management service effectiveness by comparing the ratio of the incidence of ARF cases attending a school with a sore throat management service operating at the time of onset to those ARF cases attending a school with a sore throat service that was not operating at the time of onset. We included all children aged 5–12 years who attended a decile 1–3 school with a school-based sore throat management service in our cohort. We defined ARF cases as probable or confirmed notified cases of initial episode rheumatic fever aged 5–12 years and with an onset date between January 2012 and December 2014. If an onset date was not recorded, we used hospitalisation date and if there was no hospitalisation date then we used the date notified.

We obtained the number of 5–12 year olds in decile 1–3 schools operating a sore throat management service in 2012, 2013 and 2014 from the Ministry of Education website (https://www.educationcounts.govt.nz/statistics/schooling/student-numbers/6028). We calculated time exposed as the number of days that the service was operating for each school, based on the start and end dates of the school-based service provided by the Ministry of Health. Once a service had started, we assumed it operated continuously throughout the year, and that all children
attending the school were exposed to the service (‘intention to treat’). Time exposed was divided into the number of days in each of 2012, 2013 and 2014. Total time was the total number of days in each of 2012, 2013 and 2014 and time not exposed was total time minus time exposed for each school in each year. We calculated total person-time, person-time-exposed and person-time-not-exposed by multiplying the school rolls for 2012, 2013 and 2014 by the total time, time exposed and time not exposed for each school.

We assumed that most of the children at highest risk of ARF would attend a decile 1–3 school. We extracted information on ARF cases, including the school that they attended at the time of notification, from the notifiable disease database and matched school names with Ministry of Education data to get the school decile. We used the 2012 school decile rankings as most school-based programmes began during 2012. Where the 2012 school decile was unavailable, for example new or merged schools, we used the 2014 school decile. We excluded cases that attended a school with a decile ranking of 4 or higher. If cases had an onset date within a month of the start of the school-based service they were counted as partially exposed and excluded from the analysis. Of note, in this intention to treat analysis all of the time that a school-based service was operating was classified as ‘exposed’ since children had the potential to be swabbed if they had a sore throat. We did not ascertain if children attending a school with a school-based sore throat service consented to be part of the service. In 2014, consent has been reported to be generally high (≥95%)\(^{27,28}\), although earlier consent may have been as low as 70% in some areas\(^{12}\). Figure 36 illustrates the cohort design we have used.

**Figure 36. Cohort design effectiveness analysis**

Eligible cohort: all children 5–12 years in decile 1–3 schools with a sore throat management service operating during 2012–2014.
Children eligible were all children aged 5–12 years attending decile 1–3 schools with a school-based service operating during 2012–2014. These included schools in Northland, Auckland, Waitemata, Counties Manukau, Waikato, Lakes, Bay of Plenty, Tairāwhiti, Hawkes Bay, and Capital and Coast DHBs.

Children not eligible for this effectiveness analysis were children: outside the age 5–12 years; not attending school with a sore throat service; attending a decile 4–10 school with a sore throat service; not attending school or school attended not known.

We determined service effectiveness (SE) by $SE = 1 - RR$, where $RR$ was the ratio of the incidence of ARF in exposed to non-exposed cases. We calculated test-based 95% confidence intervals.

$$RR = \frac{\text{No. of ARF cases exposed}}{\text{person-days-exposed}} \div \frac{\text{No. of ARF cases not exposed}}{\text{person-days-not-exposed}}$$

**Limitations of the effectiveness analyses**

We were unable to use our preferred approach of individual analysis using NHIs to assess the effectiveness of the sore throat service comparing those children exposed to those not exposed. Due to the lack of exposure identification at an individual level, this cohort design was used, however we note the main potential weakness is inherent in this being an observational study without random assignment and may therefore be prone to unmeasured confounding including any change in the underlying ARF incidence.

Mobility in school rolls during a school year could not be taken into account. Both the school-based service and rapid response clinics were concentrated in areas with a high incidence of ARF, with some overlapping, there was no way to distinguish the separate effects. Primary school-age children could attend either the school-based service or rapid response clinic if both were offered in their area.
Results and discussion of effectiveness of the school-based sore throat management service of the RFPP

The school-based sore throat management service under the RFPP targets children aged 5–14 years. However, after reviewing the number of ARF cases per single year of age and the ages of children attending a primary or intermediate school, we decided to determine the effectiveness for the 5–12 years age group. Approximately 18% of children aged 13 years old are in Year 8 (final year of primary and intermediate school) and very few are aged 14 years. In order to determine the maximum effect of the service without any dilution of the effect (for example by including all children aged 13 years when more than 80% would not be attending primary school), we only included the children of ages most likely to be at primary and intermediate school (Years 1–8) i.e. 5–12 years. Our analysis showed that 22% of notified ARF cases during the time period 2012–2014 attended a school of decile 4–10, these were also excluded to focus on more deprived decile 1–3 schools. Our approach therefore, intended to allow the school-based sore throat management service the best possible outcome.

Due to concerns about unmeasured confounding, we have focused here on presenting results of the analysis restricted to children attending schools with a sore throat service (i.e. (c) and (d) described in the above methods) (Table 6). These analyses of the school-based sore throat management service take advantage of having the same school populations included both in the non-exposed (before the service was implemented or after the service stopped) and exposed person-time analysis. This therefore adjusts for confounding due to person characteristics such as ethnicity or level of deprivation, however it provides little adjustment for fluctuations in the ‘underlying’ ARF incidence rates because the person-time not-exposed and exposed is largely divided into blocks before and after the RFPP commenced. This analysis was by ‘intention to treat’ meaning we did not exclude person-days exposed during school holiday periods. If a child was exposed to a school-based sore throat management service, then the entire period from after one month of implementation was included as exposed, until the end of 2014 or until the implementation ceased. This fits with evaluating an operational public health programme rather than a controlled research study.

Results of the full analyses are included in Appendix 5. Table 6 presents the results for sub-analyses (c) and (d).
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of cases exposed/person-days exposed</th>
<th>Number of cases non-exposed/person-days not exposed</th>
<th>ARF decline (proportion)</th>
<th>Lower confidence limit</th>
<th>Upper confidence limit</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools in ten DHBs with a sore throat service</td>
<td>79/34,798,158</td>
<td>52/18,960,113</td>
<td>0.17</td>
<td>-0.17</td>
<td>0.42</td>
<td>No</td>
</tr>
<tr>
<td>Schools in CMDHB with a sore throat service</td>
<td>33/15,273,980</td>
<td>31/9,945,963</td>
<td>0.31</td>
<td>-0.13</td>
<td>0.58</td>
<td>No</td>
</tr>
</tbody>
</table>

Overall the school-based service in the 10 DHBs through to the end of 2014 was associated with a 17% non-statistically significant reduction (95% CI: -0.17–0.42) in the incidence of ARF among children aged 5–12 years attending decile 1–3 schools.

In CMDHB, the school-based service was associated with a 31% non-statistically significant reduction (95% CI: -0.13 to 0.58) in the incidence of ARF cases among children aged 5–12 years attending decile 1–3 schools in the CMDHB area. This larger reduction could be attributed to the rigorous implementation of the school-based service with high coverage, and additional elements such as management of skin infections and support for improved antimicrobial adherence.

However, these results must be interpreted with caution, as they are also consistent with the service having no effect on the incidence of ARF to the end of 2014. It is possible, but by no means definite, that another year of data may strengthen findings. As noted, this restricted analysis is largely a ‘before and after’ analysis because of the temporal distribution of exposure to the RFPP, so provides little adjustment for changes in the ‘underlying’ rate of ARF over time.

It should be noted however, that to the end of 2014, the cumulative graphs do not show a decline in ARF notifications compared to 2010–2012. The decline in ARF cases is only apparent by June 2015 compared to June 2010–2012. Re-analysis of the effectiveness with a further year of data may show clearer results.

Our analysis is suitably powered (85%) to detect a true effect size of 50% effectiveness on three years of data (approximately 18 months exposed to the service and 18 months not-exposed to the service).

For similar power with a true effect size of 30%, we estimate approximately eight years of data would be required (2008 to June 2016). For 85% power with a true effect size of 15%, we estimate approximately 32 years of data would be required. Power could be increased by having more schools in the service, or by using individual data if available.
7. INTERIM EVALUATION FINDINGS FROM LABORATORY DATA ANALYSIS

Introduction

The school-based service of the RFPP involves children who self-identify with pharyngitis at school. These children are then managed in accordance with the National Heart Foundation’s recommendations for the primary prevention of ARF in high-risk populations. As part of these guidelines, it is recommended that a throat swab is taken to test for the presence of GAS. These swabs are then sent to local community laboratories for culture, and treatment of children with antibiotic therapy is initiated following culture confirmation of GAS. The RFPP also aims to improve ARF primary prevention in primary care by providing rapid access to throat swabbing and antimicrobial treatment of GAS pharyngitis.

Upon receipt in the laboratory, a throat swab is registered into the laboratory database, and cultured for the presence of GAS. Throat swab data collected by community microbiology laboratories provides a potentially rich source of data for epidemiological assessment of programme coverage and results of microbiological testing.

These findings describe the preliminary analysis of throat swab data collected from three regions in New Zealand encompassing five DHBs:

- Northland DHB
- greater Auckland region (Waitemata, Auckland and Counties Manukau DHBs)
- Capital and Coast DHB (CCDHB)

Aims

- To assess the effect of the RFPP on the targeting of throat swabbing to children at high risk of developing ARF (based on the rate and distribution of swabbing and GAS detection).
- To determine the extent to which first episode ARF hospitalisation cases are successfully identified and swabbed, either in primary health care or through a school-based sore throat management service, during the period of their presumed acute pharyngitis.

Methods

1. Data sources

Data were obtained from the following community microbiology laboratories on throat swabs taken from children aged 5–14 years:

- Northland Pathology (2011–2014) (covering Northland DHB)
- Labtests, Auckland (2010–2014) (covering three Auckland DHBs)
Aotea Pathology (2009 – 2014) (covering CCDHB)

Laboratories provided the following data fields:

- NHI (subsequently encrypted by MoH)
- age of child
- date of sample
- organism growth (yes/no) on throat swab
- organism identification (e.g. GAS; group C/G streptococci).

The following exclusion criteria were applied to the laboratory datasets:

- swabs with practitioner laboratory codes originating from DHBs outside of community microbiology catchment areas;
- age <5 years and >14 years;
- swabs taken from research-based GAS carriage prevalence studies in 2013 and 2014 from mostly asymptomatic children. These were identifiable using specific laboratory codes;
- swabs taken from sites other than the throat;
- swabs missing NHI.

For each child with a valid NHI, data on prioritised ethnicity and NZDep decile were provided by the MoH, along with any ARF hospitalisations. NZDep deciles were recoded into NZDep quintiles, whereby quintile 1 combines deciles 1 and 2 (least deprived), and quintile 5 combines deciles 9 and 10 (most deprived). Ethnicity was stratified into four groups using the following prioritisation: Māori, then Pacific, then Asian, then European/Other.

RFPP school service swabs were identified by laboratory codes assigned to health workers participating in the school service. These were cross-referenced with laboratory dates and school service implementation dates for accuracy. The following definitions were used:

- a ‘school’ swab was defined as one identified as collected from the RFPP school swabbing service;
- a ‘primary care’ swab was defined as any swab taken from a source other than the RFPP school-based service, and included primarily general practices but also rapid response clinics, public health services, midwifery services and subspecialty outpatient clinics.

First episode ARF hospitalisations in children aged 5–14 years were identified by searching the NMDS using previously defined definitions [20].
2. Statistical analysis

All rates were generated using population data by DHB derived from 2013 NZ census usually resident population. This was to enable adequate comparison between school-based and primary care rates. For swab sample data, rates and percentage test positivity were initially stratified according to sociodemographic factors (source of swab, NZDep quintile, ethnicity and DHB) to determine overall annual differences. The chi-squared test was used to investigate whether rate differences between the baseline (pre-RFPP) and most recent (post-RFPP) year were significant. A P value of <0.05 was regarded as significant.

Swab sample data were linked to first episode ARF hospitalisation cases using the encrypted NHI to calculate the prevalence of cases with a preceding throat swab for suspected GAS pharyngitis between 1 and 30 days prior to hospital admission.

Data cleaning, epidemiological and statistical analyses were undertaken using R version 2.1 (R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/).
Results

Incidence of swabbing and GAS prevalence

Results are presented as a comparison between regions, and then stratified by each individual region.

COMPARATIVE RATE OF SWABBING AND GAS POSITIVITY

Since the implementation of the RFPP, the total rates of swabbing increased in all three regions (Figure 37).

Figure 37. Annual rates of throat swabbing in children aged 5–14 years in Northland DHB, Auckland and CCDHB, 2009–2014

In 2014, the rate of swabbing was highest in the school service in Auckland and Northland (Figure 38).

Figure 38. Annual rates of throat swabbing in children aged 5–14 years in Northland DHB, Auckland and CCDHB, 2009–2014, by source
The proportion of throat swabs that cultured GAS (i.e. the GAS positivity rate of throat swabs) decreased in the Auckland region and in CCDHB, although increased in Northland DHB (Figure 39).

**Figure 39. GAS positivity rate (%) from throat swabs, by region, 2009–2014**

In all three regions in 2014, the GAS positivity rate in primary care was approximately twice as high as the GAS positivity rate in school-based services (Figure 40).

**Figure 40. GAS positivity rate (%) of throat swabs, by source and region, 2009–2014**
**NORTHLAND (2011–2014)**

**Overall number and rate of throat swabs**

A total of 51,384 throat swabs were received between 2011 and 2014 from children aged 5-14 years in Northland. Of these, 33,245 (64.7%) were received as part of the school-based service, and 18,139 (35.3%) were received from primary care. There was seasonality in swabbing, with swabbing rates highest in the winter months (Figure 41). The months with lowest numbers of swabs for the school-based service coincide with the school holidays in April, July October and December-January.

**Figure 41. Rate of throat swabs received per month in Northland DHB, from school-based services and primary care, 2014**

![Graph showing rate of throat swabs per month in Northland DHB, from school-based services and primary care, 2014](image)

Of children who had swabs taken, the mean number of throat swabs per child in 2014 was 2.9 (range 1–44 swabs). This differed significantly between the school-based service (3.8, range 1–44 swabs) and primary care (1.4, range 1–14 swabs) (P < 0.001). There was also a significant difference in the median number of throat swabs between the school-based service and primary care (2 [inter-quartile range (IQR) 1–5] vs. 1 [IQR 1–2], respectively; P < 0.001). In 2014, the majority of children in primary care only had one swab taken (Figure 42).

**Figure 42. Number of throat swabs per child in Northland DHB 2014, source**

![Graph showing number of throat swabs per child in Northland DHB 2014, source](image)
The rate of throat swabbing increased in both primary care and in school-based services (Figure 43). In 2014, the rate of throat swabbing was 2.7 times higher in the school service than in primary care (754 vs 280 swabs per 1,000 children, respectively).

**Figure 43. Annual rates of throat swabbing in children aged 5–14 years in Northland DHB, by source, 2011–2014.**

![Chart showing annual rates of throat swabbing in children aged 5–14 years in Northland DHB, by source, 2011–2014.](chart)

**Demographic characteristics of children**

The median age of children having a throat swab taken was 8.5 years (IQR 6.8–10.8 years). There was a statistically significant difference in age between children having a throat swab as part of the school-based service vs. primary care (8.4 vs. 9.3 years, respectively, \( P < 0.001 \)).

The rate of throat swabbing increased in children living in NZDep quintile 5 areas between 2010 and 2014. This was driven almost entirely by increased swabbing as part of the school service (Figure 44). Of note, throat swabbing also increased in quintile 1 children in primary care who are not a priority population.

**Figure 44. Annual rates of throat swabbing in children aged 5–14 years in Northland DHB, by source and NZDep quintile, 2011–14**

![Chart showing annual rates of throat swabbing in children aged 5–14 years in Northland DHB, by source and NZDep quintile, 2011–14.](chart)
Swabbing rates were highest in Māori children in the school service (Figure 45), although it is likely that this reflects the population structure of Northland DHB, which has a relatively high proportion of Māori children. Interestingly, although the swabbing rate in primary care also increased between 2009 and 2014, in 2014, the highest rate of swabbing in primary care was in European/Other children.

Figure 45. Annual rates of throat swabbing in children aged 5–14 years in Northland DHB, by source and ethnicity, 2011–14

Rate and incidence of GAS-positive throat swabs

Of the 51,384 throat swabs received between 2011 and 2014, 5,633 (10.9%) had GAS cultured. The overall incidence of GAS-positive throat swabs increased in Northland DHB following implementation of the RFPP. However, in contrast to the Auckland region and CCDHB, where the GAS positivity prevalence decreased, the GAS-positivity prevalence in Northland increased, from 8.4% in 2011 to 12.3% in 2014 (Figure 46).

Figure 46. Annual incidence of GAS positive throat swabs and GAS positivity rate from throat swabs from children aged 5–14 years in Northland DHB, 2011–2014
The highest incidence of GAS-positive swabs was in Māori children from the school service (Figure 47).

**Figure 47. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in Northland DHB, by source and ethnicity, 2011–14**

The highest incidence of GAS-positive swabs was from children living in NZDep quintile 5 areas in the school service (Figure 48).

**Figure 48. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in Northland DHB, by source and NZDep quintile, 2011–14**
**AUCKLAND REGION (2010–2014)**

**Overall number and rate of throat swabs**

A total of 374,041 throat swabs were received between 2010 and 2014 from children aged 5–14 years in the Auckland region. Of these, 232,487 (62.2%) were received as part of the school-based service, and 141,554 (37.8%) were received from primary care. There was marked seasonality in the incidence of swabbing in both primary care and school-based services, with swabbing rates highest in the winter months. Unsurprisingly, the incidence of swabbing declined during school holiday periods in the school service (Figure 49).

![Figure 49. Rate of throat swabs received per month in the Auckland region from school-based services and primary care, 2014](image)

The rate of throat swabbing increased in both primary care and in school-based services (Figure 50). In 2014, the rate of throat swabbing was 2.2 times higher in school service than in primary care (751 vs 337 swabs per 1,000 children, respectively).

![Figure 50. Annual rates of throat swabbing in children aged 5–14 years in the Auckland region, by source, 2010–2014](image)

---

1 NB – given the focus on CMDHB in the overall effectiveness and cost-effectiveness components, a sub-analysis for CMDHB is presented separately in Appendix 4.
Of the children who had swabs taken, the mean number of throat swabs per child in 2014 was 3.7 (range 1–37 swabs). This differed significantly between the school-based service (5.4, range 1–37 swabs) and primary care (1.6, range 1–31 swabs) \((P < 0.001)\). There was also a significant difference between the median number of swabs between children in the school-based service and primary care (median 4 [IQR 2–7] vs. 1 [IQR 1–2], respectively; \(P < 0.001\)) (Figure 51).

**Figure 51. Number of throat swabs per child in the Auckland region 2014, by source**

Demographic characteristics of children

The median age of children having a throat swab taken was 8.7 years (IQR 6.8–11.0 years). There was a statistically significant difference in age between children having a throat swab as part of the school-based service vs. primary care (8.8 vs. 9.3 years, respectively, \(P < 0.001\)).

The rate of throat swabbing increased in children living in NZDep quintile 5 areas between 2010 and 2014, and the highest rate of swabbing was in children living in NZDep quintile 5 areas from the school service (Figure 52).

**Figure 52. Annual incidence of throat swabbing in children aged 5–14 years in the Auckland region, by source and NZDep quintile, 2010–14**
Swabbing rates were highest in Pacific and Māori children in the school-based service, although swabbing rates also increased in Pacific and Māori children in primary care following the implementation of the RFPP (Figure 53).

Figure 53. Annual rates of throat swabbing in children aged 5–14 years in the Auckland region, by source and ethnicity, 2010–14

Rate and incidence of GAS-positive throat swabs

Of the 374,041 throat swabs received between 2010 and 2014, 50,776 (13.6%) had GAS cultured. Although the rate of GAS-positive throat swabs increased in the Auckland region, the prevalence of GAS positivity decreased from 21.9% in 2010, to 11.1% in 2014.

