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Cohort profile: methodology and cohort characteristics of the Aotearoa New Zealand Rheumatic Heart Disease Registry

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ABSTRACT

Purpose To create a cohort with high specificity for moderate and severe rheumatic heart disease (RHD) in New Zealand, not reliant on International Classification of Diseases discharge coding. To describe the demography and cardiac profile of this historical and contemporary cohort.

Design and participants Retrospective identification of moderate or severe RHD with disease onset by 2019. Case identification from the following data sources: cardiac surgical databases, RHD case series, percutaneous balloon valvuloplasty databases, echocardiography databases, regional rheumatic fever registers and RHD clinic lists. The setting for this study was a high-income country with continued incidence of acute rheumatic fever (ARF).

Findings to date A Registry cohort of 4959 patients was established. The initial presentation was RHD without recognised prior ARF in 41%, and ARF in 59%. Ethnicity breakdown: Māori 38%, Pacific 33.5%, European 21.9%, other 6.7%. Ethnic disparities have changed significantly over time. Prior to 1960, RHD cases were 64.3% European, 25.3% Māori and 6.7% Pacific. However, in contrast, from 2010 to 2019, RHD cases were 10.7% European, 37.4% Māori and 47.2% Pacific.

Follow-up showed 32% had changed region of residence within New Zealand from their initial presentation. At least one cardiac intervention (cardiac surgery, transcatheter balloon valvuloplasty) was undertaken in 64% of the cohort at a mean age of 40 years. 19.8% of the cohort had multiple cardiac interventions. At latest follow-up, 26.9% of the cohort died. Of those alive, the mean follow-up is 20.5±19.4 years. Māori and Pacific led governance groups have been established to provide data governance and oversight for the registry.

Future plans Detailed mortality and morbidity of the registry cases will be defined by linkage to New Zealand national health data collections. The contemporary cohort of the registry will be available for future studies to improve clinical management and outcomes for the 3450 individuals living with chronic RHD.

INTRODUCTION

Acute rheumatic fever (ARF) has been extensively chronicled in New Zealand, as highlighted by the vast bibliography listed in the

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The Aotearoa New Zealand Rheumatic Heart Disease (RHD) registry methodology has very high disease specificity for RHD with all included cases confirmed by review of clinical records.
⇒ The high specificity of the registry will allow accurate evaluation of historical and contemporary RHD mortality and morbidity by linkage to New Zealand national mortality and hospital admission data sets.
⇒ A limitation of the registry is its retrospective nature and low sensitivity for total RHD.
⇒ Māori and Pacific-led governance groups have been established to provide data governance and oversight for the registry.
⇒ The contemporary cohort of the registry will be available for future studies to improve clinical management and outcomes for the approximately 3450 individuals living with chronic RHD in Aotearoa New Zealand.

Heart Foundation New Zealand Guidelines for Rheumatic Fever: Diagnosis, Management and Secondary Prevention of Acute Rheumatic Fever and Rheumatic Heart Disease (RHD) of 2014.[1] The New Zealand primary prevention programme began in 2011, with a reduction in ARF incidence observed by 2014, however, in recent years, ARF incidence has plateaued, with widening ethnic disparities inequitably impacting Pacific peoples and Māori.[2 3]

It is known that if an individual has an episode of ARF with mild or no carditis and then receives 10 years of secondary prophylaxis with penicillin, the outcomes, including cardiac outcomes, are very good.[1] Many such patients are discharged from medical follow-up at age 21 years in New Zealand.[1 4]

When ARF leads to severe RHD, even with good secondary prophylaxis, the outcomes are often poor and the cardiac course is determined by progressive valve changes (valve regurgitation and stenosis) and cardiac muscle

changes (ventricular dysfunction) evolving over years. Heart failure, endocarditis, atrial fibrillation, stroke and premature mortality occur in many people with RHD.[1] Well-timed cardiac valve operations can limit the adverse effects of valve dysfunction. However, valve replacements and the need for lifelong anticoagulation confer additional clinical risk for individuals with severe RHD.[1 4] In summary, ARF lasts for weeks but chronic RHD lasts for a lifetime.

ARF recurrences lead to worsening RHD.[1] Adherence to secondary prophylaxis following ARF for children in New Zealand is high due to enrolment in regional RF registers, which facilitate the delivery of benzathine penicillin secondary prophylaxis by community nursing teams. However, adherence by adolescents and young adults is often challenging. New Zealand regional register data demonstrates that recurrences are more likely to occur in these older age groups.[5]

Current global disease estimates for RHD are 40 million cases and 340 000 deaths in 2019.[6] With a few notable exceptions, there are limited studies of regional disease burden of RHD. Studies in Fiji,[7] Australia[8] and countries in the African continent[9–12] have shown the burden of severe RHD within their setting. The mean age of death from RHD in Ethiopia is 25 years, and in Fiji is 39 years. The REMEDY study in Africa led by Liesl Zühlke provided powerful data of the burden of RHD in low-income and middle-income countries.[10 13 14] Major adverse outcomes and therapeutic indicators of severe RHD were investigated, including heart failure, endocarditis, the proportion of patients receiving warfarin after prosthetic valve replacements, atrial fibrillation, stroke and premature death. The data showed very poor patient outcomes for severe RHD.[13 14]

In contrast to the extensive data pertaining to ARF, the burden of chronic RHD in New Zealand is not well defined. International Classification of Diseases (ICD) hospitalisation and national mortality data estimate 150–200 deaths per year and 600–800 admissions per year for RHD.[15] However, there have been long-standing concerns regarding the poor positive predictive value of ICD valvular heart disease codes for RHD.[16 17] Some New Zealand RHD surgical outcomes are known,[18] and there is historical[19] and more contemporary New Zealand data describing RHD in pregnancy.[20]

One New Zealand study estimated the mean age of death of RHD at 55 years.[2 21] A more recent study has shown a breakdown of mortality for RHD by ethnicity being 55 years for Pacific populations, 59 years for Māori and 80 years for Europeans.[2] The latter figure is likely due to RHD in New Zealand European adults who were diagnosed with mild RHD several decades ago. To date, access to, and engagement in, care and the quality of medical and surgical management of RHD have not been systematically evaluated in New Zealand.

