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ORIGINAL ARTICLE

Public Health Costs for Northern Territory and South Australian Cardiac Surgery Patients

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Background The cost of performing cardiac surgery in the public health system in Australia is unclear. This paper analyses the cost of cardiac surgery performed at Flinders Medical Centre (FMC), South Australia, comparing cost by procedure, rheumatic valvular heart disease status, Aboriginality and location.

Methods This study is a retrospective, population-based analysis of cardiac surgery data held in the Cardiac Surgery Registry cross-referenced to cost data provided by the FMC Department of Finance and Patient Travel, Accommodation and Transport Services at the Royal Darwin Hospital. Seven hundred ninety-five (795) patients who underwent cardiac surgery at FMC from 1 July 2014 to 30 June 2016 were included.

Results Across all procedures, Northern Territory (NT) Aboriginal patients had a mean total cost of $78,506 which was $24,113 more than NT non-Aboriginal, $28,443 more than South Australian (SA) Aboriginal and $22,955 more than SA non-Aboriginal patients. The total cost of a patient undergoing a repeat sternotomy (reoperative procedure) was found to be significantly higher than a primary procedure ($85,797 versus $59,097). In patients undergoing valve surgery procedures, those identified with rheumatic heart disease had a higher mean total cost than those without (a difference of $25,094). Significantly, the rheumatic patient group showed a higher proportion of reoperative procedures (19% versus 5%).

Conclusions The cost of treating NT Aboriginal cardiac surgical patients remotely has a significant financial impact upon the health care delivery system, as does the impact of rheumatic heart disease. This study found that the cost for the NT Aboriginal patient group was substantially higher than the NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal patient groups. The additional cost to family and dislocation of social structures is not able to be calculated, but would also clearly weigh heavily on both patient groups. These findings suggest that future health funding models should recognise Aboriginality, remoteness and rheumatic heart disease.

Keywords Cardiothoracic surgery • Indigenous Australians • Rheumatic heart disease • Health economics

Background

In the current environment of increasing public health care expenditure, costs are under increasing scrutiny and, for effective planning and future budgeting, it is vital to understand the cost of performing specific procedures. The cost of performing cardiac surgery in public hospitals in Australia is challenging to understand due to the complexities in proportioning costs incurred through the patient journey, with patients transiting through ward, operating

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theatres, and critical care areas, often requiring complex and prolonged care. Additionally, some patients travel large distances from rural and remote communities to access specialist health care services, with costs further complicated by travel costs and cross-border charges.

A significant proportion of the cardiac surgery case load at Flinders Medical Centre is from the Northern Territory (NT) and includes a large number of Aboriginal and Torres Strait Islander peoples (Aboriginal Australians). The prevalence of rheumatic heart disease (RHD) among Aboriginal Australians is amongst the highest in the world and large inequalities exist between Aboriginal and other Australians. In 2015, the prevalence of RHD was 37 times as high among Aboriginal Australians as it was among other residents of the NT [1]. This results in a high number of patients presenting at our institution with RHD. One of the limitations identified in the 2018 Closing the Gap report [2], an initiative agreed between the Australian Governments and Aboriginal and Torres Strait Islander peoples in 2008 to work together to achieve equality in health status and life expectancy between Aboriginal Australians and non-Aboriginal Australians by the year 2030, was lack of data on Aboriginal health care spending. With 2% of the Aboriginal people in NT having RHD, and given RHD valve surgery is more common in young, female Aboriginal patients where the mechanical valve is not suitable thus requiring repeat valve surgery [3], attention to the expenditure in this population may provide a better understanding on where spending may be better directed.

The aim of this paper was to perform analyses of the cost for South Australian (SA) and NT Aboriginal and non-Aboriginal patient groups for cardiac surgery performed at a tertiary referral hospital for all cardiac surgical procedure types, with subgroup analyses for isolated coronary artery bypass graft (CABG) surgery, and surgery for valvular heart disease (rheumatic compared to non-rheumatic heart disease) to enable ongoing and future planning for health care expenditure for cardiac surgery in Australia.