Figure 54. Annual incidence of GAS positive throat swabs and GAS positivity rate from throat swabs from children aged 5–14 years in the Auckland region, 2010–2014
The incidence of GAS-positive swabs was highest in Pacific and Māori children from the school service (Figure 55).

**Figure 55. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in the Auckland region, by source and ethnicity, 2010–14**

The highest incidence of GAS-positive swabs was from children living in NZDep quintile 5 areas in the school service (Figure 56).

**Figure 56. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in the Auckland region, by source and NZDep quintile, 2010–14**

**Overall number and rate of throat swabs**

A total of 21,780 throat swabs were received at Aotea Pathology between 2009 and 2014 from children aged 5–14 years. The number of throat swabs received increased from 766 in 2009, to 7,026 in 2014. Of the 7,026 swabs received in 2014, 2,008 (28.6%) were received as part of the school-based service, and 5,018 (71.4%) were received through primary care. Only 12 schools implemented the school-based sore throat service in CCDHB.

In primary care, the annual rate of throat swabbing increased from 22.5 per 1,000 children in 2009 to 143.4 per 1,000 children in 2014. The rate of throat swabbing was less in the school-service, increasing from 85.1 per 1,000 children in 2012 to 99.1 per 1,000 children in 2014 (Figure 57).

*Figure 57. Annual rates of throat swabbing in children aged 5–14 years in CCDHB, by source, 2009–2014*

There was marked seasonality in the number of throat swabs in schools and primary care, with a higher number of swabs in the winter months. As expected, the number of swabs decreased in school holiday periods in the school-based service. This pattern was also seen in primary care (Figure 58).

*Figure 58. Number of throat swabs received per month in CCDHB from the school-based service and primary care, 2014*
Overall, the mean number of throat swabs per child in 2014 was 1.6 (range 1–14 swabs). This differed significantly between the school-based service (3.2, range 1–14 swabs) and primary health care (1.2, range 1–10 swabs) \( (P < 0.001) \). There was also a significant difference between the median number of swabs between children in the school-based service and primary care (median 2 [IQR 1–4] vs. 1 [IQR 1–1], respectively; \( P < 0.001 \)) (Figure 59).

Figure 59. Number of throat swabs per child in CCDHB, 2014, by source

Demographic characteristics of children

The median age of children having a throat swab taken was 9.1 years (IQR 6.9–11.7 years). There was a statistically significant difference in age between children having a throat swab as part of the school-based service vs. primary care (8.4 vs. 9.7 years, respectively, \( P < 0.001 \)).

When stratified by source of swabbing (i.e. school vs. primary care), rates of swabbing were highest in the school service, from children residing in quintile 5 (Figure 60), and from Pacific children (Figure 61).

Figure 60. Annual rates of throat swabbing in children aged 5–14 years in CCDHB, by source and NZDep quintile, 2009–14
Rate and incidence of GAS-positive throat swabs

Of the 31,489 throat swabs received between 2010 and 2014, 5,209 (16.5%) had GAS cultured. Although the rate of GAS-positive throat swabs increased in CCDHB, the GAS positivity prevalence decreased from 27.2% in 2010, to 12.4% in 2014 (Figure 62).

Figure 61. Annual rates of throat swabbing in children aged 5–14 years in CCDHB, by source and ethnicity, 2009–14

Figure 62. Annual rates of GAS positive throat swabs and GAS positivity rate from throat swabs from children aged 5–14 years in CCDHB, 2009–2014
The incidence of GAS-positive swabs increased in quintile 5 between 2009 and 2014 in primary care (Figure 63).

**Figure 63. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in CCDHB, by source and NZDep quintile, 2010–14**

The incidence of GAS-positive swabs increased across all ethnic groups, although this was largely driven by an increased GAS rate in primary care, rather than in the school-based service (Figure 64).

**Figure 64. Annual incidence of GAS culture-positive throat swabs in children aged 5–14 years in CCDHB, by source and ethnicity, 2009–14**
Pre-hospitalisation swabbing of ARF cases

1. Northland DHB

The following table illustrates the number of first episode ARF hospitalisations in the Northland region, and the number of children having a preceding throat swab.

**Table 7. First episode ARF hospitalisations, aged 5–14 years in Northland DHB, 2011–14 and preceding throat swabbing**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RF cases in Northland region</th>
<th>Cases not swabbed ≤30 days of hospitalisation (%)</th>
<th>Cases swabbed ≤30 days of hospitalisation (%)</th>
<th>Location of pre-hospitalisation swabbing</th>
<th>GAS positive cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>primary care</td>
<td>School</td>
</tr>
<tr>
<td>2011</td>
<td>16</td>
<td>15 (94)</td>
<td>1 (6)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>12</td>
<td>8 (67)</td>
<td>4 (33)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2013</td>
<td>15</td>
<td>12 (80)</td>
<td>3 (20)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>13</td>
<td>8 (62)</td>
<td>5* (38)</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

*2 children were swabbed in both primary care and school-based services

The proportion of children hospitalised with ARF who did not have a throat swab taken prior to hospitalisation decreased from 94% in 2011, to 62% in 2014.

2. Auckland region

The following table illustrates the number of first episode ARF hospitalisations in the Auckland region, and the number of children having a preceding throat swab.

**Table 8. First episode ARF hospitalisations, aged 5–14 years in the Auckland region, 2010–14 and preceding throat swabbing**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RF cases in Auckland region</th>
<th>Cases not swabbed ≤30 days of hospitalisation (%)</th>
<th>Cases swabbed ≤30 days of hospitalisation (%)</th>
<th>Location of pre-hospitalisation swabbing</th>
<th>GAS positive cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>primary care</td>
<td>School</td>
</tr>
<tr>
<td>2010</td>
<td>61</td>
<td>55 (90)</td>
<td>6 (10)</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2011</td>
<td>64</td>
<td>57 (89)</td>
<td>7 (11)</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>55</td>
<td>50 (91)</td>
<td>5 (9)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2013</td>
<td>72</td>
<td>54 (75)</td>
<td>18* (25)</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>2014</td>
<td>52</td>
<td>40 (77)</td>
<td>12** (23)</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

*1 child was swabbed in both a school-based service and primary care

** 3 children were swabbed in both school-based service and primary care

The proportion of children hospitalised with ARF who did not have a throat swab taken prior to hospitalisation decreased from 90% in 2010, to 77% in 2014.
3. Capital and Coast DHB

The following table illustrates the number of first episode ARF hospitalisations in CCDHB, and the number of children having a preceding throat swab.

Table 9. First episode ARF hospitalisations, aged 5–14 years in CCDHB, 2009–14, and preceding throat swabbing

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RF cases in CCDHB</th>
<th>Cases not swabbed ≤30 days of hospitalisation (%)</th>
<th>Cases swabbed ≤30 days of hospitalisation (%)</th>
<th>Location of pre-hospitalisation swabbing</th>
<th>GAS positive cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>primary care</td>
<td>School</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>School</td>
<td>primary care</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>School</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>10 (100)</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>12</td>
<td>12 (100)</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2011</td>
<td>12</td>
<td>12 (100)</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>5</td>
<td>5 (100)</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>9</td>
<td>8 (89)</td>
<td>1* (11)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>8</td>
<td>6 (75)</td>
<td>2 (25)</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*1 child was swabbed in both the school-based service and primary care

The proportion of children hospitalised with ARF who did not have a throat swab taken prior to hospitalisation decreased from 100% in 2009, to 75% in 2014.
Laboratory Analysis Discussion

AIM 1.

To assess the effect of the RFPP on the targeting of throat swabbing to children at high risk of developing ARF (based on the rates and distribution of swabbing and GAS detection).

This assessment used regional community laboratory throat swabbing data to assess the rates of throat swabbing of children at high risk of ARF following the introduction of the RFPP.

Overall, the introduction of the school-based service of the RFPP was accompanied by marked increases in the annual rates of throat swabbing in all regions. This increase was most marked in school-based services in Auckland and Northland. However, significant increases in throat swabbing were also observed from primary care in all regions.

The introduction of the RFPP was associated with markedly increased rates of swabbing in those populations at highest risk of ARF. Across all regions, there were annual increases in the rates of throat swabbing in Māori and Pacific children and those residing in more socioeconomically deprived areas. In this regard, the RFPP can be considered as providing effective targeted population-based coverage of throat swabbing. There were some notable regional differences in the incidence of throat swabbing. For example, in Northland DHB, the rate of throat swabbing was highest in Māori children from the school service – this is likely to reflect the demographic structure of the Northland population, and the specific schools targeted by the RFPP. In the Auckland region, rates of swabbing were highest in Pacific children from the school service – again, this is likely to reflect the population within the schools targeted by the RFPP. In CCDHB, rates of swabbing in 2014 were actually higher in primary care than in the school service, although it is important to note that CCDHB only had 12 schools implementing a school-based service, the majority of which were implemented in 2014.

In 2014, in all three regions, children within the school-based service were swabbed significantly more than children within primary care. The reasons for this are unclear, but may include time, cost and transport barriers to presenting to primary care, increased case ascertainment and, conversely, a lower threshold for throat swabbing (based on self-presentation rather than clinical assessment), or a greater frequency of pharyngitis (viral or bacterial) in children in the school-based service. The increase in throat swabbing was accompanied by an increase in the incidence of GAS culture-positive throat swabs in all three regions. In Auckland and Northland, the increase in GAS incidence was largely attributable to swabbing in the school service. In all regions, the incidence of GAS-positive throat swabs increased in populations at high-risk of ARF. However, it cannot be determined from this work whether the increase in GAS incidence reflects an increase in the detection of true GAS pharyngitis, or rather an increase in detection of GAS carriage with concurrent viral pharyngitis.
Importantly, although the rate of GAS-positive throat swabs increased, in Auckland and CCDHB the GAS positivity rate actually decreased, and in all regions the GAS positivity rate was significantly higher in primary care than the school service. There are a number of possible reasons for this. For example, it is possible that in the school service, there may be a lower threshold for swabbing compared to primary care, e.g. swabbing children following direct enquiry, and possibly those children with more frequent, milder viral disease. Conversely, it is possible that in primary care, children who are swabbed may have a higher clinical likelihood of having true GAS pharyngitis. In addition, there are more likely to be a number of barriers to overcome prior to a throat swab being taken in primary care (transportation; provision of caregiver time; financial), which may increase the pre-test probability of a positive throat swab representing true GAS pharyngitis, compared to the school service. Therefore, higher rates of swabbing with a low clinical threshold i.e. children self-identify as having a sore throat in the school service, may be accompanied by higher sensitivity to detecting GAS pharyngitis (more swabs taken therefore the chance for more swabs to be GAS positive), but potentially reduced specificity in detecting GAS pharyngitis over GAS carriage and concurrent viral pharyngitis.

There are a number of obvious limitations with the use of laboratory data to assess adequate coverage of the RFPP. Firstly, although laboratory data provide an unambiguous measure of whether a child has had a throat swab taken and received in the laboratory, it does not provide any confirmation on the presence or severity of clinical symptoms, or whether a child is seen and treated empirically. As such, laboratory data should not be regarded as a measure of true GAS pharyngitis, rather as the detection of pharyngeal GAS. Secondly, although regional laboratories were able to distinguish throat swabs coming from school services and primary care, it was not possible to differentiate between swabs that had been sent from rapid-response clinics and those sent from routine primary care using existing laboratory codes. Therefore, a definitive evaluation of the comparative use and effectiveness of rapid response clinics and primary care is not currently possible using laboratory data. It is unfortunate that this was not considered prior to the implementation of rapid response clinics. Finally, the retrospective use of laboratory data does not provide any meaningful information on the pre-analytical processes prior to obtaining a positive / negative culture result. For example, it is not possible to ascertain the adequacy of swab collection technique, or microbiological methodology, from these data.

In summary, this analysis has demonstrated that targeting of throat swabbing to children at high risk of ARF improved following implementation of the RFPP, although this finding should be taken in conjunction with other components, such as the cost-effectiveness of this approach, and whether the increase in throat swabbing has translated to a substantial decrease in ARF rates in this population. Also of note was the unintended consequence of an increase in swabbing seen in non-priority populations in all regions.
**AIM 2.**

To determine the extent to which first episode ARF hospitalisation cases are successfully identified and swabbed, either in primary care or through a school service, during the period of their presumed acute pharyngitis.

This assessment utilised the laboratory datasets described above, and data derived from the NMDS. First episode ARF hospitalisations from the NMDS were matched to the laboratory dataset to identify those cases that had a swab taken within a biologically plausible time period (between 1 and 30 days) for primary prevention prior to hospitalisation with ARF.

In 2014, when the school-based service of the RFPP could be expected to be functioning at maximum impact, we found that the majority of children with ARF aged 5–14 years in 2014 did not have a throat swab taken prior to hospitalisation (62% in Northland DHB, 77% in the Auckland region and 75% in CCDHB). The fact that the majority of patients did not have a throat swab taken (in either primary care or the school-based service) suggests that other factors, including asymptomatic GAS infections and persisting healthcare access barriers, are likely to be important contributors to high rates of ARF, and that the sore-throat management component alone is unlikely to be the sole means of reducing the incidence of ARF. These findings are in keeping with the Root Cause Analysis section which found that for notified ARF cases aged 5–12 years in the 11 DHBs implementing the RFPP in 2014, the proportion of ARF cases who had a sore throat and had a throat swab taken (in school or primary care) was only 28% (9/32).

It is interesting to note that in 2014, similar proportions of children who developed ARF had throat swabs in primary care and through the school-based service. This finding, coupled with the finding of improved targeting of throat swabbing in primary care in high-risk populations suggests that primary care continues to play an important role in primary ARF prevention strategies. However, as described above, a limitation of this dataset is the inability to differentiate between swabs taken at rapid-response clinics, and those taken in routine primary care.
8. ECONOMIC EVALUATION OF THE SCHOOL-BASED SORE THROAT MANAGEMENT SERVICE

Introduction

In order to ensure optimal use of resources in the school-based sore throat management service, the MoH needs to evaluate both the effectiveness and the cost effectiveness of this service compared to mainstream primary care. The MoH has requested that the following question be addressed:

‘What is the value-for-money of the different elements of the sore throat management component of the RFPP?’

The value for money of any programme is always a comparison with some alternative use of the resources. In this evaluation, the alternative is usual primary care, constituting consultations with the general practitioner (GP) for a sore throat.

The economic analysis is restricted to children 5–12 years of age in CMDHB, in decile 1–3 schools that are implementing the school-based sore throat management service. This economic analysis synthesises information on the costs and patient outcomes of the school-based sore throat management intervention in CMDHB. This particular DHB was selected for analysis for three reasons: (1) the coverage of the priority population primary and intermediate-age children attending a school with a school-based sore throat management service is relatively high and therefore the intervention is likely to be more cost-effective than elsewhere; (2) the epidemiological information is more precise because of the larger number of cases of rheumatic fever; and (3) given the high incidence of ARF and relatively high coverage of the school-based sore throat service, CMDHB is a good case study to test possible cost effectiveness.

The primary health outcome of the model is the QALY, which takes into account health-related quality of life as well as length of life. One QALY is equivalent to one year of life lived in full health. The QALY gain is based on the number of years of life that would be added by the intervention, adjusted for quality of life. Each year in perfect health is assigned the value of 1.0 down to a value of 0.0 for death. If the extra years would not be lived in full health, for example if the patient suffered from heart failure as a result of rheumatic heart disease, then the extra life-years are given a value between 0 and 1 to account for this.

The economic outcome of the model is measured in the cost per case of rheumatic fever prevented, or cost per life year gained, or cost per quality adjusted life year gained (QALYs). This is standard methodology for the economic evaluation of health care interventions. The cost per QALY is frequently called the incremental cost utility ratio (ICUR), which is the ratio of the
incremental costs of the intervention divided by the net benefits of the intervention in QALYs, over a specified period of time, usually the lifetime of a cohort.

The analysis takes the perspective of the healthcare payer (Government plus patient) by including diagnosis-related group (DRG)-based hospital admission costs, outpatient clinics, GP consultation fees, laboratory costs and pharmaceuticals. Non-medical costs such as transportation to hospital or the GP are excluded. Indirect costs to the family such as caregiver costs and loss of income are also excluded because these are very difficult to determine and they are not directly relevant to the Government's health care budget.

The time horizon of the model is 80 years, that is, the outcomes to the hypothetical cohort of patients are considered over the lifetime of those patients, starting at 10 years of age to represent a cohort of children aged 5–12 years. Costs include the RFPP school-based sore throat management service and medical and surgical management of the patient - primarily hospital admissions. Long-term costs of patient care, other than secondary prevention until 20 years of age, are not included because no information is available. The analysis is conservative in this regard, i.e. it favours usual primary care.

‘Discounting to present value’ is a mathematical technique designed to assess the current value of future costs or health benefits, in order to compare it with alternative health care programmes. Costs and QALYs are discounted at a rate of 3.5% per annum, which is the rate used by PHARMAC and also by the National Institute for Health and Care Excellence (NICE) in the UK.

**Aim of the economic analysis**
To evaluate the cost effectiveness of the school-based sore throat management service in preventing ARF in CMDHB.

**Methods**

1. **The structure of the model**

The cost effectiveness (or otherwise) of the school-based sore throat management intervention was estimated using a lifetime Markov model, incorporating ARF incidence rates, programme service effectiveness, hospital admissions, costs and mortality. The economic model follows two hypothetical identical cohorts of school children aged 10 years old as a proxy for children aged 5–12 years as described above, followed for the remainder of their lives. The model assumes that the school-based intervention is active for one year in one of the cohorts and usual primary care applies in the other cohort. This approach was adapted from a previous model of a school sore throat service that was reported to the MoH in 2011, but using empirically derived transition probabilities and more accurate costs. The model contains two arms: one representing the intervention group and the other representing usual primary care as a comparator group. Because it concerns primary prevention of ARF, the model excludes the costs and outcomes associated
with any diagnosis of RHD that is not preceded by a hospital admission for ARF, although these will probably contribute to the national RHD mortality rate. Because of the focus on ARF, the model does not include co-benefits of the school sore throat service such as diagnosis and treatment of skin disease.

The economic model incorporates the effectiveness of the school-based sore throat management service and the observed incidence of ARF in NZDep 8–10 children in CMDHB. It also includes the major costs of ARF and RHD during disease progression and surgery.

The costs for all children who consult a GP for a sore throat are included in the model, along with the costs of hospital admissions for all children who develop ARF, if they had a throat swab. No cost information is available for high-risk children who could be GAS positive but who do not consult a GP or who are treated empirically with antibiotics or remain untreated. These are likely to contribute to the incidence rate.

In the intervention group, on school days a child with a sore throat can obtain a throat swab from a lay health worker or school nurse, funded from the intervention budget. If the swab returns a GAS positive test result, the child will be given a 10-day course of amoxicillin or an equivalent antimicrobial. It is assumed that children in the intervention group consult a GP only during the holiday periods (14 weeks each year). Although in practice the GP consultation rate should affect the incidence of ARF, in the model it affects only the cost because the background incidence of ARF is taken from national admissions, which intrinsically reflect primary care consultation rates and treatment.

The economic model incorporates the probabilities and costs of visiting a health professional, having a throat swab, having a GAS positive throat swab, and receiving a course of an antimicrobial, which for simplicity is assumed to be 10 days of amoxicillin. Adherence or non-adherence to dispensed antimicrobial therapy is not included in the costings because it does not affect the costs. However, it could also be one of the drivers of the ARF incidence rate.

A small proportion of children with a sore throat develop ARF. Many of these have carditis at the time of their first admission and go on to develop RHD, while others have no sequelae. Most of these children are treated medically and eventually some of them are admitted to hospital for repair or replacement of the mitral and/or aortic cardiac valve. All children are assumed to have secondary prevention of ARF until 20 years of age. The model includes the cost of repeat admissions.

First episode (‘incident’ or ‘index’) hospital admissions with a principal diagnosis of ARF (ICD-10-AM I00 or I01) for the period 1990–2014 were obtained from the NMDS and linked by encrypted NHI with RHD admissions, cardiac valve surgery and death with an underlying cause of RHD. First episode admissions for children less than 5 years of age or greater than 12 years of age were excluded. It was intended that patient-level ARF admissions would be linked with laboratory tests and prescribing (or dispensing) through the encrypted NHI, but this level of detailed information
was not available. Therefore, population-based information was obtained from various sources. The effectiveness of the intervention was obtained through a cohort design before and after analysis for children in person-days-exposed or not exposed to the school-based sore throat management service (see Effectiveness of the Sore Throat Service of the RFPP section).

