

Supplementary Material

Pattern of hospital admissions and costs associated with acute rheumatic fever and rheumatic heart disease in Australia, 2012–2017

Ingrid Stacey^{A,B,*} (BSc(Hons), MBiostat, PhD, Research Fellow), *Judith Katzenellenbogen*^A (BSc (Occ Ther), BSc Hons (Epidemiol), MSc, PhD, Associate Professor), *Joseph Hung*^C (MBBS, FRACP, FCSANZ, FACC, Emeritus Professor), *Rebecca Seth*^D (BSc, GradCertBiostat, Research Associate), *Carl Francia*^{E,F} (BPhy(Hons), Physiotherapist, PhD candidate), *Bradley MacDonald*^{A,G} (BSc(Hons) MBBS, DCH, FRACP, Consultant Paediatrician, PhD candidate), *James Marangou*^{H,I,J} (MBBS, FRACP, Cardiologist, Honorary Research Fellow), *Kevin Murray*^A (BSc, MSc, PhD, Associate Professor) and *Jeffrey Cannon*^K (BBus BSc(Hons) PhD, Health Economist)

^ACardiovascular Epidemiology Research Centre, School of Population and Global Health, The University of Western Australia, Perth, WA, Australia

^BCardiology Population Health Laboratory, Victor Chang Cardiac Research Institute, Darlinghurst, Sydney, NSW, Australia

^CMedical School, The University of Western Australia, Perth, WA, Australia

^DSchool of Population Health, Curtin University, Perth, WA, Australia

^ESchool of Health and Rehabilitation Sciences, The University of Queensland, Brisbane, Qld, Australia

^FDepartment of Physiotherapy, The Prince Charles Hospital, Brisbane, Qld, Australia

^GDepartment of General Paediatrics, Perth Childrens Hospital, Perth, WA, Australia

^HMenzies School of Health Research, Charles Darwin University, Darwin, NT, Australia

^IDepartment of Cardiology, Royal Perth Hospital, Perth, WA, Australia

^JDepartment of Cardiology, Fiona Stanley Hospital, Perth, WA, Australia

^KThe Kids Research Institute Australia, Perth, WA, Australia

*Correspondence to: Email: Ingrid.Stacey@uwa.edu.au

Supplementary material file S1: ICD-10AM codes used to identify RHD surgeries and exclude persons with congenital condition

ICD-10AM procedure codes used to identify RHD-related surgical procedures:

38456-10	Open valvotomy of aortic valve
38483-00	Decalcification of aortic valve leaflet
38480-00	Repair of aortic valve, 1 leaflet
38481-00	Repair of aortic valve, ≥ 2 leaflets
38488-00	Replacement of aortic valve with mechanical prosthesis
38488-01	Replacement of aortic valve with bioprosthesis
38489-00	Replacement of aortic valve with homograft
38489-01	Replacement of aortic valve with unstented homograft
38456-15	Other intrathoracic procedures on aortic valve without cardiopulmonary bypass
38653-04	Other intrathoracic procedures on aortic valve with cardiopulmonary bypass
38487-00	Open valvotomy of mitral valve
38485-01	Decalcification of mitral valve
38480-01	Repair of mitral valve, 1 leaflet
38481-01	Repair of mitral valve, ≥ 2 leaflets
38475-00	Mitral valve annuloplasty
38477-00	Mitral valve annuloplasty with ring insertion
38488-02	Replacement of mitral valve with mechanical prosthesis
38488-03	Replacement of mitral valve with bioprosthesis
38489-02	Replacement of mitral valve with homograft
38485-00	Reconstruction of mitral valve annulus
38456-16	Other intrathoracic procedures on mitral valve without cardiopulmonary bypass
38653-05	Other intrathoracic procedures on mitral valve with cardiopulmonary bypass
38456-11	Open valvotomy of tricuspid valve
38480-02	Repair of tricuspid valve, 1 leaflet
38481-02	Repair of tricuspid valve, ≥ 2 leaflets
38475-01	Tricuspid valve annuloplasty
38477-01	Tricuspid valve annuloplasty with ring insertion
38488-04	Replacement of tricuspid valve with mechanical prosthesis
38488-05	Replacement of tricuspid valve with bioprosthesis
38489-03	Replacement of tricuspid valve with homograft
38456-17	Other intrathoracic procedures on tricuspid valve without cardiopulmonary bypass
38653-06	Other intrathoracic procedures on tricuspid valve with cardiopulmonary bypass
38456-01	Open valvotomy of pulmonary valve
38488-06	Replacement of pulmonary valve with mechanical prosthesis
38488-07	Replacement of pulmonary valve with bioprosthesis
38489-04	Replacement of pulmonary valve with homograft
38489-05	Replacement of pulmonary valve with unstented heterograft
38456-18	Other intrathoracic procedures on pulmonary valve without cardiopulmonary bypass
38653-07	Resection of endotracheal stricture by laser, with graft
38475-02	Aortic valve annuloplasty
38477-02	Aortic valve annuloplasty with ring insertion
38270-01	Percutaneous balloon aortic valvuloplasty
38270-02	Percutaneous balloon mitral valvuloplasty
38270-03	Percutaneous balloon pulmonary valvuloplasty
96222-00	Percutaneous balloon mitral valvuloplasty using closure device
38488-08	Percutaneous replacement of aortic valve with bioprosthesis
38488-09	Percutaneous replacement of mitral valve with bioprosthesis
38488-10	Percutaneous replacement of tricuspid valve with bioprosthesis
38488-11	Percutaneous replacement of pulmonary valve with bioprosthesis