The aim of the registry is to describe the demographics, care and outcomes of people with moderate and severe RHD in New Zealand. We aimed to create a baseline cohort with very strong positive predictive value for RHD. In addition, data linkage with the baseline cohort to the National Minimum Data Set (NMDS), National Mortality Collection and Pharmaceutical Collection could be performed to define the morbidity and mortality due to RHD, along with hospitalisation and treatment trends.

COHORT DESCRIPTION

This is a retrospective cohort study of all cases of significant RHD across New Zealand, to create a contemporary cohort of patients to form 'The Aotearoa New Zealand Rheumatic Heart Disease Registry'. Significant RHD is defined as any case identified with moderate or severe valve disease at any time point.

Study period

The registry includes individuals with significant RHD diagnosed prior to 31 December 2019. Follow-up data were included until the end of 2020.

Data sources

Patients were identified from multiple data sources, as listed in table 1. Duplication was avoided by linkage to the National Health Index (NHI) number, a unique identifier assigned to every person who uses health and disability services in New Zealand. The NHI system was created in 1992. Definitions of categories were established by three investigators (ET, BM and NW). For all data sources, clinical records of all patients were examined by the research team to establish whether the patient had RHD. One investigator (ET) provided oversight of data entry for consistency.

Eligibility and inclusions

▶ All cases with moderate or severe RHD at any time point.
▶ ARF cases with moderate or severe carditis confirmed via echocardiography.
▶ Residing in New Zealand.

Exclusions

▶ Congenital mitral valve prolapse.
▶ Mild RHD (includes mild latent RHD detected by screening programmes and those found in echocardiographic databases).
▶ Isolated tricuspid regurgitation (TR) in the absence of rheumatic mitral or aortic valve changes.
▶ Bicuspid aortic valve.
▶ Isolated aortic stenosis (AS). AS coded as rheumatic was excluded if the surgical description emphasised degenerative valvar changes, unless there was a clear past history of ARF and/or rheumatic changes on the mitral valve including histopathological changes on the explanted valve.
▶ Overseas residents from the South Pacific Islands with RHD referred for cardiac surgery in New Zealand, unless there was evidence that they came to reside in New Zealand postoperatively.

The data sources to establish the RHD registry are shown in table 1.

Table 1 Data sources to establish the RHD registry

Data source	DHB's/hospitals		Notes
Cardiac Surgical Databases	Green Lane Hospital (until 2003)		
	Auckland City Hospital (2003 onwards)		Northland, Waitemata, Counties Manukau DHBs refer to Auckland City Hospital
	Starship Children's Hospital (2003 onwards)		Starship Children's Hospital is the sole cardiac unit for under 16 years in New Zealand
	Waikato Hospital		Bay of Plenty, Lakes, Tairāwhiti, Taranaki DHBs refer to Waikato Hospital
	Wellington Hospital		Whanganui, Mid-Central, Hawkes Bay, Wairarapa DHBs refer to Wellington Hospital
	Christchurch Hospital		Nelson/Marlborough, West Coast DHBs refer to Christchurch Hospital
	Dunedin Hospital		Southland DHB refers to Dunedin Hospital
Previous case series	Green Lane Hospital/Starship Children's Hospital RHD cardiac surgical cohort (3–19 years) (1990–2006)[18]		
	Australasian Maternal RHD in pregnancy dataset, Auckland District Health Board[19 20]		
	RHD admissions to Starship and Auckland City Hospitals all ages (2007 and 2012) (audit, Webb R, unpublished)		
	Chronic RHD cases from a KidzFirst Hospital		
	ARF case series (audit, Nicholson R, unpublished)		
Percutaneous Mitral Balloon Valvuloplasty Databases	Green Lane Hospital/Auckland City Hospital		
	Waikato Cardiothoracic Unit		
	Wellington Cardiothoracic Unit		
Echocardiography Databases	Auckland City Hospital	Tairāwhiti DHB	Echocardiographic database coding varies according to propriety software and individual department reporting protocols, and not all have ARF or RHD as specific codes
	Starship Children's Hospital	Capital Coast DHB	
	Waitematā DHB	Canterbury DHB	Non cardiac centres other than Waitemata and Tairāwhiti were not obtained
	Waikato DHB	Southern DHB	Mitral stenosis regarded as RHD unless features of a congenitally malformed mitral valve
Regional Rheumatic Fever Registers	Northland	Hawkes Bay	
	Auckland	Tairāwhiti	
	Waikato	Capital Coast / Hutt Valley	ARF registers are primarily for the delivery of secondary penicillin prophylaxis delivery, with the bulk of patients entered in childhood
	Bay of Plenty	Canterbury	
	Lakes	Southern	Only those cases with ARF and moderate or severe carditis were added to the Registry, cases of ARF with no or mild RHD were not included
Clinic lists	Northland	Bay of Plenty	These DHBs have dedicated RF/RHD clinics or ability to identify clinic visits for ARF/RHD
	Counties Manukau	Capital Coast	
ICD discharge coding	Bay of Plenty (1999–2019)	Canterbury (2007 - 2020)	Where identification of patients with RHD was limited via other sources, local collaborators from these DHBs provided ICD discharge case lists of their region.
	Lakes (2010–2019)	Southern (2000–2020)	

ARF, acute rheumatic fever; DHB, District Health Board; ICD, International Classification of Diseases ; RHD, rheumatic heart disease.