The economic evaluation is based on a static semi-Markov model as described below, where one cohort is given the school-based intervention and the other cohort continues with usual primary care. The outcome of the model is measured in the cost per case of ARF prevented, the cost per RHD death prevented (undiscounted), and the cost per QALY gained (discounted to present value at 3.5% per annum).

The structure of the model is shown in Figure 65. The intervention arm is shown at the top and ‘usual primary care’ is shown at the bottom in the form of two collapsed clones of the intervention arm. A hypothetical cohort of school students, each of whom reports to a GP or a school health worker and has a GAS positive throat swab, proceed to the Markov tree (indicated with a small circle). Students who do not report their sore throat are not included in the model but could contribute to the observed ARF incidence rate that is used in the model.

There are eight health states in the Markov tree, as follows:

1. no ARF
2. admissions for ARF with or without carditis (‘ARF’)
3. medical treatment of RHD
4. management of the first 12 months of RHD prior to cardiac valve surgery
5. post-surgical management
6. management beyond 12 months after surgery
7. death from RHD
8. death from any other cause.

States 7 and 8 are clinically equivalent, but are shown separately so that the long-term impact of ARF can be highlighted. The comparator arm (usual primary care) has an identical structure and internal disease progression probabilities to the intervention arm, but a higher risk of ARF and no programme cost.
Figure 65. Schematic structure of economic model
2. Admissions and state transition probabilities

The model was populated as follows:

- ARF hospitalisations (ICD10-AM-I100 and I101) and RHD hospitalisations (ICD10-AM-I105 to I109) were obtained from the NMDS using the principal diagnosis for ARF and the first two diagnoses for RHD.

- Transition probabilities from ARF to medically managed RHD to valve surgery were obtained by Kaplan-Meier survival analysis of 14 years of admissions in the period 1990–2014.

- Transition probabilities from valve surgery to RHD death or medically managed RHD to death were obtained by Kaplan-Meier survival analysis of admissions in the period 2000–2011.

3. Costs

Hospital costs comprised admissions with a diagnosis of ARF or RHD. Multiple admissions for the same individual on different days at the same or different hospitals were counted individually for costing purposes. The economic model includes mean admission costs and other medical costs in the first and subsequent periods from the start of each health state to the transition to a subsequent state or to 12 months, discounted to present value. Costs of cardiac valve repair or replacement were included, but the cost of repeated admissions in successive years were not included because limited information is available and they are likely to be relatively small when discounted to present value. Mean cost weights per person for each health state were obtained from cost weights in the NMDS. DRG-based costs for each individual admission were estimated by multiplying the cost weight by the national price for financial year 2013/14 ($4682)\(^{31}\). For example, a surgical admission with a cost weight of 2.0 would be costed at 2\times$4682 = $9364. The relevant surgical procedure codes for cardiac valve repair or replacement are given in Table 10.

Use of DRG-based admission costs is recommended by PHARMAC\(^{32}\) and is consistent with the government perspective of this study. The cost of transportation between hospitals was excluded because information is not readily available and these costs are comparatively minor.

<table>
<thead>
<tr>
<th>ICD-10</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>622</td>
<td>3848000  Repair of aortic valve, 1 leaflet</td>
</tr>
<tr>
<td>622</td>
<td>3848100  Repair of aortic valve, 2 or more leaflets</td>
</tr>
<tr>
<td>623</td>
<td>3848800  Replacement of aortic valve with mechanical prosthesis</td>
</tr>
<tr>
<td>623</td>
<td>3848801  Replacement of aortic valve with bioprosthesis</td>
</tr>
<tr>
<td>623</td>
<td>3848900  Replacement of aortic valve with homograft</td>
</tr>
<tr>
<td>623</td>
<td>3848901  Replacement of aortic valve with unstented heterograft</td>
</tr>
<tr>
<td>626</td>
<td>3848001  Repair of mitral valve, 1 leaflet</td>
</tr>
<tr>
<td>626</td>
<td>3848101  Repair of mitral valve, &gt;= 2 leaflets</td>
</tr>
<tr>
<td>627</td>
<td>3847500  Mitral valve annuloplasty</td>
</tr>
<tr>
<td>627</td>
<td>3847700  Mitral valve annuloplasty with ring insertion</td>
</tr>
<tr>
<td>628</td>
<td>3848802  Replacement of mitral valve with mechanical prosthesis</td>
</tr>
<tr>
<td>628</td>
<td>3848803  Replacement of mitral valve with bioprosthesis</td>
</tr>
<tr>
<td>628</td>
<td>3848902  Replacement of mitral valve with homograft</td>
</tr>
</tbody>
</table>
4. Effectiveness

The incidence rates for ARF and the effectiveness of the school-based sore throat management intervention in Counties Manukau were taken from the effectiveness analysis described in a previous section and are shown in Table 11 below.

Table 11. Incidence rate and effectiveness for the CMDHB school-based sore throat management service

<table>
<thead>
<tr>
<th>Group</th>
<th>Incidence rate per 100,000 in 2009–2011</th>
<th>ARF decline (proportion)</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children 5–12 years attending a school with a school-based service</td>
<td>87.1</td>
<td>31%</td>
<td>-13%</td>
<td>58%</td>
</tr>
</tbody>
</table>

These figures indicate that the intervention is probably less than 60% effective and that it could be ineffective. Because this economic evaluation is a ‘what if’ analysis, it addresses the question of whether the school service intervention could be cost effective over a range of effectiveness values. In the base case the effectiveness was assumed to be 30%, with a range of 10% to 50%. Lower values of effectiveness are not included because the ICUR becomes very large and reaches infinity when the intervention is ineffective.

5. Funding of the school-based sore throat service

The annual school-based service cost per child was estimated in three ways:

1. From the CMDHB RFPP Plan, annual expenditure on the Mana Kidz programme is $6.582m, of which $2.9 million was provided by the Ministry of Health and $0.6m was for laboratory testing. This is part of a broader programme of primary health care delivered to children aged 5–12 years through schools. It includes assessment and treatment of skin infections and other primary health interventions as well as sore throat management. It is therefore an overestimate of the cost of the sore throat management service of the programme. Based on this document, the annual cost per child is $6.582m/25,013 = $263.

2. From the CMDHB evaluation report by Kinnect, the stated cost per participating child per year was $280 in 2013/14. Estimated from the budget allocation for FY2013/14 ($5.28m) and FY2014/15 ($6.38m) and assuming 24,787 children covered by the service in 2014 (Phil Light, National Hauora Coalition; personal communication) the cost per child per year was $237.

3. From an internal financial model at Mana Kidz, the cost for sore throat swabbing and treatment alone was estimated by allocating community health worker time, public health
nurse time, supplies and pharmaceuticals relevant to sore throat swabbing and treatment only. Laboratory tests were excluded. The cost in 2014 was $3.331m for 24,787 students. For example, 70% of the time of community health workers was allocated to sore throat management, whereas only 30% of public health nurse time was allocated to sore throats (Phil Light, National Hauora Coalition; personal communication). Including $600,000 for laboratory testing brings the cost per child per year to ($3.331m+$0.6m)/24,587 = $160.

Based on the contribution of the Ministry of Health in 2014 ($135 per child per annum) plus the cost of swabs determined as (four swabs per child per annum in 2014)\(^*\)($cost per laboratory test) = 4*6.00 per child per annum gives a total of $159 per child per annum.

Because of the wide discrepancy between these figures, the cost in the base case analysis was set at $200 per child per year, with a sensitivity analysis from $150 to $300. The higher costs were included to reflect the real costs of implementing a school-based service that included management of skin infections alongside sore throat management. This cost is augmented by usual primary care during school holidays (14 weeks per year).

### 6. Secondary prevention of ARF

Secondary prevention of ARF consists of four-weekly home visits (13 per year) by a district nurse for injection of benzathine benzyl penicillin (Bicillin®) up to 20 years of age.

### 7. Anticoagulation

Following cardiac surgery, anticoagulation with warfarin or one of the new antithrombotic agents is indicated. The annual cost of anticoagulation with warfarin, including GP and pharmacist time, is approximately $570 (Table 12).

**Table 12. Estimated annual cost of INR monitoring for patients who are on warfarin following cardiac surgery**

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
<th>Unit cost</th>
<th>Annual cost</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warfarin</td>
<td>365d</td>
<td>$0.08</td>
<td>$30.30</td>
<td>Pharmaceutical schedule (mean 2.7mg/d, IMS)</td>
</tr>
<tr>
<td>Lab tests</td>
<td>25</td>
<td>$13.78</td>
<td>$344.50</td>
<td>Young et al. 2004(^{35}); mean of LabTests and Diagnostic MedLab unit costs</td>
</tr>
<tr>
<td>GP time</td>
<td>2h</td>
<td>$80.00</td>
<td>$120.00</td>
<td>Geevasinga 2004(^{35}); GP salary $150,000; PN level 3 (New Zealand Medical Association)</td>
</tr>
<tr>
<td>PN time</td>
<td>3h</td>
<td>$23.41</td>
<td>$74.91</td>
<td></td>
</tr>
<tr>
<td><strong>Cost per patient</strong></td>
<td></td>
<td></td>
<td><strong>$569.71</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: GP = General Practitioner; PN = Practice nurse; d = days; h = hours*
8. Health state transition probabilities

Transition probabilities from ARF to medically managed RHD to valve surgery to death from RHD were obtained by Kaplan-Meier survival analysis of first episode ARF hospitalisations, RHD and subsequent cardiac valve surgery using Stata v.12 software. The transition from the index admission for ARF to medical treatment for RHD is very steep over the first 12 months, mostly reflecting admissions for ARF that were also coded for RHD (Figure 66); whereas the much slower decline probably corresponds to successful secondary prevention (Figure 67).

Figure 66. Kaplan-Meier analysis in days of the transition from first episode ARF admission to first RHD admission

Figure 67 shows a steep initial transition from RHD to surgery followed by a slower decline.
Figure 67. Kaplan-Meier analysis in days of the transition from RHD to surgery

Number at risk
374 201 141 59 14 0

Time from first RHD to surgery (days)
Figure 68 illustrates the transition from first cardiac surgery to death from RHD over a period of 3000 days (eight years). Analysis beyond this period of time was not possible because of the limitations of the mortality data set. Because of the relatively high mortality rate within the first 12 months of surgery, mortality was divided into ‘early’ (within 12 months of surgery) and ‘late’ (annually until death from RHD, with a constant hazard function determined from survival analysis). Deaths from other causes were censored.

9. Health state utility

During ARF, quality of life declines by about 20% for 2–6 weeks, implying an average annual health utility of $1 - (0.2\times4/52) = 0.985$ during the 12 months period including diagnosis and treatment and a health utility of 1.0 thereafter.

Following a diagnosis of carditis, quality-of-life declines gradually until cardiac valve repair or replacement is indicated. To the best of our knowledge there are no studies of the progression of quality of life in RHD based on clinical markers. However, studies are available of the health state utility (quality of life) before and after cardiac valve surgery.

Severe RHD leading to decompensated heart failure reduces the quality of life and activities of daily living. We assumed that prior to valve surgery, patients were distributed by NYHA functional class according to the findings of a study of 212 paediatric surgical patients at Starship Children’s Hospital and (for adults) a study of 966 patients prior to mitral valve repair. The health state utility...
utility in this six-month period is assumed to correspond to that found in a US study using the time trade-off method of revealed preferences\textsuperscript{39} for adult patients in a US heart failure service\textsuperscript{40}.

The New Zealand study\textsuperscript{37} showed that 36\% of paediatric patients had class III or IV functional status prior to valve surgery and 95\% of contactable survivors of surgery had class I or II functional status\textsuperscript{37}. Similarly, a prospective longitudinal multicentre study which followed a cohort of 267 patients undergoing mitral valve repair or replacement showed dramatic improvements in NYHA functional status and health status 12 months after mitral valve surgery\textsuperscript{41}. Twelve months after mitral valve repair, less than 2\% of patients had NYHA functional status III or IV, while after mitral valve replacement, about 12\% of patients had functional status III or IV. In an older French study of 951 young adults with rheumatic mitral valve insufficiency, the proportion with functional status NYHA II\textsubscript{a} or above was 67\% prior to mitral valve repair but only 3\% following recovery from surgery\textsuperscript{42}.

A recent survey of 48 adult patients in a hospital in South Africa reported a health state utility of 0.848\textsuperscript{43}. However, it is difficult to know how to interpret this finding because an unknown proportion of these patients could have been candidates for valve surgery, with a low utility, whereas others could have been relatively well.

In the current model the health state utility following the first diagnosis of RHD was assumed to be 0.95 (range 0.9 to 1.0). In addition, a step decline in utility of 0.216 is provided for those children with RHD or 0.122 for adults with RHD who transition to cardiac valve surgery, based on pre-surgical values in Table 13. Following surgery, the health state utility is assumed to stabilise at the post surgery value of 0.945 for children or 0.881 for adults (Table 13).

<table>
<thead>
<tr>
<th>Functional class of heart failure</th>
<th>Distribution prior to surgery</th>
<th>Distribution after surgery</th>
<th>Weight before surgery</th>
<th>Weight after surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Utility \textsuperscript{40}</td>
<td>Children \textsuperscript{37}</td>
<td>Adults \textsuperscript{38}</td>
<td>Children \textsuperscript{37}</td>
</tr>
<tr>
<td>NYHA I</td>
<td>0.97</td>
<td>0.19</td>
<td>0.29</td>
<td>0.84</td>
</tr>
<tr>
<td>NYHA II</td>
<td>0.90</td>
<td>0.45</td>
<td>0.57</td>
<td>0.11</td>
</tr>
<tr>
<td>NYHA III</td>
<td>0.65</td>
<td>0.25</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>NYHA IV</td>
<td>0.30</td>
<td>0.11</td>
<td>0.018</td>
<td>0.01</td>
</tr>
<tr>
<td>Weighted mean utility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline in utility prior to surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NYHA = New York Heart Association
\textsuperscript{a} Weight = utility times proportion
\textsuperscript{b} Unadjusted for population utility
10. Other parameters

Hospital admission costs for each health state were obtained from the sum of costs of all admissions prior to the next transition or within the 12-month period. Inspection of the NMDS data showed that the costs for subsequent health states, within the time span of available admissions data (except for repeat surgery) were relatively minor and could be ignored. Repeat surgery (or surgical revision) therefore was incorporated into a separate branch in the model. Only the first repeat admission was considered. This is likely to underestimate the costs slightly. Costs of cardiac surgery and other related admissions in adults were excluded but these will have little impact on the net present cost because of discounting.

Costs of GP consultations per child for a sore throat in the ‘usual care’ group were estimated conservatively by the number of swabs per child per year, plus an estimate of GP consultations that do not produce a swab. It is assumed that only the first presentation for a sore throat incurs a patient co-payment.

The annual cost per patient for patients that present to a GP is given by:

\[
c_{\text{Prevent, uc}} = N_{\text{swab, uc}}(c_{\text{Swab}} + c_{\text{GP}} + p_{\text{GAS}}c_{\text{Rx}}) \]

where \( N_{\text{swab}} \) = mean annual number of (swabbed) sore throats in usual care
\( c_{\text{Swab}} \) = cost of swab at approximate DHB price
\( c_{\text{GP}} \) = cost to Government and patient/family of consultation
\( p_{\text{GAS}} \) = probability that a swab is positive for GAS
\( c_{\text{Rx}} \) = cost of a 10-day course of amoxicillin

This expression does not capture the cost of consultations without a throat swab, either with or without empirical antimicrobial treatment, although these could contribute to the incidence of ARF.

It is assumed conservatively that following cardiac surgery patients will have four outpatient visits per year. Medically treated patients are assumed to have two outpatient visits per year, ongoing.

11. Summary of parameters

Table 14 summarises the fixed and variable parameters in the model.
### Table 14. Probabilities, costs, health state utilities and other parameters for the Markov decision model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Description</th>
<th>Source/comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costs ($)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cAnticoag</td>
<td>570</td>
<td>Annual cost of anticoagulation</td>
<td>See Table 12</td>
</tr>
<tr>
<td>cARF</td>
<td>12,692</td>
<td>Cost of first 12 mths following index ARF admission</td>
<td>NMDS</td>
</tr>
<tr>
<td>cDNS</td>
<td>70</td>
<td>Cost of DNS visit for sec prevention</td>
<td>District Nursing Service</td>
</tr>
<tr>
<td>cGP</td>
<td>cGP_govt+cGP_copay</td>
<td>Total cost of GP consultation</td>
<td>4.4 (1.5 to 7.3) NZDep 8-10 M/P,NZ Health Survey, Auckland</td>
</tr>
<tr>
<td>cGP_copay</td>
<td>4.4</td>
<td>GP co-payment for NZDep 8-10</td>
<td></td>
</tr>
<tr>
<td>cGP_govt</td>
<td>40</td>
<td>Government contribution to GP fee (MoH website)</td>
<td>Access PHO, High NZDep, no HUHC</td>
</tr>
<tr>
<td>cOP1</td>
<td>410</td>
<td>First outpatient consultation post-surgery</td>
<td>Kinnect report 27, p. 37 footnote</td>
</tr>
<tr>
<td>cOP2</td>
<td>277</td>
<td>Second and subsequent outpatient consultation</td>
<td>Kinnect report 27, p. 37 footnote</td>
</tr>
<tr>
<td>COST_pcpa</td>
<td>200</td>
<td>Cost per child per annum</td>
<td>Assumed (see text)</td>
</tr>
<tr>
<td>cPrevent_uc</td>
<td>Nswab_uc*(cSwab+cGP + pGAS_sc*cRx)</td>
<td>Annual cost per child of primary care in usual care group</td>
<td>Each swab = one GP visit</td>
</tr>
<tr>
<td>pRevisiion</td>
<td>0.023</td>
<td>Annual probability of revision surgery or repeat surgery</td>
<td>NMDS</td>
</tr>
<tr>
<td>cRHD</td>
<td>46.551</td>
<td>Cost of 12 months RHD admissions</td>
<td>NMDS</td>
</tr>
<tr>
<td>cRx</td>
<td>5+10*21/500</td>
<td>Cost of antibiotics for sore throat</td>
<td>Assume 10 days amoxicillin at $5 pharmacy fee</td>
</tr>
<tr>
<td>cSec</td>
<td>13*cDNS</td>
<td>Annual cost of secondary prevention to age 20y</td>
<td>13 DNS visits pa for Bicillin injection to age 20y</td>
</tr>
<tr>
<td>cSurg</td>
<td>49.889</td>
<td>Cost of valve surgery+12 months follow up admissions</td>
<td>NMDS</td>
</tr>
<tr>
<td>cSwab</td>
<td>6</td>
<td>Cost per swab</td>
<td>$6 (Kinnect report 27, page 36)</td>
</tr>
<tr>
<td><strong>Probabilities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pARF</td>
<td>1-exp(-INCIDENCE/100,000;1)</td>
<td>Probability of ARF</td>
<td>Counties, age 5-12y, NZDep8-10</td>
</tr>
<tr>
<td>pDth</td>
<td>Mortality Māori Male</td>
<td>Māori male life table</td>
<td>Statistics NZ</td>
</tr>
<tr>
<td>pDth_med</td>
<td>0.0424</td>
<td>Death within 12 months of first RHD admission if no surgery</td>
<td>NMDS (other-cause death censored)</td>
</tr>
<tr>
<td>pDth_surg_early</td>
<td>0.0395</td>
<td>Probability of RHD death within 12 months of surgery</td>
<td>NMDS</td>
</tr>
<tr>
<td>pDth_surg_late</td>
<td>0.01775</td>
<td>Probability of surgery after 12 months beyond first surgery</td>
<td>NMDS</td>
</tr>
<tr>
<td>pGAS_sc</td>
<td>0.1417</td>
<td>Probability of GAS+ swab in intervention group in CMDHB in 2014</td>
<td>NMDS</td>
</tr>
<tr>
<td>pGAS_uc</td>
<td>0.0887</td>
<td>Probability of GAS+ swab in primary care group in CMDHB in 2014</td>
<td>Interim Evaluation report</td>
</tr>
<tr>
<td>pRHD_early</td>
<td>0.44</td>
<td>Probability that RHD will be diagnosed within 12 months of first episode ARF hospitalisation</td>
<td>Interim Evaluation report</td>
</tr>
<tr>
<td>pRHD_late</td>
<td>0.0254</td>
<td>Annual probability of RHD after the first 12 months</td>
<td>NMDS</td>
</tr>
<tr>
<td>pSurg_early</td>
<td>0.33</td>
<td>Probability of valve surgery within 12 months of RHD</td>
<td>NMDS</td>
</tr>
<tr>
<td>pSurg_late</td>
<td>0.055</td>
<td>Annual probability of valve surgery after 12 months</td>
<td>NMDS</td>
</tr>
<tr>
<td><strong>Health state utilities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uarfe</td>
<td>0.985</td>
<td>Utility in year of any ARF admission</td>
<td>4 weeks at 20% disutility 36</td>
</tr>
<tr>
<td>Udecline</td>
<td>0.216 (0.122)</td>
<td>Transitional decrement in utility for children (adults)</td>
<td>Table 13</td>
</tr>
<tr>
<td>Upostsurg</td>
<td>0.945 (0.881)</td>
<td>Utility after valve surgery for children (adults)</td>
<td>Table 13</td>
</tr>
<tr>
<td>Urhd</td>
<td>0.95 (0.85–1.00)</td>
<td>Utility during medically treated RHD</td>
<td>Assumed</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>10</td>
<td>Median age of developing ARF</td>
<td>See Figure 18</td>
</tr>
<tr>
<td>D</td>
<td>0.035</td>
<td>Discount rate</td>
<td>PHARMAC</td>
</tr>
<tr>
<td>EFFECTIVENESS</td>
<td>0.3 (0.1 to 0.5)</td>
<td>Programme service effectiveness</td>
<td>Assumed (see text)</td>
</tr>
<tr>
<td>INCIDENCE</td>
<td>87.1</td>
<td>Incidence per 100K</td>
<td>CMDHB, NZDep 8-10</td>
</tr>
<tr>
<td>Nswab_uc</td>
<td>1.9</td>
<td>Annual number of swabs pcpa in intervention group</td>
<td>Interim Evaluation report</td>
</tr>
<tr>
<td>PRICE</td>
<td>$4682</td>
<td>National mean price of all admissions</td>
<td>MoH</td>
</tr>
<tr>
<td>RR_gp</td>
<td>14/52</td>
<td>Relative risk of consulting GP for sore throat in intervention arm based on school holidays</td>
<td>GP consults are required only in school holidays (14/52 weeks)</td>
</tr>
<tr>
<td>Term</td>
<td>80</td>
<td>Termination of model (years)</td>
<td>Cohort maximum lifetime</td>
</tr>
<tr>
<td>X</td>
<td>0 (0 to 2)</td>
<td>Annual number of standard standard admissions after 12 months (at $4682 per admission)</td>
<td>Range 0 to 2</td>
</tr>
</tbody>
</table>

