

SUPPLEMENTARY MATERIAL

Morbidity and Mortality Outcomes of Patients requiring Isolated Tricuspid Valve Surgery

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Supplementary Table 1. Study comorbidities International Classification of Diseases Tenth Revision Australian Modification (ICD-10AM) codes and Australian Classification of Health Interventions (ACHI) procedural codes

No.	Comorbidity *	ICD-10AM codes
1	Endocarditis (indication for cardiac valve surgery)	I33, I38, I39
2	Atrial fibrillation/flutter	I48
3	Acute myocardial infarction	I21, I22, I23
4	Ischemic heart disease	I20, I21, I22, I23, I24, I25
5	Prior PCI / CABG	Z95.1, Z95.5
6	Congestive cardiac failure	I42, I43, I50, I11.0, I13.0, I13.2
7	Peripheral vascular disease	E09.5, E10.51, E10.52, E11.51, E11.52, E13.51, E13.52, E14.51, E14.52, I70, I71, I72, I73, I74, I77, I78, I79
8	Stroke	G45-45.9, G46-G46.8, I60, I61, I62, I63, I64
9	Prosthetic heart valve	Z95.2, Z95.3, Z95.4
10	Cardiovascular disease (defined as morbidities item nos. 2, 4-9)	I48, I20-I25, Z95.1, Z95.5, I42, I43, I50, I11.0, I13.0, I13.2, I70, I71, I72, I73, I74, I77, I78, I79, E09.5, E10.51, E10.52, E11.51, E11.52, E13.51, E13.52, E14.51, E14.52, G45-45.9, G46-G46.8, I60-I62, I63-I64, Z95.2, Z95.3, Z95.4
11	Hypertension	I10, I11, I12, I13, I15
12	Hyperlipidaemia	E78
13	Diabetes	E09, E10, E11, E13, E14, Z92.22
14	Current/ex-smoker	F17, Z72.0, Z86.43
15	Cardiac risk factors (defined as morbidities item nos. 11-14)	I10, I11, I12, I13, I15, E78, E09, E10, E11, E13, E14, Z92.22, Z72.0, F17, Z86.43
16	Systemic connective tissue disease	M30, M31, M32, M33, M34, M35, M36
17	Chronic pulmonary disease (include asthma, chronic airways limitation, interstitial lung disease, cystic fibrosis with pulmonary manifestation)	E84.0, J40, J41, J42, J43, J44, J45, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67, J68, J70, J82, J84, J99
18	Malignancy	C00-C96, D00-D09
19	Chronic kidney disease	N18, N19
20	Dementia	F00, F01, F02, F03
21	Neurodegenerative diseases (defined as dementia, central nervous systemic atrophies, Parkinson's disease, basal ganglia degeneration and/or nervous systemic degenerative diseases)	F00, F01, F02, F03, G10-G14, G20, G23, G30, G31
22	Peptic ulcer disease	K25, K26, K27, K28
23	Liver disease – mild	K70.0, K70.1, K70.2, K70.9, K71.0, K71.1, K71.2, K71.3, K71.4, K71.5, K71.6, K71.8, K71.9, K73, K75, K76, K77
24	Liver disease – moderate-severe	I82.0, K70.3, K70.4, K71.7, K72, K74
25	Chronic kidney disease – moderate-severe	N18.3, N18.4, N18.5
26	Diabetes with organ damage	E09.21, E09.29, E09.31, E09.32, E09.40, E09.42, E09.51, E09.52, E09.71, E09.72, E09.8, E10.21, E10.22, E10.29, E10.31, E10.32, E10.33, E10.34, E10.35, E10.36, E10.39, E10.40, E10.41, E10.42, E10.43, E10.49, E10.51, E10.52, E10.53, E10.61, E10.62, E10.63, E10.69, E10.71, E10.73, E10.8,