Data management

Cases were entered into the Registry during the years 2018–2020. The minimum dataset was collated into a Microsoft Excel spreadsheet, and stored in a password-protected folder. The minimum dataset fields are described in online supplemental table 1. Serial echocardiographic data were not recorded. Clinical data were restricted to that available at the time the case was entered into the registry unless identified from a later data source.

Patient and public involvement

Regional research locality agreements from participating District Health Boards (DHBs) involved wide consultation including with Māori for the public good of the formation of the Registry. In addition, Māori and Pacific led Governance groups have now been established to provide oversight for future utility of the Registry.

The multidisciplinary background of the investigators included clinical disciplines caring for patients with

RHD. This informed the research question, which was to address the gap in knowledge of health outcomes for moderate and severe patients with RHD in New Zealand. Of note, Dr Anneka Anderson, coinvestigator has led previous qualitative research on the lived experiences of patients with ARF and RHD in New Zealand.[22]

Patients were not directly involved in recruitment or study conduct. Dissemination of findings will be guided by the Māori and Pacific Governance groups, which include community representatives.

Minimum data set fields descriptors

The original source data or the demographics page on the hospital electronic records. Ethnicity is self-designated in the New Zealand health system. Defined ethnicity groups include Māori ethnicity, Pacific ethnicity (Samoan, Tongan, Niuean, Rarotongan, Fijian, other Pacific included Tokelauan, Tuvaluan, Tahitian), European ethnicity (New Zealand European also known as Pākehā, other European ethnicities) and 'other' ethnicities (Chinese, Indian, Middle Eastern, other Asian and no ethnicity recorded).

Type and date of presentation

Presentation type was defined as one of:
1. Chronic RHD—first presentation with moderate or severe RHD without a clear history of ARF episode. Presentation varied widely including those with severe disease requiring cardiac surgery, presentation of RHD in pregnancy and the detection of moderate or severe RHD during school echocardiographic screening studies.[23–25]
2. ARF
   – ARF with moderate or severe carditis—meeting New Zealand Heart Foundation Guidelines[11] definition of ARF at the time of initial presentation (or retrospectively from history of a medically confirmed episode), or entered from a regional ARF database. Both initial and recurrent episodes of ARF were coded in this category.
   – Acute on chronic rheumatic fever—a first recognised episode of ARF but with unequivocal chronic RHD changes identified on echocardiography or clinical presentation. This also includes 'missed cases' of ARF where the clinical records revealed a previous presentation consistent with ARF but not identified by the health professionals at that time.
   – Indolent carditis—insidious onset of ARF with slow progression, without evidence of recovery from the acute phase of illness.[1]
3. Unknown—patients where the details of the initial presentation could not be determined.

The patient's address at the time of initial diagnosis was used to define their region of domicile or DHB at presentation.

Presentation date

If the ARF episode was only recorded 'as a child', the patient's 10th birthday was used as the presentation date,

this being the approximate median age of ARF presentations.[1 4] Where an age at the time of the ARF episode was specified but not a date, the patient's birthday of that age was used. Where only a year of presentation was recorded, this was assigned to the first day of that year or first day of the recorded month if a year and month was identified. If none of this detail was available, the date was recorded as unknown.

Valve disease and severity details

Valve gradings assigned: nil, mild, moderate or severe. 0 or trivial or no=nil; trivial-mild=mild; mild to moderate=moderate; moderate to severe=severe; torrential=severe. Where grading was not included in the body or conclusion of the echocardiogram report, it was presumed 'nil'.

Valve disease and severity were based on the echocardiogram at the time of initial diagnosis, the echocardiogram immediately prior to surgery (where applicable) or the surgical report. As RHD (and the carditis of ARF) evolve over time, the registry recorded the severest grading of the index valve involved. A 'severity date' was recorded. The echocardiogram at latest follow-up, if available, was included. Serial echocardiographic data were not collected.

Mitral stenosis (MS): recorded as nil unless the severity of MS was defined.

Multivalve disease is common in RHD. A second left-sided heart valve was recorded as rheumatic for all such cases whether the disease severity was mild, moderate or severe. Tricuspid disease was also recorded as rheumatic if there was mild or greater TR.

RHD surgical details

Limited surgical data were collected including dates of surgery, valves operated and type of surgery. Dates of surgery included only RHD-related surgical dates. Inclusions: first and redo valve RHD surgery, and cardiac transplantation due to complications from RHD. Exclusions: non-valve-related complications including wound infection, delayed chest closure or other minor complications that do not result in permanent sequelae.

Follow-up

Follow-up date was defined as the date of the most recent cardiology or other clinical letter. The patient DHB of domicile at most recent follow-up was recorded. If they had relocated overseas, the country to which they moved was recorded. Discharge from medical follow-up was recorded. Where it appeared that the patient repeatedly did not attend follow-up without a clear reason, they were deemed 'lost to follow-up'. Patient deaths were recorded.

Statistics

Numerical data were expressed as mean and SD for parametric data, and median for non-parametric data. χ^2 test was used for categorical variables presented as counts and percentages. Generalised linear model was carried out for comparing age between ARF and RHD groups.