Methods

This study was a retrospective, population-based analysis of data held in the Cardiac Surgery Registry (CSR) cross-referenced to cost data provided by the Flinders Medical Centre Department of Finance (FMC DoF) and Patient Travel, Accommodation and Transport Services at the Royal Darwin Hospital (RDH PT). Ethics approval for this audit was waived according to the SALHN (South Australia Local Health Network) Office for Research Quality Assurance versus Research Project Exemption Guidelines v1 (01.12.2016).

Patient Population

All patients who underwent cardiac surgery at Flinders Medical Centre and were admitted in the 2014/15 and 2015/16 financial years (1 July 2014 to 30 June 2016) were included (n = 795). Patients were identified for region, Aboriginal status, and presence of RHD from information stored in the CSR Database. Specifically, patients were identified as Aboriginal if they self-reported as Aboriginal on admission or to their treating/referring physician, as NT for their state of origin if their postcode began with "08", and for RHD if there was an aetiology of RHD disease identified in the patient's records or at the time of surgery. Of 205 patients from the NT, 132 were identified as Aboriginal (64%); and of 590 from SA, 23 were identified as Aboriginal (4%) (see Supplementary Table 1 for a breakdown of patient numbers by procedure type, state of origin and Aboriginal status).

Demographic, risk and acuity data was collected from CSR and four patient groups were defined: NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal.

Cost Data

Data includes all costs borne by the SA and NT public health systems. Specifically, hospital costs and the indirect costs incurred by RDH PT as part of facilitating patient transport to and from FMC. Travel and accommodation costs incurred by SA patients are not included as these are funded by the patient, not the SA public health system. Similarly patient out-of-pocket costs and private funding is not included in the analysis.

Data was provided by the FMC DoF and RDH PT. FMC DoF cost data was sourced from the National Hospital Cost Data Collection (NHCDC) and provided pre-allocated into cost buckets (see Appendix A for definitions). Indirect Costs were summed with Direct Costs as these costs are wholly allocated to patient accounts, and therefore, contribute to the total cost of surgery. RDH PT cost data was bucketed into two categories: travel (includes taxis, buses, and flights—commercial and medical care flights) and accommodation. RDH PT could not provide data on two patients with a state of origin of the NT who would qualify for the travel scheme. These patients were allocated mean travel costs (Accommodation Total Costs of $1,300 and Travel Total Costs $4,180). All costs are in Australian dollars.

All Procedures

Total cost, mean, standard deviation, median and interquartile range were calculated for each patient group (NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal) by procedure type. Standard deviation was only included if $n \geq 20$. Mean, median and interquartile range was calculated for total length of stay (LOS), length of pre-stay, and time in intensive care unit (ICU). Means were calculated for individual cost buckets.

Coronary Artery Bypass Graft Only Procedures

Total cost, mean, median and interquartile range was calculated for each patient group (NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal). Mean, median and interquartile range was calculated for total length of stay (LOS), length of pre-stay, and time in ICU. Means were calculated for individual cost buckets.

Rheumatic Heart Disease vs Non-Rheumatic Heart Disease Patients

Total cost, mean, median and interquartile range and mean, median and interquartile range for total LOS, length of pre-stay and time in ICU were calculated for rheumatic versus non-rheumatic patients. Total cost, mean, median and interquartile range was calculated for each patient group (NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal). Total cost, mean, median and interquartile range were calculated for total LOS, length of pre-stay, and time in ICU. Statistics for reoperative procedures were also calculated for rheumatic versus non-rheumatic Aboriginal patients only.

Statistical Analysis

All data used in this study and analyses performed were performed on de-identified data.

All analysis was performed in Excel version 14.0.7190.5000.

Results

Seven hundred ninety five (795) patients were identified as having undergone cardiac surgery at FMC during the study period. The breakdown of procedure type by region, Aboriginal status, and RHD status is shown in Supplementary Table 1. Of note 48/132 (36%) Aboriginal NT patients were identified as with RHD, compared with 3/73 (4%) non-Aboriginal NT patients. In the SA cohort, note 17% Aboriginal patients and 4% of non-Aboriginal patients were identified with RHD.