		E11.21, E11.22, E11.29, E11.31, E11.32, E11.33, E11.34, E11.35, E11.36, E11.39, E11.40, E11.41, E11.42, E11.43, E11.49, E11.51, E11.52, E11.53, E11.61, E11.62, E11.63, E11.69, E11.71, E11.72, E11.73, E11.8, E13.21, E13.22, E13.29, E13.31, E13.32, E13.33, E13.34, E13.35, E13.36, E13.39, E13.40, E13.41, E13.42, E13.43, E13.49, E13.51, E13.52, E13.53, E13.61, E13.62, E13.63, E13.69, E13.71, E13.72, E13.73, E13.8, E14.21, E14.22, E14.29, E14.31, E14.32, E14.33, E14.34, E14.35, E14.36, E14.39, E14.40, E14.41, E14.42, E14.43, E14.49, E14.51, E14.52, E14.53, E14.61, E14.62, E14.63, E14.69, E14.71, E14.72, E14.73, E14.8
27	Lymphoma	C81, C82, C83, C84, C85, C86, C88
28	Leukemia	C90, C91, C92, C93, C94, C95, C96
29	Metastatic solid tumour	C76, C77, C78, C79, C80
30	Hemiplegia	G81, G82
31	Acquired Immune Deficiency Syndrome (AIDS)	B20, B21, B22, B23, B24
32	Any tumor/malignancy excluding lymphoma and/or leukemia	C00-C80, D00-D09
33	Primary pulmonary hypertension	I27.0
34	Secondary pulmonary hypertension	I27.2
35	Intravenous drug use (IVDU) history	F11, F11.0, F11.1, F11.2, F11.3, F11.4, F11.5, F11.6, F11.7, F11.8, F11.9, F15.0, F15.00, F15.01, F15.02, F15.09, F15.1, F15.10, F15.11, F15.12, F15.19, F15.2, F15.20, F15.21, F15.22, F15.29, F15.3, F15.30, F15.31, F15.32, F15.39, F15.4, F15.40, F15.41, F15.42, F15.49, F15.5, F15.50, F15.51, F15.52, F15.59, F15.6, F15.60, F15.61, F15.62, F15.69, F15.7, F15.70, F15.71, F15.72, F15.79, F15.8, F15.80, F15.81, F15.82, F15.89, F15.9, F15.90, F15.91, F15.92, F15.99, T40.0, T40.1, T40.2, T40.3, T40.4, T40.6, T43.61
36	Rheumatic disease involving the tricuspid valve	I07, I07.0, I07.1, I07.2, I07.8, I07.9, I08.1, I08.2, I08.3

* To calculate the Charlson Comorbidity Index (CCI) score, without age adjustment, for individual patient during a particular admission of interest, use the following morbidity item numbers with their corresponding ICD-10AM codes to derive the patient's CCI score:

- 1 score for each morbidity item – 3, 6, 7, 8, 13, 16, 17, 20, 22, 23
- 2 score for each morbidity item – 25, 26, 27, 28, 30, 32
- 3 score for morbidity item – 24
- 6 score for morbidity item – 29, 31

No.	ACHI procedures	ACHI procedural codes
1	Coronary angiography (cardiac catheterization with or without angioplasty or stenting)	38200-00, 38203-00, 38206-00, 38215-00, 38218-00, 38218-01, 38218-02, 38300-00, 38303-00, 38306-00, 38306-01, 38306-02
2	Transoesophageal echocardiogram	55118-00
3	CABG (Coronary artery bypass graft)	38456-19, 38497-00, 38497-01, 38497-02, 38497-03, 38497-04, 39497-05, 38497-06, 38497-07, 38500-00, 38500-01, 38500-02, 38500-03, 38500-04, 38500-05, 38503-00,

