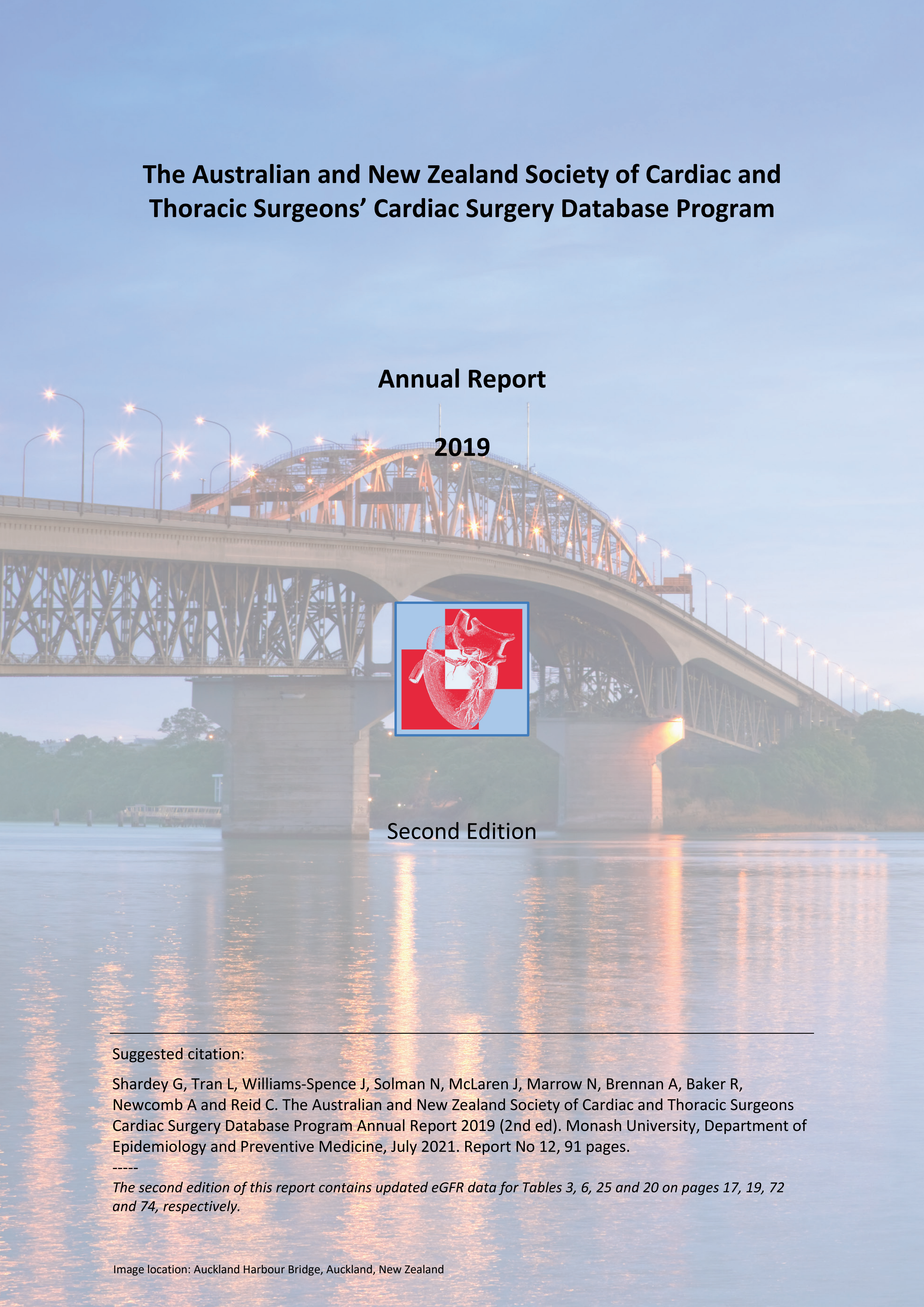
ANZSCTS Cardiac Surgery Database Program

Annual Report

2019

Second Edition



The Australian and New Zealand Society of Cardiac and Thoracic Surgeons' Cardiac Surgery Database Program

Annual Report

2019

Second Edition

Suggested citation:

Shardey G, Tran L, Williams-Spence J, Solman N, McLaren J, Marrow N, Brennan A, Baker R, Newcomb A and Reid C. The Australian and New Zealand Society of Cardiac and Thoracic Surgeons Cardiac Surgery Database Program Annual Report 2019 (2nd ed). Monash University, Department of Epidemiology and Preventive Medicine, July 2021. Report No 12, 91 pages.

The second edition of this report contains updated eGFR data for Tables 3, 6, 25 and 20 on pages 17, 19, 72 and 74, respectively.

Image location: Auckland Harbour Bridge, Auckland, New Zealand

Table of Contents

List of Figures

List of Tables

Abbreviations

AoV	Aortic valve
AVR	Aortic valve replacement
BITA	Bilateral internal thoracic artery
BMI	Body mass index
BSA	Body surface area
CABG	Coronary artery bypass graft
CCS	Canadian Cardiovascular Society
CL	Control limit
CO	Cardiac output
CPB	Cardiopulmonary bypass
DNRI	Derived new renal insufficiency
DSWI	Deep sternal wound infection
eGFR	Estimated glomerular filtration rate
GEPA	Gastroepiploic artery
GM	Geometric mean
ICU	Intensive care unit
KPIs	Key performance indicators
LITA	Left internal thoracic artery
LVD	Left ventricular dysfunction
LVEF	Left ventricular ejection fraction
LVF	Left ventricular function
MI	Myocardial infarction
MV	Mitral valve
MVR	Mitral valve replacement
NCA	New cardiac arrhythmia
NICOR	National Institute for Cardiovascular Outcomes Research
NRBC	Non-red blood cell
NSTEMI	Non-ST elevation myocardial infarction
NYHA	New York Heart Association
OM	Observed mortality
PLOS	Procedural length of stay
RA	Radial artery
RAMR	Risk-adjusted mortality rate
RBC	Red blood cell
RITA	Right internal thoracic artery
STEMI	ST-elevation myocardial infarction
STS	Society of Thoracic Surgeons
SV	Saphenous vein
SVR	Systemic vascular resistance
SWEDEHEART	Swedish Web-system for Enhancement and Development of Evidence-based Care in Heart Disease Evaluated According to Recommended Therapies
Tri/Pulm	Tricuspid or pulmonary
TAVR	Transcatheter aortic valve replacement
TMVR	Transcatheter mitral valve replacement

Acknowledgements

The Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZSCTS) Cardiac Surgery Database is funded by: the Department of Health and Human Services, Victoria; the Clinical Excellence Commission, New South Wales; Queensland Health, Queensland; and through participation fees from contributing private and public units.

The ANZSCTS Cardiac Surgery Database Steering Committee reviews the statistical data, oversees the management of outliers, reviews data definitions and guides the management of the Database. The ANZSCTS Cardiac Surgery Database Research Committee evaluates applications for research involving the Database and ensures the probity and quality of ensuing publications. The ANZSCTS Cardiac Surgery Database Data Custodian – Professor Chris Reid, and the Chairman of the Steering Committee and Clinical Lead – Mr Gil Shardey, guide and oversee the entire Program.

The data and project management staff at the Centre for Cardiovascular Education in Therapeutics at Monash University (Dr Jenni Williams-Spence, Dr Lavinia Tran, Mr Noah Solman, Ms Jenna McLaren, Mrs Nicole Marrow, Mr Mark Lucas, and Ms Jill Edmonds) are responsible for the critical tasks required for the day-to-day operation of the Database including cleaning the submitted data, and running analyses that help inform the Committees. Without their contributions, the Committees would be unable to function.

During 2019, Professor Chris Reid was supported by a National Health and Medical Research Council Fellowship that enabled him to contribute to initiatives such as the ANZSCTS Database.

The work of the ANZSCTS Database relies on the continuing interest and efforts of surgeons, data managers, and other relevant hospital staff who contribute data.

Photograph by Mark Lucas 2018 ©

Foreword

For the past twelve years, the ANZSCTS Cardiac Surgery Database Program has published an Annual Report. There were 41 units enrolled in the Program in 2019. Regrettably, two were unable to submit the proportion of cases required for analysis and inclusion, so that this report describes the data from surgery performed in 39 public and private hospital cardiac surgical units.

Data presented in this report provide unit comparisons for surgery performed in the 2019 calendar year. 30-day follow-up dictates that surgical outcomes are collected to the end of January 2020. Information is also presented as pooled (four or five year) and annual (five years) data.

Units are de-identified by random coding. The report demonstrates unit performance compared to other contributing units, and the group average.

The Program has an important quality assurance function. Therefore, unit outcomes are compared against a set of performance indicators. Heads of units are notified of outlying status in accordance with the ANZSCTS Database's outlier management procedure (Appendix A, pg. 82).

Overall, in the five-year period, although there is variation in practice, most participating cardiac surgical units had satisfactory outcomes for key performance indicators (mortality and complications).

In Section 2, this year's theme documents some cogent differences between the clinical characteristics and outcomes of males and females having cardiac surgery.

The Society's purpose is to ensure that high standards are maintained in all units performing cardiac surgery in Australia and New Zealand and where necessary, assist units to achieve that standard.

Mr Gil Shardey

Chairman
ANZSCTS Database Program
Steering Committee

Key Messages

- This annual report includes data on 69,003 operations performed between 2015 and 2019 in 39 public and private units in Australia and New Zealand.
- Isolated CABG was still the most commonly performed surgery in 2019 (49.2%), however the proportion of 'other' surgery categories continued to increase.
- Of the 7,641 isolated CABG operations in 2019, the proportion of reported 'urgent' cases ranged from 0 to 67.4% of the unit's caseload. Over the past five years, approximately 60% of all cases were reported as elective.
- A larger proportion of female than male patients having isolated CABG surgery were aged 70 years and over, accounting for 49.3% of the female caseload in 2019, an increase from previous years.
- Approximately 80% of patients had normal LVF or mild LVD, with little change over the past five years. On average 14.9% of patients had moderate and 3.77% had severe LVD.
- The overall proportion of redo operations for isolated CABG decreased from 2.07% in 2015 to 1.16% in 2019, however is still twice that reported by the SWEDEHEART registry.
- Isolated CABG patients with pre-operative eGFR ≤60 mL/min/1.73m^2 had a three-fold increase in the incidence of DNRI.
- The OM rates for isolated CABG and isolated AVR were widely comparable to those reported by the New Zealand, SWEDEHEART and STS registries.
- Of the 3,047 isolated valve operations reported to the Database in 2019, 85.4% were elective and 57.8% were single aortic operations.
- The proportion of male patients presenting for isolated valve surgery decreased in 2019 by approximately 5%.
- Patients having combined valve and CABG surgery tend to be older than those having isolated CABG: 64.9% of males and 70.9% of females aged 70 years or older compared to only 38.0% and 46.4% having isolated CABG, respectively.
- There was clear inter-unit variation between the post-operative outcomes for the major surgery groups.
- Resource utilisation, including duration of ICU stay and ventilation, pre- and post-procedural length of stay, and the rate of blood product use, also varied markedly between units, however values were similar for isolated CABG and isolated valve.
- Females presenting for cardiac surgery had a higher NYHA class and increased urgency based on reported clinical status.
- For isolated CABG, females had more SV only grafts than males.
- Long-term survival for isolated CABG and isolated valve surgery was higher among females over 80 years of age compared to males in the same age group.
- Females had a lower likelihood of MV repair for the same valve pathology.

Introduction

The ANZSCTS Cardiac Surgery Database Program 2019 Annual Report presents data on patient characteristics, operative details and unit outcomes for a range of key performance indicators (KPIs), including post-operative complications and mortality. This year, sex differences in presentation, treatment and outcomes were explored as an additional theme. The report is presented as follows:

- Section 1: Isolated CABG Surgery
- Section 2: Sex Differences in Cardiac Surgery
- Section 3: Isolated Valve Surgery
- Section 4: Combined Valve and CABG Surgery
- Section 5: Other Cardiac Surgery

Key performance indicators

The Database collects and analyses data for a range of clinically relevant surgical outcomes, from which the following KPIs are applied to monitor the performance of units. The KPIs are defined in detail in Appendix B (pg. 83).

- Mortality (risk-adjusted and/or observed)
- Permanent stroke
- Derived new renal insufficiency
- Deep sternal wound infection
- Re-operation for bleeding

Units that fall outside the upper 99.7% control limit for any of these KPIs are managed according to the Database outlier escalation policy (Appendix A, pg. 82).

The additional outcomes that are presented in this report are:

- New cardiac arrhythmia
- Duration of intensive care unit stay
- Duration of ventilation
- Red blood cell transfusions
- Non-red blood cell transfusions
- Pre- and post-procedural length of stay

These metrics may be used by units to compare their performance against all contributing units in Australia and New Zealand.

Contributing units

In 2001, the ANZSCTS with the support of the Victorian Department of Health and Human Services developed a Program to collect and report data on cardiac surgery performed in Victorian hospitals. The Program expanded to National coverage, producing annual reports to inform its participants since 2002 for Victorian units, and since 2007 at a National level. It then expanded to embrace New Zealand in 2019 with the addition of Auckland City Hospital.

The 2019 report delivers a detailed analysis of data, providing an overview of annual trends and outcome measures based on KPIs. The data includes reported cardiac surgery performed in the 2019 calendar year, including 30-day follow-up, from 39 public and private cardiac units. The 2019 data is presented adjacent to pooled data for the preceding four years, and as part of average annual data over five years, to show trends in outcomes. Where the number of cases in the current year is low (Sections 3 and 4), pooled data includes the current year. Details of data preparation and key variable definitions are presented in Appendix C (pg. 85).

The cardiac units listed in Table 1 contributed data to this report. Some units joined the Program more recently, therefore have not provided data over the full five years. Only units that submitted greater than 75% of their expected caseload in 2019 are included in Sections 1, 3, 4 and 5 of the report. Figure 1 displays the density of the cardiac surgery population (by postcode) between 2015 and 2019 based on the units that contributed during that time.

Figure 1. Density of cardiac surgery population

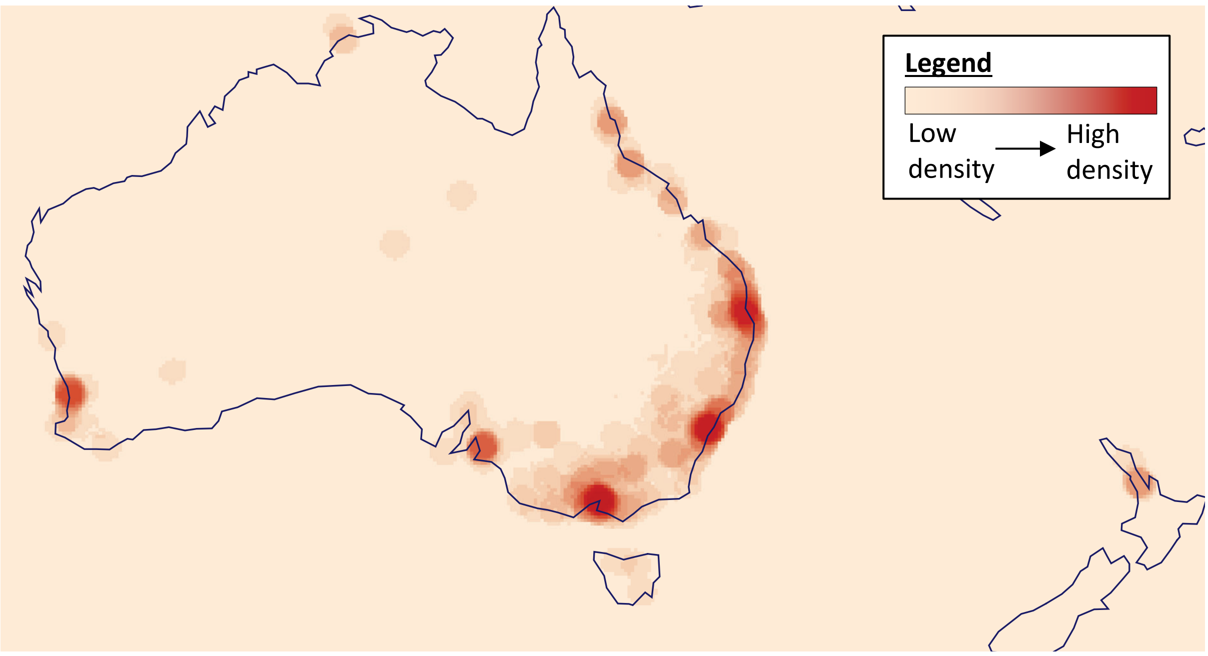


Table 1. Hospital participation

Contributing Hospitals	Hospital Type	2015	2016	2017	2018	2019
VICTORIA						
Alfred Hospital	Public	●	●	●	●	●
Austin Hospital	Public	●	●	●	●	●
Cabrini Private Hospital	Private	●	●	●	●	●
Epworth Eastern	Private	●	●	●	●	●
Epworth Richmond	Private	●	●	●	●	●
University Hospital Geelong	Public	●	●	●	●	●
Jessie McPherson Private Hospital	Private	●	●	●	●	●
Monash Medical Centre	Public	●	●	●	●	●
Peninsula Private Hospital	Private	●	●	●	●	●
Royal Melbourne Hospital	Public	●	●	●	●	●
St Vincent's Hospital (Melbourne)	Public	●	●	●	●	●
Warringal Private Hospital	Private			○	●	●
NEW SOUTH WALES						
John Hunter Hospital	Public	●	●	●	●	●
Lake Macquarie Private Hospital	Private	●	●	●	●	●
Liverpool Hospital	Public	●	●	●	●	●
North Shore Private Hospital	Private			○	†	†
Prince of Wales Hospital	Public	●	●	●	●	●
Royal Prince Alfred Hospital	Public	●	●	●	●	●
Royal North Shore Hospital	Public	●	†	†	●	●
St George Hospital	Public	●	●	●	●	●
St George Private Hospital	Private			○	●	●
Strathfield Private Hospital	Private			○	†	†
St Vincent's Hospital (Sydney)	Public	●	●	●	●	●
Westmead Hospital	Public	●	●	●	●	●
Westmead Private Hospital	Private			○	●	●
AUSTRALIAN CAPITAL TERRITORY						
Canberra Hospital	Public	●	●	●	●	●
QUEENSLAND						
Gold Coast University Hospital	Public	●	●	●	●	●
Greenslopes Private Hospital	Private			○	●	●
St Vincent's Private Hospital Northside	Private	●	●	●	●	●
John Flynn Private Hospital	Private			○	●	●
Mater Hospital	Private	●	●	●	●	●
Prince Charles Hospital	Public	●	●	●	●	●
Princess Alexandra Hospital	Public	●	●	●	●	●
Townsville Hospital	Public	●	●	●	●	●
Sunshine Coast University Private Hospital	Private				●	●
SOUTH AUSTRALIA						
Flinders Hospital	Public	●	●	●	●	●
Royal Adelaide Hospital	Public	●	●	●	●	●
WESTERN AUSTRALIA						
Fiona Stanley Hospital	Public	○	●	●	●	●
Sir Charles Gairdner Hospital	Public	●	●	●	●	●
St John of God Subiaco Hospital	Private	●	●	●	●	●
NEW ZEALAND						
Auckland City Hospital	Public					●