ICD-10AM diagnosis codes used to identify congenital conditions (excluded):

Q76-Q90	mucopolysaccharide disorders or chromosome disorders (includes congenital heart diseases, Q20)
Q90.2	Trisomy 21 (Down syndrome)
Q91.	Trisomy 13 (Patau syndrome)
Q91.3	Trisomy 18 (Edwards syndrome)
Q93.8, .82, .87	Williams syndrome

Q96.	Turner's syndrome
Q87.4	Marfan's syndrome
Q87.1	Noonan's syndrome
Q82.1	Di George syndrome, 22q11 deletion syndrome
E76.0, .01	Hurler syndrome
E76.02	Hurler-Scheie syndrome
E76.03	Scheie syndrome
E76.1	Hunter's syndrome
E76.2	Sly syndrome

Supplementary material file S2: Hospital costs calculation method

Hospitalisation cost for each episode was estimated in three steps. First, SAS scripts provided by the Independent Health and Aged Care Pricing Authority (IHACPA) were used to calculate the National Weighted Activity Unit (NWAU) value, which is based on several patient and clinical factors, for each admission. For any admission that was not fully government funded, only the government contribution could be estimated using the calculators. Thus, the proportion of an admission that was paid privately by any non-government source was not reported. Second, the NWAU values for each admission were multiplied by the National Efficient Price (NEP) to determine the cost of the admission at the corresponding year of admission (see table below). Third, all costs were indexed to 2016/17 price levels in Australian Dollars (AUD) using the Reserve Bank of Australia Inflation Calculator Indexation rates (see table below, rates from <https://www.rba.gov.au/calculator/financialYearDecimal.html>). Admission costs were aggregated into episodes, to account for patient transfers.

	Financial year				
	2012-13	2013-14	2014-15	2015-16	2016-17
National Efficient Price (NEP) values	\$4,808	\$4,993	\$5,007	\$4,971	\$4,883
Indexation rates	7.7%	4.9%	3.1%	1.7%	NA

Hospitals included in this study were de-identified, so that those receiving block funding could not be identified. Hospital remoteness information for each admission was available however. The IHPA calculators used to assign NWAU values incorporate a remoteness adjustment factor of 20-30% (depending on financial year and level of remoteness). So whilst an activity based model of cost funding has been applied to all admissions, the IHPA calculators have adjusted costs to account for some of the extra expenses associated with rural healthcare delivery.

Supplementary material Table S1. Tabulated data presented graphically

Hospital admission data presented graphically in Figure 1

	FY12/13	FY13/14	FY14/15	FY15/16	FY16/17	TOTAL	5-year mean	Avg. annual change (%, 95% CI)
Paediatric (≤16 years)								
Persons	191	196	232	255	262	791	158	+9.2% (4.9-13.9)
Total admissions	262	266	306	325	321	1480	296	+6.1% (2.4-10.1)
Total episodes	229	229	269	290	304	1321	264	+8.3% (4.3-12.6)
People with >1 episodes	25	27	26	29	26	133	26	
Total bed days	2403	1796	2639	2445	2676	11959	2392	+5.1% (3.8-6.5)
Total surgeries	13	13	12	9	13	60	12	-1.8% (-18.5-18.3)
Avg. bed days/person/year	12.6	9.2	11.4	9.6	10.2	NA	10.6	
Avg. episodes/person	1.2	1.2	1.2	1.1	1.2	NA	1.2	
Avg. bed days/ person/ episode	10.5	7.8	9.8	8.4	8.8	NA	9.1	
Adult (16-64 years)								
Persons	838	867	878	851	836	2761	552	-0.3% (-2.3-1.9)
Total admissions	1389	1402	1436	1531	1451	7209	1442	+1.8% (0.1-3.4)
Total episodes	1244	1222	1274	1316	1259	6315	1263	+0.9% (-0.8-2.8)
People with >1 episodes	239	219	242	259	231	1190	238	
Total bed days	10175	11345	11607	12482	11576	57185	11437	+3.5% (2.9-4.1)
Total surgeries	305	338	331	335	299	1608	322	-0.5% (-3.9-3.0)
Avg. bed days/person/year	12.1	13.1	13.2	14.7	13.8	NA	13.4	
Avg. episodes/person	1.5	1.4	1.5	1.5	1.5	NA	1.5	
Avg. bed days/ person/ episode	8.2	9.3	9.1	9.5	9.2	NA	9.1	