		38503-01, 38503-02, 38503-03, 38503-04, 38503-05, 38637-00, 38653-08, 90201-00, 90201-01, 90201-02, 90201-03
4	Lone tricuspid valve surgery (Only single valve surgery in single admission) (exclude percutaneous approach)	38456-11, 38456-17, 38475-01, 38477-01, 38480-02, 38481-02, 38488-04, 38488-05, 38489-03, 38653-06
5	Combined aortic, mitral, tricuspid and pulmonary valves surgery (All four valves surgery in single admission) (exclude percutaneous approach)	38456-01, 38456-10, 38456-11, 38456-15, 38456-16, 38456-17, 38456-18, 38475-00, 38475-01, 38475-02, 38477-00, 38477-01, 38477-02, 38480-00, 38480-01, 38480-02, 38481-00, 38481-01, 38481-02, 38483-00, 38485-00, 38485-01, 38487-00, 38488-00, 38488-01, 38488-02, 38488-03, 38488-04, 38488-05, 38488-06, 38488-07, 38489-00, 38489-01, 38489-02, 38489-03, 38489-04, 38489-05, 38653-04, 38653-05, 38653-06, 38653-07
6	Combined aortic, mitral and tricuspid valves only surgery (All three valves surgery in single admission) (exclude percutaneous approach)	38456-10, 38456-11, 38456-15, 38456-16, 38456-17, 38475-00, 38475-01, 38475-02, 38477-00, 38477-01, 38477-02, 38480-00, 38480-01, 38480-02, 38481-00, 38481-01, 38481-02, 38483-00, 38485-00, 38485-01, 38487-00, 38488-00, 38488-01, 38488-02, 38488-03, 38488-04, 38488-05, 38489-00, 38489-01, 38489-02, 38489-03, 38653-04, 38653-05, 38653-06
7	Combined aortic, tricuspid and pulmonary valves only surgery (All three valves surgery in single admission) (exclude percutaneous approach)	38456-01, 38456-10, 38456-11, 38456-15, 38456-17, 38456-18, 38475-01, 38475-02, 38477-01, 38477-02, 38480-00, 38480-02, 38481-00, 38481-02, 38483-00, 38488-00, 38488-01, 38488-04, 38488-05, 38488-06, 38488-07, 38489-00, 38489-01, 38489-03, 38489-04, 38489-05, 38653-04, 38653-06, 38653-07
8	Combined mitral, tricuspid and pulmonary valves only surgery (All three valves surgery in single admission) (exclude percutaneous approach)	38456-01, 38456-11, 38456-16, 38456-17, 38456-18, 38475-00, 38475-01, 38477-00, 38477-01, 38480-01, 38480-02, 38481-01, 38481-02, 38485-00, 38485-01, 38487-00, 38488-02, 38488-03, 38488-04, 38488-05, 38488-06, 38488-07, 38489-02, 38489-03, 38489-04, 38489-05, 38653-05, 38653-06, 38653-07
9	Combined aortic and tricuspid valves only surgery (All two valves surgery in single admission) (exclude percutaneous approach)	38456-10, 38456-11, 38456-15, 38456-17, 38475-01, 38475-02, 38477-01, 38477-02, 38480-00, 38480-02, 38481-00, 38481-02, 38483-00, 38488-00, 38488-01, 38488-04, 38488-05, 38489-00, 38489-01, 38489-03, 38653-04, 38653-06
10	Combined mitral and tricuspid valves only surgery (All two valves surgery in single admission) (exclude percutaneous approach)	38456-11, 38456-16, 38456-17, 38475-00, 38475-01, 38477-00, 38477-01, 38480-01, 38480-02, 38481-01, 38481-02, 38485-00, 38485-01, 38487-00, 38488-02, 38488-03, 38488-04, 38488-05, 38489-02, 38489-03, 38653-05, 38653-06

11	Combined tricuspid and pulmonary valves only surgery (All two valves surgery in single admission) (exclude percutaneous approach)	38456-01, 38456-11, 38456-17, 38456-18, 38475-01, 38477-01, 38480-02, 38481-02, 38488-04, 38488-05, 38488-06, 38488-07, 38489-03, 38489-04, 38489-05, 38653-06, 38653-07
12	Tricuspid valve surgery sub-category: • Tricuspid valve open valvotomy	38456-11
13	Tricuspid valve surgery sub-category: • Tricuspid valve repair	38480-02, 38481-02
14	Tricuspid valve surgery sub-category: • Tricuspid valve annuloplasty	38475-01, 38477-01
15	Tricuspid valve surgery sub-category: • Tricuspid valve replacement (exclude percutaneous approach)	38488-04, 38488-05, 38489-03
16	Tricuspid valve surgery sub-category: • Other intrathoracic procedures on tricuspid valve	38456-17, 38653-06

Supplementary Table 2. Univariable associations with all-cause mortality during study period