Table 2 Patient Characteristics, by gender, ethnicity and age at clinical presentation with ARF or previously unrecognised RHD

	ARF (n=2718)	RHD (n=1892)	Unknown (n=349)	Overall (n=4959)
Gender				
Female	1469 (54.0%)	1350 (71.4%)	232 (66.5%)	3051 (61.5%)
Male	1249 (46.0%)	542 (28.6%)	117 (33.5%)	1908 (38.5%)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Ethnicity				
Māori	1121 (41.2%)	624 (33.0%)	140 (40.1%)	1885 (38.0%)
Pacific	1009 (37.1%)	619 (32.7%)	32 (9.2%)	1660 (33.5%)
European	498 (18.3%)	451 (23.8%)	135 (38.7%)	1084 (21.9%)
Other ethnicities	90 (3.3%)	198 (10.5%)	42 (12.0%)	330 (6.7%)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Age at presentation				
Mean (SD)	11.6 (5.45)	38.4 (20.1)		
P value (mean age ARF vs RHD)	<0.0001			
Unknown	91 (3.3%)	94 (5.0%)		

1. Pacific ethnicity (n=1660) breakdown is Samoan (822, 49.5%), Tongan (318, 19.2%), Rarotongan (322, 19.4%), Niuean (76, 4.6%), Fijian (39, 2.3%), other Pacific ethnicities (83, 5%).
2. European ethnicity (n=1084) includes NZ European known as Pākehā (938, 86.5%) and other European (146, 13.5%).
3. Other ethnicity (n=330) breakdown is Chinese (90, 27.3%), Indian (93, 28.2%), Other Asian (86, 26.1%), Middle Eastern (16, 4.8%), other (35,10%).
4. Ethnicity was not specified in 10 cases (0.2%) of the total registry.
5. Ethnicity of New Zealand population: Māori 14.7%, Pacific 7.2%, European 62.3%, Other 15.8% (Statistics New Zealand 2018 census).
6. ARF subclassification: A. ARF n=2612; B. Acute on chronic n=103; C. Indolent carditis n=3.
ARF, acute rheumatic fever; RHD, rheumatic heart disease.

FINDINGS TO DATE
Demography
The cohort comprises 4959 individuals. Table 2 shows the demography of the registry, by gender, ethnicity and age at clinical presentation.

Type of first presentation
The type of presentation was not able to be determined in 7% of cases (349/4959) due to missing clinical information. Of the remaining 4610, the first presentation was RHD without a recognised prior episode of ARF in 41% (1892/4610). The first presentation was ARF in 59% (2718/4610), of whom 96.1% (2612/2718) were first episodes, 3.8% (103) were acute on chronic presentation and 0.1% (3) indolent carditis.

Decade of presentation by ethnicity
Figure 1 shows presentation by ethnicity and by decade. The year of presentation was identifiable from available records in 89.4% (4436/4959) of the cohort. The proportion of Māori ethnicity by decade increased from 25.3% pre-1960 to 37.4% in the most recent decade. The proportion of Pacific ethnicities steadily rose over each decade from 6.7% pre-1960 to 47.2% currently. In contrast, the ethnicity dominantly affected by RHD prior to 1960 was NZ European at 64.3%, decreasing to 10.7% in 2010–2019. Online supplemental table 2 details the numbers and proportions of cases by ethnicity and decade.

Online supplemental table 3 records the numbers and percentage of the cohort residing within each region at presentation and at latest follow-up. At the time of the most recent recorded follow-up, 89.7% of cases were residing in the North Island and 6.8% residing in the South Island. 53% of the cohort resided in the greater Auckland region (Auckland Waitemata and Counties Manukau DHBs) at follow-up. Compared with their region at presentation, 32% (1328 of 4089) of the cohort resided in a different region at latest follow-up.

Registry data sources
For the total cohort, 38% (1868) of patients were identified from more than one data source for entry into the registry and 62% (3091) were identified from a single source.

The source datasets for those identified from a single data source are shown in online supplemental figure 1). The proportion of the cohort identified solely from ICD discharge data was less than 2%.

RHD valve type at presentation
Valve pathology was classified in 99% of the cohort (4904) as shown in figure 2. Classification used was comparable to that used in the remedy study.[10]

Online supplemental table 4 details the numbers of each valve category, and the proportion with associated TR.
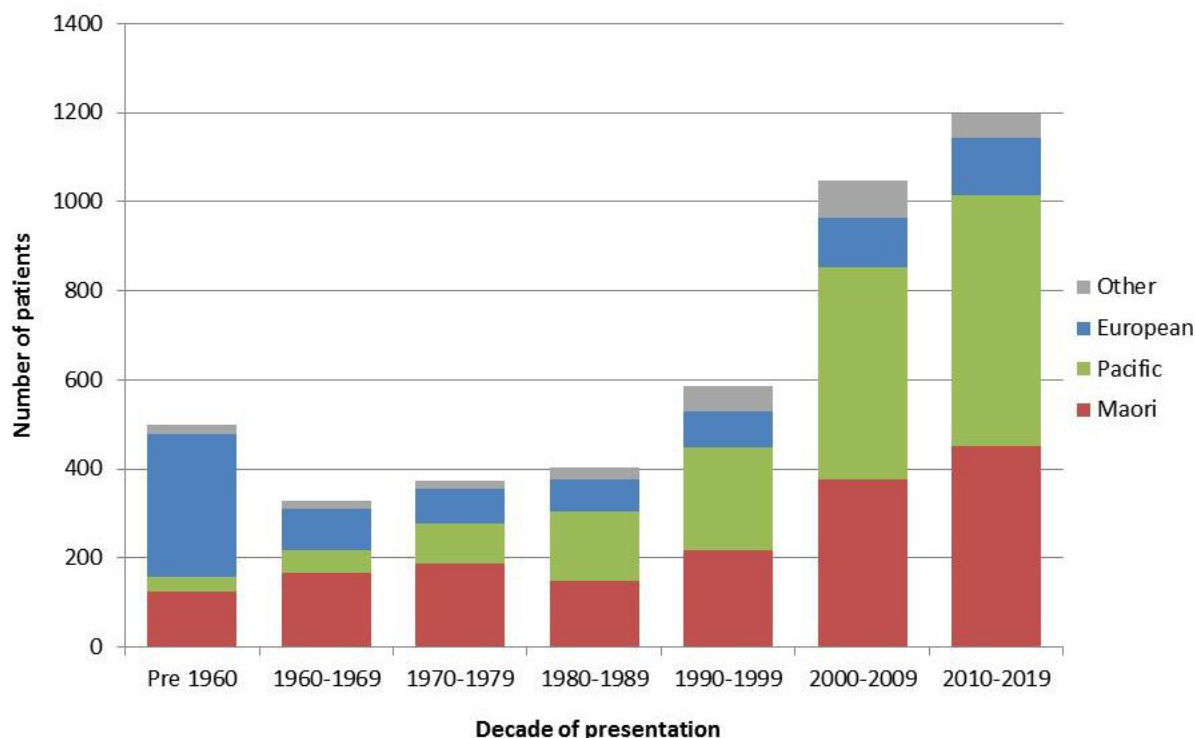
Figure 1 Decade of presentation by ethnicity. Footnote: numbers of the largest Pacific ethnicities. 1. Pacific Samoan 3% pre-1960 (n=15), increasing to 23.7% (284) 2010–2019. 2. Pacific Tongan1.2% pre-1960 (6), increasing to 11.8% (141) 2010–2019. 3. Pacific Rarotongan 1.8% pre-1960 (n=9), increasing to 7.2% (86) 2010–2019