Demographics

A detailed breakdown of the demographic and acuity statistics is shown in Table 1. A number of factors highlighted the differences between both Aboriginal and non-Aboriginal patients and between SA and NT patients. Aboriginal patients were significantly younger than non-Aboriginal patients for NT and SA respectively: 45.6 ± 12.9 compared to 60.8 ± 11.7 and 51.8 ± 15.8 and 67.4 ± 13.3. The Aboriginal groups had significantly higher proportions of female patients (approximately 45%).

When evaluating risk factors, due to the low number of SA Aboriginal patients, comparisons were not made. The NT Aboriginal group had a significantly higher proportion of patients with a history of RHD and alcohol use, with trends for increased diabetes ($p = 0.053$) and renal disease ($p = 0.065$), less peripheral vascular disease, and smaller body surface area than non-Aboriginal NT patients. Northern Territory Aboriginal, NT and SA non-Aboriginal patients varied significantly (see Table 1).

Costs

All procedures

Cost analysis demonstrates higher cost per patient for the NT Aboriginal patient group, with the mean total cost being $78,506, compared with $54,393 for the NT non-Aboriginal group, and $50,063 and $55,551 for SA Aboriginal and SA non-Aboriginal groups respectively. The detailed breakdown of cost statistics by patient group and procedure type can be seen in Table 2. The main driver of the higher cost per patient for the NT Aboriginal group was longer time spent in the high cost high acuity care area (intensive care or coronary care units (CCU)). On average, NT Aboriginal patients spent 40 hours longer in ICU, and 3 days longer in overall length of stay than other groups (Table 3). Higher operating rooms and pathology costs and the breakdown of costs by patient group and cost bucket areas are shown in Supplementary Table 2. For NT patients, total travel costs (travel and accommodation) accounted for 7% of total expenditure (mean $5,840) for Aboriginal patients and 9% of total expenditure (mean $4,980) for non-Aboriginal patients. The total cost of a patient undergoing a repeat sternotomy (reoperative procedure) requires highlighting, as they represent groups of procedures with higher costs. In the total patients group, reoperative procedures were approximately $25,000 more expensive. This was reflected in each group (see Supplementary Table 3).

Coronary artery bypass graft only procedures

Cost statistics reflect the same trend across all procedure types, and are highlighted in the cost of coronary artery bypass graft procedures, and show a substantially higher average cost per patient for the NT Aboriginal patient group. The mean total cost for NT Aboriginal $66,766 was higher than all other groups, NT non-Aboriginal $48,021, SA Aboriginal $40,311 and SA non-Aboriginal $52,325 (see Supplementary Table 4 and Supplementary Table 5 for a breakdown of cost and stay statistics by patient group).

Paradoxically, total travel costs (travel, accommodation and car rental costs) accounted for 9% of total expenditure (mean of $5,806 per patient) for NT Aboriginal patients and 15% of total expenditure (mean of $7,109 per patient) for NT non-Aboriginal patients, so was not a driver for the higher cost per patient for NT Aboriginal patients relative to the NT non-Aboriginal group (see Supplementary Table 6 for a breakdown of costs by patient group and cost bucket).

Rheumatic heart disease vs non-rheumatic heart disease patients

Patients identified as having a history of RHD were found to have higher total cost statistics across all patient groups, for the entire cohort mean total cost for the rheumatic group was $81,697 compared with non-rheumatic of $56,604 (see Table 4). The main drivers of the higher cost per patient for the rheumatic patients were longer time spent in intensive care or coronary care units, overall length of stay, operating room costs, pathology costs and travel costs (see Supplementary Table 7) and the higher percentage of reoperative procedures. Mean total costs were consistently higher across all patient groups; however, due to the small number of patients, in some group's length of stay and ICU hour data show some variation (see Supplementary Table 8).

Aboriginal patients with a history of RHD were found to have higher total cost and stay statistics, averaging a $16,000

Table 1 Demographic and acuity statistics for NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal patients (n = 795).