**Notes:**
- DNS=District Nursing Service; NMDS=National Minimum Data Set; NZHS=New Zealand Health Survey (for Auckland only, Māori and Pacific, NZDep 8-10); primary care=primary health care; pcpa= per child per annum
- Probabilities, costs, health state utilities and other parameters for the Markov decision model.
Results

Figure 69 and 70 show the probability of being in each health state at various points in time, for patients under the ‘usual care’ (primary care) scenario. Time ‘zero’ represents 10 years of age and time ‘80’ is 90 years of age. Initially, nearly half of the cohort progresses to medical treatment, some of these progress to cardiac surgery and others die before surgery is indicated or possible. By 40 years of age about 60% of individuals who were admitted at least once with ARF have had valve surgery, despite secondary prevention. By the end of the 80-year period, approximately 15% of patients have died with RHD given as the underlying cause.

Figure 69. Health state probabilities for the lifetime Markov model (stage = years since age 10)
Figure 70. Health state probabilities for the first 20 years of the Markov model (stage = years since age 10)

Markov Probability Analysis

Results of the economic analyses

As neither the cost per child per year nor the effectiveness (if any) of the intervention is well-defined, the results are presented in tabular form.

Table 15 shows the outcomes of the intervention compared with primary care, for high-risk children 5–12 years of age in the CMDHB Mana Kidz programme, over a plausible range of annual cost per child ($150 to $300), and a range of effectiveness (10% to 50%). Assuming 30% effectiveness and expenditure of $200 per student per year ($5m for one year for a cohort of 25,000 children), the intervention would prevent about six first episode cases of ARF in that year and avert one premature death from RHD over the lifetime of the cohort. Accordingly, it would provide a lifetime gain (discounted to present value) of 26.5 QALYs for that cohort of children (Table 15).
Table 15. Estimated cases and deaths prevented and QALYs gained for a cohort of 25,000 students in CMDHB in 2014 (incidence rate 87.1 per 100,000)

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>0.10</th>
<th>0.20</th>
<th>0.30</th>
<th>0.40</th>
<th>0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cases prevented</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>19.5</td>
<td>17.5</td>
<td><strong>15.3</strong></td>
<td>13.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Usual care</td>
<td>21.8</td>
<td>21.8</td>
<td><strong>21.8</strong></td>
<td>21.8</td>
<td>21.8</td>
</tr>
<tr>
<td>Increment</td>
<td>2.3</td>
<td>4.3</td>
<td><strong>6.5</strong></td>
<td>8.8</td>
<td>10.8</td>
</tr>
<tr>
<td><strong>RHD deaths averted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>2.5</td>
<td>2.3</td>
<td><strong>2.0</strong></td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Usual care</td>
<td>3.0</td>
<td>3.0</td>
<td><strong>3.0</strong></td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Increment</td>
<td>0.5</td>
<td>0.8</td>
<td><strong>1.0</strong></td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>QALYs gained</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>621358.0</td>
<td>621366.8</td>
<td><strong>621375.8</strong></td>
<td>621384.5</td>
<td>621393.3</td>
</tr>
<tr>
<td>Usual care</td>
<td>621349.3</td>
<td>621349.3</td>
<td><strong>621349.3</strong></td>
<td>621349.3</td>
<td>621349.3</td>
</tr>
<tr>
<td>Increment</td>
<td>8.8</td>
<td>17.5</td>
<td><strong>26.5</strong></td>
<td>35.2</td>
<td>44.0</td>
</tr>
</tbody>
</table>

Table 16 shows cost effectiveness ratios. In the base case ($200 per child per year; 30% effectiveness) the cost to prevent one case of ARF or one premature death from RHD is $0.37m or $2.4m respectively, and the cost to achieve one QALY is $90,043. This represents $1,000,000/$90,043 = 11.1 QALYs gained per million dollar expenditure, at net present value.

The cost per QALY ranges from about $12,735 (annual cost $150 per student; 50% effectiveness) to $624,201 (annual cost $300 per student; 10% effectiveness).

Table 16. Cost effectiveness ratios for high-risk children in CMDHB (incidence rate of ARF 96.5 per 100,000)

<table>
<thead>
<tr>
<th>Annual cost per student</th>
<th>Effectiveness</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost per case prevented</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td>$761,013</td>
<td>$335,128</td>
<td>$174,816</td>
<td>$96,951</td>
<td>$52,124</td>
<td></td>
</tr>
<tr>
<td>$200</td>
<td>$1,316,491</td>
<td>$629,204</td>
<td>$367,097</td>
<td>$239,788</td>
<td>$168,387</td>
<td></td>
</tr>
<tr>
<td>$250</td>
<td>$1,871,969</td>
<td>$923,281</td>
<td>$559,378</td>
<td>$382,625</td>
<td>$284,649</td>
<td></td>
</tr>
<tr>
<td>$300</td>
<td>$2,427,447</td>
<td>$1,217,357</td>
<td>$751,659</td>
<td>$525,462</td>
<td>$400,912</td>
<td></td>
</tr>
<tr>
<td><strong>Cost per RHD death averted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td>$3,424,560</td>
<td>$1,899,057</td>
<td>$1,136,306</td>
<td>$678,655</td>
<td>$373,555</td>
<td></td>
</tr>
<tr>
<td>$200</td>
<td>$5,924,210</td>
<td>$3,565,491</td>
<td>$2,386,131</td>
<td>$1,678,515</td>
<td>$1,206,771</td>
<td></td>
</tr>
<tr>
<td>$250</td>
<td>$8,423,861</td>
<td>$5,231,924</td>
<td>$3,635,956</td>
<td>$2,678,375</td>
<td>$2,039,988</td>
<td></td>
</tr>
<tr>
<td>$300</td>
<td>$10,923,511</td>
<td>$6,898,358</td>
<td>$4,885,781</td>
<td>$3,678,235</td>
<td>$2,873,205</td>
<td></td>
</tr>
<tr>
<td><strong>Cost per QALY gained</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$150</td>
<td>$195,689</td>
<td>$81,388</td>
<td>$42,879</td>
<td>$24,066</td>
<td>$12,735</td>
<td></td>
</tr>
<tr>
<td>$200</td>
<td>$338,526</td>
<td>$152,807</td>
<td>$90,043</td>
<td>$59,522</td>
<td>$41,140</td>
<td></td>
</tr>
<tr>
<td>$250</td>
<td>$481,363</td>
<td>$224,225</td>
<td>$137,206</td>
<td>$94,978</td>
<td>$69,545</td>
<td></td>
</tr>
<tr>
<td>$300</td>
<td>$624,201</td>
<td>$295,644</td>
<td>$184,369</td>
<td>$130,434</td>
<td>$97,950</td>
<td></td>
</tr>
</tbody>
</table>

Note: ARF incidence rate estimated at 87.1 per 100,000 for high-risk children in CMDHB
Pink shading indicates less than one GDP per capita (‘very cost effective’ by WHO standards) and bold font is the base case. As the effectiveness of the service approaches zero, the cost effectiveness ratio approaches infinity, and is not shown.

Figure 71 illustrates the relationship between the school-based service cost, effectiveness and cost effectiveness. The area in the right lower corner (in blue) illustrates the combination of cost and effectiveness that would provide a cost-effective intervention if the funder is willing to pay one GDP per capita ($52,735), assuming an incidence rate of 87.1 per 100,000. Higher effectiveness and/or lower cost would improve the cost effectiveness and shift the colour boundary to the left. The school-based sore throat service would meet the WHO threshold criterion for ‘very cost effective’ if the annual cost was less than $215 per child and if it was at least 50% effective, which seems unlikely based on the epidemiological findings. Alternatively it would meet this criterion if it was 27% effective and cost less than $150 per child per year.

In addition to costs and effectiveness, the cost effectiveness of the intervention depends on the baseline incidence rate. For the target group in CMDHB, this is 87.1 per 100,000. To assist in targeting the intervention within other DHBs, a one way sensitivity analysis is provided for the incidence rate (Figure 72). At a cost of $200 per child per year, the intervention would be ‘very cost effective’ by WHO criteria if it was at least 50% effective and the incidence rate was at least 80 per 100,000 (shown at the intersection of the lower horizontal line and the 30% line). It would be ‘cost effective’ by WHO criteria if the cost per QALY lies between the two dotted horizontal lines.
The cost per QALY gained is sensitive to the rate of transition from ARF to RHD after the first year, illustrating the importance of secondary prevention (Figure 73).

**Figure 72. Cost per QALY (ICUR) as a function of ARF incidence rate (range 20 to 150 per 100,000) and effectiveness (range 10% to 50%), based on cost of $200 per child per year.**

**Figure 73. Dependence of the ICUR on the probability of a transition from ARF to RHD within 12 months.**

Sensitivity Analysis
One parameter for which no information is available is the health state utility during RHD. Most individuals in the cohort remain in the medically treated state for quite some time, but their utility is not known. Varying their utility from 0.85 (equivalent to the pre-surgery state) to 1.0 (full health) has only a small impact on the ICUR (not shown).

**Discussion**

**Summary of findings**

This economic analysis is built around the results of the effectiveness analysis, which show a modest degree of effectiveness (31%) of the school-based sore throat management service for children attending a school with a school-based sore throat management service in CMDHB, albeit not statistically significant. Essentially, the effectiveness analysis had sufficient power to detect a 50% or more true effect size but not a more modest effectiveness.

In the base case, with an observed baseline incidence rate of 87.1 per 100,000 and 30% effectiveness of the school-based service in CMDHB, and $200 investment per child per year, the ICUR (or cost per QALY) is $90,043, or 11.1 QALYs per million dollars invested in the school-based sore throat service.
The results of this (or any) economic analysis will be just one of many inputs to the decision by DHBs on whether to continue funding the service. Ultimately the results of this analysis need to be compared with the results of cost utility analyses of other interventions or programmes that are under consideration in any given budget year. If these are not available, a possible way forward is to use an agreed funding threshold (the ‘willingness to pay’ for a new intervention) as a guide to funding a programme.

New Zealand has no formal benchmark ICUR (willingness to pay) for health care interventions. The WHO Commission on Macroeconomics and Health recommends using gross domestic product (GDP) as a readily available indicator to derive the following three categories of cost-effectiveness: ‘highly cost-effective’ (less than GDP per capita); ‘cost-effective’ (between one and three times GDP per capita); and ‘not cost-effective’ (more than three times GDP per capita)\textsuperscript{44}. GDP is reported as $52,735 in 2014/15 (March 2015, Statistics New Zealand).

If DHBs were to adopt the WHO criterion (one GDP per capita, or $1,000,000/$52,735 = 19.0 QALYs per million dollar expenditure), assuming that the school-based sore throat management service is 30% effective and costs $200 per child per year, it would be considered cost effective but not highly cost effective in terms of reduction of ARF and its sequelae. Co-benefits would improve its cost effectiveness.

Alternatively, the cost effectiveness of the school service could be compared with the cost effectiveness of new pharmaceuticals that have been funded recently by PHARMAC. PHARMAC uses a relative approach that compares new interventions within a fixed budget where the ‘value for money’ depends on what interventions are available. In FY2013/14, new pharmaceuticals and/or line extensions or new indications funded by PHARMAC provided a minimum weighted average of 28 QALYs per million dollars ($35,714 per QALY)\textsuperscript{45}. Therefore based on PHARMAC’s recent history of funding pharmaceuticals, the school-based intervention might not be considered cost effective compared with usual care, at current costs and the estimated mean value of effectiveness. However, PHARMAC’s figure includes some new pharmaceuticals with a higher ICUR, so it provides only a rough guide to funding of public health programmes and it could be argued that different thresholds would be appropriate. Another possible comparison would be the infant rotavirus vaccination programme which was funded recently, with an ICUR of $46,092\textsuperscript{46} or the school-based human papillomavirus vaccination programme ($US33,000 per QALY)\textsuperscript{47}. Both of these interventions are likely to be more cost-effective than the school-based sore throat service, especially because the negotiated cost of both the vaccines may be lower than the cost used in the economic models.

In summary, for high risk children 5–12 years of age in CMDHB, if the effectiveness could be confirmed to be 30% and the service costs less than $200 per child per year, school-based sore throat management service might not be cost effective compared to PHARMAC’s recent history of funding pharmaceutical care but may be considered cost effective by WHO criteria. Lower service
costs and/or higher effectiveness or higher incidence rates resulting from better targeting would improve their cost effectiveness. Cost effectiveness is sensitive largely to the baseline incidence rate, the effectiveness and the annual cost per student.

This cost per QALY in this analysis can be compared with an earlier analysis based on much less secure information on disease progression and costs, which reported a cost per QALY in the base case analysis of $59,00048. The earlier analysis assumed 59% effectiveness based on a meta-analysis of community interventions and $135 annual cost per student (including laboratory testing) based on a randomised controlled trial, conducted as part of a research study, rather than current service-based implementation.

The cost effectiveness of the intervention depends strongly on the incidence rate, which emphasises the need to target the programme carefully. The probability of developing RHD following an index admission for ARF is also a strong driver. Because RHD can develop after several episodes of ARF, this finding emphasises the importance of secondary prevention.

**Limitations of this analysis**

This analysis has some inherent limitations, as follows.

1. It is a ‘what if’ analysis based on an unconfirmed effectiveness value.
2. It is limited to Counties Manukau, but could be generalised to other DHBs with comparable costs and ARF incidence rates.
3. Only the first 12 months of admission costs are included, which will introduce a small bias against the intervention.
4. Consistent with the study perspective, the model excludes indirect costs such as loss of income and costs to carers. It also excludes co-benefits of the school service, such as education of children and families and treatment of skin infections and other health issues that could potentially be diagnosed in the school setting. A more extensive analysis would be required to include all these benefits.
5. The model makes some simplifying assumptions that may not all be correct. For example, it assumes that children in the intervention group consult a GP during the holiday periods (14 weeks each year) when they have a sore throat. There is little evidence that this is the case, as throat swabs for GAS laboratory testing in the GP setting do not increase during school holidays, suggesting that parents of children in the school-based service do not seek such care during these holiday periods. With more time and resources, we could investigate such assumptions to reduce uncertainty in the analysis.
6. Because of time pressures and insufficient information, a probabilistic sensitivity analysis is not provided. However, this is unlikely to change the conclusions.

The analysis has not been applied to other DHBs; however the results are unlikely to be more favourable to the interventions and the relatively small numbers of ARF admissions in other DHBs
will lead to more uncertainty in the modelling. Applying the model to disparate groups of school students across a number of DHBs would be inappropriate because of the variation in baseline incidence rates and service costs per child.
9. ROOT CAUSE ANALYSIS OF NOTIFIED ARF CASES

A review of the root cause analysis data was used to identify potential gaps or failures in sore throat management in relation to RFPP guidelines.

Rheumatic fever is a notifiable disease in New Zealand. Under the Health Act 1956, health professionals are required to inform their local Medical Officer of Health of any cases that they suspect or diagnose. Both initial and recurrent episodes are notifiable.

Information on cases is entered at each Public Health Unit via a secure web-based portal into the notifiable disease database (EpiSurv). ESR collates and analyses national notification data on behalf of the Ministry of Health. The data collected includes patient demographics, outcome, basis of diagnosis, risk factors and clinical management information.

In July 2014 a new case report form was introduced which collected additional information on sore throat treatment prior to hospital admission and throat swabbing history of cases and their contacts. The current version of the case report form is available at https://surv.esr.cri.nz/episurv/CaseReportForms/Rheumatic-Jul2014.pdf.

We reviewed EpiSurv data on initial episodes of rheumatic fever with onset dates (or hospitalisation dates if onset was unavailable) between 1 July and 31 December 2014 for the 11 DHBs in the RFPP. We were unable to verify the quality of information reported and there was missing data for some variables. This root cause analysis represents only six months of information with small numbers and provides a ‘snap shot’ of sore throat management for ARF cases diagnosed during that time period.