Cardiac interventions

Of the cohort, 64% (3196/4959) had at least one cardiac intervention (cardiac surgery, transcatheter balloon valvuloplasty or transcatheter valve replacement) (figure 3). The mean (SD) age at initial procedure was 40.7 (19.9) years (range 2–85 years). Of these 3196 patients, 88.7% had cardiac surgery only, 5.6% had cardiac surgery and a transcatheter balloon valvuloplasty or valve replacement, 5.6% had balloon valvuloplasty only and 0.1% had isolated transcatheter valve replacement (figure 3).

Online supplemental figure 2 shows the cardiac interventions by valve type. Online supplemental table 5 details the cardiac interventions excluding valvular cardiac surgical procedures. Note that for those with isolated MS, 91% (335/368) had initial Percutaneous Mitral Balloon Valvuloplasty (PMBV) (online supplemental tables 4 and 5).

Multiple interventions

In total, 19.8% (981/4959) of the cohort had between two and eight interventions. The second intervention occurred after a mean time of 11 years (range 0 days to 51 years). Of those who had multiple interventions, 738 patients had two interventions, 194 had three interventions, 36 had four interventions, 10 patients had five interventions and 1 patient each had six, seven and eight total interventions. Overall, 95.4% (1232) of multiple interventions were repeat cardiac surgery.

Cardiac surgery

A total of 4107 cardiac surgeries were performed on 3015 patients, 268 patients had valve repair/valvotomy without subsequent valve replacement and 246 patients had initial valve repair/valvotomy with subsequent valve replacement. Valve replacements (at any operation) occurred in 2588 patients, including 2021 prosthetic valves, 520 bioprosthetic valves and 47 unknown type of replacement. The details of valve replacement types are shown in online supplemental table 6.

Follow-up

Of the cohort, 1336 (26.9%) are deceased and 173 have relocated overseas, with 3450 patients alive and residing in New Zealand. Of these, 73.8% (2545) have recorded clinical follow-up with a mean (SD) duration of 20.5 years (19.4 years), range 1 month to 79 years. There were 9.4% (326) who were medically discharged from follow-up and 16.8% (579) appeared to be lost to medical follow-up at the time of entry to the registry.

Future plans

The primary analysis of the Registry will be the linkage to NMDS to define the health burden of significant RHD, namely the morbidity and mortality of moderate and severe RHD in New Zealand. Mortality data recorded in the Registry will be linked with the mortality data from the New Zealand Ministry of Health coded mortality collection[26] The NMDS mortality data provide the cause of death and other contributing causes. Risk factors for
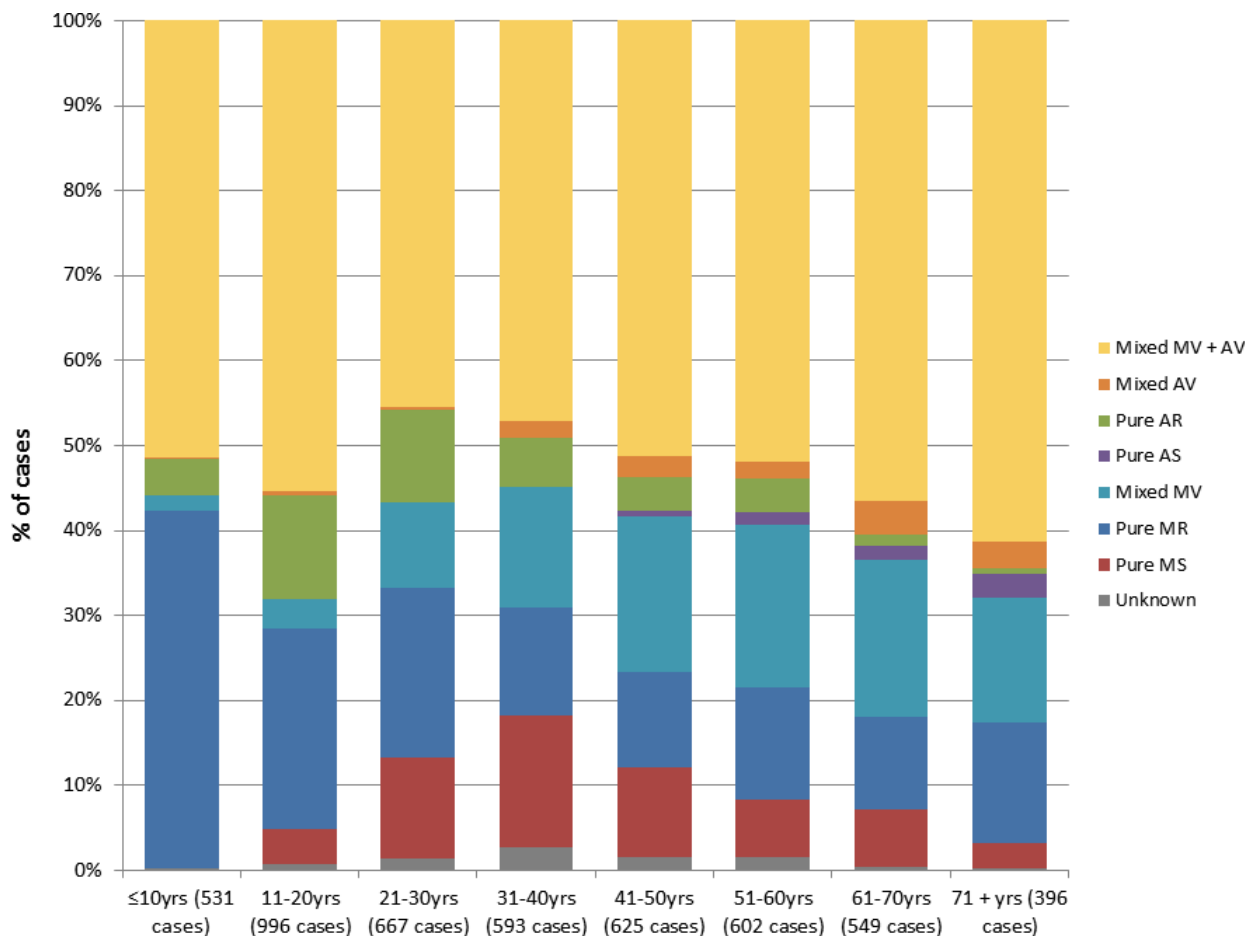
Figure 2 Type of valve pathology by age. AR, aortic regurgitation; AS, aortic stenosis; AV aortic valve; MR, mitral regurgitation; MS, mitral stenosis, MV mitral valve;