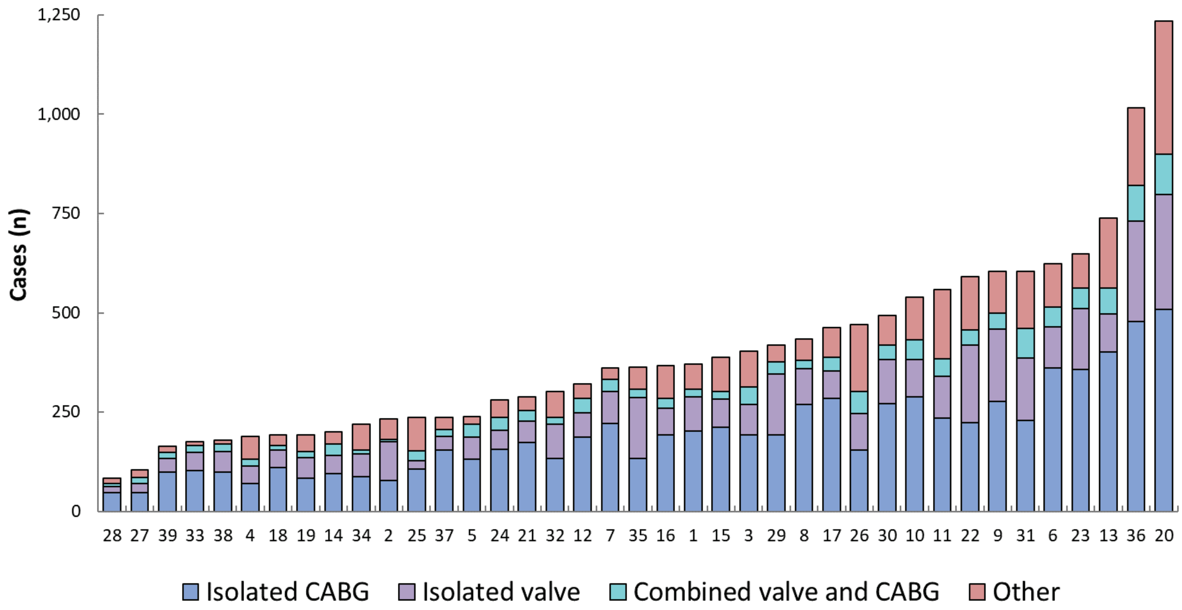
● Hospital engaged and contributing
○ Hospital engaged but contributing <12 months
† Hospital engaged but contributed insufficient data (<75% of expected caseload)

Overview of surgical groups

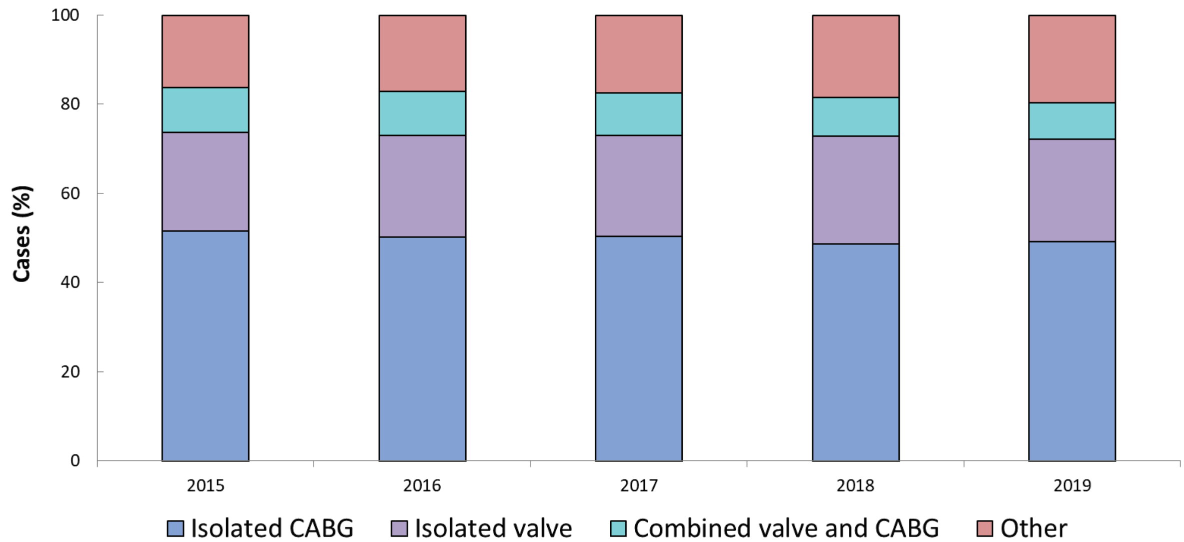
Isolated coronary artery bypass graft (CABG) surgery continued to be the most commonly performed surgery at the majority of units in 2019 (Figure 2a). Overall, isolated CABG surgery accounted for 49.2% of all cardiac surgery in 2019 (Figure 2b). The proportion of combined valve and CABG surgery decreased slightly in 2019, while the proportion of the ‘other’ surgery category continued to increase from 16.3% in 2015 to 19.6% in 2019.

Figure 2. Cardiac surgery groups

a. Units in 2019

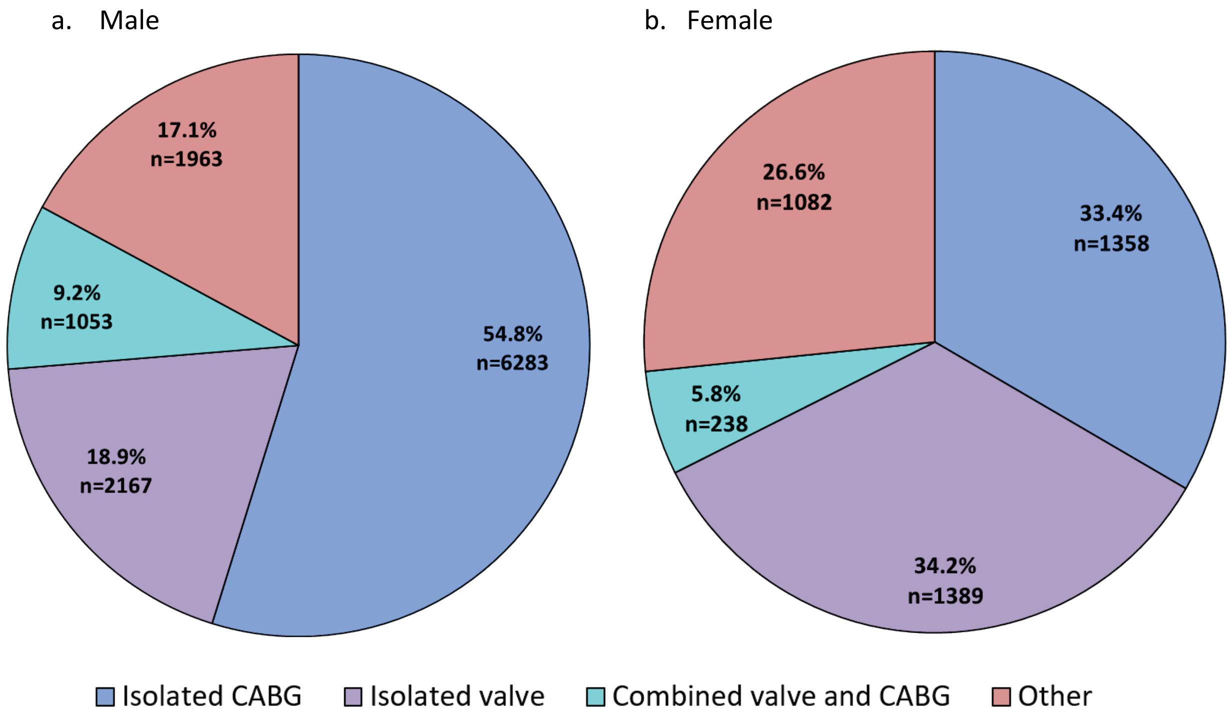


b. Year



There were sex-based differences in the distribution of surgical groups (Figure 3). Overall, approximately one third of females had either isolated valve or CABG surgery (34.2% and 33.4%, respectively) and approximately a quarter had one of the range of 'other' operations (26.6%). Over half of the males had an isolated CABG (54.8%), so that a smaller proportion had either isolated valve, combined valve and CABG or one of the 'other' group of operations. Demographic, surgical and outcome sex differences are further explored in Section 2 of this report.

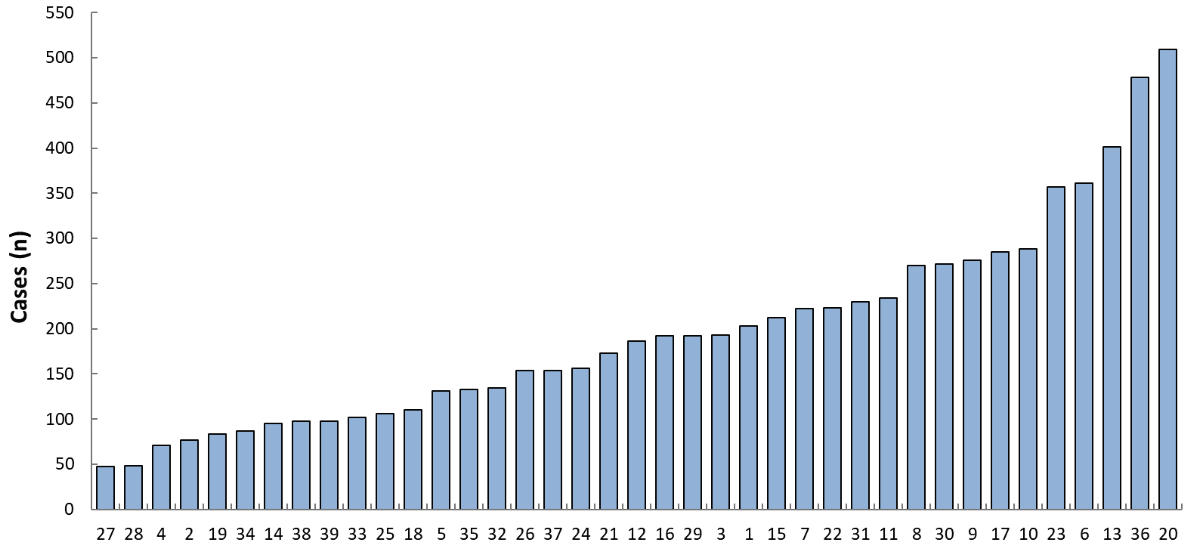
Figure 3. Cardiac surgery groups by sex, 2019



1. Isolated CABG Surgery

Due to hospital size and overall caseload there was a wide range in the number of isolated CABG operations performed in each unit that contributed to the ANZSCTS Database in 2019 (Figure 4). The number of operations ranged from 47 to 509.

Figure 4. Isolated CABG surgery performed by unit, 2019



1.1 Patient characteristics

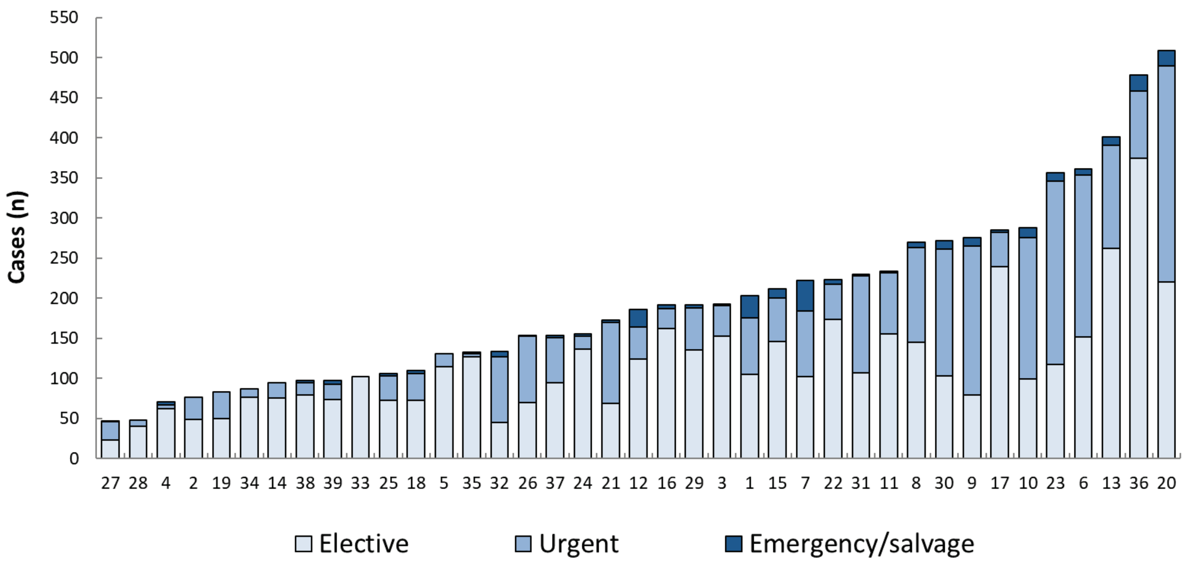
The risk profile of isolated CABG patients has changed significantly over time, in that patients increasingly present later in life and with more comorbidities[1–4]. Key patient characteristics that influence the outcomes of surgery include clinical status, sex, age and comorbidities. The frequency of these factors in the Australian and New Zealand cardiac surgery patient population are explored in the following sections.

1.1.1 Clinical status

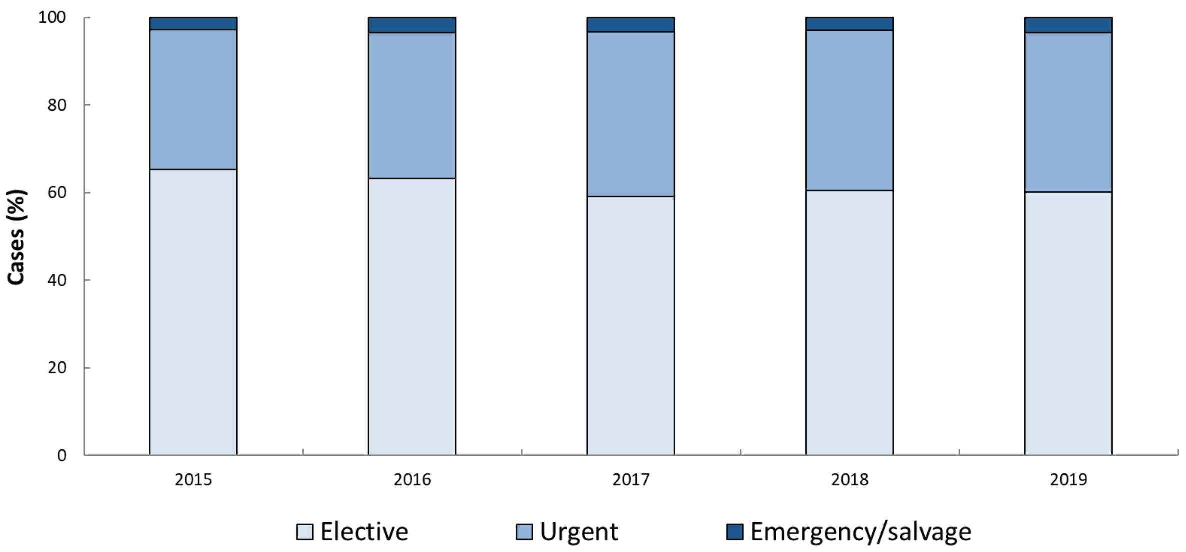
The number of cases reported as elective or urgent varied markedly between units (Figure 5a) with 'urgent' cases ranging from 0 to 67.4% of unit caseload. The proportions for isolated CABG have remained consistent over the last three years with elective surgery accounting for approximately 60% of all cases (Figure 5b). Emergency and salvage cases remain the smallest proportion of patients with an average of 3.2%. It should be noted that clinical status is a reported variable, therefore variation can occur due to the interpretation of the Database's data definitions (Appendix C, pg. 85).