There were a total of 60 cases with 57 hospitalisations reported. Two cases were not hospitalised and for one case hospitalisation was unknown. The following table (Table 17) shows the root cause analysis for cases aged 5–19 years. There were 49 cases and 48 hospitalisations in this age group. A particular focus is on the 32 children aged 5–12 years who would be potentially eligible to be included in the school-based service.
Table 17. Root Cause Analysis for ESR notification cases of ARF (5–19 years) July-December 2014

<table>
<thead>
<tr>
<th>Description</th>
<th>[Children 5–12 years]</th>
<th>Proportion (%)</th>
<th>[Young people 13–19 years]</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARF notifications</strong></td>
<td>32</td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>ARF cases hospitalised</strong></td>
<td>32</td>
<td>32/32 (100)</td>
<td>16 (1 unknown)</td>
<td>16/17 (94)</td>
</tr>
<tr>
<td>Had sore throat 4 weeks prior to admission/health care</td>
<td>19 (4 unknown)</td>
<td>19/28 (68)</td>
<td>12 (2 unknown)</td>
<td>12/15 (80)</td>
</tr>
<tr>
<td>Had a sore throat and sought health care (GP/nurse/school service/rapid response clinic)</td>
<td>13</td>
<td>13/19 (68)</td>
<td>8 (1 unknown)</td>
<td>8/11 (73)</td>
</tr>
<tr>
<td>Number of cases who were seen and had a throat swab that was GAS+</td>
<td>6</td>
<td>6/12 (50)</td>
<td>5</td>
<td>5/7 (71)</td>
</tr>
<tr>
<td>Number of cases who were seen and prescribed an antibiotic for this sore throat</td>
<td>8 (2 unknown)</td>
<td>8/13 (62)</td>
<td>6 (1 unknown)</td>
<td>6/8 (75)</td>
</tr>
<tr>
<td>Number of cases who were seen and prescribed an appropriate antibiotic</td>
<td>5 (1 unknown)</td>
<td>5/7 (71)</td>
<td>5 (1 unknown)</td>
<td>5/5 (100)</td>
</tr>
<tr>
<td>Number of cases who were seen, given appropriate antibiotics and completed a full course</td>
<td>3 (1 unknown)</td>
<td>3/5 (60)</td>
<td>2 (1 unknown)</td>
<td>2/5 (40)</td>
</tr>
<tr>
<td>Number of cases who saw a doctor more than one time before ARF was diagnosed/suspected</td>
<td>3</td>
<td>3/32 (9)</td>
<td>4</td>
<td>4/17 (24)</td>
</tr>
<tr>
<td><strong>GP (Usual Care)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat and went to a GP (usual care)</td>
<td>6</td>
<td>6/19 (32)</td>
<td>5</td>
<td>5/11 (45)</td>
</tr>
<tr>
<td>Number of cases who had a sore throat and went to a GP (usual care) and had a throat swab</td>
<td>6</td>
<td>6/6 (100)</td>
<td>3</td>
<td>3/5 (60)</td>
</tr>
<tr>
<td>Number of cases who had a sore throat and went to a GP (usual care), had a throat swab and swab was GAS+</td>
<td>3</td>
<td>3/6 (50)</td>
<td>2</td>
<td>2/3 (67)</td>
</tr>
<tr>
<td>Number of cases who had a sore throat and went to a GP (usual care), had a throat swab and swab was GAS+ and received antibiotics</td>
<td>3</td>
<td>3/3 (100)</td>
<td>2</td>
<td>2/2 (100)</td>
</tr>
<tr>
<td>Completed the course</td>
<td>1 (1 unknown)</td>
<td>1/2 (50)</td>
<td>2</td>
<td>2/2 (100)</td>
</tr>
<tr>
<td><strong>Rapid Response Sore Throat Clinic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat and attended a sore throat rapid response clinic</td>
<td>0</td>
<td>0/19 (0)</td>
<td>0</td>
<td>0/12 (0)</td>
</tr>
<tr>
<td><strong>School-based Sore Throat Service</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who attended a school with a sore throat management service (as noted in the case report form)</td>
<td>13 (6 unknown)</td>
<td>13/26 (50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat and attended a school with a sore throat service</td>
<td>9</td>
<td>9/19 (47%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat, attended a school with a sore throat service and had throat swabbed at school</td>
<td>3</td>
<td>3/9 (33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat, attended a school with a sore throat service and had throat swabbed at school and were GAS+</td>
<td>3</td>
<td>3/3 (100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who had a sore throat, attended a school with a sore throat service and had throat swabbed at school and were GAS+ and received antibiotics</td>
<td>3</td>
<td>3/3 (100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number who completed a full course</td>
<td>2 (1 unknown)</td>
<td>2/2 (100)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 18. Referral to housing initiatives and pacific engagement worker, notified ARF cases July-December 2014

<table>
<thead>
<tr>
<th>Description</th>
<th>Children 5–12 years</th>
<th>Proportion (%)</th>
<th>Total all ages</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Housing Initiatives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Auckland only</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases who usual household has ever been referred to the Auckland-wide Healthy Homes initiative</td>
<td>12</td>
<td>12/16 (75)</td>
<td>18</td>
<td>18/24 (75)</td>
</tr>
<tr>
<td><em>Other DHBs in RFPP</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cases whose household ever been referred to a local service to address household crowding</td>
<td>7</td>
<td>7/16 (44)</td>
<td>16</td>
<td>16/36 (44)</td>
</tr>
<tr>
<td><strong>Pacific Cases of ARF</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Pacific cases</td>
<td>13</td>
<td>13/32 (41)</td>
<td>21</td>
<td>21/60 (35)</td>
</tr>
<tr>
<td>Number of Pacific cases whose household ever had contact with a Pacific engagement strategy community worker</td>
<td>1 (8 unknown)</td>
<td>1/5 (20)</td>
<td>1 (13 unknown)</td>
<td>1/8 (13)</td>
</tr>
</tbody>
</table>
From the root cause analysis detailed above, acknowledging missing data and small numbers, several factors related to sore throat management may have contributed to the lack of sizeable effectiveness.

Some of these findings can be partly validated through comparison with results of the laboratory data analysis (from an earlier section of this report), notably:

- the proportion of ARF cases aged 5–14 years who had a sore throat and had a throat swab (school + primary care). For Auckland in 2014 this was 29% (15/52). For Northland in 2014 it was 38% (5/13). In the root cause analysis (above) for notified ARF cases aged 5–12 years in the 11 DHBs implementing the RFPP (school + primary care) in 2014 it was 28% (9/32);

- the proportion of ARF cases who had a sore throat and had a throat swab and were GAS+. For Auckland in 2014 this was 19% (10/52). For Northland in 2014 this was 15% (2/13). In the root cause analysis (above) for notified ARF cases aged 5–12 years in the 11 DHBs implementing the RFPP (school + primary care) in 2014 it was 19% (6/32).

Several factors related to sore throat management may have contributed to intervention failures. Some of the factors are largely non-modifiable, notably the important minority (about a third) of children who do not report having had a sore throat. Other factors, such as encouraging those with sore throats to attend a suitable service for assessment; prescribing of appropriate antibiotics; and ensuring adherence are all modifiable to varying degrees. These points are discussed further in the section on Interpretation of Outcomes.

It is important to note that root cause analysis, by definition, is only applied to intervention failures i.e. those who have developed ARF despite the RFPP. Findings cannot therefore be generalised to estimate these measures for the entire population of children 5–19 years. Such population estimates may be obtained from sources such as the NZ Health Survey, at least for self-reported behaviour such as visiting a GP with a sore throat. Findings from the root cause analysis can also be combined with data on coverage of the RFPP to give a crude estimate of programme service effectiveness. This approach uses the 'screening method' borrowed from the vaccine effectiveness (VE) area (36). It uses two sets of data to estimate effectiveness.

- Proportion of ARF cases who report being exposed to the school-based service. The root cause analysis shows that 50% (13/26) of ARF cases (5–12 years) reported attending a school with a throat management service in the second half of 2014.

- Coverage of the RFPP school-based service is estimated to be approximately 50% of priority population children aged 5–12 years during that period.

If the school-based sore throat management service of the RFPP has no effect and there are no biases or confounders (which there are) then crudely the proportion of ARF cases with a history of participating in it should be the same as the service coverage i.e. ~50%. If the school service was effective then <50% of cases would report a history of participating in it (at the extreme where it
was 100% effective, none of the ARF cases would report attending a school that offered it, which would be a very unlikely result). If these current data are used for illustrative purposes, they would suggest that the current school-based sore throat management service is not effective since the proportion of cases who attended a throat swabbing school is about 50%.

These comments are also intended to show the importance of having a suitable comparison or control group when analysing and interpreting ARF case data. A robust analysis also requires good data on potential confounders. The screening method is one approach that could be considered in future for a more definitive assessment of the effectiveness of the school based sore throat management service of the RFPP. However, the ARF case-control study is ultimately likely to provide a far more robust assessment of the effectiveness of the sore throat management service of the RFPP.
10. INTERPRETATION OF OUTCOMES

1. Has the high incidence of RF in high-risk communities in NZ decreased? If yes, what contribution has the sore throat management services made to this reduction? What relative contributions have the school-based service and the rapid response clinics made? What contributions have mainstream primary care services made to any reduction?

This interim quantitative evaluation has assessed the effectiveness of the school-based service of the RFPP in two ways. Firstly, at the most simplistic level, we would have expected to see a decline in ARF rates following commencement of the RFPP in 2011, and this decline would be greatest in 2014 when the RFPP reached maximum coverage and intensity. The analysis therefore assessed whether NZ is on-track to reach the BPS target of 1.4 cases per 100,000 population by June 2017. This summative assessment includes the cumulative effects of all components of the RFPP so cannot isolate the effects of particular components of the RFPP. On its own, this first analysis is a simple ‘before and after’ comparison, so cannot consider other background factors that might have changed the baseline rate of RF independently of the RFPP.

The second, more sophisticated analysis is based on the assumption that implementation of the sore throat management component of the RFPP is associated with a larger reduction in those exposed to the component than those not exposed. The fundamental premise of the sore throat management component is the timely treatment of GAS sore throats in individuals thus preventing the autoimmune process that leads to ARF. The lag time for developing ARF following GAS throat infection is estimated at three weeks, on average. As would be expected with an intervention to prevent an acute illness, we would therefore expect to see a rapid reduction in ARF rates in those populations exposed to the sore throat management component of the RFPP, if such a component was effective and delivered effectively with good coverage. These direct effects should be most apparent in populations exposed to the school-based sore throat management service, i.e. Māori and Pacific children aged 5–12 years in high risk areas covered by this service.

A more detailed analysis could have compared levels of ARF risk across different components of the RFPP, notably the school-based service, areas covered by rapid response clinics, and others who receive ‘usual care’ from GPs (though even this care has changed over time as a result of considerable efforts to raise awareness about sore throat management aimed at both GPs and patients). However, such an analysis would have required detailed data on the timing of implementation of these components, and individual-level data which were not available for this interim evaluation.

These are effectively ‘intention to treat’ analyses as they are focused on outcomes and assume that populations covered by the RFPP are receiving the intervention.
The first simple descriptive analysis does show a significant decline in rates of ARF first episode hospitalisations in New Zealand by June 2015 compared to baseline years (2009–11) for all ages of 27% (Figure 1, Table 1). Rates in the 5–12 years age group targeted by the school-based service of the RFPP declined significantly by 32% by June 2015 compared with baseline years.

There was a 19% non-statistically significant decline by June 2015 compared to baseline years observed in young people aged 13–19 years who are (largely) not covered by the intense school-based service (calculated from data presented in Table 1). This descriptive analysis also reveals considerable heterogeneity in ARF rates across populations and DHBs, but numbers are generally too small to allow conclusions on whether these differences indicate significant trends. Of particular note is a recent (2014) decline compared to 2010–2012 in incidence of ARF among Māori children and an increase (2013-14) among Pacific children.

Cumulative graphs based on notified probable and confirmed ARF cases for children and young people aged 4–19 years overall in NZ and in the 10 DHBs that were implementing the school-based sore throat management service show that that the notifications of ARF began a downward 'trajectory' sometime between August (in CMDHB but not other Auckland DHBs) and November 2014 (other North Island DHBs) and this decline has continued during the first six months of 2015. However, this decline was observed for 5–12 years overall i.e. both exposed to and not exposed to the school-based service, and for young people aged 13–19 years who were largely not exposed to the school-based service. These findings suggest that the decline in ARF may be driven by processes other than exposure to school-based service. If this decline persists, then it would be useful to consider whether it can be linked to aspects of the RFPP, such as the messaging that generally increases emphasis on sore throat treatment in whānau, communities and primary care or the emphasis on primordial prevention such as housing initiatives.

Effectiveness analysis using ARF probable and confirmed notification data shows that to the end of 2014 participation in the school-based sore throat management service is associated with a modest (17%) non-statistically significant decline in ARF cases in the 10 DHBs implementing the school-based sore throat management service of the RFPP. CMDHB has arguably implemented the most comprehensive service including management of skin infections and support for antimicrobial adherence with 80% coverage of their high-risk primary and intermediate school child population. Participation in their school-based sore throat management service to the end of 2014 is associated with a 31% non-statistically significant decline in ARF cases. The decline appears to have started in mid-2014 when all the selected schools were fully implementing the school-based service.

However, these results must be interpreted with caution, as they are also consistent with the service having no effect on the incidence of ARF to the end of 2014. In addition, the effectiveness analysis was an observational ‘before and after’ analysis and unable to take into account unmeasured confounding such as the ‘underlying’ rate of ARF over time. Therefore, if the
underlying rates of ARF were declining for reasons other than exposure to the school-based service, this would impact the effectiveness findings.

Due to an overlap of the school-based service and rapid response clinics in the same areas, we were unable to determine the relative contribution to effectiveness of the school-based service compared to rapid response clinics, or compared to primary care.

2. If there has been no reduction in the incidence of rheumatic fever in high-risk communities - are we confident that the sore throat management aspects of the programme will deliver a sufficient reduction? If not - why not? What more should be done in the area of sore throat management to ensure the most likelihood of delivering the BPS target?

There are well-established potential barriers to the sore throat management component of the RFPP achieving its intended impact on ARF. These barriers include: lack of symptomatic sore throat preceding ARF, lack of throat swabbing, lack of sensitivity of the throat swab collection and culture, lack of delivery of antibiotics, lack of adherence with antimicrobial treatment, and treatment failures. Some of these ‘failures’ are modifiable. Understanding the relative size of these contributions would provide an indication of the maximum potential effectiveness of sore throat management.

Our analysis aimed to assess the aggregate effectiveness of the national RFPP, particularly the school-based sore throat management service. However the national programme is actually a collection of diverse DHB programmes and sore throat management services so the intervention implementation is quite heterogeneous. The sore throat component has been variably rolled out with differing coverage of the high-risk children and young people population, different intensity of sore throat swabbing, variable follow-up of children who were GAS positive, and varying support for children who were prescribed appropriate antimicrobials to ensure they took the full course.

Based on school roll populations, for schools implementing the school-based sore throat service at the peak of the roll out in the 10 DHBs, there was an overall estimated average coverage of just over 50% for children in Years 1–8 attending decile 1–3 schools. This roughly corresponds with children in NZDep 8, 9 and 10. School-based service coverage ranged from 20% coverage to over 100% coverage. Given the a priori assumption of the school-based sore throat service having a possible maximum effectiveness of 60%\(^{52}\), at best the effectiveness for the school-based sore throat service would be a 30% reduction in ARF incidence (coverage \(\times\) effectiveness = programme impact: 50% \(\times\) 60% = 30%).

If we look at the three DHBs with the highest number of ARF cases in the last 14 years (Northland, Auckland and Counties Manukau), the average coverage of the RFPP sore throat school service in these DHBs was 75%. If the sore throat service were 60% effective in these areas we would expect to see a 45% reduction in ARF hospitalisations (coverage \(\times\) effectiveness = programme impact i.e. 75% \(\times\) 60% = 45%).
Compared to the 21%–28% effectiveness reported from the Auckland RCT conducted under research conditions, our finding of a non-statistically significant 17% reduction in ARF cases overall in the schools where the school-based service was implemented may reflect implementation under ‘field conditions’. Our findings of a 31% non-statistically significant reduction in ARF cases in CMDHB are comparable to the upper end of the RCT findings. Overall our findings, support the non-significant reduction in ARF cases as found by Lennon et al in their cluster randomised trial of sore throat swabbing and management of GAS programme in schools.

Even if these apparent declines in ARF incidence are sustained, it is not certain whether they can be attributed to any specific component of the RFPP. These reductions appear to be taking place across all age groups of vulnerable children irrespective of whether they are attending schools offering the sore throat management service.

**Treatment of sore throats as a strategy to reduce ARF**

It must be acknowledged that targeting the treatment of GAS pharyngitis as a strategy to reducing the incidence of ARF has shortcomings. There is surprisingly limited evidence supporting the treatment of GAS pharyngitis as primary prevention of ARF from randomised trials although there is no dispute that treatment of GAS pharyngitis is necessary to prevent ARF. As noted earlier, the current understanding of the pathophysiology is that ARF is triggered by a throat infection with group A streptococcus (GAS) bacteria. A small proportion of untreated GAS pharyngitis (0.3% to 3%) activate an autoimmune reaction that results in ARF. It is thought that repeated episodes of GAS sore throat might be needed to cause ARF.

A systematic review and meta-analysis performed on controlled trials and quasi-randomised studies conducted before 2004 reported a mean 68% reduced risk of initial ARF when cases received injectable penicillin or oral chlortetracycline for GAS pharyngitis compared to controls (RR 0.32, 95% CI: 0.21–0.48), with a protective effect of 80% (RR 0.20, 95% CI: 0.11–0.36) when restricted to only IM penicillin. However, the quality of trials included in the meta-analysis was noted to be poor with potential bias and confounding, and a limited duration of follow-up thereby potentially missing cases. Lennon et al. recognised the lack of conclusive evidence for the effectiveness of antimicrobials in the primary prevention of ARF in children in a community setting. However, the systematic review and meta-analysis conducted by Lennon et al concluded that despite poor quality studies included in the review and ‘imperfect information’, the best available evidence indicated that the incidence of ARF would be expected to be reduced by 60% by implementing community or school-based clinics to treat GAS pharyngitis. Largely based on this meta-analysis, the recently updated New Zealand Group A Streptococcal Sore Throat Management Guidelines continues to state that the correct treatment of GAS pharyngitis ‘will substantially reduce the occurrence of ARF’.

Other challenges in targeting the assessment and management of GAS pharyngitis to reduce ARF include the difficulty in diagnosing and distinguishing GAS pharyngitis from viral pharyngitis, and GAS pharyngitis from a viral infection with GAS carriage. Furthermore, more than one third to a half of ARF cases do not recall having a sore throat.
The schools in the RFPP adopted varying approaches to throat swabbing from opportunistic throat swabbing if a child complained of a sore throat, to daily (school days only) classroom visits to ask children if they had a sore throat and then swabbing, to offering a service only three days per school week. Some schools in addition periodically performed swabs on all children regardless of sore throat status. No schools offered sore throat swabbing services during the school holidays.

**Implications of root cause analysis**

From the root cause analysis detailed in the results section, several factors related to sore throat management may have contributed to the lack of a sizeable difference.

**Factors not modifiable through improved sore throat management:**

A substantial proportion of ARF cases do not report having a sore throat in the four weeks prior to admission. For first episode ARF hospitalised cases aged 5–19 years with onset from July to December 2014, for those where information was known, 72% (31/43) of cases reported having a sore throat in the four weeks prior to admission, with 70% (21/30) of those seeking care. So for all ARF hospitalised cases only 44% (21/48) had a sore throat and sought care, with 40% (19/48) being swabbed and 23% (11/48) being GAS positive. Around 30% therefore did not report a sore throat prior to admission which is consistent with a review reporting 58% (range 22% to 76%) of patients had no preceding history of pharyngitis. This is also consistent with cases in analysis B of the Auckland schools sore throat swabbing trial where 8 of 22 (36%) consented cases in the intervention arm did not report a sore throat prior to admission.

Along with sore throat management in schools and rapid response clinics and health promotion, the RFPP also has a component addressing housing issues aiming to reduce household crowding and improve housing quality. The Healthy Homes Initiative implemented in Auckland and more recently in Northland, Waikato, Capital and Coast, Lakes, Bay of Plenty, Hawkes Bay and Tairāwhiti DHB regions, identifies families that meet eligibility criteria for a housing assessment. From the root cause data, 75% of ARF cases were referred to the Auckland Healthy Homes initiative, and 44% of cases from other DHBs were referred to a local service to address household crowding. It is unknown how many children at high risk of developing ARF have been referred and assessed for improved housing in order to prevent ARF. The housing initiatives were started later than the school-based service and implementation data was scant at the time of this interim evaluation. This root cause analysis is a ‘snap shot’ of a brief period of time and may therefore not reflect current practice.

**Factors modifiable through improved sore throat management:**

Modifiable factors would include ensuring that all children and young people in high-risk populations with a sore throat seek care and are assessed and treated appropriately, and that families are supported to ensure the full course of antimicrobials is completed.
For those children and young people who did report a sore throat, 21/31 (68%) saw a health professional with 14/21 (67%) prescribed an antimicrobial. Throat swabs were taken in 9/11 (82%) of cases presenting to usual primary care with 5/9 (56%) being GAS positive. Of the children with GAS positive swabs, all were prescribed appropriate antibiotics although less than two-thirds completed the full course. In this six-month analysis (July–December 2014), no children or young people with ARF reported attending a rapid response sore throat clinic. For primary school aged children (5–12 years) 13/26 (50%) of cases attended a school with a school-based sore throat service. Of those 13 cases, nine reported a sore throat but only three had a throat swab taken (33%) – the reasons were not documented as to why no throat swab was taken. All who had a throat swab were GAS positive and were prescribed appropriate antibiotics and for those recorded, all completed the course (one unknown).