mortality will be calculated. The morbidity of RHD of the cohort will be examined by linkage to the NMDS hospital admissions for expected and unexpected morbidity of RHD. Expected morbidity includes the prevalence of heart failure, atrial fibrillation, endocarditis and stroke. This New Zealand data will allow comparisons with previously reported Registries of RHD.[8 13 14] Linkage to pharmaceutical data sets will potentially give insights of the contemporary registry cohort with respect to oral anticoagulant therapy and antiarrhythmic therapy.

Beyond this initial establishment and analysis phase, there are many potential uses for the registry as approved by the Māori and Pacific governance groups. The registry will be used to interrogate the equity and quality of care for RHD in New Zealand in a contemporary subset of the registry, by comparing to the New Zealand RF/RHD guidelines for recommended best practice care for patients with RHD.[1] The registry cohort could be combined with the recently announced national rheumatic fever register to help improve and maintain secondary prevention of ARF across the country. The registry will evolve to a prospective registry of those alive with significant RHD to be known as the Aotearoa RHD registry. The registry may form the basis for multiple future studies by groups including but not limited to researchers, civil societies and patient groups, non-government organisations and the New Zealand Ministry of Health. Such endeavours have the potential to help address current RHD ethnic inequities and improve outcomes for those living with chronic RHD in New Zealand. This will contribute to fulfilling Te Tiriti o Waitangi obligations to Māori enabling the monitoring and improvement of RHD health outcomes.[27]

Figure 3 Venn diagram of all valve interventions.

COLLABORATION

This collaborative study involves investigators from diverse medical specialties including Nursing, Children's and Adult Cardiac Services, Paediatrics, General Medicine, Infectious Diseases, Māori Health and Public Health. An additional strength is the national collaboration involving nearly all health districts in New Zealand particularly regional cardiac centres.

DISCUSSION

High specificity of RHD cases in the registry

The registry methodology ensured that cases entered have a very high specificity for significant RHD, avoiding potential misclassification by relying solely on ICD discharge data.[16 17] We found a high specificity for RHD for cases identified from the cardiac surgical, mitral valvuloplasty, previous RHD case series and regional rheumatic fever registers. In contrast, echocardiography database searches were problematic. The search terms 'RHD', 'Rheumatic Heart Disease', 'Rheumatic Fever', 'ARF' and 'Mitral stenosis were often useful for searching. In comparison, the terms 'moderate' or 'severe mitral regurgitation' or 'aortic regurgitation' resulted in large lists of undifferentiated adult valve disease. Echocardiographic searching was a labour-intensive process and the usefulness varied with different echocardiographic software reporting systems.

The Aotearoa New Zealand Registry will provide data similar to the Northern Territory, Australia dataset of similar methodology where patients with a high specificity for ARF and RHD entered over a 20-year period were later linked to Australian national data sets for both known medical complications of RHD but also with other known health outcomes.[28]

Decade and ethnicity data

The methodology used demonstrated a doubling of cases of significant RHD in the last two decades. This may be attributable to true disease increase but also reflects population increase, heightened recognition of ARF/RHD, and wider application of echocardiography and utilisation of cardiac surgery.

The changes in the ethnic makeup of the cohort over time are significant. The absolute number and proportion of Māori and Pacific with significant RHD has increased over the last three decades, mirroring the well-documented increase in ARF over that time period.[1 2 15 21 29] The proportion and absolute numbers of cases of RHD in those of European ethnicity has fallen steadily over the last five decades and is currently low.

The late Professor Dian Lennon, paraphrasing clinicians from the USA, described RHD as the long shadow of rheumatic fever. The sobering implication of this 'long shadow' is that the lives of young Māori and Pacific individuals with recently acquired chronic heart disease from ARF will continue to be affected by the morbidity of RHD and premature mortality for decades. In summary, the registry highlights the continued unacceptable ethnic inequities of the burden of RHD in New Zealand.[27]

Cardiac characteristics of the registry

The cardiac disease burden of people identified with significant RHD in the Registry is high, with 64% of cases having undergone cardiac interventions, often multiple and predominantly cardiac surgery.[8 10 13 14] The mean age at first intervention was 40 years. The dominant intervention was a prosthetic valve replacement. PMBV for isolated MS accounted for a minority of the interventions reflecting that isolated MS was less common than isolated valvular regurgitation or mixed valve pathology.