Figure 5. Clinical status of isolated CABG patients

a. Units in 2019



b. Year

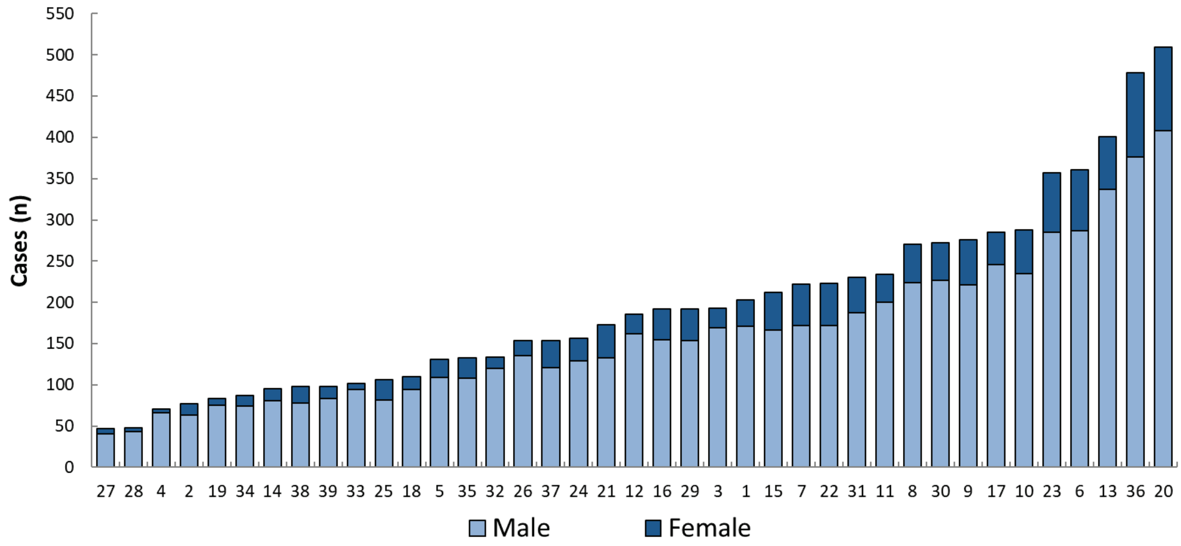


1.1.2 Sex and age

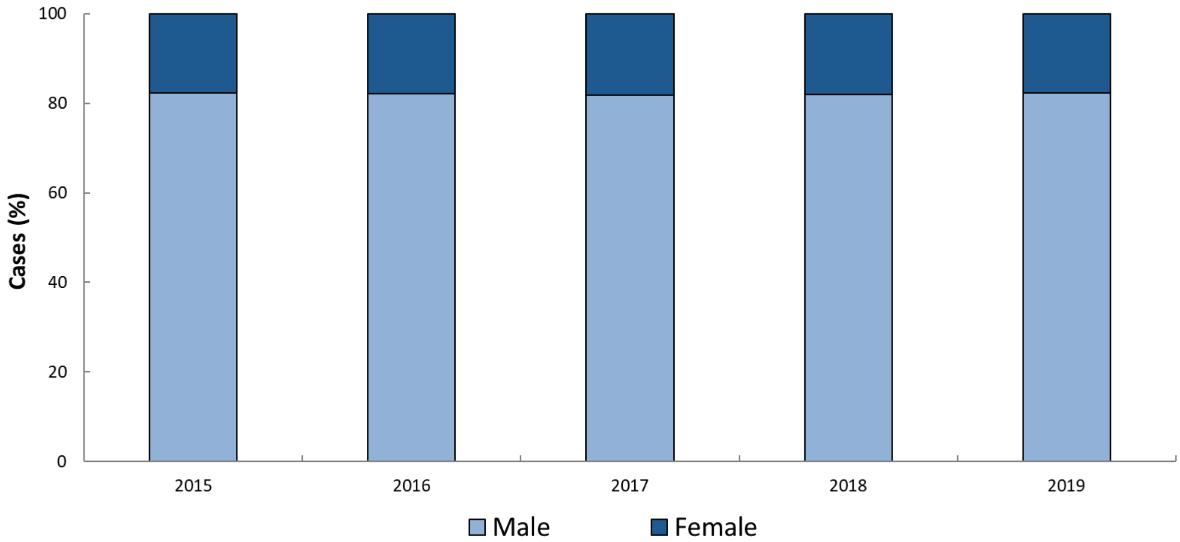
The ratio of male to female isolated CABG patients was similar between units and steady over the last five years, 81.9% of this cohort being male (Figure 6a and b). This ratio is consistent with that reported by the Swedish Web-system for Enhancement and Development of Evidence-based Care in Heart Disease Evaluated According to Recommended Therapies (SWEDEHEART) registry in 2019, and the New Zealand Cardiac Surgery National Report 2017[5-6].

Figure 6. Sex of isolated CABG patients

a. Units in 2019

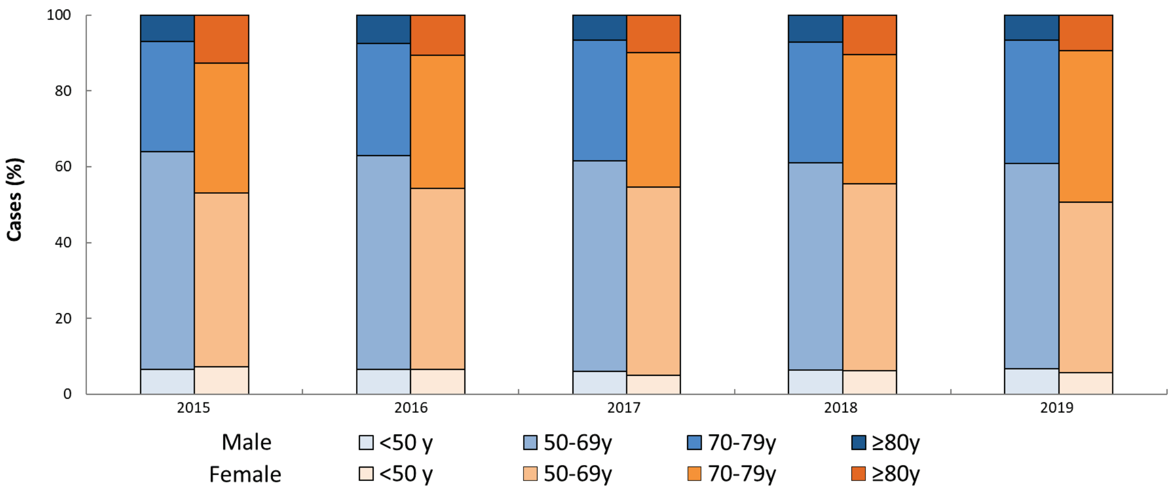


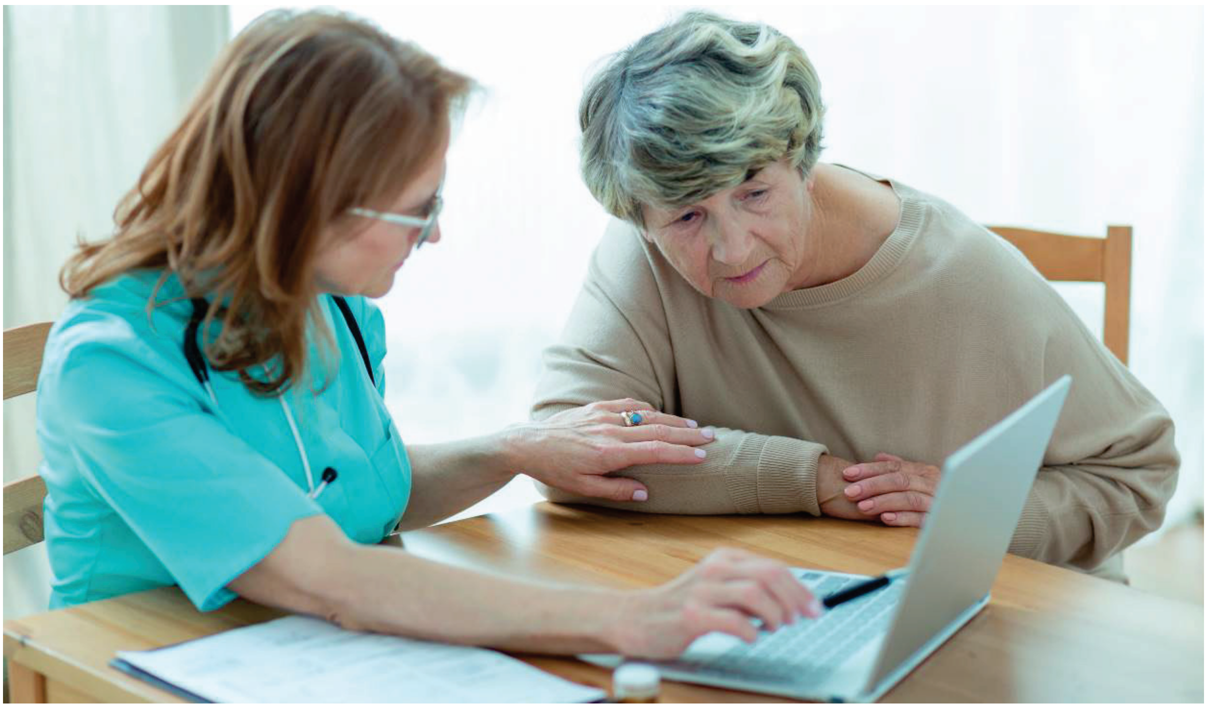
b. Year



As in previous years, the proportions of males and females in each age group undergoing isolated CABG surgery remain fairly consistent (Figure 7). In 2019, a larger proportion of females were aged 70 years and over, accounting for 49.3% of the female caseload. This was a slight increase from previous years. It is well understood that females commonly present later in life, which is consistent with this finding[7].

Figure 7. Age groupings for male and female isolated CABG patients, 2015-2019



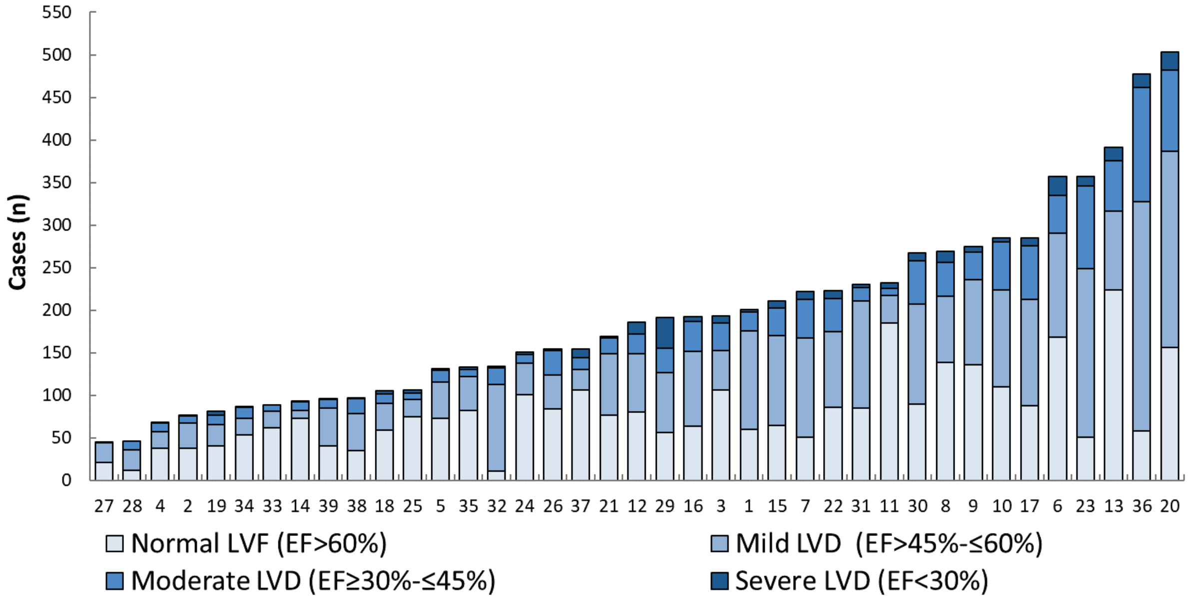


1.1.3 Left ventricular function

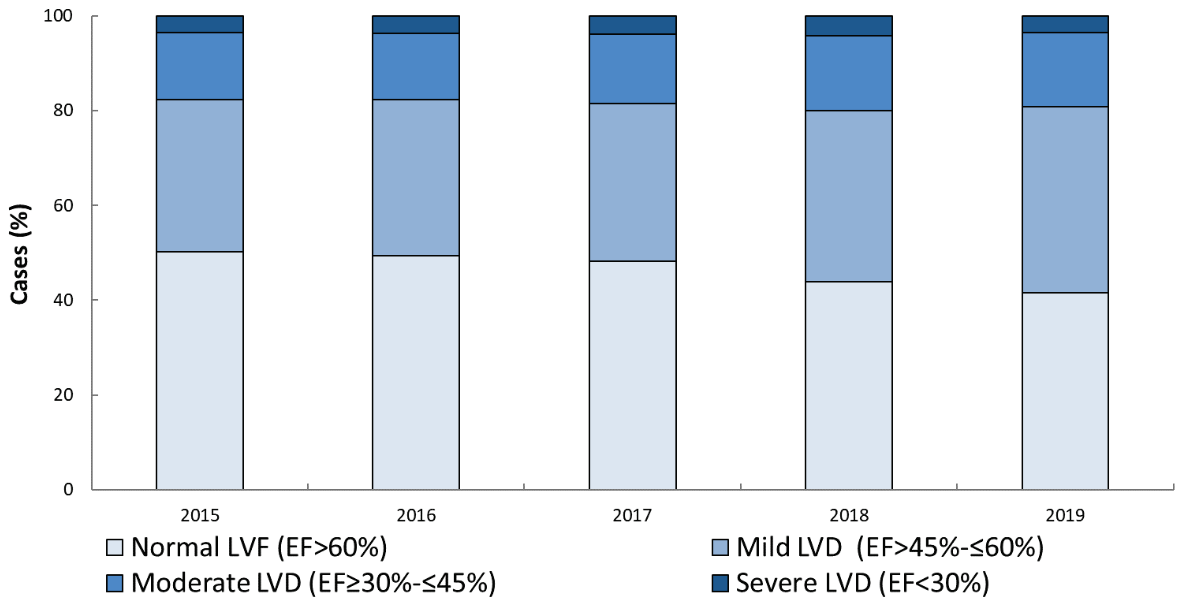
The proportion of patients with normal left ventricular function (LVF) or mildly impaired left ventricular dysfunction (LVD), and those with moderate or severely impaired LVD varied greatly between units in 2019 (Figure 8a). Overall, approximately 80% of patients had normal LVF or mild LVD, with little change over the past five years (Figure 8b). On average 14.9% of patients had moderate and 3.77% had severe LVD. For the left ventricular ejection fraction (LVEF) values that determine LVF and LVD for the ANZSCTS Database refer to Appendix C (pg. 85).