Although the numbers of this root cause analysis are small, and the timeframe was limited, they serve to demonstrate that approximately one third of children who went on to develop ARF did not seek medical care for their sore throat. The RFPP has invested in health promotion targeting high-risk populations to increase awareness of ARF, what causes it, and how to prevent it. Along with providing sore throat management services, schools are also contracted to carry out health promotion and awareness activities with students and families to educate about sore throats and the link between sore throats, GAS, and ARF. The 2014 Winter Rheumatic Fever Awareness Campaign ran from May to August 2014 and was followed up by a 2015 campaign running from April to August 2015. A Pacific Engagement service in Auckland and Wellington providing face-to-face awareness raising among Pacific families, stressing the importance of getting sore throats checked, has been underway since late 2013. However, in our root cause analysis only one of eight Pacific families with children or young people who developed ARF was documented as being in contact with a Pacific engagement strategy community worker. In 2014/15 funding was provided through the Pacific Community Innovations Fund to support Pacific communities to raise awareness to help reduce rheumatic fever and to implement their own ideas. In 2015/16 the community innovations fund will focus on Māori-led initiatives. Our analysis through to the end of 2014 may not yet reflect the improved awareness that these campaigns and initiatives may yield.

**Sore throat management failure**

There are several possible causes of sore throat management failure including selection of children and young people to be swabbed; swabbing failures due to poor technique; inappropriate antimicrobial prescribing; and lack of adherence to prescribed antimicrobials. These are discussed in detail below.

**Swabbing issues**

**Who to swab**

Schools implementing a sore throat service as part of the RFPP follow the current National Heart Foundation guidelines to swab all children complaining of a sore throat without using any further clinical assessment or clinical prediction scores. Despite these guidelines, primary care health
professionals interviewed as part of the review on current sore throat management practices in primary care in areas of high and low rheumatic fever incidence in NZ did place importance on clinical assessment as a tool in deciding if a patient’s sore throat was likely to be due to GAS or a virus\(^{62}\). Our interim evaluation data demonstrate a clear difference in throat swab GAS positivity between the school-based service and primary care clinics, most likely due to children at school presenting with a less severe sore throat compared to those presenting to primary care. In addition, children attending primary care may be sicker and GPs may exercise clinical judgement where only those children more likely to have GAS pharyngitis would be swabbed, compared to any child self-reporting a sore throat who would be swabbed in schools.

**Swabbing failures**

Swabbing failures could be due to inappropriate or inadequate swabbing techniques, and laboratory shortcomings. The current gold standard for detecting GAS pharyngitis involves using a rayon-tipped throat culture swab taken from the back of the throat and tonsils, being careful to avoid the tongue and other areas of the oral cavity\(^{58,63}\). The full correct throat swabbing technique is described in Appendix 7 of the New Zealand Group A Streptococcal Sore Throat Management Guideline\(^{58}\). The swab is inserted into a tube containing transport media and transferred to the laboratory, ideally within two hours of swabbing. The swab is then inoculated onto a 5% sheep blood agar plate for culture. Throat swab cultures have a reported sensitivity of 90–95% if well performed\(^{64}\). Although this is a consistently higher sensitivity compared to rapid diagnostic tests for GAS, a false negative rate of 5–10% indicates that an important proportion may miss opportunity for treatment. In the Auckland trial, Lennon et al considered 4/14 (29%) of the ARF cases to be possible throat culture test failures\(^{53}\).

Although we were not able to directly observe throat swabbing in schools or rapid-response clinics during this interim evaluation, an earlier evaluation highlighted potential issues with technique and quality of throat swabs reaching the laboratories\(^{12}\). As noted, some DHBs use only public health nurses or other trained medical personnel to perform the throat swabs, whereas some DHBs have trained kaiāwhina (community support workers) and whānau [family] support workers, or use a mixture of personnel to perform the throat swabs. No formal evaluation of the quality of throat swabbing techniques has been undertaken for the RFPP areas. Other studies document that performance of rapid streptococcal antigen testing has been reported to vary by personnel, with improvements seen after retraining of non-laboratory personnel\(^{65}\). The inoculum size for rapid tests is important, with a larger inoculum of GAS producing consistent positive results compared to a lighter inoculum that may be rapid test negative but blood agar culture positive\(^{66,67}\). However, as noted above, even for the gold standard culture-based methods, pre-analytical factors such as throat swabbing technique and specimen processing are important in detecting GAS\(^{58}\).

**Antimicrobial prescribing**

A recent qualitative review on current sore throat management practices in primary care in areas of high and low rheumatic fever incidence in New Zealand revealed considerable differences in
approach in the management of sore throats. The review had two components: reviewing sore throat management guidelines currently being used in New Zealand in high and low risk areas for ARF; and a review of actual patient management through interviews with 32 primary care providers including 10 GPs, 11 practice nurses, four Primary Healthcare Organisation staff members, one DHB staff member, three Emergency Department doctors, and two pharmacists. The report noted that there is significant variation in the management of sore throats in New Zealand. Health professionals use a combination of clinical judgement and clinical guidelines influenced by the incidence of ARF in their area and patient population. Specifically for antimicrobials, New Zealand guidelines recommend empiric treatment with or without a throat swab, for patients at high risk of developing ARF. High-risk patients are defined as those with a personal, family or household history of rheumatic fever, or who have two or more of the following criteria: Māori or Pacific ethnicity, age 3–35 years, or living in crowded circumstances, or in lower socioeconomic areas of the North Island.

There is national and international consensus recommending a 10-day course of oral antimicrobials or a single dose of intramuscular Benzathine penicillin G for the treatment of GAS positive pharyngitis. Once daily amoxicillin is considered to be as effective as penicillin V given two to three times daily in eradicating GAS. Once daily amoxicillin is the preferred choice of oral antimicrobial as it is easier for patients to adhere to, can be taken with food, and is more palatable for children compared to the established first line oral antimicrobial of penicillin V.

Several local New Zealand guidelines including those in Northland, Tairāwhiti, and Porirua recommend amoxicillin as first line treatment, whereas other guidelines in low risk areas such as in the South Island continue to recommend penicillin V.

**Adherence**

From the six-month root cause analysis, for those children with sore throats who did seek care, most had a throat swab and were appropriately prescribed antimicrobials. However, not all completed the course. Adherence to antimicrobials is critical to eradicate GAS from the throat and therefore minimize the risk of developing ARF.

A recent report on the RFPP Antibiotic Adherence Trial conducted in Counties Manukau DHB, where the National Hauora Coalition (Mana Kidz) is implementing the sore throat management service in schools, was reviewed. The trial tested four strategies to improve antimicrobial adherence among children who had a GAS positive throat swab:

- Directly observed therapy (DOT)
- Blister pack
- Daily text message
- Intra-muscular (IM) Bicillin® (Benzathine Penicillin G)
The patients were not randomised to the interventions. Children who had a positive GAS throat swab were invited to participate in the various strategies and parents/caregivers gave consent. A single control group of usual antimicrobial treatment was used for comparison with the first three alternative strategies. The sample size calculations were not reported. Children were swabbed within 72 hours of completion of their prescribed antimicrobials for the first three strategies, and at day 11 (or within 72 hours of day 11) for IM Bicillin® to be comparable with the other strategies.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>N</th>
<th>GAS+ (%)</th>
<th>N</th>
<th>GAS+ (%)</th>
<th>P value</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOT</td>
<td>110</td>
<td>4.6</td>
<td>89</td>
<td>21.4</td>
<td>0.01</td>
<td>0.18 (0.05–0.60)</td>
</tr>
<tr>
<td>Blister pack</td>
<td>67</td>
<td>20.9</td>
<td>89</td>
<td>21.4</td>
<td>0.58</td>
<td>0.76 (0.29–2.0)</td>
</tr>
<tr>
<td>Text message</td>
<td>72</td>
<td>18.1</td>
<td>89</td>
<td>21.4</td>
<td>0.86</td>
<td>0.90 (0.30–2.73)</td>
</tr>
<tr>
<td>IM Bicillin®</td>
<td>41</td>
<td>36.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It was noted that most of the children who received IM penicillin (70.7%) had previous GAS positive sore throats (range 2–8) in the same school year (who presumably had been treated with oral antimicrobials appropriately, although this is not stated). It was not reported if the control or other three groups of children had previous GAS positive throat swabs. For those children receiving IM Bicillin® who had more than one GAS positive throat swab, 35.7% had a positive GAS swab post-intervention compared to 18.2% of children who received IM Bicillin® for their first GAS positive throat swab.

Due to the methodological limitations noted above it is difficult to draw conclusions from this trial. Directly observed therapy may be more effective than usual treatment. The report also notes the increased time, and therefore cost, for delivering DOT to children that would need to be carefully considered if the DOT strategy were to be implemented at scale. Although children and their families appreciated blister packs and daily text messaging reminders, neither appeared to improve adherence according to the post treatment throat swab results. Intra-muscular Bicillin® given with lignocaine and the use of a distraction device to manage the pain was found to be an acceptable alternative to oral antimicrobials to children and families in this South Auckland community. Although self-identification of future sore throats did not seem to be affected in this small sample, they noted that this would need to be further investigated.

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2 Estimated extra cost $87.33 per child for Registered Nurse (RN, or $73.90 per child for Whānau Support Worker (WSW); 127.9 additional minutes per child. Average RN contract $85,000 per annum; Average WSW contract $65,000 per annum).
Around 20% of children in this trial who received usual treatment, blister packs or text reminders remained GAS positive on their post-treatment follow up throat swab. This was even higher for children post IM Bicillin® who had previous GAS positive throat swabs. This could indicate incomplete adherence, antimicrobial failure, or GAS carriage despite treatment.

As previously discussed, a meta-analysis conducted to determine the effectiveness of antibiotics for the primary prevention of ARF reported an overall protective effect of 68% (RR 0.32, 95% CI: 0.21–0.48). The studies were generally of poor methodological quality and were all conducted from 1950 to 1961. Most of the studies included were of populations of young male adults living on United States military bases. When restricted to studies with only penicillin (all given IM) an 80% protective effect against ARF (RR 0.20, 95% CI: 0.11–0.36) was reported.

Shaikh et al performed a meta-analysis conducted to determine the prevalence of GAS pharyngitis and GAS carriage in children. The 14 studies included were published between 1975 and 2005 with a pooled GAS prevalence of 37% (95% CI: 32%–43%) among children presenting with a sore throat. The prevalence of GAS carriage among asymptomatic children older than 5 years was 12% (95% CI: 9%–14%). They comment that children who are carriers are likely to have persistent GAS despite appropriate antimicrobial treatment. It is unclear why such a large proportion of the group in the Counties Manukau study who received IM Bicillin® remained GAS positive; if this is GAS carriage, then this is not consistent with other carriage prevalence rate reports in the literature.

The optimal regime of IM penicillin to eradicate GAS as secondary prevention of ARF has been challenged. Peloso et al. reported that following appropriate dose per weight IM benzathine penicillin, most patients had adequate minimal inhibitory concentrations up to two weeks although by three weeks, 30% of patients had inadequate concentrations. They suggested that larger doses of benzathine penicillin may be required or more frequent injections needed. The children in the Counties Manukau antibiotic adherence trial who received IM penicillin were swabbed about 11 days after the injection when adequate concentrations of penicillin would still be expected. The dosage regimen for this trial was 600,000 units for children with a weight < 30kg and 1,200,000 units for those >30 kg. Arnold and Victor suggest some factors that have not been definitively established that may contribute to inadequate eradication effects of penicillin including: penicillin tolerance where the penicillin concentration to inhibit GAS may be different than to kill the organism; resistance of intracellular organisms to antimicrobial eradication; colonisation and growth of GAS by other pharyngeal flora. These factors would need to be explored further in the Counties Manukau children.

In order for New Zealand to be able to meet the BPS target of reducing the incidence of ARF hospitalisations by two-thirds by 2017, we estimate that both school-based and rapid response clinics would need 100% coverage of priority populations aged 4–19 years and more than 60% effectiveness (1.0 x 0.67). Unfortunately, there is no evidence that a sore throat management
component such as in the RFPP could support this possibility. This situation appears to be well recognised by the MoH who alongside the sore throat clinics are implementing a wider programme of promotion of appropriate sore throat care seeking; adherence to a full course of appropriate antimicrobials for GAS positive sore throats; investigation on the use of probiotics to prevent GAS, and addressing the wider determinants of improved housing to decrease close-contact transmission of GAS and vulnerability to close-contact infectious diseases including GAS.

DHBs have generally targeted and provided a sore throat management service in schools for children in primary and intermediate schools in more deprived areas with the highest incidence of ARF. However, gaps remain in the implementation within the school-based service with not all children with a sore throat being swabbed, and then not all children with GAS positive sore throats taking the full course of antimicrobials. It is too early to determine the effectiveness of the rapid response sore throat clinics that have been progressively rolled out since 2014.

The laboratory-based component of the project utilised the laboratory datasets described above, and data derived from the NMDS. First episode hospitalisations of ARF from the NMDS were matched to the laboratory dataset to identify those cases that had a swab taken within a biologically plausible time period for primary prevention prior to hospitalisation with ARF.

In 2014, when the school-based service of the RFPP could be expected to be functioning at maximum impact, we found that the majority of children aged 5–14 years in 2014 did not have a throat swab taken prior to hospitalisation (71% in Auckland and 62% in Northland). Our data have shown a marked increase in high-risk children having throat swabs when self-reporting a sore throat. However, the hospitalised ARF cases in 2014 did not reflect this. Had we shown that most cases of ARF did have a throat swab, this would have suggested that the RFPP had effectively increased the provision of sore throat swabbing primary prevention strategies to those children at highest-risk of ARF, and that other factors, such as ineffective throat swabbing, or treatment failure may be responsible for failed prevention of ARF. The fact that the majority of patients did not have a throat swab taken suggests that other factors, particularly asymptomatic infections and persisting healthcare access barriers, remain important contributors to high rates of ARF.

3. What is the value-for-money of the different elements of the sore throat management component of the RFPP?

The economic analysis synthesises information on the costs and patient outcomes of school sore throat in CMDHB. This particular DHB was selected for analysis because, given the high incidence of ARF and relatively high coverage of the school-based service, CMDHB is a good case study to test possible cost effectiveness.

In summary, for high-risk children aged 5–12 years in CMDHB, if the effectiveness could be confirmed to be 30% and the school-based service cost $200 per child per year, the school-based sore throat management service would not be considered to be cost effective based on
PHARMAC’s recent history of funding pharmaceuticals but may be cost effective by WHO criteria compared to usual primary care.

The economic analysis has not been applied to other DHBs, however the results are unlikely to be more favourable to the interventions and the relatively small numbers of ARF admissions in other DHBs will lead to more uncertainty in the modelling. Applying the model to disparate groups of school students across a number of DHBs together would be inappropriate because of the variation in baseline incidence rates, coverage and service costs per child.

4. Have we improved access to appropriate community based primary care services for sore throat management in high-risk communities?

This component of the project utilised regional community laboratory throat swabbing data to assess the rates of throat swabbing of children at high risk of ARF following the introduction of the RFPP.

The introduction of the school-based service of the RFPP was associated with markedly increased rates of swabbing in those populations at highest risk of ARF. Across the Northland, Auckland and Wellington regions, there were annual increases in the rates of throat swabbing in Māori and Pacific children and those residing in areas of low socioeconomic status. In this regard, the RFPP can be considered as providing effective targeted coverage of throat swabbing. However, there was also an increase in throat swabbing in non-priority populations, which does not reflect best practice and unnecessarily consumes resources.

There were some notable regional differences in the rates of throat swabbing. For example, in Northland, the rate of throat swabbing was highest in Māori children from the school service – this may partially reflect the demographic structure of the Northland population, and the specific schools targeted by the RFPP. In Auckland and Wellington, rates of swabbing were highest in Pacific children from the school service – again, this may partially reflect the schools targeted by the RFPP.

If the sore throat management component of the RFPP is effective at improving access, then we would expect to see increased rates of throat swabbing, GAS detections and appropriate antimicrobial treatment in Māori and Pacific children aged 5–14 years, compared to low risk populations. Throat swab testing data generated by testing laboratories provides an unambiguous and relatively unbiased method for assessing coverage. Appropriate treatment and adherence was not examined in this interim evaluation although monitoring data from the MoH suggests that during the 2013/14 year, for children exposed to a school-based sore throat management service, 98% of children who had a GAS positive throat swab were treated with an antibiotic. The same monitoring data however report that only 2% of those children received antibiotics within nine days of contracting a sore throat. These data have not been verified and anecdotally DHBs report much more timely treatment.
Barriers to accessing appropriate care may exist in primary care services for sore throat management in high-risk communities that once identified may be modifiable.

There are a number of obvious limitations with the use of laboratory data to assess adequate coverage of the RFPP. Firstly, although laboratory data provide an unambiguous measure of whether a child has had a throat swab taken and received in the laboratory, these data do not provide any confirmation on the presence or severity of clinical symptoms, and should not be regarded as a measure of true GAS pharyngitis, rather as the detection of pharyngeal GAS in those presenting for a swab. Secondly, although all regional laboratories were able to distinguish throat swabs coming from the school service and primary care, it was not possible to differentiate swabs that had been sent from rapid response clinics and those sent from routine primary care, using existing laboratory codes. Therefore, a definitive evaluation of the comparative utility and effectiveness of rapid response clinics and primary care is not currently possible using laboratory data. It is unfortunate that this was not considered prior to the implementation of rapid response clinics. Finally, the retrospective use of laboratory data do not provide any meaningful information on the pre-analytical processes prior to obtaining a positive / negative culture result. For example, it is not possible to ascertain the adequacy of swab collection technique, or microbiological methodology, from these data.

In summary, this section has demonstrated that targeting of throat swabbing to children at high risk of ARF improved following implementation of the RFPP, although this finding should be taken in conjunction with other components, such as the cost-effectiveness of this approach, and whether the increase in throat swabbing has translated to a substantial decrease in ARF rates in this population.

5. Can the Ministry be reassure that the management of sore throats in primary care is clinically and culturally appropriate? If not what else needs to be done?

Assessing this aspect of the RFPP assumes that there is an agreed standard of care for those at risk of ARF that has clinical and cultural aspects that can be measured in a meaningful way. Many of these aspects are described in National Guidelines and RFPP Service Agreements i.e. that every Māori and Pacific child/youth is rapidly assessed if presenting with a sore throat, throat swab taken and treated appropriately. Recent work suggests that there may not yet be uniform standards of clinical management of sore throats across all geographic areas and primary care settings in NZ62.

Ideally data from primary care practices to determine diagnosis and management of sore throats would be reviewed, however this was not possible within the time-frame of this interim evaluation. A qualitative evaluation will be undertaken to more fully answer whether management of sore throats in primary care is culturally appropriate. In addition, an evaluation of the Mana Kidz School Based Primary Health Care Programme Evaluation in Counties Manukau included an assessment of the cultural appropriateness of school-based services27.
However, we used existing data on swabbing uptake and potential failures (root cause analysis) to partially address these questions.

As noted, overall, the introduction of the RFPP was accompanied by marked increases in the annual rates of throat swabbing in all regions. This increase was most marked in the school service in Auckland and Northland, although significant increases in throat swabbing were also seen in primary care in Auckland and Northland.

In all regions, the incidence of GAS-positive throat swabs increased in the high-risk priority populations (Māori and Pacific, living in more deprived areas) who the RFPP is targeting. In Auckland and Wellington, the prevalence of GAS detection decreased, and in all regions, the prevalence of GAS detection was significantly higher in primary care compared to the school service. It is possible that variations in swabbing practices between these settings may explain differences in GAS prevalence. For example, in the school service, there may be a lower threshold for swabbing compared to primary care, e.g. swabbing children following direct enquiry or self-report, and possibly those children with more frequent, milder viral disease. Qualitative research conducted in Northland on whānau experiences of the diagnosis and management of ARF suggest some barriers of access and inappropriate swabbing and management practices in high-risk families.