	NT Aboriginal		NT Non-Aboriginal		P-value*	SA Aboriginal		SA Non-Aboriginal		P-value**
	No.		No.			No.		No.		
Patients	132	17%	73	9%		23	3%	567		71%
Age (year), Mean ± SD		45.6 ± 12.9		60.8 ± 11.7	<0.000		52 ± 16		67.4 ± 13.2	<0.000
Female	59	45%	11	15%	<0.000	10	43%	158	28%	<0.000
Prognosis										
Reoperative procedures	13	10%	3	4%	NS	0	0%	35	6%	NS
EuroSCORE, Mean ± SD		4.0 ± 4.9		4.6 ± 5.3	NS		4.9 ± 5.2		6.9 ± 8.3	<0.000
BSA (Body Surface Area), Mean ± SD		1.8 ± 0.2		2.0 ± 0.2	=0.0002		1.9 ± 0.5		1.9 ± 0.4	NS
Risk Factors										
Rheumatic heart disease	48	36%	3	4%	<0.000	4	17%	24	4%	<0.000
Alcohol	51	39%	23	32%	=0.002	8	35%	98	17%	<0.000
Diabetes	56	42%	21	29%	=0.053	7	30%	165	29%	=0.019
Renal disease	28	21%	8	11%	=0.065	3	13%	60	11%	=0.004
Smoker (previous or current)	103	78%	58	79%	NS	18	78%	379	67%	<0.000
Respiratory disease	36	27%	22	30%	NS	7	30%	136	24%	NS
Congestive heart failure	71	54%	39	53%	NS	12	52%	291	51%	NS
Substance abuse	7	5%	6	8%	NS	5	22%	12	2%	=0.022
Hypertension	87	66%	49	67%	NS	16	70%	412	73%	NS
PVD	3	2%	10	14%	=0.001	2	9%	50	9%	=0.009
CVD	5	4%	6	8%	NS	1	4%	69	12%	=0.001
Hypercholesterolaemia	81	61%	42	58%	NS	16	70%	412	73%	=0.003
Family history	58	44%	31	42%	NS	12	52%	328	58%	=0.002
Previous Surgery										
Previous CABG	0	0%	3	5%	=0.019	1	4%	32	6%	=0.019
Previous valve	14	11%	1	1%	=0.015	0	0%	17	3%	<0.000
Previous percutaneous intervention	17	13%	10	14%	NS	5	22%	113	20%	NS
Pre-op										
Pre-op arrhythmias	50	38%	26	36%	NS	7	30%	192	34%	NS
Pre-op blood transfusions	4	3%	0	0%	NS	1	4%	12	2%	NS
Procedure Urgency										
Emergency	2	2%	2	3%	NS	3	13%	17	3%	NS
Urgent	15	11%	10	14%		1	4%	88	16%	
Elective	115	87%	61	84%		19	83%	462	81%	

Abbreviations: CABG, coronary artery bypass graft; CVD, cardiovascular disease; PVD, peripheral vascular disease; SD, standard deviation; EuroSCORE, European System for Cardiac Operative Risk Evaluation; NS, not significant; NT, Northern Territory; SA, South Australia.

*NT Aboriginal vs NT non-Aboriginal.

**NT Aboriginal vs NT non-Aboriginal vs SA Non-Aboriginal.

higher mean cost, driven by a 19% higher rate of reoperative procedure, nearly 3-day increased length of stay, and 11-hour longer ICU stay (see Table 5).

Discussion

The two main findings of this report are, firstly the high cost to the health care system for patients treated for valvular disease with a history of rheumatic heart disease, and secondly the increased cost associated with management of NT patients requiring cardiac surgery performed in a remote setting. Unlocking the drivers underlying these costs, and understanding the costs associated with both rheumatic heart disease and remote medical management, is important to work toward both managing health care expenditure but importantly bridging the gap to equality in health care in Australia.