Univariable analysis	Parameters	HR (95% CI)	P value
All-cause death during study follow-up (4.82 ± 3.94 years)	Age ≥59 years *	2.16 (1.60-2.89)	<0.001
	Male	1.02 (0.78-1.34)	0.87
	Referral source	-	0.27
	Emergency Department	1.00 (reference)	-
	Physician-referred	0.70 (0.48-1.02)	0.06
	External hospital-referred	0.84 (0.54-1.32)	0.45
	Others	1.33 (0.41-4.34)	0.63
	Unknown	0.52 (0.12-2.16)	0.37
	Indication for valve surgery †	-	-
	Endocarditis	0.57 (0.33-0.96)	0.03
	Rheumatic tricuspid valve	1.32 (0.98-1.77)	0.07
	Types of TV surgery ‡		
	Annuloplasty	0.92 (0.70-1.21)	0.56
	Replacement	1.35 (1.03-1.77)	0.03
	Repair	0.50 (0.32-0.79)	0.003
	Open valvotomy	0.39 (0.06-2.80)	0.35
	Others	0.57 (0.24-1.39)	0.22
	Concomitant CABG §	1.63 (1.16-2.29)	0.005
	Ischemic heart disease	1.55 (1.14-2.12)	0.006
	Prior PCI / CABG	1.30 (0.77-2.20)	0.33
	Congestive cardiac failure	1.94 (1.48-2.54)	<0.001
	Stroke	2.79 (1.23-6.31)	0.01
	Peripheral vascular disease	1.67 (0.95-2.93)	0.07
	Prosthetic heart valve	1.11 (0.74-1.65)	0.61
	Atrial fibrillation/flutter	1.28 (0.98-1.69)	0.07
	Hypertension	1.15 (0.86-1.55)	0.35
	Hyperlipidaemia	1.29 (0.68-2.44)	0.43
	Diabetes	1.54 (1.08-2.19)	0.02
	Current/ex-smoker	0.96 (0.73-1.28)	0.80
	Primary PHT	1.03 (0.43-2.51)	0.94
	Secondary PHT	2.05 (1.45-2.88)	<0.001
	Malignancy	3.54 (1.81-6.91)	<0.001
	Chronic pulmonary disease	2.62 (1.64-4.18)	<0.001
	Neurodegenerative disease ¶	1.73 (0.43-6.97)	0.44
	Chronic kidney disease	1.78 (1.24-2.57)	0.002
	IVDU history	0.64 (0.39-1.07)	0.09
	CCI score – per 1-score #	1.25 (1.18-1.33)	<0.001
	CCI score ≥1	2.39 (1.79-3.20)	<0.001
	Year of surgery	-	0.87
	2002-2005	1.00 (reference)	-
	2006-2009	0.86 (0.56-1.31)	0.48
2010-2013	0.90 (0.59-1.38)	0.63	
2014-2018	0.82 (0.51-1.35)	0.44	

Plus-minus value represents mean \pm standard deviation (SD).

CABG, coronary artery bypass graft; CCI, Charlson comorbidity index; CI, confidence interval; HR, hazards ratio; IVDU, intravenous drug use; NA, not applicable due to small sample size; PCI, percutaneous coronary interventions; PHT, pulmonary hypertension; TV, tricuspid valve.

* Age was dichotomized based on mean age of study cohort.

† Indication for cardiac valve surgery was either for endocarditis or for non-endocarditis cardiac valvular pathology.

‡ More than one type of TV surgery might be performed on a patient during the same admission.

§ Concomitant CABG performed during same admission for cardiac valve surgery.

|| Neurodegenerative disease includes dementia, central nervous systemic atrophies, Parkinson's disease, basal ganglia degeneration, and/or nervous systemic degenerative diseases.

Conditions included in the Charlson Comorbidity Index include myocardial infarction, congestive cardiac failure, peripheral vascular disease, stroke, dementia, chronic pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease (mild vs. moderate to severe), diabetes (with or without organ damage), hemiplegia, moderate to severe renal disease, any tumour (within last 5 years), lymphoma, leukemia, metastatic solid tumour and acquired immunodeficiency syndrome.

Supplementary Table 3. Independent predictors for all-cause mortality during study period

Multivariable analysis *	Parameters	aHR (95% CI)	P value
All-cause death during study follow-up (4.82 ± 3.94 years)	Age ≥59 years (mean age)	1.76 (1.26-2.47)	0.001
	Male	1.01 (0.76-1.34)	0.96
	Indication for valve surgery †		
	Endocarditis	1.00 (0.56-1.77)	0.99
	Types of TV surgery ‡		
	Replacement	1.32 (0.98-1.79)	0.07
	Repair	0.78 (0.047-1.28)	0.33
	Concomitant CABG §	1.34 (0.86-2.08)	0.20
	Ischemic heart disease	1.14 (0.77-1.70)	0.51
	Congestive cardiac failure	1.78 (1.33-2.38)	<0.001
	Stroke	2.25 (0.96-5.26)	0.06
	Diabetes	1.12 (0.77-1.65)	0.55
	Secondary PHT	1.36 (0.95-1.95)	0.10
	Malignancy	3.49 (1.73-7.07)	<0.001
	Chronic pulmonary disease	2.21 (1.36-3.59)	<0.001
Chronic kidney disease	1.26 (0.85-1.87)	0.25	

Plus-minus value represents mean ± standard deviation (SD).