Figure 8. Isolated CABG: pre-operative LVF

a. Units in 2019



b. Year

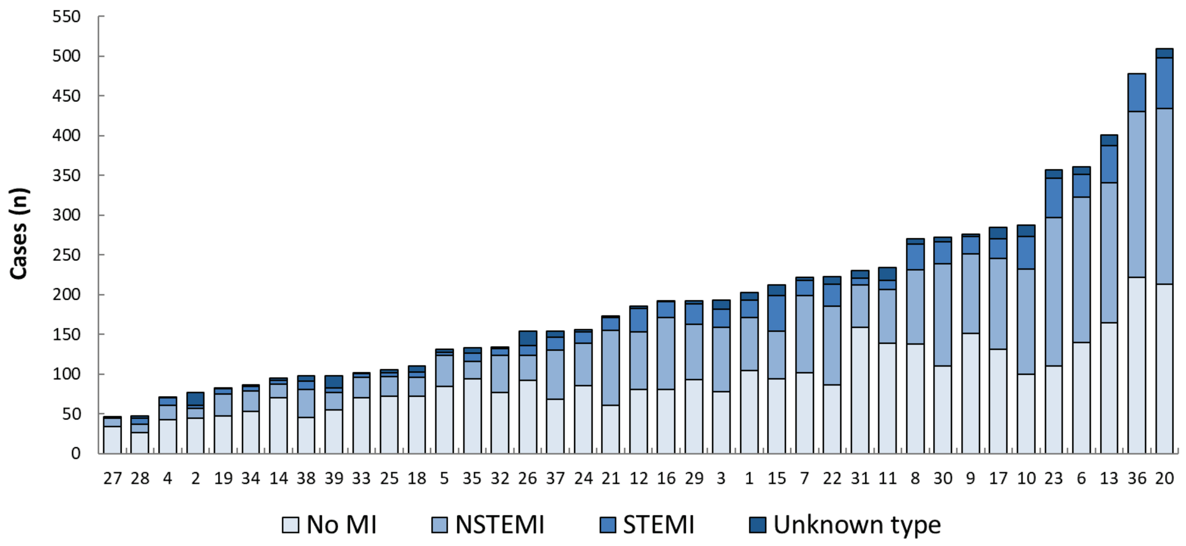


1.1.4 Previous myocardial infarction

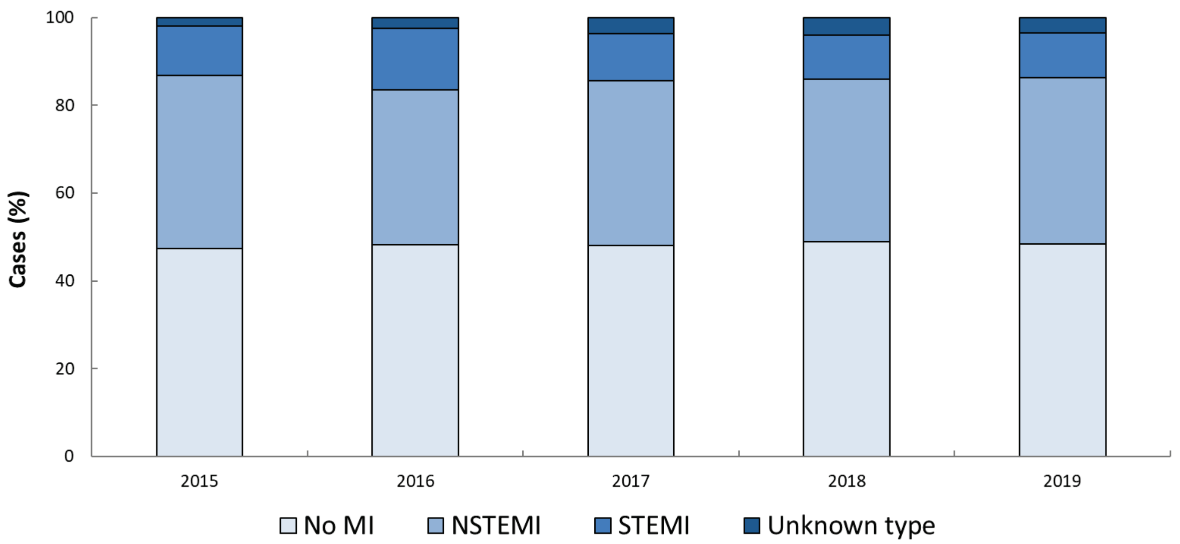
Despite the variability in overall case load, the frequencies of non-ST elevation myocardial infarction (NSTEMI) and ST elevation myocardial infarction (STEMI) prior to isolated CABG surgery were relatively consistent between units (Figure 9a). The proportion of patients presenting with no previous myocardial infarction (MI), NSTEMI, STEMI and unknown MI type has also remained consistent over the past five years. Approximately half of isolated CABG patients had no history of MI (Figure 9b).

Figure 9. Isolated CABG: prior MI

a. Units in 2019



b. Year

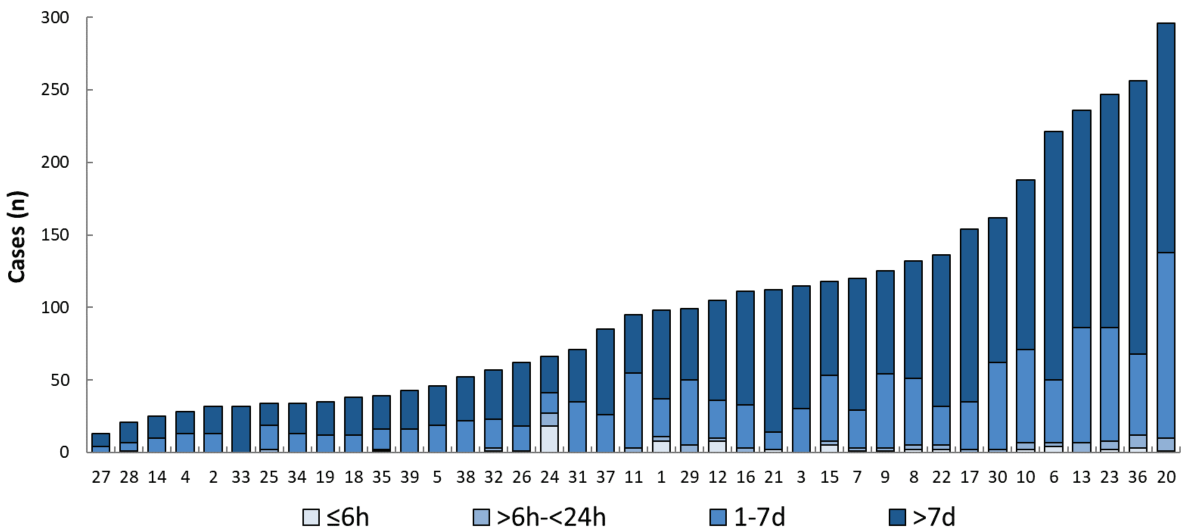


1.1.5 Timing of previous myocardial infarction

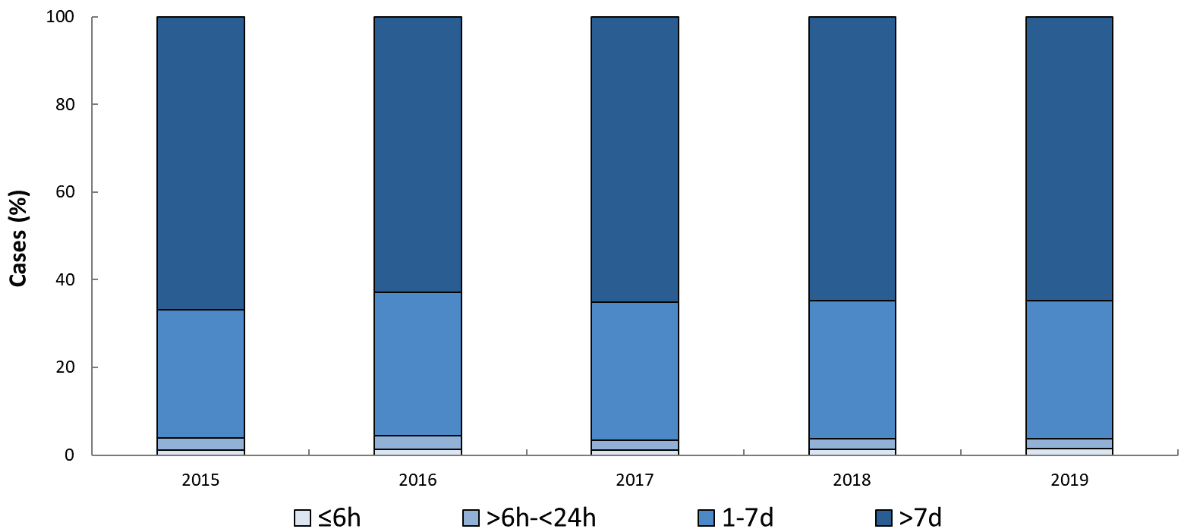
The majority of previous MIs occurred more than seven days prior to surgery with the exception of one unit that showed a higher proportion of MIs occurring equal to or less than six hours prior to the surgery (Figure 10a). The timing of MI in 2019 remained consistent with previous years, so that in 64.8% of patients, the MI occurred more than seven days before surgery.

Figure 10. Isolated CABG: timing of pre-operative MI

a. Units in 2019



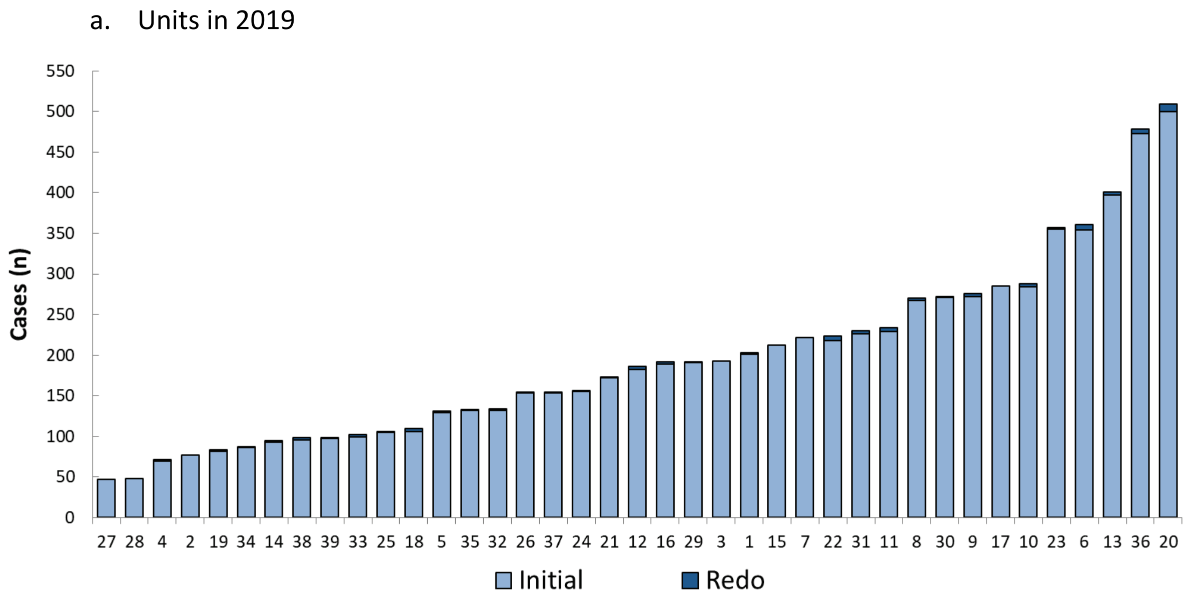
b. Year

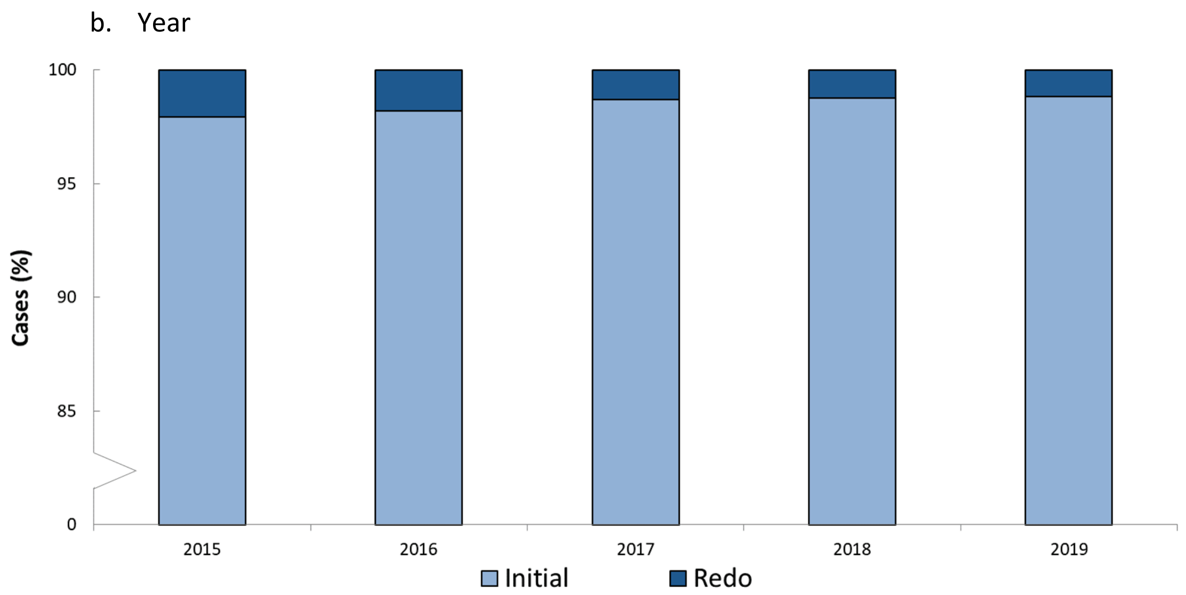


1.2 Previous coronary surgery

An operation is considered a redo if the patient had any prior cardiac surgery. In 2019, 1.16% of isolated CABGs were redo operations (Figure 11b). This was consistent between units (Figure 11a). The proportion of redo operations continued to decrease in 2019, however it is double that reported by the SWEDEHEART registry[5] (0.53%).

Figure 11. Isolated CABG: initial and redo surgery



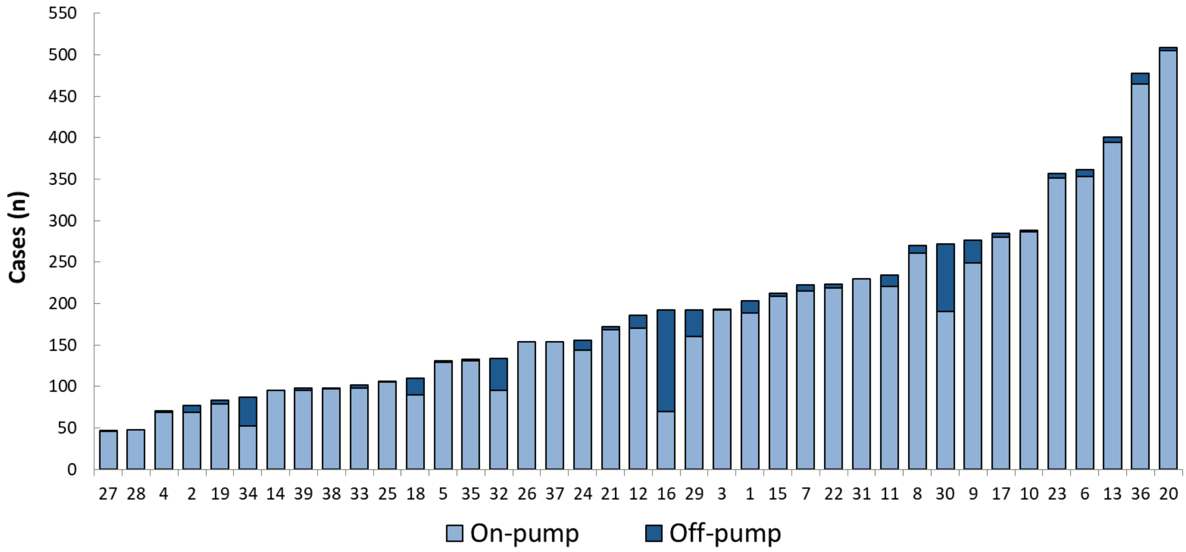


1.3 On-pump and off-pump coronary surgery

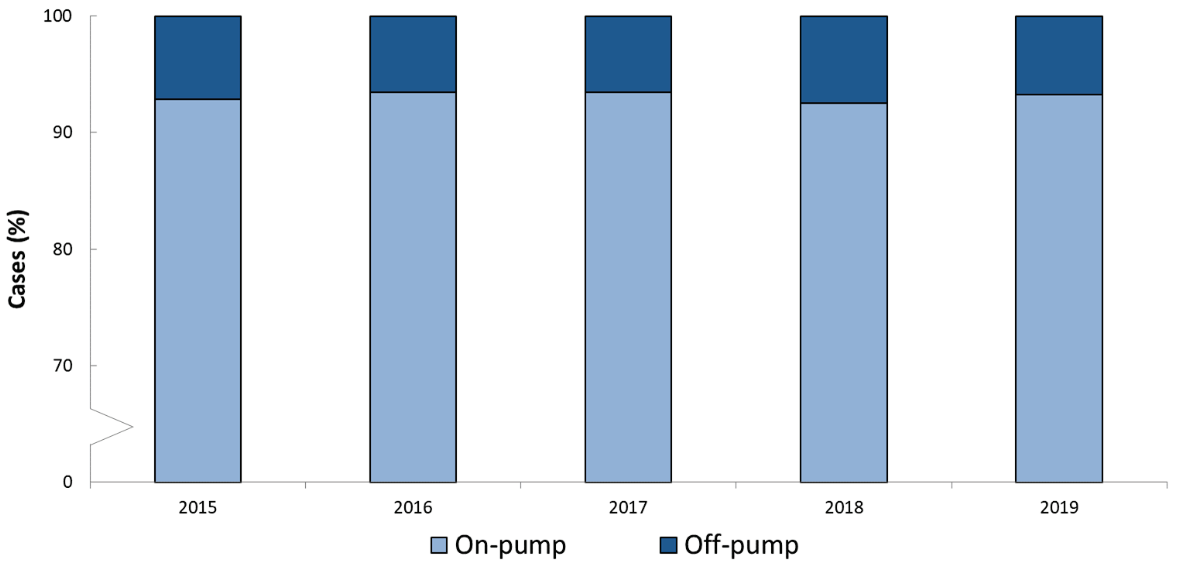
Most units perform relatively few off-pump CABGs; however, in 2019 four units performed more than one quarter of their cases without cardiopulmonary bypass (CPB; Figure 12a). The majority of isolated CABGs performed by unit 16 were off-pump (63%). Despite the high proportion of off-pump isolated CABG surgery for those units, the overall proportion has remained consistent over the past five years at approximately 7% (Figure 12b).