All Patients

The mean total cost for the NT Aboriginal patient group was substantially higher than all other groups. The majority of the difference in cost was due to higher direct costs and salaries and wages incurred as a result of longer inpatient stays. Higher operating room costs also contributed to these differences. These costs are, in part, attributed to the higher acuity of the group, which is reflected in a higher proportion of

Table 2 Cost Statistics (Total, Mean/Standard Deviation, Median and Interquartile Range) for NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal patients by procedure type.

	n	Total Cost	Mean ± SD	Median	Interquartile Range
NT Aboriginal					
Bypass graft operation	69	$4,606,888	$66,766 ± $93,099	$44,169	$33,301–$56,849
Valve repair/replacement	43	$3,880,025	$90,233 ± $82,795	$61,746	$52,195–$88,117
Valve percutaneous	1	$50,526	$50,526	$50,526	$50,526–$50,526
Valve/graft	4	$453,187	$113,297	$96,586	$82,373–$127,511
Other/combined	2	$141,476	$70,738	$70,738	$53,059–$88,417
Dissection/replacement	5	$466,073	$93,215	$66,016	$64,926–$117,421
Other	3	$204,970	$68,323	$47,192	$39,514–$86,567
AVR/MVR	5	$559,653	$111,931	$75,797	$65,488–$172,681
Total	132	$10,362,797	$78,506 ± $84,945	$55,378	$39,126–$81,208
NT Non-Aboriginal					
Bypass graft operation	40	$1,920,857	$48,021 ± $21,161	$42,325	$34,108–$50,618
Valve repair/replacement	22	$1,184,447	$53,839 ± $39,068	$37,460	$33,849–$53,902
Valve percutaneous	3	$191,634	$63,878	$51,075	$49,816–$71,538
Valve/graft	5	$509,414	$101,883	$83,666	$37,937–$99,574
Other/combined	2	$107,219	$53,610	$53,610	$37,205–$70,014
Dissection/replacement	1	$57,126	$57,126	$57,126	$57,126–$57,126
Total	73	$3,970,698	$54,393 ± $36,901	$42,868	$34,165–$55,004
SA Aboriginal					
Bypass graft operation	10	$403,107	$40,311	$27,292	$24,702–$54,061
Valve repair/replacement	9	$598,610	$66,512	$45,755	$39,626–$71,710
Valve percutaneous	1	$60,453	$60,453	$60,453	$60,453–$60,453
Valve/graft	1	$43,979	$43,979	$43,979	$43,979–$43,979
Other/combined	2	$45,307	$22,654	$22,654	$22,295–$23,013
Total	23	$1,151,456	$50,063 ± $37,927	$43,452	$25,879–$57,328
SA Non-Aboriginal					
Bypass graft operation	250	$12,377,071	$49,508 ± $37,123	$38,421	$30,489–$52,504
Valve repair/replacement	149	$8,799,897	$59,060 ± $51,752	$42,431	$33,407–$62,257
Valve percutaneous	62	$3,150,266	$50,811 ± $16,939	$48,982	$42,247–$54,547
Valve/graft	45	$2,906,707	$64,593 ± $57,331	$52,276	$42,133–$75,604
Other/combined	34	$2,292,998	$67,441 ± $62,013	$42,283	$36,738–$58,415
Dissection/replacement	13	$1,039,137	$79,934	$64,181	$40,317–$76,933
Other	10	$565,110	$56,511	$44,848	$30,580–$58,546
AVR/MVR	4	$366,143	$91,536	$86,287	$79,304–$98,518
Total	567	$31,497,329	$55,551 ± $44,637	$43,181	$33,717–$58,373
Bypass graft operation	369	$19,307,923	$52,325 ± $51,413	$39,957	$31,821–$54,285
Valve repair/replacement	223	$14,462,979	$64,856 ± $59,053	$47,275	$35,223–$66,374
Valve percutaneous	67	$3,452,878	$51,535 ± $17,083	$50,073	$42,461–$54,651
Valve/graft	55	$3,913,288	$71,151 ± $60,799	$54,064	$42,427–$80,271
Other/combined	40	$2,587,000	$64,675 ± $58,981	$42,104	$35,036–$58,975
Dissection/replacement	19	$1,562,336	$82,228	$47,192	$48,080–$90,581
Other	13	$770,080	$59,237	$45,524	$31,836–$58,811
AVR/MVR	9	$925,796	$102,866	$81,544	$72,586–$120,984
Total	795	$46,982,280	$59,097 ± $53,387	$44,889	$34,086–$61,233