In addition, there are more likely to be a number of barriers to overcome prior to a throat swab being taken in primary care (transportation; provision of caregiver time; financial), which may increase the pre-test probability of a positive throat swab representing true GAS pharyngitis, compared to the school service. Therefore, higher rates of swabbing including a wider spectrum of symptoms in the school service may be accompanied by higher sensitivity to detecting GAS pharyngitis, but potentially reduced specificity in detecting GAS pharyngitis over GAS carriage and concurrent viral pharyngitis.

As noted earlier, health professionals interviewed as part of the review on current sore throat management practices in primary care in areas of high and low rheumatic fever incidence in New Zealand did place importance on clinical assessment as a tool in deciding if a patient’s sore throat was likely to be due to GAS or a virus despite the latest recommendation from the National Heart Foundation Sore Throat Management Guidelines. This may be supported by our interim evaluation data that demonstrates a clear difference in throat swab GAS positivity between the school-based service and primary care clinics, most likely due to sicker children presenting and a greater level of clinical judgement exercised in primary care where only those children more likely to be GAS positive would be swabbed.

The sore throat management practices review also noted that given the low incidence of ARF in most high-income countries, many international guidelines for the assessment and management of sore throat in primary care are not applicable to the New Zealand setting, especially in the North

The following table (Table 20) outlines sore throat management guidelines from the RFPP contracts to DHBs, National Heart Foundation, and DHB guidelines for the North Island DHBs where the RFPP is being rolled out. This has largely been summarised from Goldfinch et al.'s report\textsuperscript{62}. 
<table>
<thead>
<tr>
<th>Risk factors for GAS pharyngitis/ARF considered</th>
<th>Use of clinical score</th>
<th>Throat swab recommendation</th>
<th>Rapid antigen test</th>
<th>Chronic GAS carriage</th>
<th>Use of empiric antimicrobials</th>
<th>Antimicrobial recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFPP contract guidelines for the school-based service</td>
<td>Children aged 5–14 years in designated low decile schools; household contacts &gt;3 years old where there have been three or more GAS pharyngitis cases in past three months, or past history of ARF</td>
<td>-</td>
<td>All who self-identify as having a sore throat</td>
<td>-</td>
<td>-</td>
<td>Amoxicillin Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>RFPP contract guidelines for rapid response clinics</td>
<td>Aged 4–19 years, Māori and Pacific Living in NZDep quintile 5 areas Household contacts aged 3–35 years of eligible patient</td>
<td>-</td>
<td>All who present with a sore throat and are eligible</td>
<td>-</td>
<td>-</td>
<td>If follow up is not possible Amoxicillin Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>NZ National Guidelines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ Guidelines Group, 2011[20]</td>
<td>-</td>
<td>-</td>
<td>Promising, but not yet recommended</td>
<td>Treat asymptomatic carriers in closed or semi-closed community, in severe/persistent GAS outbreaks, or household outbreak</td>
<td>-</td>
<td>Penicillin for first line. Potential role for amoxicillin, carbacephem, cephalosporins</td>
</tr>
<tr>
<td>NZ Primary Care Handbook, 2012</td>
<td>Māori, Pacific people 3–45 years old Living in lower SES areas of North Island Past history of ARF</td>
<td>Centor criteria, McIsaac modified Centor criteria Swab medium and high risk patients</td>
<td>-</td>
<td>-</td>
<td>Treat high risk patients empirically</td>
<td>Amoxicillin first line Penicillin V Benzathine Penicillin G (IM) Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>National Heart Foundation Guidelines (2014)</td>
<td>Māori, Pacific people 3–35 years old Living in lower SES areas, or crowded houses Past history of ARF personal, family or household</td>
<td>None</td>
<td>All patients at high risk of ARF in primary care, emergency department, and in the school service</td>
<td>Should not be used to diagnose GAS in high risk patients. Can be used in low risk patients</td>
<td>GAS carriage is the isolation of GAS without clinical signs and symptoms, and a lack of progression to disease. Treat carriers if someone else in household has GAS pharyngitis</td>
<td>All patients at high risk of ARF in primary care and emergency departments Penicillin V Amoxicillin Benzathine Penicillin G Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>bpac™, 2013 Antibiotics – choices for common infections</td>
<td>Māori, Pacific people Past history of RF Living in lower SES areas in the North Island Aged 3–45 years</td>
<td>Yes Features of a GAS infection: Temperature &gt;38 °C No cough Tender cervical nodes Tonsillar swelling/</td>
<td>Anyone with one or more ‘high risk’ criteria as well as clinical features of GAS pharyngitis</td>
<td>-</td>
<td>-</td>
<td>Consider in patients with one or more ‘high risk’ criteria as well as clinical features of GAS pharyngitis</td>
</tr>
</tbody>
</table>
Table 20. Key features of sore throat management guidelines currently operating in NZ, 2015 (continued)

<table>
<thead>
<tr>
<th>Local DHB Guidelines</th>
<th>All high risk</th>
<th>None</th>
<th>All children with sore throat (swabbing services in decile 1-3 schools)</th>
<th>-</th>
<th>-</th>
<th>Amoxicillin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northland DHB, RFPP 2013-2017</td>
<td>Māori, Pacific people 3-35 years old Living in lower SES areas, or crowded houses Past history of ARF personal, family or household</td>
<td>None</td>
<td>Everyone presenting with a sore throat</td>
<td>-</td>
<td>-</td>
<td>Link to Heart Foundation recommendations</td>
</tr>
<tr>
<td>Northern Regions Clinical Pathway for Sore Throat Management, HealthPoint Pathways, 2014</td>
<td>Yes – as per 2014 Heart Foundation Algorithm</td>
<td>None</td>
<td>All patients presenting with a sore throat</td>
<td>-</td>
<td>-</td>
<td>Penicillin V Amoxicillin Benzathine Penicillin G Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>Standing Order Sore Throat Clinics primary care, Northern Regions HealthPoint Pathways (2014)</td>
<td>Yes, Fever &gt;38°C Tender cervical nodes Tonsillar swelling/exudate</td>
<td>Everyone aged 3-45 years presenting with a sore throat in the area</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Penicillin V Amoxicillin Benzathine Penicillin G Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>Management of sore throats, Tairāwhiti DHB, 2013</td>
<td>Māori, Pacific people 3–45 years old Living in lower SES areas of the North Island</td>
<td>Yes, Fever &gt;38°C Tender cervical nodes Tonsillar swelling/exudate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Penicillin V if GAS is confirmed</td>
</tr>
<tr>
<td>Antimicrobial Handbook, Waikato DHB, 2014</td>
<td>Yes, Fever &gt;38°C Tender cervical nodes Tonsillar swelling/exudate No cough</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Penicillin V if GAS unconfirmed Erythromycin (Penicillin allergy)</td>
</tr>
<tr>
<td>Tonsillitis and Sore Throat, Health Pathways, 2014: Wairarapa, Hutt Valley, Capital &amp; Coast DHB regions</td>
<td>Māori, Pacific people 3–35 years old Living in lower SES areas, or crowded houses</td>
<td>No *Viral and bacterial causes of sore throats cannot be reliably differentiated by clinical signs or symptoms,</td>
<td>Only patients with 2 or more RF risk factors OR Severely unwell, low risk patients Only if follow up possible</td>
<td>-</td>
<td>-</td>
<td>Penicillin V Amoxicillin Benzathine Penicillin G In Porirua, daily amoxicillin is first line</td>
</tr>
</tbody>
</table>

*Viral and bacterial causes of sore throats cannot be reliably differentiated by clinical signs or symptoms.
severity, or duration of illness".
The above table highlights some differences in approach to the management of sore throats, even in DHBs where the RFPP is being implemented. With the time available and resources allocated to this evaluation project we were not able to conduct a valid assessment of the extent to which these guidelines are being followed in primary care settings. We have reported an increase in throat swabbing in at least three high-risk regions (Northland, Auckland and Wellington regions) in primary care, with a higher prevalence of GAS positivity compared to the school-based service. Unfortunately, we were not able to ascertain these data for rapid response clinics. From these data, and the recent review on the management of sore throats in primary care, it appears that GPs and nurses in primary care are likely to be using clinical criteria and scoring in their decision to swab and treat patients presenting with pharyngitis.

Several steps are needed to institutionalise best practice treatment of sore throats in primary care settings.

- Consistent, evidence-based guidelines that can take account of the huge age, ethnic and regional differences in risk of ARF.
- Working with GPs and the providers of their practice management systems to implement these best practice guidelines.
- As part of that process, establish summary indicators that can be easily generated and reported by practice management systems. The indicators are likely to include measures of those presenting with sore throat and their subsequent management. The root cause analysis framework provides a good starting point for these indicators.

6. Have we reduced the prevalence of circulating streptococcus in high-risk communities? Is it clinically significant (i.e. will reducing the prevalence of circulating streptococcus result in a decrease in rheumatic fever)?

Although supportive evidence is extremely limited, it is theoretically possible that there may be indirect population protective effects of the RFPP mediated through reduced levels of circulating GAS as a consequence of effective sore throat management in high-risk communities (which has resulted in high levels of treatment of children with broad spectrum antibiotics). Carefully designed prospective studies would be needed to measure whether the sore throat management component of the RFPP was reducing levels of circulating GAS. Such studies do not appear to have been done in a robust and comprehensive manner.

One indicator that could be used to measure such effects is the GAS positivity proportion (%) detected by throat swabbing over time. Such data are available for swabs submitted by GPs in the Auckland Region (and several other regions) from before the RFPP (the 2010–2011 period) and following its partial and full implementation (2012–2014). If this effect is operating, then we would expect to see a decline in GAS positivity in those populations and areas which experienced the most intensive GAS treatment relative to other areas and populations.

Laboratory data from Auckland, Northland and Wellington regions paint a mixed picture in terms of measured GAS positivity (Figure 40). In all three areas, primary care data provide the longest time-
Quantitative Findings: Interim Evaluation of Sore Throat Component of the NZ RFPP
October 2015

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series (Wellington - six years from 2009 to 2014, Auckland - five years from 2010 to 2014, Northland - four years from 2011 to 2014). The trend was in different directions for Northland compared to Auckland and Wellington. In Auckland and Wellington from 2010 to 2013, positive GAS detections in swabs from primary care were fairly stable at about 21-22% and then declined to 15% for 2014. By contrast, in Northland GAS positivity increased fairly steadily from 8% in 2011 to 22% in 2014. The data series is a year shorter for swabs collected in the school setting. In the three regions, these school data show a similar temporal pattern to primary care, but with a much lower incidence (approximately half that observed in primary care).

High-risk populations in Auckland and Northland experienced similar huge increases in throat swabbing and presumably antibiotic treatment for presumed GAS pharyngitis, but to a lesser extent for Wellington (Figure 37). The rate of throat swabbing increased from about 100 per 1000 in 2011 to 1000 per 1000 in 2014. Despite this similar rise in Auckland and Northland, GAS positivity changed in different directions as noted (Figure 38 and Figure 39). Consequently, based on these data, it is hard to conclude that we have reduced the prevalence of circulating streptococcus in these high-risk communities.

Even if we had observed a consistent decline in the prevalence of GAS positive swabs, it would be extremely difficult to establish that these were clinically important or causally associated with any reductions in ARF rates. Despite its high profile, the pathophysiology of ARF remains poorly understood. The published literature has identified high GAS prevalence in populations where ARF incidence is very low 60. In addition, we do not know the relationship between GAS positive throat swabs and true GAS pharyngitis, for example, GAS detection may be caused by GAS carriage with concurrent viral pharyngitis. Moreover, the importance of other factors in the pathogenesis of ARF (skin infection; asymptomatic carriage) has not been well-defined in the published literature.
11. LIMITATIONS OF THE INTERIM EVALUATION

This interim evaluation has several important limitations:

- The major outcome, ARF, can be difficult to diagnose in some cases. Diagnostic behaviour may have changed over time, particularly with increasing awareness and interest in this disease. Additionally, there is no established national ARF register, so it is necessary to use ESR notifications or hospitalisations to track this disease over time. Even with an agreed set of decision rules for analysing these data, there are inevitably some potential errors in using these data sources in measuring the incidence of ARF.

- ARF is an uncommon disease so a change in incidence will need to be large to be statistically significant. That said, the decline in incidence specified in the BPS target is so large that it will be easily identified statistically.

- Monitoring of the sore throat component of the RFPP was not standardised and reporting on deliverables and indicators was inadequate until recently. Children consenting to participate in the school-based sore throat service did not have National Health Index (NHI) numbers routinely recorded. Evaluating the sore throat component of the RFPP therefore has been extremely challenging with the preferred and more robust approach of undertaking individual level analysis through linking data by NHI not possible. Throat swabs taken from the school-based service are clearly identified in laboratory data, however throat swabs taken in rapid response clinics are not currently identified. Consequently, any contribution to effectiveness of rapid response clinics as differentiated from usual primary care has not been possible.

- This interim evaluation has shown that the nature of the intervention also varies considerably across DHB regions in terms of coverage of throat swabbing and management in priority populations, frequency of throat swabbing offered, support for adherence to antimicrobial treatment, and additional elements such as management of skin infections.

- Some of the surveillance data used here require careful interpretation. It is important to note that the root cause analysis, by definition, only applies to intervention failures i.e. those who have developed ARF despite the RFPP and it was based on six months of data with small numbers. Findings therefore cannot be generalised to estimate these measures for the entire population of children aged 5–19 years.

- Obtaining complete, consistent data on the costs of the RFPP has been difficult and the data used in the current model are likely to be questioned by some users of this report. As with the RFPP itself, there is considerable regional diversity in the costs of the programme. Partly for this reason, the economic analysis has focused on a single DHB, considered to be a best performer and thus more likely to demonstrate any benefit it there is one.
This interim evaluation focused on quantitative effectiveness and cost-effectiveness of the school-based sore throat management service of the RFPP to the end of 2014. A qualitative study of parents/whānau service users and suppliers is being carried out separately and the findings will be available later in the year.

Some potential benefits are not being measured, such as additional health benefits from operating school-based health services, particularly for deprived populations who may have poor access to primary care services. Some potential harms are also not being measured by this interim evaluation, notably the potential negative impact of increased antibiotic use on resistance has not been assessed here, although this question is being addressed separately.

This interim evaluation was conducted over a very short time period and largely relied on existing routine data sources, the quality of which can vary across time and region. This may have limited the ability of this interim evaluation to assess the true effectiveness and cost-effectiveness of the sore throat management services. More time would have allowed the researchers the opportunity to check and validate some of these data more fully.

Rapid response clinics and services aimed at reducing household crowding were being implemented during 2014 with increasing coverage in 2015. Therefore findings from this interim evaluation largely do not reflect any significant impact from those particular interventions.
12. STRENGTHS OF THE INTERIM EVALUATION

This interim evaluation has several important strengths:

- Despite the limitations of ARF surveillance, New Zealand does have two long established national sources of ARF surveillance data: hospitalisations and notifications. After considerable work, these data sources are showing a high level of concordance, particularly over the last 5 years (2010–2014).

- Laboratory data provide a complete and fairly unambiguous measure of the extent and results of throat swab testing across populations.

- The unique patient identifier (NHI) allows additional data quality improvements and, in particular, linking of multiple surveillance data sources, notably laboratory and cases data.

- Surveillance systems have been refined to provide additional insights, notably school attended (which allows us to identify if a child was attending a school which is providing the sore throat management service). Also, the more recent addition of root cause analysis data collection to the ARF notification system allows a comprehensive analysis of modifiable factors contributing to the ARF cases occurring.

- The timing of this evaluation seems particularly useful as the RFPP is still operating, providing opportunities for the MoH to act on the findings in terms of decisions to continue and/or modify this component. This is the earliest that such an evaluation could be conducted. The school-based sore throat management service has operated at maximum intensity for an entire year (2014). The rationale for the sore throat management component of the RFPP is that by detecting and treating presumed GAS pharyngitis, the development of ARF will be prevented. The lag time for ARF following GAS throat infection is estimated at three weeks, on average\(^1\). We would therefore expect to see a rapid reduction in ARF rates in those populations exposed to the sore throat management component of the RFPP, if such a programme was effective and delivered effectively. There is no reason why the effectiveness of the component should necessarily increase further with time, unless this occurs through some other completely different mechanism (such as a reduction in circulating GAS caused by the widespread use of antibiotics in the programme, although supporting evidence for this theory is extremely limited).
13. CONCLUSIONS OF THE INTERIM EVALUATION

- This interim evaluation was conducted just over half-way through a planned six year programme of work that aims to decrease the incidence of ARF by two-thirds by 2017.
- National rates of ARF, as measured by first episode hospitalisations, show a statistically significant decline following implementation of the RFPP by June 2015 compared to baseline years (2009–2011).
- The cumulative number of ARF notifications in children and young people 4–19 years also shows a statistically significant decline through to June 2015 compared to 2009–2011, both overall (28%), and in the ten DHBs implementing a school-based service (29%). Notification data suggest that the incidence of ARF began to decline with a downward ‘trajectory’ sometime between August 2014 (in CMDHB but not other Auckland DHBs) and November 2014 (other North Island DHBs) and continued during the first six months of 2015.
- In the 10 DHBs that implemented a school-based service, for 5–12 year old children regardless of exposure to the school-based service there was a decline in ARF notifications to June 2015 of 26% compared to June 2009–2011. There was also a 40% decline in young people 13–19 years who are largely not covered by the school-based service. Consequently, it is difficult to attribute this decline solely to exposure to the school based service of the RFPP. If this decline persists, then it would be useful to consider whether it can be linked to other aspects of the RFPP, such as the generally increasing emphasis on sore throat treatment in primary care or the emphasis on primordial (social and environmental e.g. improved housing) prevention.
- The effectiveness analysis shows that to the end of 2014, attending a school with a school-based sore throat management service was associated with a modest but non-statistically significant decline in ARF notifications (17%). There was a larger decrease in ARF notifications associated with the school-based sore throat management service in CMDHB (31%) but again this was not statistically significant. It is possible that an additional year of data may help determine if these recent downward trends are sustained and become statistically significant.
- In order for New Zealand to be able to meet the BPS target of reducing the incidence of ARF hospitalisations by two-thirds (67%) by 2017, the school-based service alone will not be adequate.
- The school-based sore throat management service of the RFPP appears effective at targeting throat swabbing to high-risk populations attending schools with a school-based
service with a marked increase in the rate of throat swabbing after implementation of the RFPP. There was also a smaller increase in throat swabbing in high-risk and low-risk children in primary care.

- The overall coverage of the school-based service for high-risk children is relatively low in several DHBs.

- The economic analysis is a ‘what if’ assessment noting that the effectiveness of the school-based sore throat service of the RFPP to date is modest and not statistically significant. For CMDHB with a high incidence of ARF, good school-based service coverage, at a cost of $200 per child per year and an assumed effectiveness of 30%, the school based service would not be considered cost effective by current PHARMAC criteria. However, it is cost effective by WHO criteria, although not highly cost effective. For other areas with a lower incidence of ARF, lower coverage of high risk children and more modest effectiveness the school-based service would not be considered cost effective. However, a high cost may be acceptable in ongoing attempts to reduce marked ethnic and socioeconomic disparities in ARF.

- It is not possible, using existing data, to separate out the effectiveness of the school-based service from rapid response clinics, or rapid response clinics from routine primary care management of sore throats.

- Several aspects of the school-based sore throat management service could be strengthened including encouraging all children with sore throats to have throat swabs taken, timely initiation of antimicrobial treatment, and receive support for antimicrobial adherence. However, there is insufficient information at this stage to know if these changes would in fact improve the effectiveness of the school-based service.

- The school-based service of the RFPP was not adequately designed to be systematically and comprehensively evaluated. A further evaluation, incorporating at least an additional year of data, and/or using individual level data, could be considered to provide more certainty around the conclusions contained in this report. However, it is important to note that based on data from 2012–2014 the effectiveness analysis does have adequate power to determine a 50% reduction in ARF incidence, had that been seen according to the expected effectiveness of such an intervention as per the meta-analysis and National Heart Foundation guidelines. More modest reductions would need require many years of data with the service fully implemented to gain sufficient power to demonstrate statistical significance.