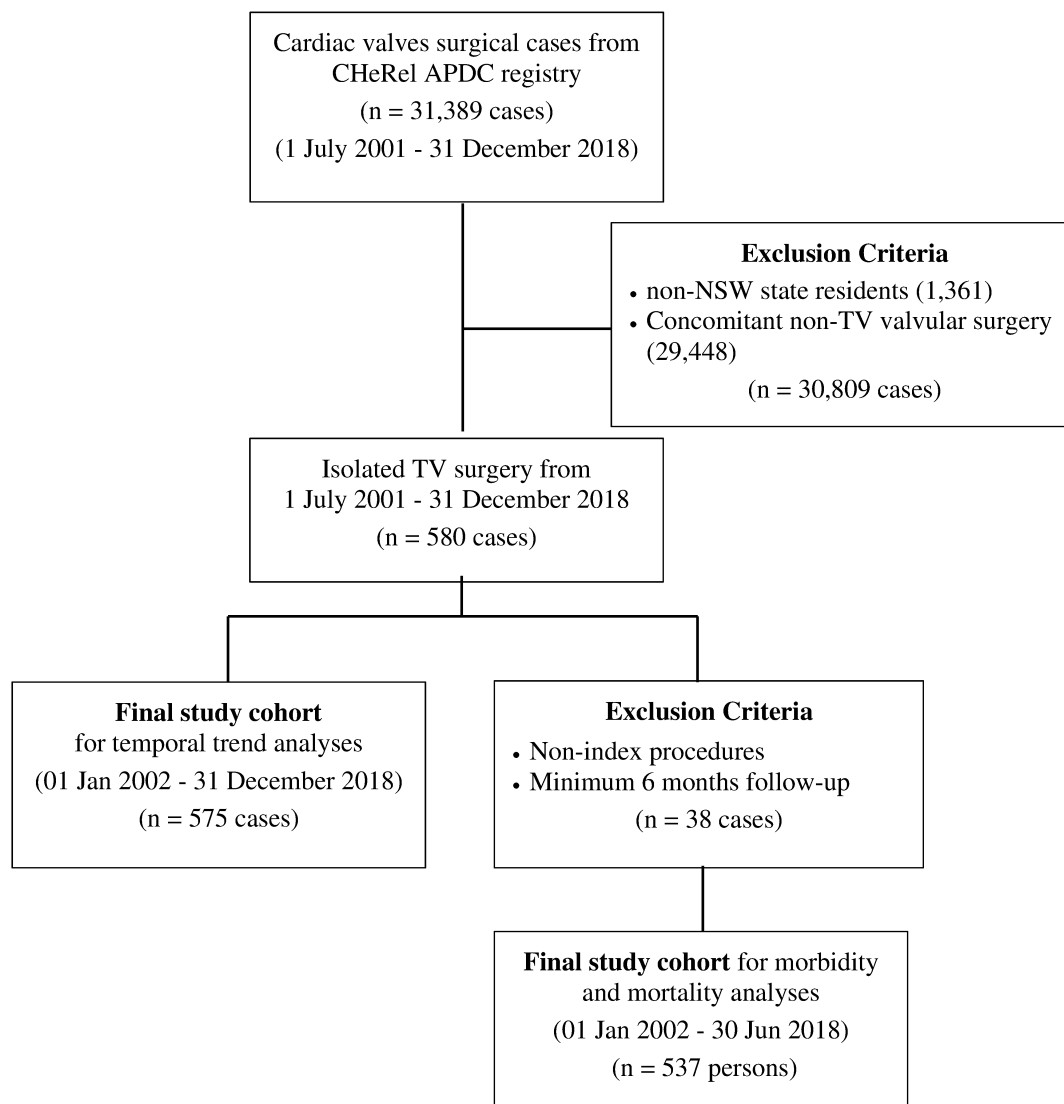
CABG, coronary artery bypass graft; CI, confidence interval; aHR, adjusted hazards ratio; PCI, percutaneous coronary interventions; PHT, pulmonary hypertension; TV, tricuspid valve.