Figure 12. On-pump and off-pump isolated CABG

a. Units in 2019



b. Year



1.4 Conduit selection

1.4.1 Conduits used and distal anastomoses performed

Over the last five years, the all-arterial technique was used in approximately one fifth of on-pump cases but in more than half of off-pump. Off-pump CABG involved a lower mean number of anastomoses (Table 2a).

In 2019, 87.8% and 85.4% of patients having on- or off-pump isolated CABG, respectively, had a left internal thoracic artery (LITA) or a right internal thoracic artery (RITA) conduit, with or without other arterial or vein conduits (Table 2b). Radial artery (RA) conduits were used in 38.4% of on-pump, and 21.2% of off-pump cases. Bilateral internal thoracic artery (BITA) conduits and T or Y grafts were less common, but used more frequently in off-pump surgery.

Table 2a. Summary of anastomoses and conduits for on-pump and off-pump isolated CABG

		On-pump	Off-pump
n	2019	7127	513
	2015-2018	24941	1853
Mean no. anastomoses	2019	3.1	2.5
	2015-2018	3.2	2.5
Only arterial conduits (%)	2019	21.0	44.8
	2015-2018	21.4	58.6
Arterial with saphenous vein conduits* (%)	2019	79.0	55.0
	2015-2018	78.6	41.3

*Proportion of operations in which at least one vein conduit was used

Table 2b. Arterial conduits used for on-pump and off-pump isolated CABG (% of cases)

		On-pump	Off-pump
BITA	2019	7.4	10.7
	2015-2018	8.3	22.3
GEPA~	2019	0.1	0.0
	2015-2018	0.2	0.2
LITA or RITA	2019	87.8	85.4
	2015-2018	86.0	75.1
RA (x1 or x2)	2019	38.4	21.2
	2015-2018	37.1	27.5
T or Y grafts*^	2019	7.5	15.1
	2015-2018	9.2	18.3

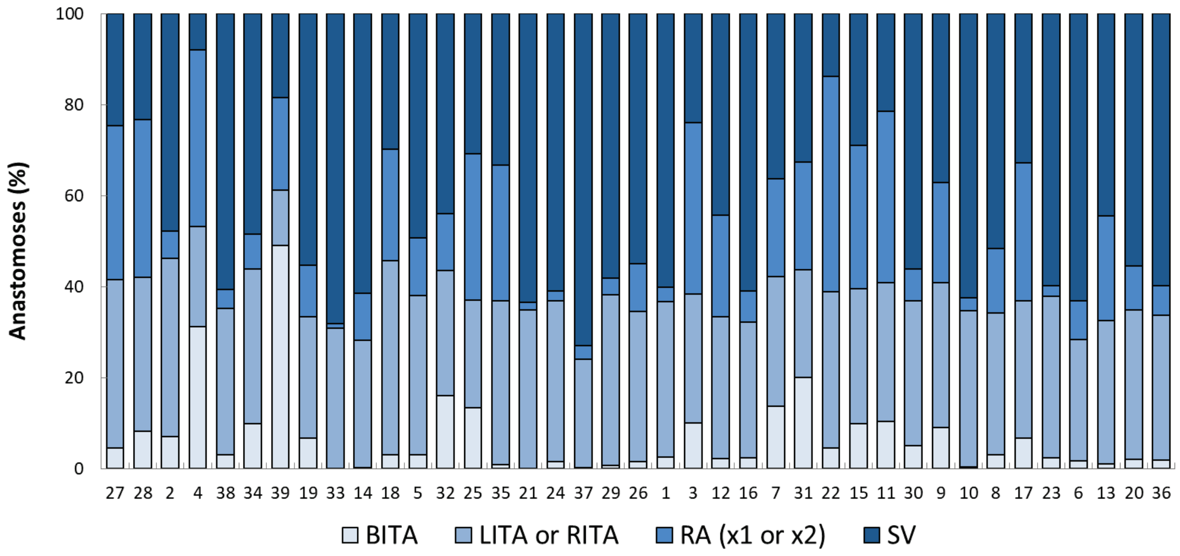
~GEPA = gastroepiploic artery
*Arterial only
^16 and 14 missing cases in 2019 and 2015-2018, respectively

1.4.2 Conduits used for anastomoses

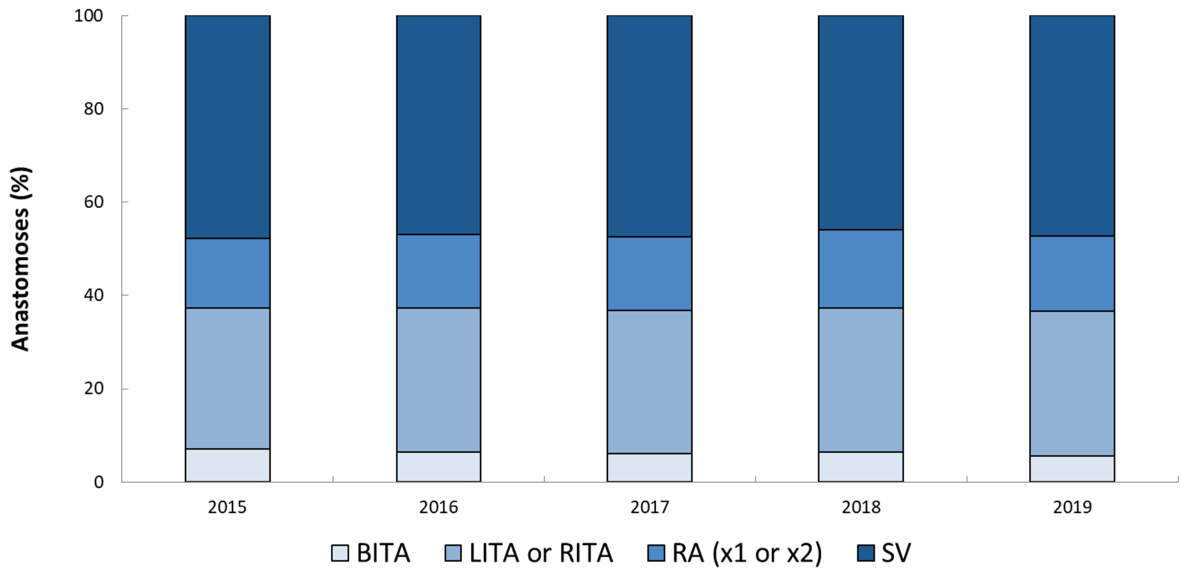
The choice of conduits for isolated CABG varied greatly, with saphenous vein (SV) or LITA or RITA accounting for the highest proportion at most units (Figure 13a). The overall proportions of anastomoses performed using each type of conduit remained consistent between 2015 and 2019, inclusive, in that approximately 47% of all anastomoses were performed using vein, 31% using LITA or RITA, 16% using RA and 6% using BITA (Figure 13b).

Figure 13. Percentage of arterial and venous anastomoses performed in isolated CABG

a. Units in 2019



b. Year



1.5 Influence of co-morbidities on complications

Post-operative complications considered in this report include permanent stroke, deep sternal wound infection (DSWI), new cardiac arrhythmia (NCA), and re-operation (re-op) for bleeding or tamponade. Data on the incidence of derived new renal insufficiency (DNRI) are presented separately (refer to Appendix B, pg. 83, for definition of DNRI), to allow for the exclusion of patients with pre-operative renal impairment. In the following section, these complications are evaluated in the context of comorbidities.

1.5.1 Pre-existing diabetes and renal impairment

The proportion of patients with diabetes in the isolated CABG cohort remained consistent with that reported by the ANZSCTS Database in 2018 (39%), which is higher than the 31.7% reported in New Zealand first-time isolated CABG patients at public hospitals in 2017[6,8].

This report compares two parameters of renal impairment: patients with a pre-operative creatinine level of ≥200 µmol/L or those with a pre-operative estimated glomerular filtration rate (eGFR) ≤60 mL/min/1.73m^2.

The data demonstrate that the incidence of permanent stroke and DSWI was higher in patients with diabetes and those with either measure of pre-operative renal impairment (Table 3). The incidence of NCA and re-op for bleeding in 2019 was higher in those with either measure of pre-operative renal impairment, but was not influenced by the presence of diabetes.

Table 3. Influence of pre-operative diabetes and of renal function on complications (%) for isolated CABG patients

		Diabetes*^		Pre-op creatinine		Pre-op eGFR¥	
		No	Yes	<200 µmol/L	≥200 µmol/L	>60mL /min/1.73m^2	≤60mL /min/1.73m^2
n	2019	4614	3026	7424	217	6226	1409
	2015-2018	16344	10438	26046	748	21534	5231
Permanent stroke#	2019	0.9	1.4	1.1	3.7	1.0	1.8
	2015-2018	0.8	1.1	0.8	2.0	0.7	1.7
DSWI~	2019	0.8	1.3	0.9	2.8	0.9	1.3
	2015-2018	0.9	1.9	1.3	3.0	1.2	1.6
NCA†	2019	25.8	24.4	25.2	27.8	24.5	28.7
	2015-2018	26.6	25.5	26.1	29.8	25.1	30.8
Re-op for bleeding‡	2019	2.5	2.3	2.3	5.1	2.2	3.6
	2015-2018	2.3	2.2	2.2	3.9	2.1	30.0

*1 and 12 cases missing diabetes data in 2019 and 2015-2018, respectively
^Refers to all diabetes, regardless of type of therapy
¥6 and 27 cases missing eGFR data in 2019 and 2015-2018, respectively
#8 and 15 cases missing permanent stroke data in 2019 and 2015-2018, respectively
~13 and 118 cases missing DSWI data in 2019 and 2015-2018, respectively
†8 and 15 cases missing NCA data in 2019 and 2015-2018, respectively
‡8 and 14 cases missing re-op for bleeding data in 2019 and 2015-2018, respectively

Note: eGFR data was updated in the second edition, July 2021

1.5.2 Age

The incidence of NCA increases with advancing age (Table 4). Other complications tended to be less influenced by age, however, the incidence of permanent stroke and DSWI did increase with advancing age in 2019. Re-op for bleeding demonstrated no clear trend based on patient age.

Table 4. Influence of patient age~ on complications (%) for isolated CABG patients

		Age*			
		<50 y	50-69 y	70-79 y	≥80 y
n	2019	500	4018	2582	541
	2015-2018	1704	14615	8402	2071
Permanent stroke	2019	1.0	0.8	1.6	1.5
	2015-2018	0.4	0.7	1.2	1.0
DSWI	2019	0.8	0.9	1.1	1.7
	2015-2018	0.9	1.3	1.5	1.0
NCA	2019	10.4	22.1	31.0	34.8
	2015-2018	11.0	22.6	33.0	36.8
Re-op for bleeding	2019	2.0	2.5	2.5	2.2
	2015-2018	2.8	2.0	2.4	2.9

~Same missing data for complications applies as for Table 3
*2 cases missing age group data from 2015-2018

1.5.3 Surgical history or use of cardiopulmonary bypass

The incidence of post-operative complications was similar between patients who did or did not have redo or off-pump surgery, although in 2019, redo surgery was associated with a relatively high incidence of stroke and re-op for bleeding (Table 5).

Table 5. Influence of redo surgery or use of CPB~ on complications (%) for isolated CABG patients

		Surgery		CPB*	
		Initial	Redo	On-pump	Off-pump
n	2019	7552	89	7127	513
	2015-2018	26367	427	24941	1853
Permanent stroke	2019	1.1	2.3	1.1	1.2
	2015-2018	0.9	1.4	0.9	0.7
DSWI	2019	1.0	0.0	1.0	0.8
	2015-2018	1.3	1.7	1.3	1.0
NCA	2019	25.3	26.1	25.3	24.6
	2015-2018	26.2	27.0	26.4	23.8
Re-op for bleeding	2019	2.4	4.5	2.5	1.8
	2015-2018	2.3	1.9	2.2	2.8

~Same missing data for complications applies as for Table 3
*1 case missing CPB data in 2019

1.5.4 Influence of comorbidities on derived new renal insufficiency

The incidence of post-operative DNRI was markedly higher in patients with diabetes, increasing age, and those having redo or on-pump surgery (Table 6). In 2019, patients with pre-operative creatinine ≥200 µmol/L or eGFR ≤60 mL/min/1.73m^2 had eight- and three-fold increases in the incidence of DNRI, respectively. These data exclude patients who had pre-operative dialysis.

Table 6. DNRI (%) for isolated CABG patients on the basis of diabetes, renal insufficiency, age, surgical history and use of CPB

	2019		2015-2018	
	n	DNRI (%)‡	n	DNRI (%)‡
Diabetes*^				
No	4570	1.8	15596	2.2
Yes	2926	3.3	9788	3.5
Pre-op creatinine				
<200 µmol/L	7398	2.2	25030	2.5
≥200 µmol/L	99	17.2	354	18.4
Pre-op eGFR#				
>60mL/min/1.73m^2	6209	1.6	20713	2.0
≤60mL/min/1.73m^2	1283	6.1	4664	5.7
Age†				
<50y	482	1.5	1606	2.3
50-69y	3935	1.8	13803	2.2
70-79y	2542	3.0	7999	3.2
≥80y	538	4.5	1974	4.1
Previous surgery				
Initial	7412	2.3	24988	2.7
Redo	85	7.1	396	4.0
CPB~				
On-pump	6995	2.4	23580	2.7
Off-pump	501	1.8	1804	1.9

‡11 and 952 cases missing DNRI data in 2019 and 2015-2018, respectively

Note: the amount of missing data for DNRI in 2015-2018 is largely due to a lack of post-operative creatinine data from one hospital for a portion of this period.

*1 case missing diabetes data in 2019

^Refers to all diabetes, regardless of type of therapy

#5 cases missing eGFR data in both 2019 and 2015-2018

†2 cases missing age group data in 2015-2018

~1 case missing CPB data in 2019

Note: eGFR data was updated in the second edition, July 2021

1.6 Influence of patient characteristics on 30-day mortality

In 2019, in hospital and 30-day observed mortality (OM) increased with more exigent clinical status. Interesting trends were observed for age and sex. Mortality increased with age, however this was more evident in the female cohort, with overall OM being higher in female patients. Worsening LVF, previous STEMI or NSTEMI, decreased timing between previous MI and isolated CABG surgery, and redo surgery were also associated with increased OM. It should be noted that OM is not risk-adjusted and does not account for differences in patient characteristics.

Table 7. Influence of patient characteristics on OM (%) for isolated CABG surgery, 2019 and 2015-2018

	2019		2015-2018	
	n	OM (%)	n	OM (%)
Clinical status				
Elective	4593	0.4	16630	0.8
Urgent	2779	1.5	9346	1.3
Emergency/salvage	269	7.8	818	6.1
Sex/age				
Male*	6283	0.8	21979	1.0
<50y	423	1.2	1402	0.6
50-69y	3406	0.6	12300	0.7
70-79y	2040	1.0	6726	1.6
≥80y	414	1.4	1549	2.0
Female	1358	2.1	4815	1.5
<50y	77	0.0	302	0.0
50-69y	612	1.3	2315	0.8
70-79y	542	3.0	1676	2.2
≥80y	127	3.9	522	2.7
LVF^				
Normal LVF (EF>60%)	3141	0.6	12665	0.7
Mild LVD (EF>45%-≤60%)	2969	0.5	8885	0.8
Moderate LVD (EF≥30%-≤45%)	1186	2.4	3881	1.8
Severe LVD (EF<30%)	267	5.6	1015	5.8
Previous MI				
No MI	3698	0.6	12906	0.7
NSTEMI	2902	1.3	10018	1.4
STEMI	771	2.2	3048	1.9
Unknown type	270	0.7	822	1.0
Timing of prior MI				
≤6h	61	8.2	172	8.7
>6h-<24h	88	5.7	363	5.2
1-7d	1240	1.6	4342	1.5
>7d	2550	1.1	9005	1.1
Previous surgery				
Initial	7552	1.0	26367	1.1
Redo	89	3.4	427	3.0
CPB				
On-pump	7127	1.1	24941	1.1
Off-pump	513	1.0	1853	1.0

*2 cases missing male age group data in 2015-2018

^78 and 348 cases missing in 2019 and 2015-2018, respectively, due to LVEF not measured or unknown/missing EF data.