Abbreviations: Avg. – average (mean); CI – confidence interval; FY – financial year.

Master table of hospital admissions and costs data stratified by paediatric and adult age groups and presented graphically in Figure 2. Costs represent subsets and are not mutually exclusive.

	2012/13		2013/14		2014/15		2015/16		2016/17		Total		Average annual cost change (%)	LCI (%)	UCI (%)	P value
	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost				
<i>Paediatric <16 years</i>																
<i>Any ARF, RHD or complication admission in principal diagnosis</i>																
Total	262	3,554,252	266	3,042,678	306	3,687,178	325	3,121,074	321	4,167,571	1,480	17,572,754	+3.4%	0.0	+18.5	0.48
Cost per admission		13,566		11,439		12,050		9,603		12,983		11,873				
Via Emergency	210	2,315,586	225	2,333,601	241	2,816,128	267	2,688,137	283	3,764,776	1,226	13,918,228	+11.8%	+0.7	+24.0	0.04
Non-Emergency	52	1,238,666	41	709,077	65	871,050	58	432,938	56	402,795	272	3,654,526				
<i>ARF in principal diagnosis</i>	202	2,203,237	205	1,978,398	257	2,613,333	266	2,466,178	295	3,356,300	1,225	12,617,447	+11.2%	0.0	+26.0	0.07
<i>RHD in principal diagnosis</i>	51	1,211,837	53	925,303	45	1,041,580	57	637,573	39	610,299	245	4,426,592	-16.0%	-27.4	-2.9	0.03
<i>RHD-related cardiovascular complication in principal diagnosis</i>																
Total	9	127,025	5	136,481	<5	32,265	<5	17,323	<5	66,532	20	379,626	-32.4%	-76.2	+91.9	0.31
Atrial fibrillation																
Heart failure	9	139,178			<5	25,211	<5	7,219			9	164,388				
Stroke			<5	42,302	<5	7,054	<5	10,104	<5	66,532	6	125,993				
Infective endocarditis			5	94,179							5	94,179				
<i>Valvular surgeries and procedures</i>																
Total	13	956,354	13	785,078	12	840,114	9	373,124	13	709,790	60	3,664,460				

Cost per surgery			73,566		60,391		70,010		41,458		54,599		60,005
Within RHD	admission	9	522,870	10	602,690	11	778,475	8	279,267	9	408,532	47	2,591,835
Within RHD-related	admission	12	916,110	11	671,741	12	840,114	9	373,124	12	626,831	56	3,427,920
<i>Jurisdiction (number of episodes)</i>													
Northern Territory		93	1,458,660	92	1,000,885	130	1,784,434	151	1,630,195	133	1,653,833	599	7,528,007
South Australia		<5	28,093	<5	57,443	<5	29,304	<5	18,619	9	251,204	21	384,664
Queensland		56	636,056	71	1,061,746	82	1,235,257	74	599,997	102	1,623,332	385	5,156,388
Western Australia		62	1,302,251	40	539,320	32	341,388	36	690,837	16	208,157	186	3,081,954
New South Wales		16	129,191	23	383,285	23	296,795	21	117,954	45	431,045	128	1,358,270

Abbreviations used – ARF – acute rheumatic fever; AUD, Australian dollars; N – number; RHD – rheumatic heart disease; LCI – lower confidence interval; UCI – upper confidence interval.