* Multivariable Cox regression method was used to identify independent predictors of all-cause mortality. Only univariables with P<0.05 were included in the multivariable analysis (see Supplementary Table 2 for univariable analysis results).

† Indication for cardiac valve surgery was either for endocarditis or non-endocarditis cardiac valvular pathology

‡ More than one type of TV surgery might be performed on a patient during the same admission.

§ Concomitant CABG performed during same admission for cardiac valve surgery.

Supplementary Figure 1. Study flow chart.**Legend**

Flow chart shows the derivation of the study cohort.

APDC, Admitted Patient Data Collection; CHeRel, Centre for Health Record Linkage; NSW, New South Wales.

* Dataset containing all statewide admitted patients who underwent a broad range of cardiac procedures including coronary angiography, percutaneous coronary intervention, electrophysiology procedures and transesophageal echocardiography.

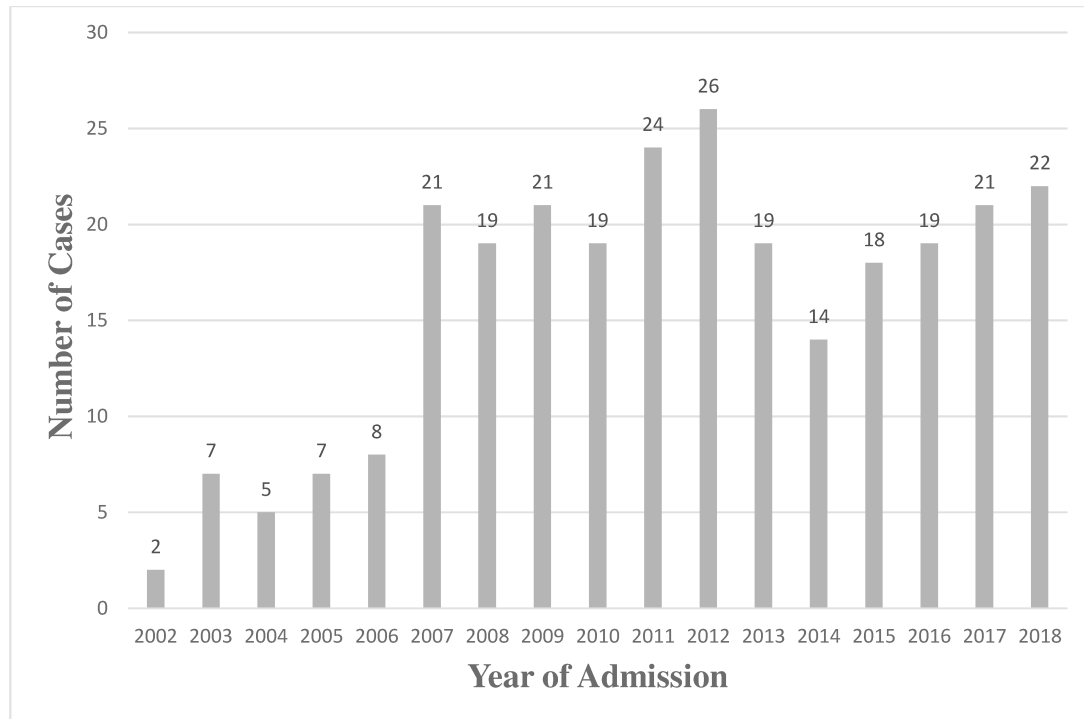
Supplementary Figure 2. Temporal trend of tricuspid valve annuloplasty during study period.**Legend**

Figure shows temporal trend of tricuspid valve annuloplasty during study period (n=272), with a mean (\pm SD) of 16.0 ± 7.3 cases per annum. Tricuspid valve annuloplasty caseload increased significantly over the course of the study period by an average of 0.46 cases per year (95% CI 0.21-0.72, $p=0.002$).