1.7 Unit outcomes – mortality, complications and resource utilisation

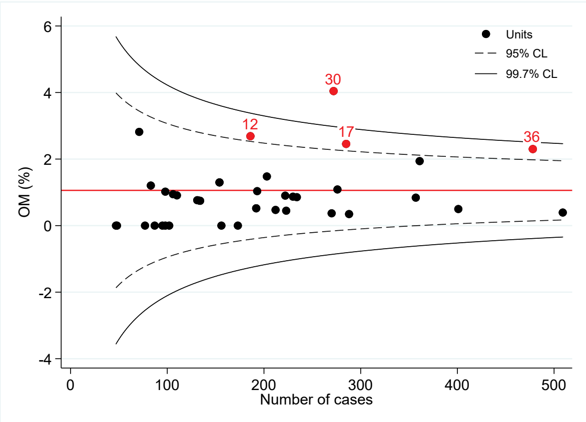
Unit outcomes for mortality and complications are presented in funnel plots, which are explained in Appendix D-I (pg. 87). Units above the upper 99.7% control limit (CL) for KPIs are notified and managed as outlined in Appendix A (pg. 82). Definitions for KPIs are outlined in Appendix B (pg. 83). The complications explored in this section are permanent stroke, DNRI, DSWI, NCA, readmission, and re-op for bleeding. The resource utilisation variables include duration of intensive care unit (ICU) stay and ventilation, red blood cell (RBC) and non-RBC transfusion (NRBC), and pre- and post-procedural length of stay (PLOS). Cases with missing outcome data are excluded from the analyses.

1.7.1 30-day mortality

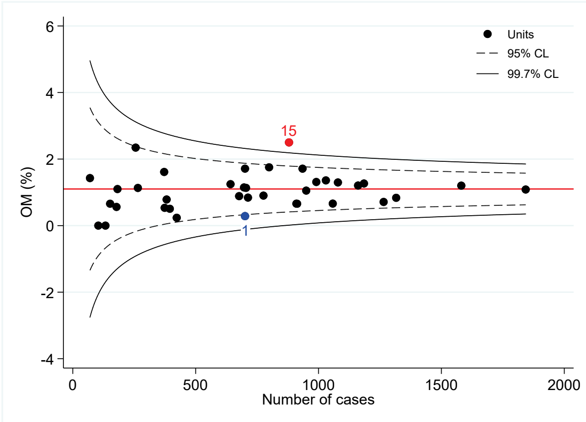
OM was 1.06% in 2019, and 1.10% in 2015-2018 for all isolated CABG patients in the ANZSCTS Database (Figure 14a and b). In comparison, New Zealand reported 2.2% in-hospital mortality in 2017; the National Institute for Cardiovascular Outcomes Research (NICOR) National Adult Cardiac Surgery 2019 Summary Report reported 0.99% mortality in non-emergency isolated CABG patients in 2017/18; the Society of Thoracic Surgeons (STS) published a 30-day mortality rate of 2.2% for the 2016 calendar year; and the SWEDEHEART registry had a 30-day mortality rate of 0.66% for 2019[5-6,9-10]. The risk-adjusted mortality rate (RAMR) was below 1% in 2019 and also in the pooled data for the preceding four years (Figure 14c and d). Refer to Appendix E (pg. 89) for further information regarding how the Database determines the risk adjusted mortality rate.

Figure 14. Mortality by unit following isolated CABG

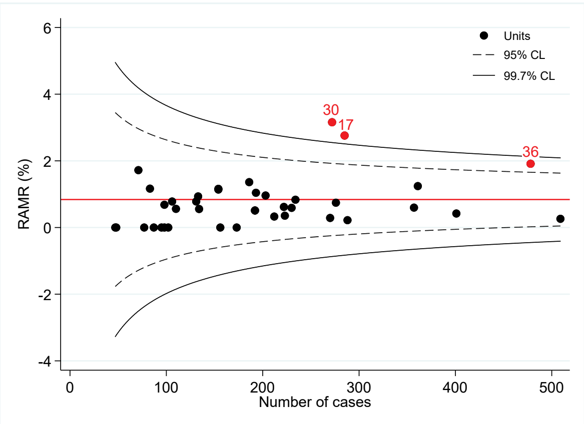
a. 2019 OM



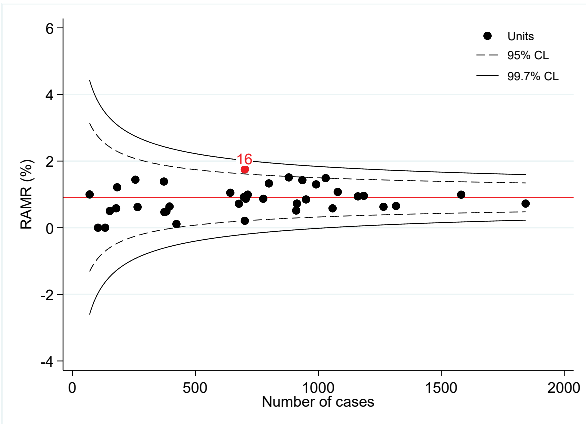
b. 2015-2018 OM



c. 2019 RAMR



d. 2015-2018 RAMR



1.7.2 Complications

The average rates of post-operative complications in 2019 were similar to the preceding four years (Figures 15-20). The lowest frequency events were DSWI (mean of 1.00%) and permanent stroke (1.13%), followed by DNRI (2.37%) and re-op for bleeding (2.42%). Mean rates of readmission and NCA were 10.2% and 25.3%, respectively. It is interesting to note that in 2017, New Zealand reported higher incidences for DSWI, re-op for bleeding and readmission, being 2.10%, 3.10% and 11.0% respectively[6]. The data for DNRI excludes patients who received pre-operative dialysis (Figure 16).

Figure 15. Permanent stroke by unit following isolated CABG

a. 2019 Permanent stroke   b. 2015-2018 Permanent stroke

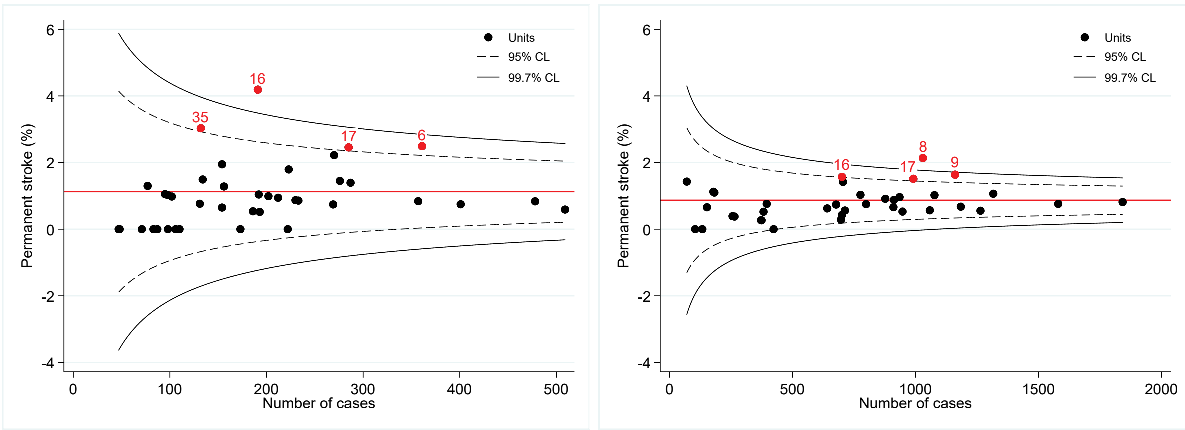


Figure 16. DNRI by unit following isolated CABG

a. 2019 DNRI   b. 2015-2018 DNRI

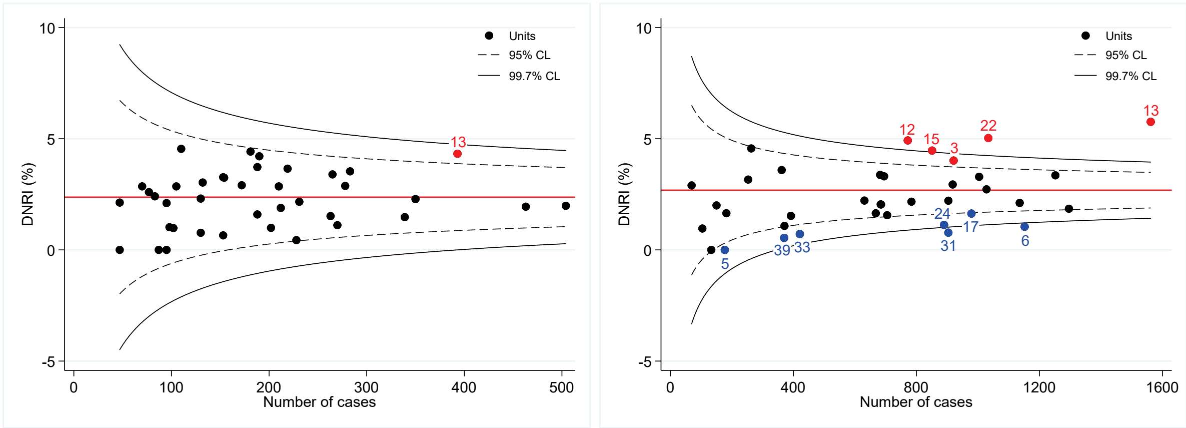


Figure 17. DSWI by unit following isolated CABG

a. 2019 DSWI

b. 2015-2018 DSWI

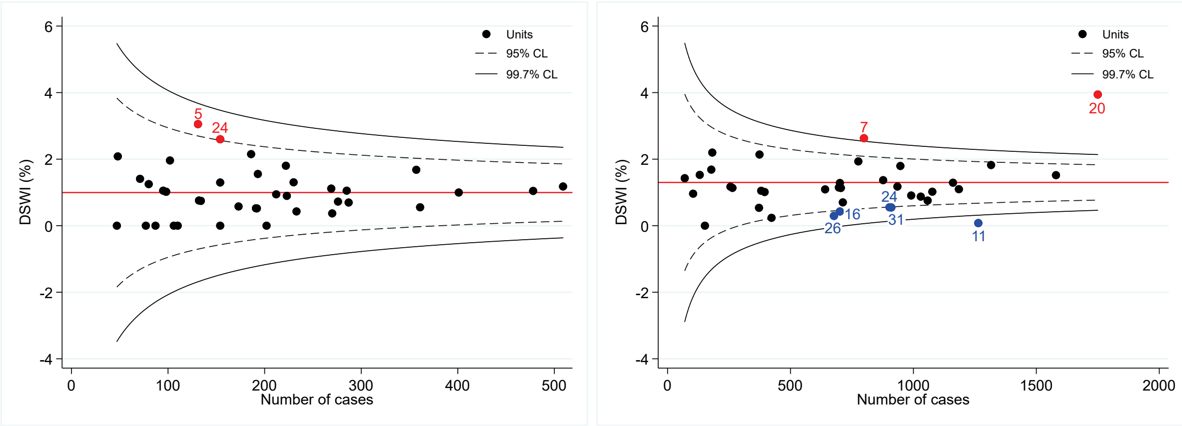


Figure 18. NCA by unit following isolated CABG

a. 2019 NCA

b. 2015-2018 NCA

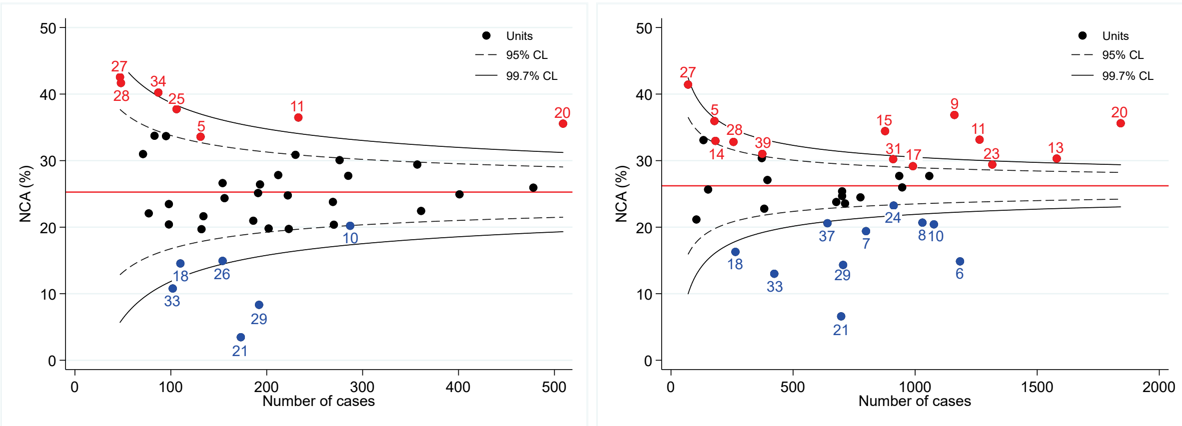


Figure 19. Re-op for bleeding by unit following isolated CABG

a. 2019 Re-op for bleeding

b. 2015-2018 Re-op for bleeding

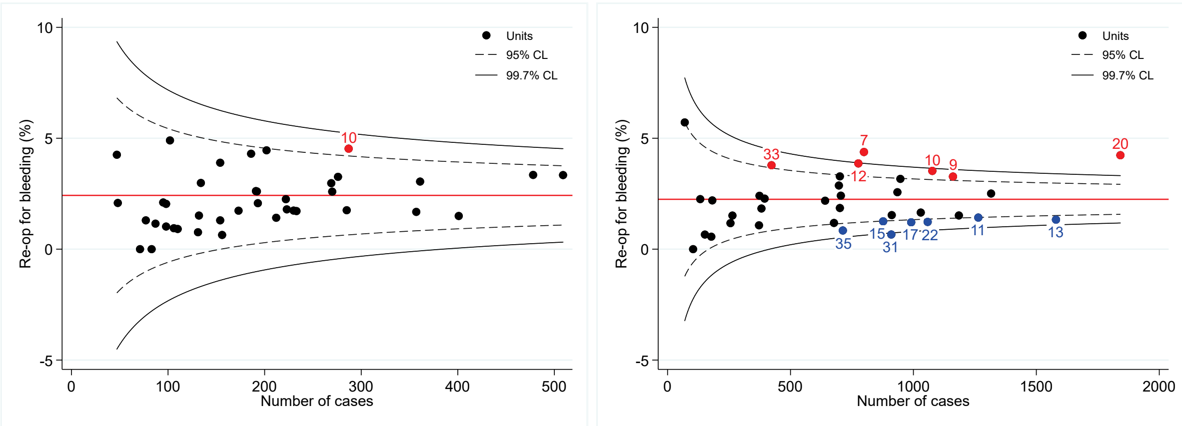
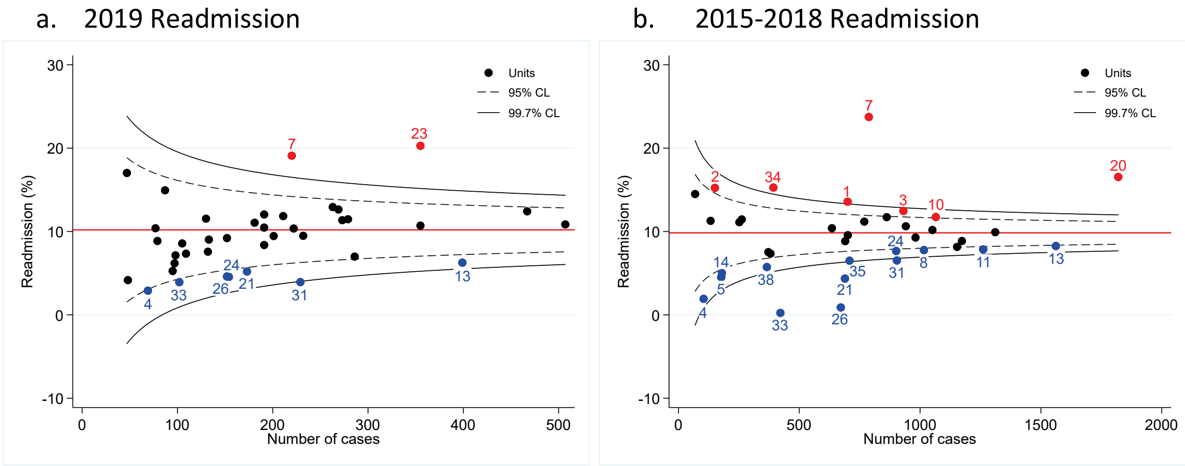


Figure 20. Readmission by unit following isolated CABG



1.7.3 Resource utilisation

Due to the skewed distribution of the ICU length of stay and ventilation data, the geometric means (GM) are used. The GM is defined as the nth root of a product of n numbers. It is less sensitive to outlying values, so describes the central tendency of a set of skewed data more accurately.

In 2019 and the pooled data for the preceding four years, there was marked variation between units in the time patients spent in the ICU, the duration of ventilation, and the percentage of patients who received RBC or NRBC transfusions (Tables 8 and 9).