	2012/13		2013/14		2014/15		2015/16		2016/17		Total		Ave annual cost change (%)	LCI (%)	UCI (%)	P value
	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost	N	AUD cost				
Adult ≥16 years																
<i>Any ARF, RHD or complication admission in principal diagnosis</i>																
Total	1,389	21,253,265	1,402	22,568,467	1,436	23,675,015	1,531	22,307,131	1,451	23,163,031	7,209	112,966,908	+1.6%	-76.2	+92.0	0.27
Cost per admission		15,301		16,097		16,487		14,570		15,963		15,670				
Via Emergency	887	11,985,830	901	13,690,907	922	14,282,516	884	13,480,212	910	14,270,581	4,504	67,710,046	+3.4%	-2.3	+9.4	0.16
Non-Emergency	502	9,267,435	501	8,877,560	514	9,392,499	647	8,826,919	541	8,892,450	2,705	45,256,862				
<i>ARF in principal diagnosis</i>	141	1,239,081	113	1,018,062	101	824,467	112	909,608	132	1,119,730	599	5,110,948	-3.1%	-19.0	+15.8	0.61
<i>RHD in principal diagnosis</i>	419	10,312,865	445	10,598,174	512	12,480,493	564	10,980,077	443	6,074,292	2,383	50,445,900	-9.8%	-30.6	+17.4	0.30
<i>RHD-related cardiovascular complication in principal diagnosis</i>																
Total	829	9,701,318	844	10,952,231	823	10,370,055	855	10,417,447	782	9,753,055	4,133	51,194,106	-0.4%	-6.1	+5.5	0.84
Atrial fibrillation	313	1,679,397	290	1,382,460	250	1,211,926	277	1,524,730	302	1,494,392	1,432	7,292,904				
Heart failure	393	3,991,057	379	4,371,921	411	4,152,844	344	3,783,284	315	3,459,110	1,842	19,758,216				
Stroke	57	1,981,628	88	2,106,976	79	1,879,513	157	2,080,242	73	1,476,874	454	9,525,233				
Infective endocarditis	66	2,049,236	87	3,090,874	83	3,125,773	77	3,029,191	92	3,322,679	405	14,617,753				
<i>Valvular surgeries and procedures</i>																
Total	305	15,510,157	338	16,896,051	331	16,614,557	335	14,322,676	299	15,577,621	1,608	78,921,063				
Cost per surgery		50,853		49,988		50,195		42,754		52,099		49,080				
Within RHD admission	204	9,002,414	227	9,351,597	234	11,110,074	251	9,487,414	224	10,672,113	1,140	49,623,612				

Within RHD-related admission	230	10,914,082	258	11,670,158	258	12,704,078	272	11,396,687	246	12,241,813	1,264	58,926,818	+2.0%	-3.7	+8.1	0.34
<i>Jurisdiction (number of episodes)</i>																
Northern Territory	294	3,377,771	255	3,417,587	281	3,699,323	249	3,440,295	257	3,278,561	1,336	17,213,538				
South Australia	79	2,007,013	112	3,324,647	103	2,897,958	120	4,601,087	113	4,145,771	527	16,976,475				
Queensland	319	5,337,218	337	6,485,622	356	7,475,413	394	5,122,744	365	6,259,709	1,771	30,680,707				
Western Australia	204	3,119,706	207	2,698,923	211	2,997,008	195	3,200,470	148	2,798,383	965	14,814,490				
New South Wales	355	7,411,556	319	6,641,689	332	6,605,312	369	5,942,535	385	6,680,606	1,760	33,281,698				

Abbreviations used – ARF – acute rheumatic fever; AUD, Australian dollars; N – number; RHD – rheumatic heart disease; LCI – lower confidence interval; UCI – upper confidence interval.

Supplementary material file S3: Sensitivity analysis, the impact of missing interstate surgeries

As ERASE lacks Victorian hospital data, a sensitivity analysis was done for NT paediatric RHD patients to estimate the cost of valvular surgery done in Victoria, where many children with RHD were sent for valvular surgery. RHD register-sourced surgical records identified children receiving surgery not captured by admissions data. Surgery cost was then estimated based on average cost from the primary analysis.

Paediatric surgery, Northern Territory register sensitivity analysis

	FY12/13	FY13/14	FY14/15	FY15/16	FY16/17	TOTAL
Surgery frequency (hospital data)	13	13	12	9	13	60
Surgery costs (actual)	\$956,354	\$785,078	\$840,114	\$373,124	\$709,790	\$3,664,460
Surgery frequency (register data)	18	16	19	16	8	77
Surgery cost (estimated, based on \$64,326 average cost)	\$1,157,868	\$1,029,216	\$1,222,194	\$1,029,216	\$514,608	\$4,953,102
Difference (register minus hospital)	+5	+3	+7	+7	-5	17
	+\$201,514	+\$244,139	+\$382,080	+\$656,092	-\$195,182	+\$1,288,642

Abbreviations used – FY, financial year.

For adult sensitivity analyses, interstate surgeries were determined by interrogating linked national cardiac surgery records from The Australian and New Zealand Cardiac and Thoracic Surgeons (ANZSCTS) database.