Abbreviations: AVR, aortic valve replacement; MVR, mitral valve replacement

reoperative surgeries, incidence of RHD, diabetes, renal disease and the resultant burden of comorbidities these produce. Further, previous analyses support the demographic findings of Aboriginal patients presenting at a younger age and with more severe heart disease [4–6], the elevated complexity of the population as evidenced by excess operative mortality [7] and prolonged ventilation, combined morbidity outcome and reduced long-term survival [8]. In turn, the

Table 3 Stay Statistics (Mean, Median and Interquartile Range for Length of Stay, Pre-Stay and Hours in ICU) for NT Aboriginal, NT non-Aboriginal, SA Aboriginal and SA non-Aboriginal patients for all procedures.

	NT Aboriginal (n = 132)	NT Non-Aboriginal (n = 73)	SA Aboriginal (n = 23)	SA Non-Aboriginal (n = 567)	Total (n = 795)
Mean length of stay (days)	12.4	9.1	8.6	9.1	9.6
Median length of stay (days)	8.0	7.0	6.0	7.0	7.0
Interquartile range of length of stay (days)	6–13	5–9	5–8	5–10	5–10
Mean length of pre-stay (days)	3.1	3.1	2.1	2.9	2.9
Median length of pre-stay (days)	2.0	2.0	1.0	1.0	1.0
Interquartile range of length of pre-stay (days)	2–2	2–3	1–2	1–2	1–3
Mean time in intensive care unit (ICU) (hr)	119	71	81	83	88
Median time in ICU (hr)	50	41	51	45	46
Interquartile range of time in ICU (hr)	27–108	24–93	26–73	25–95	25–96

higher acuity of this patient group results in significantly longer lengths of stay time in intensive care and coronary care units.

Travel costs were significant for patients travelling from the NT with an average expenditure of $5,534 per patient not incurred by a SA patient. Total travel costs also reflect increased cost burden due to the contribution of relatives' travel and accommodation expenses while the patient is an inpatient and is increased by the longer average length of stay.

Coronary Artery Bypass Graft Only Procedures

Analysis of CABG only patients supported the findings of increased costs for the NT Aboriginal group with the exception of operating room costs which were equivalent across all patient groups. The mean total cost for the NT Aboriginal patient group was approximately $18,000 against all groups. The majority of the difference in this cost was due to higher direct costs and salaries and wages incurred as a result of longer stay.

Travel costs were significant for patients travelling from the NT with an average expenditure of $5,806 per NT Aboriginal patient and $7,109 per NT non-Aboriginal patient not incurred by a SA patient. The greatest cost burden is attributable to flights. Patients and their carers may travel via Air Ambulance (Careflight NSW, LifeFlight, MedStar, JetCity or Millennium Medical Charters) or commercial airline (Qantas, Jetstar and Virgin Australia) independently with family, or occasionally with Registered Nurse escort, depending on the

Table 4 Cost (Mean, Median and Interquartile Range of Total Cost), Reoperative Procedure and Stay Statistics (Mean and Interquartile Range for Length of Stay, Pre-Stay and Hours in ICU) by Rheumatic Status.

	Rheumatic	Non-Rheumatic	Difference
Mean total cost	$81,697	$56,604	$25,094
Median total cost	$63,761	$42,987	$20,774
Interquartile range of total cost	$49,300–$89,855	$33,598–$57,860	
Number of patients	79	716	
Number of reoperative procedures	15	36	
Reoperative procedure %	19%	5%	14%
Mean of length of stay (days)	13.1	9.3	3.8
Median of length of stay (days)	9.0	7.0	2.0
Interquartile range of length of stay (days)	7–14	5–10	
Mean of pre-stay (days)	3.1	2.9	0.2
Median of pre-stay (days)	2.0	1.0	1.0
Interquartile range of pre-stay (days)	1–3	1–3	
Mean of ICU hours (hr)	122	84	38
Median of ICU hours (hr)	71	44	27
Interquartile Range of ICU hours (hr)	46–118	25–94	

Table 5 Cost (Mean, Median and Interquartile Range of Total Cost), Reoperative Procedure and Stay Statistics (Mean and Interquartile Range for Length of Stay, Pre-Stay and Hours in ICU) for Aboriginal patients by Rheumatic Status.