Table 8. Resource utilisation by unit for isolated CABG patients, 2019

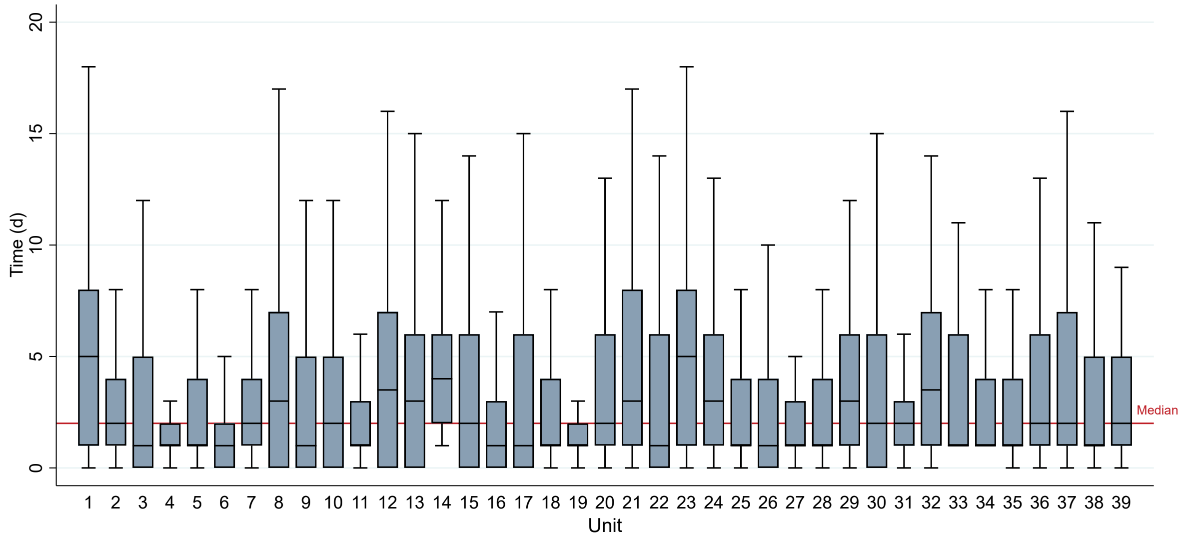
	2019			
Unit	ICU (GM, h)	Ventilation (GM, h)	RBC usage (%)	NRBC usage (%)
1	32.2	10.3	28.6	26.6
2	36.4	5.5	29.9	44.2
3	36.1	9.3	33.7	23.8
4	47.3	7.6	23.9	18.3
5	75.9	13.6	18.3	5.3
6	102.6	11.7	44.0	30.2
7	40.8	12.3	23.9	11.7
8	66.5	12.6	30.0	18.9
9	83.9	7.1	32.6	19.6
10	60.4	8.9	38.9	30.6
11	57.2	10.3	33.3	19.7
12	43.7	11.8	29.6	21.5
13	40.3	9.3	23.9	14.2
14	57.3	13.5	25.3	36.8
15	40.8	9.0	9.0	4.2
16	47.7	8.7	22.9	16.1
17	32.6	12.6	33.0	17.5
18	58.8	8.0	27.3	16.4
19	70.1	8.7	21.7	32.5
20	33.0	7.5	22.2	19.4
21	42.5	10.7	10.4	11.6
22	32.9	8.6	31.8	10.3
23	27.1	10.0	17.9	9.2
24	47.0	13.2	40.6	20.6
25	65.8	8.9	49.1	18.9
26	40.2	8.3	22.7	31.8
27	67.2	8.3	25.5	12.8
28	33.7	10.7	10.4	12.5
29	41.9	11.2	27.1	16.1
30	39.0	7.0	18.8	11.4
31	53.9	11.2	10.4	9.6
32	71.1	10.5	19.4	15.7
33	83.0	13.5	12.7	6.9
34	54.6	6.3	10.3	19.5
35	36.7	5.9	25.6	21.1
36	35.3	10.8	39.7	15.9
37	69.2	11.2	52.6	37.0
38	42.5	7.1	23.5	3.1
39	55.6	12.5	20.4	12.2
Total	**46.6**	**9.7**	**27.4**	**18.2**

Table 9. Resource utilisation by unit for isolated CABG patients, 2015-2018

	2015-2018			
Unit	ICU (GM, h)	Ventilation (GM, h)	RBC usage (%)	NRBC usage (%)
1	31.9	9.9	22.8	23.1
2	34.6	5.9	18.4	34.9
3	36.9	9.8	33.5	25.5
4	46.2	7.1	23.1	20.2
5	74.5	14.2	11.2	3.4
6	100.3	12.4	39.7	17.1
7	39.3	11.7	28.4	21.3
8	60.8	12.3	30.4	17.3
9	83.3	10.7	37.5	20.2
10	54.8	9.8	28.5	20.1
11	59.1	8.5	37.9	19.1
12	37.6	10.8	33.5	26.4
13	47.8	8.3	28.0	14.4
14	62.3	14.4	30.8	42.9
15	41.4	10.7	15.7	9.7
16	36.9	7.7	26.0	21.1
17	31.4	11.0	34.2	16.2
18	62.5	6.5	21.9	12.8
19	67.7	7.5	24.8	33.8
20	33.6	9.5	27.0	18.3
21	34.3	11.6	33.3	27.1
22	33.1	9.3	28.9	10.4
23	25.8	9.3	14.4	5.7
24	43.9	11.0	42.1	21.6
26	37.5	8.2	24.2	24.7
27	80.1	7.4	32.9	12.9
28	32.4	9.2	14.1	9.0
29	47.4	13.2	33.8	18.6
30	39.2	8.6	22.1	11.8
31	52.7	8.5	10.9	5.6
32	68.7	13.9	24.6	14.1
33	75.6	15.3	19.4	5.4
34	57.0	7.6	18.0	18.5
35	35.9	5.8	17.8	15.1
37	61.6	15.2	46.6	29.0
38	36.3	9.6	25.1	8.9
39	56.9	13.4	28.3	18.4
Total	45.4	9.9	28.1	17.4

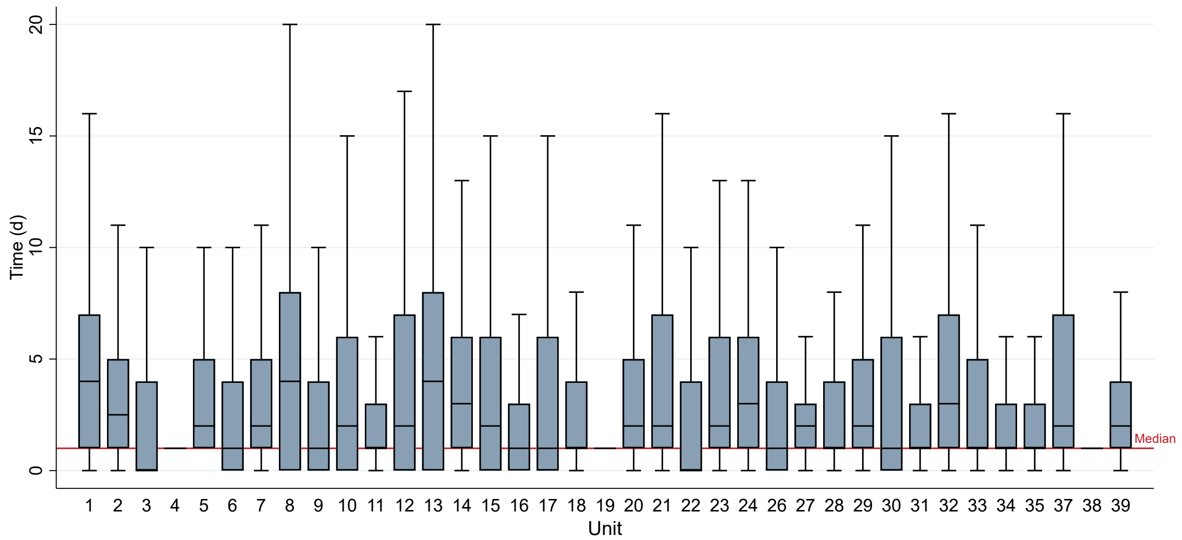
The median is used instead of the GM in this section to present data for pre- and post- procedural length of stay (PLOS) as we consider '0 days' as valid data (whereas the GM excludes '0'). In 2019 and the preceding four years, there was variability between units in the pre- and post-PLOS data (Figures 21-24). In 2019, the medians ranged from 1-5 days for pre-PLOS and 5-9 days for post-PLOS. Refer to Appendix D-II (pg. 88) for an explanation as to how to interpret box plots, including information about the exclusion of outliers.

Figure 21. Pre-procedural length of stay for isolated CABG patients by unit, 2019



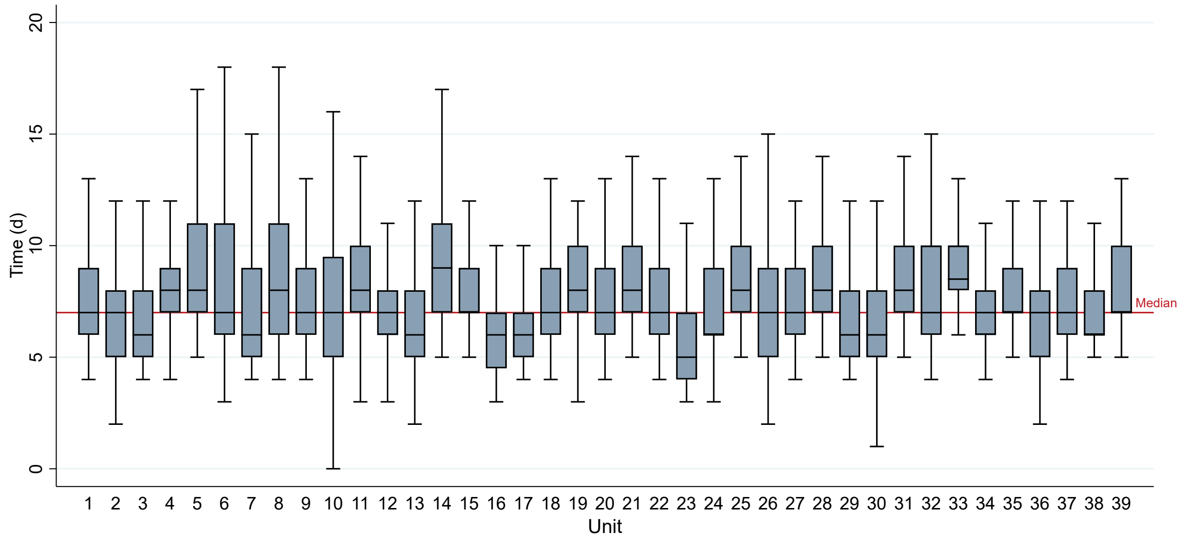
Note: excludes outliers

Figure 22. Pre-procedural length of stay for isolated CABG patients by unit, 2015-2018



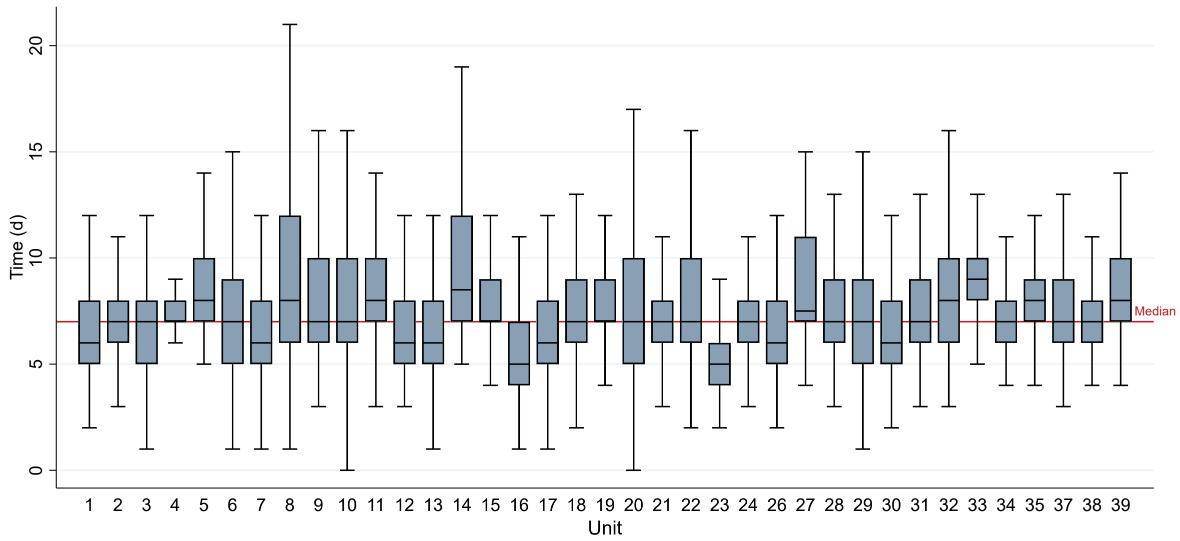
Note: excludes outliers

Figure 23. Post-procedural length of stay for isolated CABG patients by unit, 2019



Note: excludes outliers

Figure 24. Post-procedural length of stay for isolated CABG patients by unit, 2015-2018



Note: excludes outliers

2. Sex Differences in Cardiac Surgery

2.1 Data analysis and preparation

This section explores the differences in presentation, treatment, and outcomes between males and females. Summary and trend data for the binational dataset are filtered for the past 10 years, unless otherwise specified.

Long-term survival data was formulated using data submitted to the Database between January 2009 and December 2018, and a linkage with the National Death Index (censor date August 1st, 2019). Other data in this section covers the period from 2010-2019, inclusive.

2.2 Introduction

There has been much debate regarding whether sex is an independent risk factor for mortality in cardiac surgery. It is has been suggested that female sex is associated with poorer long-term survival after cardiac surgery[11]. Others have suggested that sex is not an independent risk factor, but rather a surrogate for differences specific to the female sex like smaller coronary artery size, fewer bypass grafts, lower body surface area (BSA) and timing of presentation[12].

Other topics of debate include whether sex is an independent risk factor for acute kidney injury and requirement for blood transfusion[13-14].

The following section describes the differences in presentation and treatment between males and females and will explore the ideas presented in research literature through the lens of the ANZSCTS Database data.

Figure 25. Sex differences in patient presentation for all surgery, 2010-2019

Average age

2010	2019
65.2±12.3	65.3±12.2

Average Body Mass Index

2010	2019
29.1±15.2 kg/m²	29.0±8.5 kg/m²

Average Body Surface Area

2010	2019
1.9 ± 0.2m²	2.0 ± 0.2m²

% with low eGFR*

2010 32%
2019 19%

Average age

2010	2019
67.4±14.1	65.7±14.7

Average Body Mass Index

2010	2019
28.4±6.5 kg/m²	28.7±6.6 kg/m²

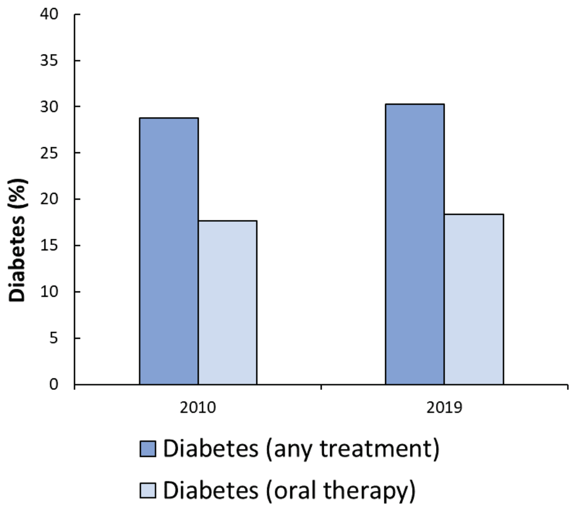
Average Body Surface Area

2010	2019
1.7 ± 0.2m²	1.7 ± 0.2m²

% with low eGFR*

2010 52%
2019 32%

*Low eGFR where eGFR≤60mL/min/1.73m²



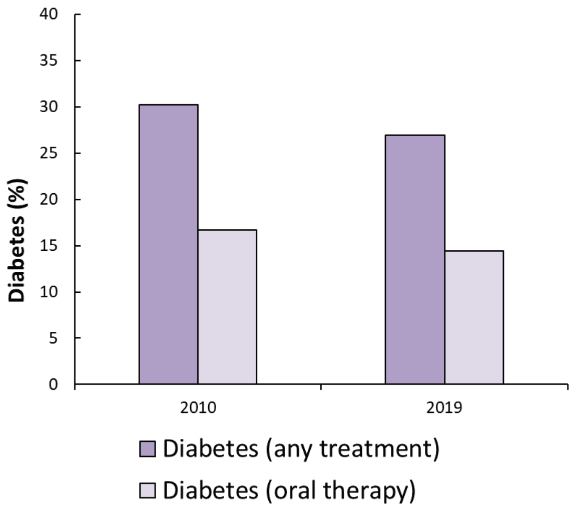
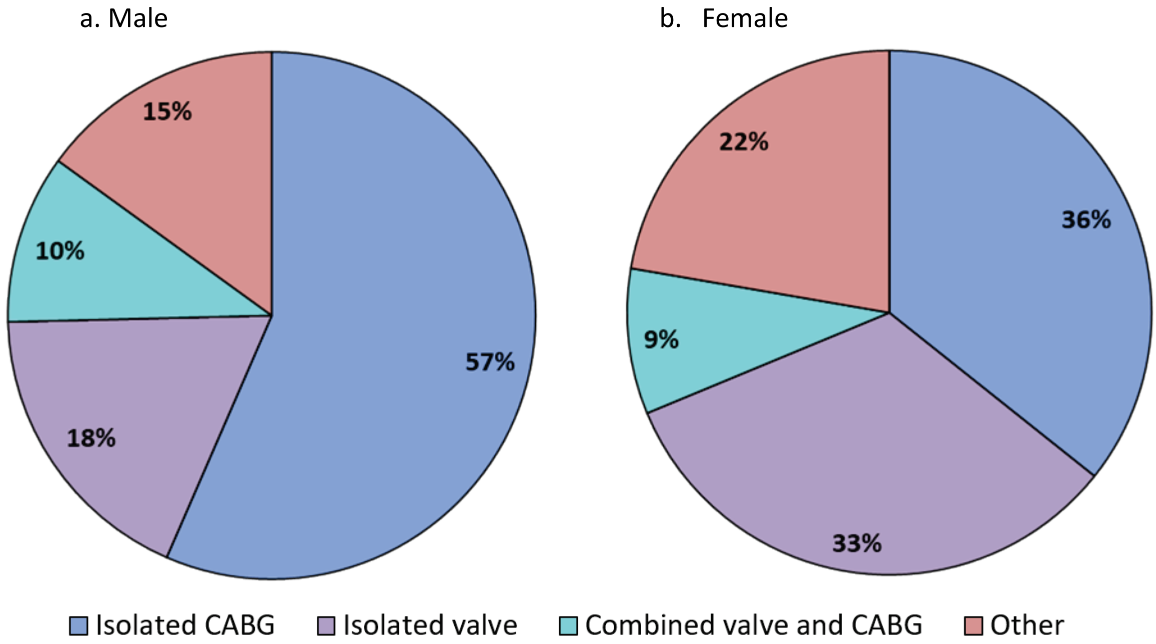


Figure 26. Cardiac surgery groups by sex, 2010-2019



The frequency distribution of isolated CABG, isolated valve surgery, combined CABG and valve surgery and the heterogeneous 'other' group of operations is quite different for males and females as illustrated in Figure 26.