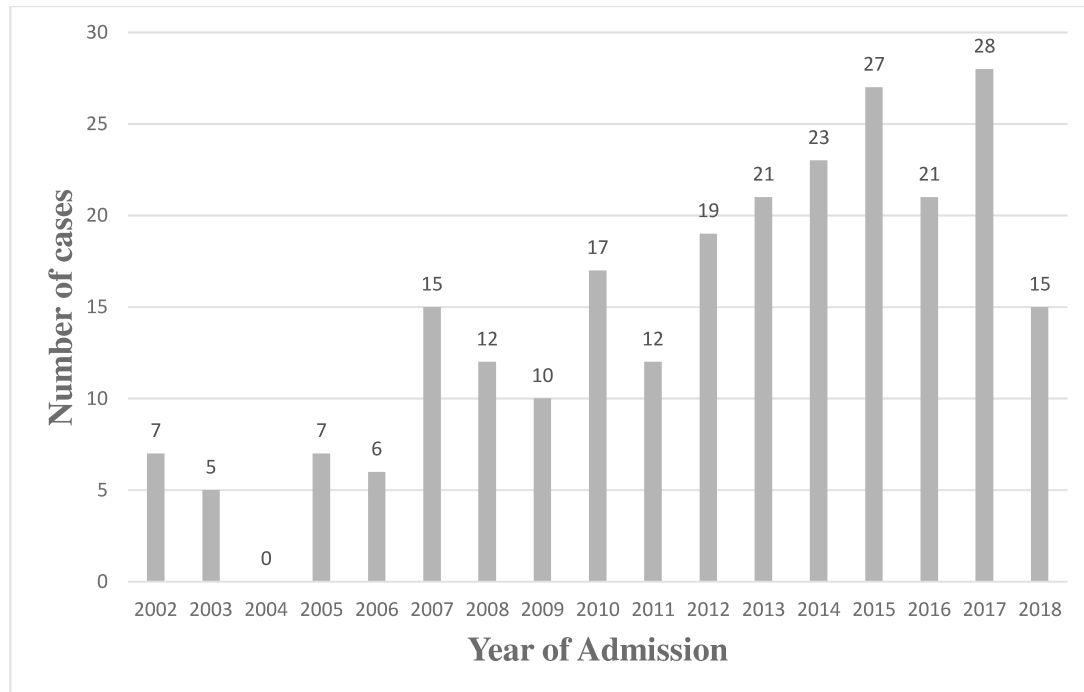
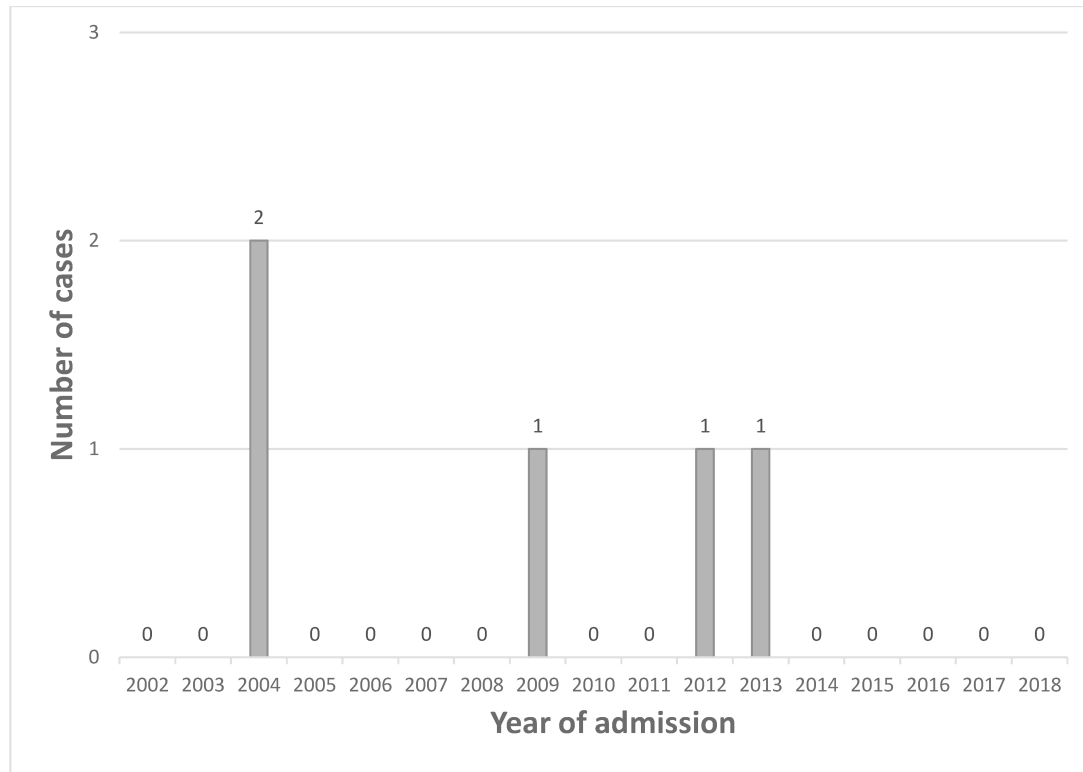
Supplementary Figure 3. Temporal trend of tricuspid valve replacement during study period.**Legend**