	Aboriginal (n = 154)		
	Rheumatic	Non-Rheumatic	Difference
Mean total cost	$84,967	$68,893	$16,074
Median total cost	$63,086	$47,051	$16,034
Interquartile range of total cost	$52,604–$89,680	$33,139–$61,578	
Number of patients	51	103	
Number of reoperative procedures	11	2	
Reoperative procedure %	22%	2%	20%
Mean of length of stay (days)	13.7	10.9	−2.8
Median of length of stay (days)	10.0	7.0	−3.0
Interquartile range of length of stay (days)	7–14	5–11	
Mean of pre-stay (days)	2.7	3.1	0.4
Median of pre-stay (days)	2.0	2.0	0.0
Interquartile range of pre-stay (days)	2–3	1–2	
Mean of intensive care unit (ICU) hours (hrs)	121	110	−11
Median of ICU hours (hrs)	70	47	−22
Interquartile range of ICU hours (hrs)	45–105	25–99	

level of medical care the patient requires to safely make the flight. Specific providers are then selected based on availability, cost and need. The paradoxically higher cost for NT non-Aboriginal patient travel reflected the higher use of non-commercial air travel in this group (NT non-Aboriginal patients had four instances of non-commercial air travel out of 74 patients while NT Aboriginal patients had only one instance of non-commercial air travel out of 134 patients).

Rheumatic Heart Disease vs Non-Rheumatic Heart Disease Patients

Patients with a history of RHD, irrespective of geographical location or race, were found to have a higher mean total cost than non-rheumatic patients (difference $25,094). This reflects the higher acuity of the group leading to substantially longer length of stay (difference 3.8 days) and time in intensive care units (difference 38 hours), higher operating room and pathology costs. Other analyses have found that the RHD patient group is higher acuity as compared to the non-RHD patient group [3] and this is supported in this study in the group's higher proportion of reoperative surgeries and comorbidities.

The majority of the difference in mean total cost between the RHD patient and non-RHD patient groups was contributed by higher direct costs and salaries and wages incurred as a result of longer stays (59% of the difference), and operating room costs (26% of the difference). Ten per cent (10%) of the difference in cost was due to increased travel costs. Travel costs were higher as a greater proportion of rheumatic patients originated from the NT and were Aboriginal, reflecting the prevalence of rheumatic heart disease in the NT Aboriginal community [9].

The increased burden of RHD on the Aboriginal community is reflected in the high proportion of NT Aboriginal patients with a rheumatic heart disease history. The current lack of availability of resources in the NT exposes Aboriginal patients to seek surgical intervention in remote locations, increasing the burden of disease both on local Aboriginal communities and on the health care system.

Limitations and Improvements

This study had a number of limitations and opportunities for improvement. Small sample sizes for multiple groups, such as specific procedure types for the individual patient groups and the SA Aboriginal patient group, limited the power of the study.

Conclusions

The cost of treating cardiac surgical patients remotely has a significant financial impact upon the health care delivery system, as does the impact of rheumatic heart disease. Patients from the NT had significantly greater costs for cardiac surgery due to cost of travel. The additional cost to family and dislocation of social structures is not able to be calculated, but would also clearly weigh heavily on both patient groups. The burden on NT Aboriginal and non-Aboriginal communities would be reduced by providing appropriate surgical solutions in the NT. Underlying inequality in the prevalence of RHD and increased likelihood of other risk factors in Aboriginal patients need to be addressed separately and immediately.

Aboriginal patients, regardless of origin, had a greater burden of co-morbidities, and increased complexity

procedurally, producing greater cost to provide care to these patients for comparable outcomes to non-Aboriginal patients. Currently, no increased funding for Aboriginal status exists, but it is clear our analysis would indicate greater cost to provide care, and future health funding arrangements should reflect this.

Additionally, patients with RHD clearly have a greater cost for care provided, with or without Aboriginal status. While an improved funding model based on Aboriginal status would address some of these higher costs, a loading for rheumatic patients may also be indicated in future health funding models.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2018.08.028.

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