Mobility of patients with RHD

In this cohort, we found at least 32% of patients had moved region. This spatial mobility and being 'lost to follow-up' in the context of ARF/RHD management has been shown to adversely affect outcomes.[22] The registry did not record changes of residence within the same region, which may be equally problematic. This has important implications ensuring optimal ongoing medical management and for adherence to secondary prophylaxis. The high level of inter-regional mobility also supports the urgent need for a nationally coordinated ARF/RHD patient management system.

Limitations

A limitation of the registry is its retrospective nature and low sensitivity for total RHD. In particular, underascertainment is more likely for individuals with mild cardiac involvement at baseline and who have not had subsequent RHD-related hospitalisation events and/or accessed healthcare services.

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Supplementary Material

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Supplementary Figure Legends

Figure 1: Proportions of Registry cases entered from a single data source (n = 3092)

Figure 2: All Cardiac interventions by valve type (n = 3196)

Footnote: 11 of the 13 transplant patients had prior valve surgery prior to transplantation

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Supplementary Figure 1

Single data source Registry cases

- Cardiac Surgery Database (n= 1361)
- Echo Database (n= 855)
- RF register (n=419)
- Clinic Lists (n= 222)
- Valvuloplasty Database (n= 110)
- Case Series (n= 62)
- ICD Coding (n= 63)

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Supplementary Figure 2

All Cardiac interventions by valve type (n = 3196)
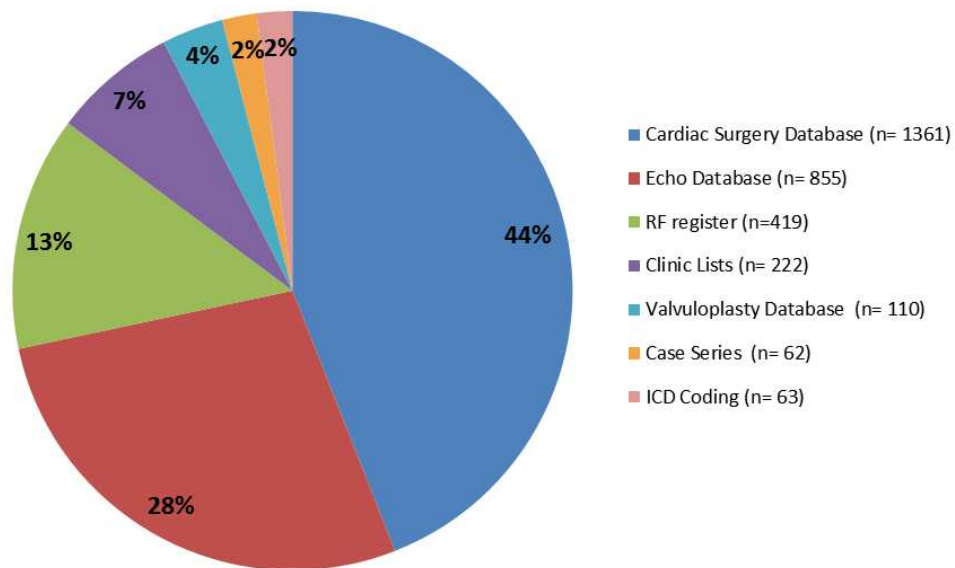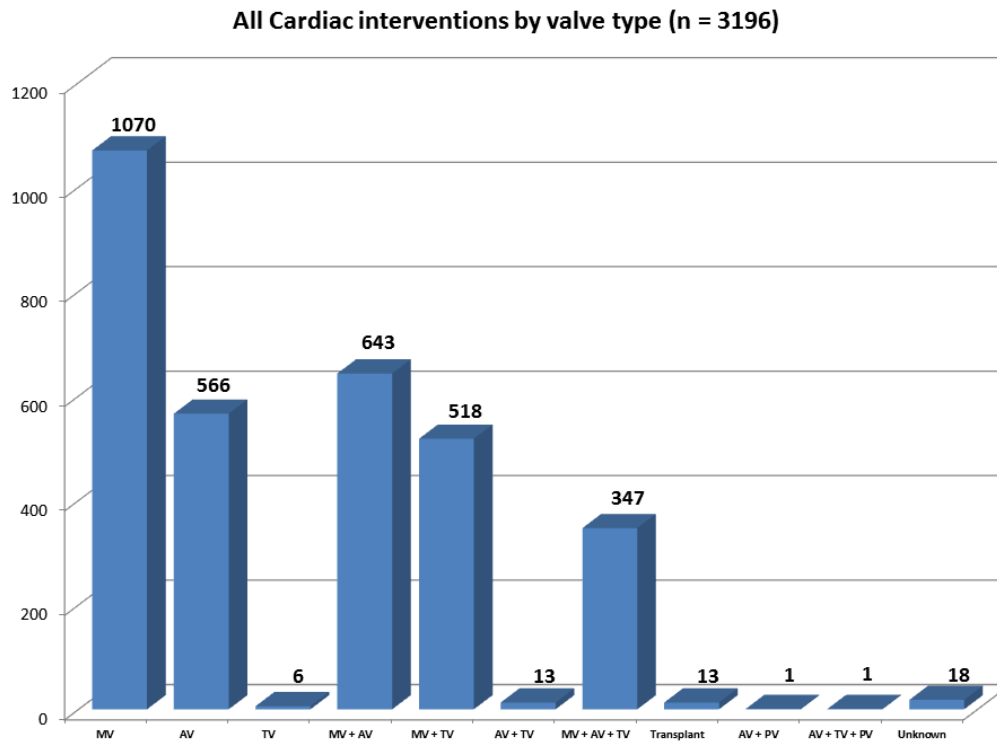
Supplementary Tables