- It would be important to repeat the main analyses in this report once complete 2015 data are available to provide a more definitive assessment of the effectiveness of the RFPP. Further updated analyses are likely to be useful in future years to support decisions about the optimum development of the RFPP.
• Further assessment of the RFPP could be strengthened by the inclusion of additional data which were not available for this interim evaluation. For example:
  • establishing a laboratory administrative marker for throat swabs and a record of who attends rapid response clinics (with NHIs) may allow contribution to any effect to be differentiated between the school-based service, rapid response clinics and usual primary care;
  • recording NHIs of all children consenting to be part of a school-based service would allow more robust individual-level analysis to be conducted. Tracking would need to document important details such as the timing of participation;
  • good quality monitoring data for both the school-based service and rapid response clinics including: children and young people swabbed, repeated swabs on the same child or young person, prescriptions given, family members swabbed, and referral to housing initiatives from RFPP programmes would allow a better assessment of implementation issues;
  • consistent reporting of RFPP costs could support a more extensive economic analysis of the programme;
  • as noted, a more complete assessment of the RFPP would include potential co-benefits from operating school-based health services as well as the potential harms of increased antibiotic use on resistance;
  • investigate the ability to track antibiotic dispensing at an individual level, linked to NHI, in order to monitor the safe and judicious use of antibiotics;
  • assessment of alternative methods of delivery including the current quality of and access to sore throat management in primary care for high-risk populations;
  • establishing a national ARF register would allow improved monitoring of ARF incidence throughout New Zealand, including more consistent application of the ARF case definition and root cause analysis.
14. REFERENCES


### 15. APPENDICES

**Appendix 1: ARF Hospitalisation Criteria (Ministry of Health, 2013)\(^8^3\)**

**Acute rheumatic fever initial hospitalisations data definitions**
The following criteria have been used to define acute rheumatic fever initial hospitalisations:

| ICD codes used: | ICD-10-AM diagnosis codes: I00, I01, I02 (Acute rheumatic fever)  
ICD 9 CM-A diagnosis codes: 390, 391, 392 (Acute rheumatic fever)  
ICD-10-AM diagnosis codes: I05-I09 (Chronic rheumatic heart disease)  
ICD 9 CM-A diagnosis codes: 393-398 (Chronic rheumatic heart disease) |
|------------------|----------------------------------------------------------------------------------|
| Inclusions:      | Principal diagnoses (Acute rheumatic fever) only  
Overnight admissions  
Day-case admissions |
| Exclusions:      | Previous acute rheumatic fever diagnosis (principal and additional) from 1988  
Previous chronic rheumatic heart disease diagnosis (principal and additional) from 1988  
New Zealand non-residents |
| Transfers:       | Transfers with a principal diagnosis of acute rheumatic fever are counted as one acute rheumatic fever hospitalisation episode |
| Timeframe:       | Trends from 2002 onwards |
2013: Statistics New Zealand 2013 census  
Appendix 2: Detailed graphs of first episode ARF hospitalisation rates

NOTE: Rates should be interpreted with caution due to small numbers of cases

Figure 75. Total first episode ARF hospitalisation rates by selected DHBs with the highest rates of ARF hospitalisations
Figure 76. Total first episode ARF hospitalisation rates by selected DHBs for children aged 5–12 years

Figure 77. Total first episode ARF hospitalisation rates by selected DHBs for young people aged 13–19 years
Figure 78. Māori first episode ARF hospitalisation rates by selected DHBs

Figure 79. Pacific first episode ARF hospitalisation rates by selected DHBs
Appendix 3: Algorithm Guide for sore throat management (New Zealand)^58

Algorithm: Guide for sore throat management

**Aim:** All GAS pharyngitis in high rheumatic fever risk patients are treated

**Sore Throat**

**High Risk for Rheumatic Fever**
- High risk of personal, family or household history of rheumatic fever or have 2 or more criteria:
  - Asian or Pacific
  - Aged 3-15 years
  - Living in crowded circumstances or lower socioeconomic area
- If only 1 criterion are given box:

**Primary Care or Emergency Departments**
- Throat swab if follow up possible
- Start 10 days of empiric penicillin or amoxicillin or single dose of IM benzathine penicillin

**School Sore Throat Clinics**
- Throat swab
- Wait for result before starting antibiotics^8^ if GAS positive:
- Start 10 days of antibiotics

If GAS positive:
- Consider swabbing all symptomatic household members,^9^
- Consider isolating at home for 24 hours post starting 10 days of antibiotics,^9^
- Swab all household members (symptomatic or not), if:
  - ≥3 cases of GAS pharyngitis in household in the last 3 months, or
  - Personal, family or household history of rheumatic fever and promptly treat all GAS positive cases
- See Household Sore Throat Management Algorithm.

If GAS negative:
- Stop antibiotics.^3^

Reasons to Throat Swab in Those at High Risk of Rheumatic Fever:
- To identify GAS pharyngitis in index case
- To desensitize antibiotics in GAS negative cases^6^
- To initiate antibiotic therapy check and reinforce 10 day adherence in following up GAS positive results
- To allow household contact tracing and initiate appropriate treatment
- To reduce unnecessary antibiotic prescribing
- To allow for surveillance of GAS pharyngitis resistant to antibiotics
- To provide education when following up throat swab results.
- Consider not throat swabbing and instead start empiric antibiotics if follow-up may be problematic.

Low Risk for Rheumatic Fever

**Aim:** Reduce unnecessary antibiotic use

**School Sore Throat Clinics**
- Throat swab
- Wait for result before starting antibiotics^8^ if GAS positive:
- Start 10 days of antibiotics

If GAS positive:
- Consider swabbing all symptomatic household members,^9^
- Consider isolating at home for 24 hours post starting 10 days of antibiotics,^9^
- Swab all household members (symptomatic or not), if:
  - ≥3 cases of GAS pharyngitis in household in the last 3 months, or
  - Personal, family or household history of rheumatic fever and promptly treat all GAS positive cases
- See Household Sore Throat Management Algorithm.

If GAS negative:
- Stop antibiotics.^3^

**Footnotes:**
^1^ Consider swabbing all symptomatic household members.
^2^ Consider isolating at home for 24 hours post starting 10 days of antibiotics.
^3^ Swab all household members (symptomatic or not), if:
  - ≥3 cases of GAS pharyngitis in household in the last 3 months, or
  - Personal, family or household history of rheumatic fever and promptly treat all GAS positive cases.

**References:**
Appendix 4: Laboratory analysis of throat swabbing data from children residing in CMDHB

**Overall number and rate of throat swabs**

A total of 275,891 throat swabs were received at Labtests from children aged 5-14 years in CMDHB between 2010 and 2014. The number of throat swabs received increased from 3,286 in 2009, to 169,482 in 2014. Of the 7,026 swabs received in 2014, 38,195 (22.5%) were received through primary care, and 131,287 (77.5%) were received as part of the school-based service.

In primary care, the annual rate of throat swabbing increased from 44.8 per 1,000 children in 2010 to 510.6 per 1,000 children in 2014. The rate of throat swabbing markedly increased in the school-based service, increasing from 16.8 per 1,000 children in 2011 to 1755.1 per 1,000 children in 2014.

**Figure 80. Annual rates of throat swabbing in children aged 5–14 years in CMDHB, by source, 2010–2014**

Overall, the mean number of throat swabs per child in 2014 was 4.9 (range 1–37 swabs). This differed significantly between the school-based service (5.7, range 1–37 swabs) and primary health care (1.9, range 1–31 swabs) (P < 0.001). There was also a significant difference between the median number of swabs between children in the school-based service and primary care (median 4 [IQR 2–8] vs. 1 [IQR 1–2], respectively; P < 0.001) (Figure 81).
Demographic characteristics of children

When stratified by source of swabbing (i.e. school vs. primary care), rates of swabbing were highest in the school service, from children residing in quintile 5 (Figure 82), and from Pacific children (Figure 83).

Figure 82. Annual rates of throat swabbing in children aged 5–14 years in CMDHB, by source and NZDep quintile, 2009–14
**Rate and incidence of GAS-positive throat swabs**

Of the 275,891 throat swabs received between 2010 and 2014, 32,598 (11.8%) had GAS cultured. Although the rate of GAS-positive throat swabs increased in CMDHB, the GAS positivity rate decreased from 22.9% in 2010, to 9.8% in 2014 (Figure 84).

*Figure 84. Annual rates of GAS positive throat swabs and GAS positivity rate from throat swabs from children aged 5-14 years in CMDHB, 2009-2014*
The rate of GAS-positive swabs increased in quintile 5 between 2010 and 2014; although this increase was most marked in the school based service (Figure 85).

Figure 85. Annual rates of GAS culture-positive throat swabs in children aged 5–14 years in CMDHB, by source and NZDep quintile, 2010–14

The rate of GAS-positive swabs increased across all ethnic groups, although this was largely driven by an increased GAS incidence in primary care, rather than in the school service (Figure 86).

Figure 86. Annual rates of GAS culture-positive throat swabs in children aged 5–14 years in CMDHB, by source and ethnicity, 2010–14.
Appendix 5. Effectiveness analysis for children attending and not attending schools with a school-based sore throat management service in the 10 DHBs with a school-based service.

The full effectiveness analysis was conducted using a cohort study design of all children aged 5–12 years in decile 1–3 schools in the 10 DHBs with the school-based service operating to the end of 2014. We also performed a series of sub-analyses resulting in four analyses in total:

a) full analysis of 10 DHBs
b) restricted to children living in CMDHB
c) restricted to children attending schools with a sore throat service operating at any time during 2012–2014
d) restricted to children attending schools with a sore throat service operating at any time during 2012–2014 AND living in CMDHB.

Because the school-based service was progressively rolled out in decile 1–3 schools in 10 DHBs in the North Island analyses (c) and (d) were effectively ‘before and after’ analyses (reported in main document). Methods and results for analyses (a) and (b) are reported here.

Methods for the statistical analysis to determine the effectiveness of the sore throat component of the RFPP (a) and (b)

The aim of our cohort study was to estimate the programme component effectiveness by comparing the ratio of the incidence of ARF cases who attend a school with a sore throat management service to those who do not. We included all children aged 5–12 years who attended a decile 1–3 school in the 10 DHBs where the school-based sore throat management service operated in our cohort. We defined ARF cases as probable or confirmed notified cases of initial episode ARF aged 5–12 years and with an onset date between January 2012 and December 2014. If an onset date was not recorded, we used hospitalisation date and if there was no hospitalisation date then we used the date reported.

We obtained the number of 5–12 year olds in decile 1–3 schools in 2012, 2013 and 2014 from the Ministry of Education website (https://www.educationcounts.govt.nz/statistics/schooling/student-numbers/6028). We calculated time exposed as the number of days that the school service was operating for each school, based on the start and end dates of the school-based service provided by the Ministry of Health. Once a service had started, we assumed it operated continuously throughout the year, and that all children attending the school were exposed to the service.
('intention to treat'). Time exposed was divided into the number of days in each of 2012, 2013 and 2014. Total time was the total number of days in each of 2012, 2013 and 2014 and time not exposed was total time – time exposed for each school in each year. We calculated total person-time, person-time-exposed and person-time-non-exposed by multiplying the school rolls for 2012, 2013 and 2014 by the total time, time exposed and time not exposed for each school.

We assumed that most of the children at highest risk of ARF would attend a decile 1–3 school. We extracted information on ARF cases, including the school that they attended at the time of notification, from the notifiable disease database and matched school names with Ministry of Education data to get the school decile. We used the 2012 school decile rankings as most school-based services began during 2012. Where the 2012 school decile was unavailable, for example new or merged schools, we used the 2014 decile. We excluded cases that attended a school with a decile ranking of 4 or higher.

If cases had an onset date within a month of the start of the school-based service they were counted as partially exposed and excluded from the analysis. Of note, in this intention to treat analysis, all of the time that a school-based service was operating was classified as ‘exposed’ since children had the potential to be swabbed if they had a sore throat. We did not ascertain if children attending a school with a school-based sore throat service consented to be part of the service. Figure 87 illustrates the cohort design we have used.
Children eligible were all children aged 5–12 years attending decile 1–3 schools in Northland, Auckland, Waitemata, Counties Manukau, Waikato, Lakes, Bay of Plenty, Tairāwhiti, Hawkes Bay, and Capital and Coast DHBs.

Children not eligible for this effectiveness analysis were children: outside the aged 5–12 years; living in the other 10 DHBs in New Zealand; attending a decile 4–10 school; school attended not known.

We determined service effectiveness (SE) by $SE = 1 - RR$, where RR was the ratio of the incidence of ARF in exposed to non-exposed cases. We calculated test-based 95% confidence intervals.

$$RR = \frac{\text{No. of ARF cases exposed}}{\text{person-days-exposed}} \div \frac{\text{No. of ARF cases not exposed}}{\text{person-days-not-exposed}}$$
The primary analysis was conducted on all children aged 5–12 years in the decile 1–3 schools in the 10 DHBs with the school-based service operating. We also carried out secondary analyses for CMDHB for children attending a school with a school-based service. Some schools began implementing the school-based sore throat management service, or closing the school-based service during the period chosen for our analysis, therefore they had both person-days-exposed and person-days-not-exposed enabling a sub-analysis of only those children attending a school with a sore throat management service.

**Limitations**

We were unable to use our preferred approach of individual analysis using NHIs to assess the effectiveness of the sore throat component comparing those children exposed to those not exposed. Due to the lack of exposure identification at an individual level, this cohort design was used, however we note the main potential weakness is inherent in this being an observational study without random assignment and may therefore be prone to unaccounted for confounding. The study population includes some decile 1–3 schools that have school populations that are of lower risk of ARF, and are both less likely to get the school-based service and less likely to have ARF cases. We note that higher risk children are more likely to be exposed to the RFPP school-based sore throat management service. Without some adjustment, this effect will tend to reduce the estimated protective effect of exposure to the RFPP. We conducted sub-analyses for CMDHB. Mobility in school rolls during a school year could not be taken into account. Both the school-based service and rapid response clinics were concentrated in areas with a high incidence of ARF, with some overlapping, so there was no way to distinguish the separate effects. Primary school-age children could attend either the school-based service or rapid response clinic if both were offered in their area.

**Effectiveness of the Sore Throat Management service of the NZ RFPP**

The flow diagram (Figure 88) accounts for notified ARF cases aged 5–12 years in the 10 DHBs where the school-based sore throat management service was operating.
Figure 88. Flow diagram of notified ARF cases aged 5–12 years in 10 DHBs

Notified ARF cases (probable and confirmed) 2012–2014 for children aged 5–12 years in 10 DHBs in the North Island
N = 260

Number of ARF cases where school was unknown
n = 3 (excluded)

Notified ARF cases (probable and confirmed) 2012–2014 for children aged 5–12 years in 10 DHBs in the North Island eligible for analysis
N = 257

Number of ARF cases not attending a school with a school-based component and attending a school with no listed decile
n = 2 (excluded)

Number of ARF cases attending decile 4–10 school with school-based component
n = 1 (excluded)

Notified ARF cases (probable and confirmed) 2012–2014 for children aged 5–12 years in 10 DHBs in the North Island attending decile 1–3 schools eligible for analysis
N = 199

Number of ARF cases not attending a school with a school-based component and attending a decile 4–10 school

Number of ARF cases attending a school with a school-based component that started the same month ARF was diagnosed
n = 6 (excluded)

EXPOSED TO PROGRAMME
Number of ARF cases attending a school with school-based sore throat component included in analysis
n = 79

NOT EXPOSED TO PROGRAMME
Number of ARF cases NOT attending a school with a school-based sore throat component from decile 1–3 schools included in analysis
n = 114
The school-based sore throat management service under the RFPP targets children aged 5–14 years, however, after reviewing the number of ARF cases per single year of age and reviewing the ages of children attending a primary or intermediate school, we decided to determine the effectiveness for the 5–12 years age group. Approximately 18% of children aged 13 years old are in Year 8 (final year of primary and intermediate school) and very few are aged 14 years. In order to determine the maximum effect of the service without any dilution of the effect (for example by including all children aged 13 years when more than 80% would not be attending primary school), we only included the children of ages most likely to be at primary and intermediate school (Years 1-8) i.e. 5–12 years. Our analysis showed that 22% of notified ARF cases during the time period 2012–2014 attended a school of decile 4–10.

During the 2012–2014 period the school-based service was progressively rolled out in decile 1–3 schools in 10 DHBs in the North Island. We restricted the analysis to the 2012–2014 time period as good information on ARF case school attendance was available. Prior to that time about a quarter of cases did not have school attendance information, which may confound outcomes.

The before and after analysis of the school-based sore throat management service takes advantage of having the same school populations included both in the unexposed (before the service was implemented or after the service stopped) and exposed person-time analysis. This therefore adjusts for confounding due to person characteristics. However, it cannot adjust well for changes in the ‘underlying’ ARF incidence rates, which may fluctuate for reasons unrelated to the operation of the RFPP.
Table 21. Effectiveness findings summary

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of cases exposed/person-days exposed</th>
<th>Number of cases non-exposed/person-days not exposed</th>
<th>ARF decline (proportion)</th>
<th>Lower confidence limit</th>
<th>Upper confidence limit</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall effectiveness for children attending decile 1–3 schools with and without a school-based service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 DHBs</td>
<td>79/34,798,158</td>
<td>114/66,945,769</td>
<td>-0.33</td>
<td>-0.78</td>
<td>-0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>CMDHB</td>
<td>33/15,273,980</td>
<td>45/18,565,288</td>
<td>0.11</td>
<td>-0.35</td>
<td>0.43</td>
<td>No</td>
</tr>
<tr>
<td>Before and after analysis for school-based service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools with a sore throat service</td>
<td>79/34,798,158</td>
<td>52/18,960,113</td>
<td>0.17</td>
<td>-0.17</td>
<td>0.42</td>
<td>No</td>
</tr>
<tr>
<td>Schools in CMDHB with a sore throat service</td>
<td>33/15,273,980</td>
<td>31/9,945,963</td>
<td>0.31</td>
<td>-0.13</td>
<td>0.58</td>
<td>No</td>
</tr>
</tbody>
</table>

Overall this analysis showed a 33% increase in ARF incidence in children attending a decile 1–3 school with a school-based service compared to children attending a decile 1–3 school without a school-based service through to the end of 2014 (Table 21). There is most likely confounding contributing to this finding as schools selected for the school-based service were the schools with a high incidence of ARF among children, therefore you would expect to see more cases in these schools unless there was a highly effective service preventing them.

The ‘before and after’ analysis on only the schools with a school-based service adjusts for this effect, but does not provide good adjustment for changes in the underlying ARF rate caused by factors outside the operation of the sore throat management service of the RFPP. This is because of the temporal distribution of unexposed and exposed person time in restricted cohort (i.e. almost all of the unexposed person time is during 2012 the first six months of 2013, whereas the exposed time is during the second six months of 2013 and 2014).

For CMDHB there was a modest 11% decrease that was not statistically significant in the incidence of ARF cases for children attending a school with a school-based service compared to children attending a school without such a service (Table 21). The same confounding would apply, but the decrease in incidence possibly suggests that the school-
based service in CMDHB was more effective than those overall in the 10 DHBs where the school-based service was implemented.

The number of cases is small and other factors that are not accounted for could be contributing to these findings.

As noted in the main report:

The before and after analysis of children attending a school that at some stage implemented a school-based service in the 10 DHBs was associated with a 17% non-statistically significant reduction (95% CI: -0.17–0.42) in the incidence of ARF among children aged 5–12 years attending decile 1–3 schools in the 10 North Island DHBs.

In CMDHB, the school-based service was associated with a 31% non-statistically significant reduction (95% CI: -0.13–0.58) in the incidence of ARF cases among children aged 5–12 years attending decile 1–3 schools that at some stage implemented a school-based service in the CMDHB area. This larger reduction could be attributed to the rigorous implementation of the school-based service with high coverage and additional elements such as management of skin infections and support for improved antimicrobial adherence.

However, as noted earlier, these results must be interpreted with caution as they are also consistent with the service having no effect on the incidence of ARF to the end of 2014. In addition, this method of effectiveness analysis does not take into account confounding such as a change in underlying ARF incidence that may be occurring. It is possible that another year of data may strengthen findings.

Our analysis is suitably powered (85%) to detect a true effect size of 50% effectiveness on three years of data (approximately 18 months exposed to the service and 18 months not-exposed to the service).

For similar power with a true effect size of 30%, we estimate approximately eight years of data would be required (2008 to June 2016). For 85% power with a true effect size of 15%, we estimate approximately 32 years of data would be required. Power can be increased by having more schools in the service, or by using individual data if available.