Figure shows temporal trend of tricuspid valve replacement during study period (n=245), with a mean (\pm SD) of 14.4 ± 8.1 cases per annum. Tricuspid valve replacement caseload increased significantly over the study period by an average of 0.53 cases per year (95% CI 0.40-0.65, $p < 0.001$).

Supplementary Figure 4. Temporal trend of open tricuspid valvotomy during study period.



Legend

Figure shows temporal trend of open tricuspid valvotomy during study period (n=5), with a mean (\pm SD) of 0.3 ± 0.6 cases per annum. There was no significant change in annual caseload valvotomies over the course of the study period ($p=0.64$).

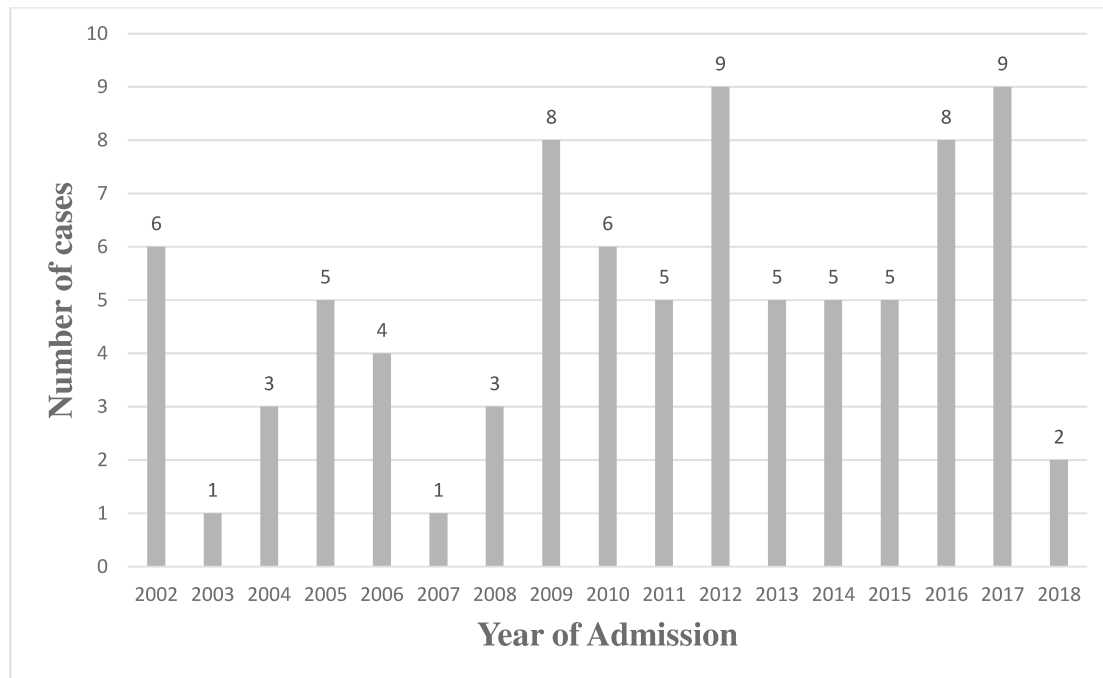
Supplementary Figure 5. Temporal trend of tricuspid valve repair during study period.**Legend**

Figure shows temporal trend of tricuspid valve repair during study period (n=85), with a mean (\pm SD) of 5.0 ± 2.5 cases per annum. Tricuspid valve repairs increased significantly over the study period by an average of 1.13 cases per year (95% CI 0.24-2.02, $p=0.02$).