Supplementary Table 1: Minimum data set

Data fields collected
National Health Identifier (NHI)
Date of Birth
Name
Gender
Ethnicity
Database source
Presentation type and date
Region of domicile at presentation
Echo date at presentation (or when valve disease moderate or severe)
Echo valve disease type and severity
Date(s) of RHD surgery / Percutaneous intervention
Type of RHD surgery / Percutaneous intervention
Latest follow-up status
Latest echo data date
Latest echo type and severity (serial echo data was not recorded)
Date of latest follow-up
Region of domicile at latest follow-up
Death
Date of Death
Cause of Death where available

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Supplementary Table 2: Numbers of cases in the Registry cohort by decade of presentation

for4436 cases whose presentation was identifiable

	Pre 1960	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019
Māori	126	166	189	148	218	376	450
Pacific	33	51	90	156	230	476	565
European	320	95	77	72	82	112	128
Other ethnicities	19	18	18	28	56	84	53
Totals (%)	498 (11.2)	330 (7.4)	374 (8.4)	404 (9.1)	586 (13.2)	1048 (23.6)	1196 (27.0)

Supplemental material

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Supplementary Table 3: Region of domicile at presentation and latest follow up

Region of Domicile	At presentation *% (n)*	At latest follow up *% (n)*
North Island DHBs	***70.4%** (3491)*	***89.7%** (4447)*
Northland	**5.4%** (268)	**5.7%** (285)
Auckland	**13.0%** (643)	**15.2%** (752)
Waitematā	**7.2%** (357)	**9.8%** (484)
Counties Manukau	**22.9%** (1136)	**27.0%** (1338)
Waikato	**7.1%** (350)	**9.2%** (454)
Taranaki	**0.6%** (29)	**1.2%** (60)
Lakes	**2.5%** (122)	**3.6%** (178)
Bay of Plenty	**2.6%** (127)	**4.5%** (223)
Tairāwhiti	**3.5%** (103)	**3.4%** (168)
Hawkes Bay	**2.6%** (112)	**2.9%** (145)
Midcentral	**0.8%** (38)	**1.4%** (68)
Whanganui	**0.3%** (15)	**0.7%** (33)
Capital Coast	**2.7%** (135)	**3.2%** (157)
Hutt Valley	**1.0%** (50)	**1.7%** (83)
Wairarapa	**0.1%** (6)	**0.4%** (19)
South Island DHBs	***2.8%**(140)*	***6.8%** (337)*
Canterbury	**1.3%**(80)	**3.5%** (174)
Southern	**1.0%**(48)	**2.6%** (127)
South Canterbury	**0.1%**(5)	**0.1%** (7)
Nelson/Marlborough	**0.1%**(4)	**0.5%** (25)
West Coast	**0.1%**(3)	**0.1%** (4)
Overseas presentation #	***9.3%**(458)*	*0*
Relocated Overseas	*0*	***3.5%**(175)*
Unknown	***17.5%**(870)*	*-*

Footnote:

South Pacific Island when developed ARF/RHD, now residing in New Zealand 5.9% (291); Other overseas countries when developed ARF/RHD, now residing in New Zealand 3.4% (167)

Supplementary Table 4: Specified valve pathology

Valve Pathology	Overall (n=4904)	Percentage with Concomitant TR
Isolated MR	935 (19.1%)	35.2%
Isolated MS	368 (7.5%)	25.5%
Isolated AR	310 (6.3%)	6.1%
Isolated AS	33 (0.7%)	9.1%
Mixed MR and MS	584 (11.9%)	57.2%
Mixed AR and AS	82 (1.7%)	1.2%
Mixed mitral and aortic disease	2592 (52.9%)	46.7%

Footnote: The specific disease e.g. mitral regurgitation was not identified in 55 patients due to unavailable pre-operative records. Of these 55 patients, 30 had Mitral valve surgery, 16 Aortic valve surgery and 9 Mitral and Aortic surgery.

Supplementary Table 5: Other cardiac interventions

Other Cardiac Interventions	n
Mitral balloon valvuloplasty (PMBV)	335
Repeat PMBV	18
Aortic balloon valvuloplasty	11
Transcatheter aortic valve replacement*	12
Transcatheter mitral valve replacement	2
Transcatheter tricuspid valve replacement	3
Cardiac transplantation**	13
Pacemaker insertion#	239

Footnote:

1. *Transcatheter Aortic Valve replacements: mean age 59 years (range 33 – 87 years) Their initial rheumatic disease was 9 mixed MV and AV RHD, 2 AR, 1 MS
2. **Cardiac Transplantation: mean age 37 years (range 8-61 years)
3. Two patients had both balloon mitral and aortic valvuloplasty
4. #20 had pacemaker as only cardiac intervention. 20 had pacemaker prior to cardiac surgery/intervention, 86 had a pacemaker within one year following cardiac surgery, 60 with the initial surgery and 26 with re-do cardiac surgery. Pacemaker insertion occurred > one year after cardiac intervention (mean 9yrs) in 105 patients.

Supplementary Table 6: Cardiac valve replacement details

Cardiac Valve replacement type	n (2588)	%
Mitral Valve	1072	41.4%
Aortic Valve	650	25.2%
Isolated Tricuspid Valve	4	0.2%
Mitral and Aortic	746	28.8%
Mitral and Tricuspid	52	2.0%
Aortic and Tricuspid	3	0.1%
Mitral, Aortic and Tricuspid	59	2.3%
Aortic and Pulmonary	1	<0.1%
Aortic, Tricuspid and Pulmonary	1	<0.1%
Valve replacement procedures	**n (2588)**	**%**
Mechanical valve	2021	78.1
Bioprosthetic /homograft	520	20.1%
Unknown	47	1.8

Footnote: Unknown valve type in 47 due to surgery occurring prior to electronic records (all such patients

clearly had RHD from other clinical and echocardiographic descriptions).