2.3 Sex differences for isolated CABG patients

The variables collected in the Database that have been identified as potential determinants of the differences in outcomes between the sexes are compared in Tables 10a-10c[15].

Table 10a details the difference in presentation between the sexes. In general, females present with more severe angina (Canadian Cardiovascular Society [CCS] class 3 and 4), higher New York Heart Association (NYHA) class (III and IV), and higher incidence of reported emergency and salvage clinical status. Females also appear to be slightly older and have a lower BSA (Table 10b). The age at presentation is examined further in Figure 27, which displays the frequency of ages for all isolated CABG cases by sex. Table 10c describes the pre-operative medications, and shows that on average, males and females are similar when it comes to anticoagulants administered within seven days prior to surgery.

Outcome differences between the sexes are described in Table 11. OM, permanent stroke and RBC transfusion rates are all higher in females, which is consistent with what is reported in the literature[13,16].

Table 10a. Sex differences in clinical characteristics for isolated CABG patients, 2010-2019

	Male	Female
n	48694	11073
Risk factors (%)		
Diabetes (oral therapy)	20.9	22.7
Hypertension	79.6	84.2
Hypercholesterolaemia	80.2	81.9
Current smoker	18.2	15.6
Peripheral vascular disease	9.8	10.5
Pre-op dialysis	1.6	2.1
Renal transplant	0.5	0.4
Arrhythmia	9.6	8.9
Redo CABG	0.4	0.4
Previous percutaneous coronary intervention	16.8	15.0
Angina class (CCS)		
None	19.6	18.2
1	12.5	11.0
2	33.7	31.1
3	20.1	22.4
4	14.0	17.3
NYHA class		
I	49.7	43.6
II	35.2	36.3
III	12.4	16.6
IV	2.6	3.5
Clinical status		
Elective	63.9	60.0
Urgent	33.1	35.5
Emergency	2.9	4.1
Salvage	0.1	0.3
LVF		
Normal LVF (EF>60%)	47.5	53.4
Mild LVD (EF>45%-≤60%)	33.9	30.9
Moderate LVD (EF≥30%-≤45%)	14.9	12.5
Severe LVD (EF<30%)	3.8	3.1
Left main stenosis (>50%)	26.8	27.4
Risk factors (means)		
Age	65.5	67.7
BMI	29.2	29.2
BSA	1.9	1.7
Pre-operative [Hb]	140.0	126.4
eGFR	84.8	71.5

Figure 27. Frequency distribution of age by sex for isolated CABG, 2010-2019

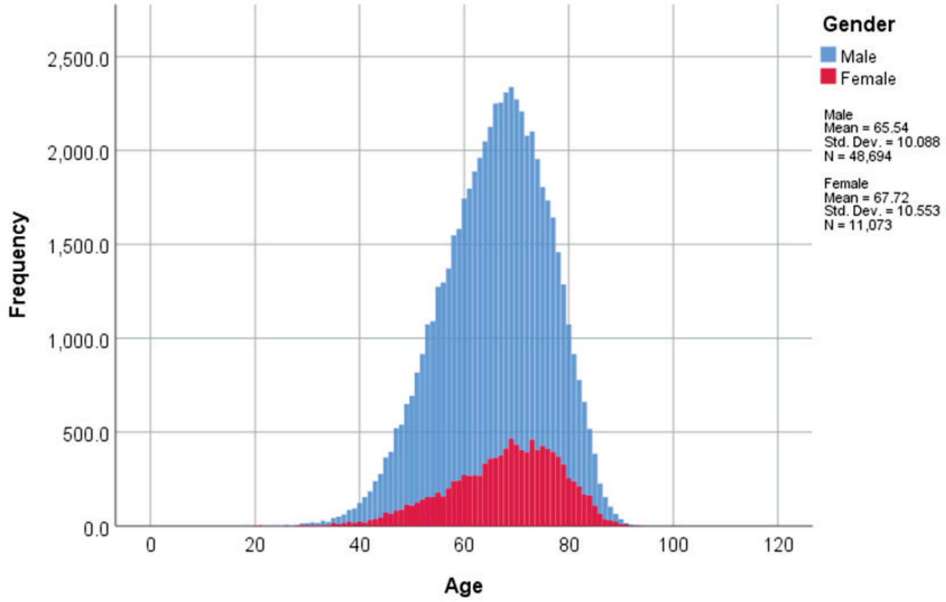


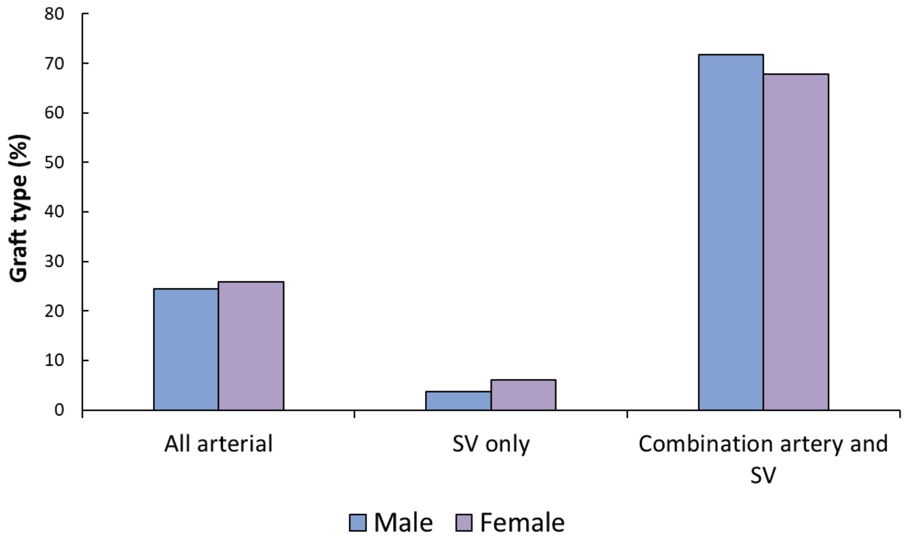
Table 10b. Medications administered within seven days prior to isolated CABG surgery, 2010-2019

	Male	Female
n	48694	11073
Medications (%)		
Inotropes	2.7	2.8
IV-Nitrates	5.0	5.9
Anticoagulants	22.6	24.2
Steroids	1.3	1.8
Aspirin	78.9	78.3
Thienopyridine	15.5	16.4
Ticagrelor*	10.8	10.9
Aggrastat	1.5	1.4
IIb/IIIa inhibitors	0.4	0.3
Other antiplatelet	4.6	4.1
**** Only collected from Sept 2016 n(male)=19788 n(female)=4349***		

Table 11. Clinical outcomes by sex for isolated CABG, 2010-2019

	Male	Female
n	48694	11073
Outcomes (%)		
OM	1.1	1.9
DSWI	1.1	1.6
Permanent stroke	0.9	1.0
DNRI	3.1	2.5
Re-op for bleeding	2.3	2.0

Figure 28. Isolated CABG graft type by sex, 2010-2019



Of all isolated CABG patients, 3.8% of males and 6.0% of females were revascularised using SV only (p<0.01). Male and female differences for the other grafting strategies are minor (Figure 28).

Figures 29 and 30 display the extent of disease in the three major coronary systems. Males tend to present with more extensive disease than females (Figure 29). Once adjusted for number of diseased systems, females have a similar number of anastomoses per diseased system (Figure 30).

Figure 29. Diseased coronary systems in isolated CABG patients by sex, 2010-2019

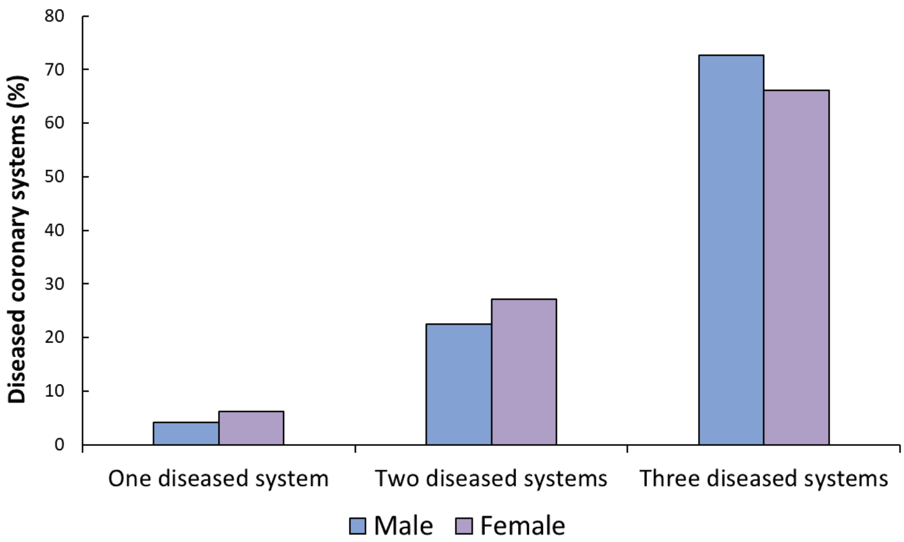


Figure 30. Anastomoses per diseased coronary system by sex for isolated CABG, 2010-2019

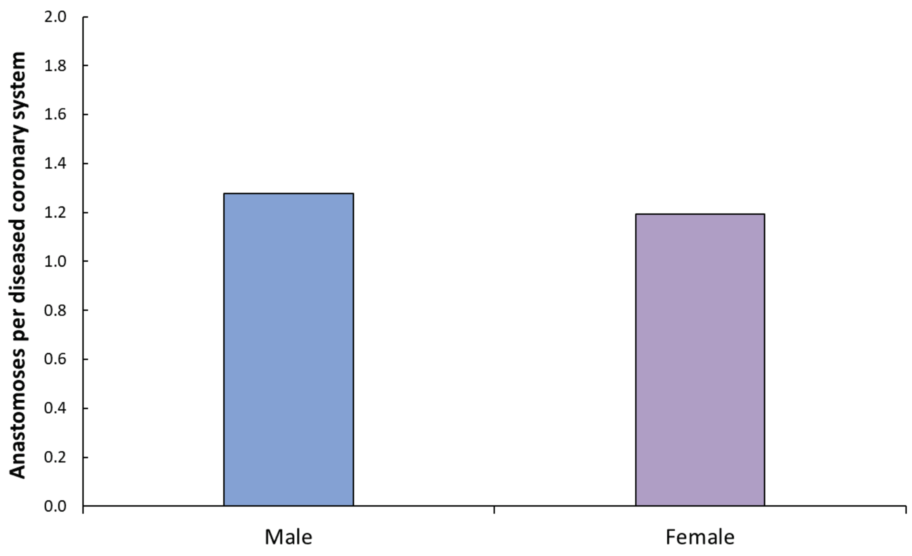
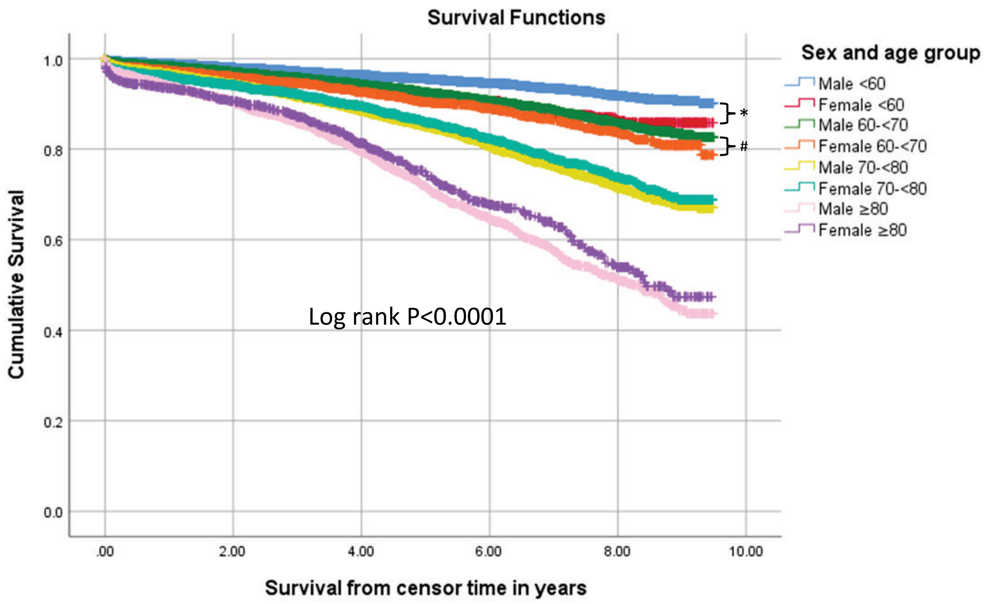


Figure 31. Long-term survival of isolated CABG patients by sex and age group, 2010-2019



*P<0.0001, #P<0.001

Table 12. Cases remaining and survival (%) by sex and age group for isolated CABG, at 1, 3, 5 and 7 years post-surgery

	Cases remaining (n)				Survival (%)			
Time since surgery	1 year	3 year	5 year	7 year	1 year	3 year	5 year	7 year
Male <60	10637	7691	4882	2556	98.8	97.1	95.5	93.3
Female <60	1875	1312	776	401	98.1	95.4	91.5	87.8
Male 60-<70	13858	9716	6012	2909	98.3	95.8	92.5	88.6
Female 60-<70	2689	1875	1148	606	97.3	94.6	90.4	86.4
Male 70-<80	11146	7404	4374	2044	96.6	91.6	85.0	76.3
Female 70-<80	3131	2216	1383	677	96.1	92.2	85.8	77.9
Male ≥80	2824	1919	1060	449	93.9	85.8	71.8	57.4
Female ≥80	1047	745	443	204	93.4	87.0	74.6	63.4

It has been reported that long-term all-cause survival is generally lower in females than males[17]. Our data follows a similar trend in Figure 31 and Table 12 in female patients between the ages of 60-<70 (P<0.001) and under age 60 (P<0.0001). However, as age increases the gap between males and females reduces. In patients more than 70 years old, long-term survival in females is higher than that of males (non-significant).

This is explored in more detail in the LOTTERY (Long-Term outcome following coronary arTERy bYpass surgery in females) study, a meta-analysis utilising data from America, Japan, Sweden and Australia (Australian data was sourced from the ANZSCTS Database after receiving approval from the ANZSCTS Database Research Committee). The results of this study have not yet been published though early results point to decreased survival for females less than 70 years, similar to what is displayed in Figure 31.

2.4 Sex differences for isolated valve surgery patients

Proportionally, females have more isolated valve surgery than isolated CABG. The following is an exploration of aortic valve (AoV) and mitral valve (MV) surgery.

AoV surgery includes any surgery performed in isolation on the AoV, excluding transcatheter aortic valve replacement (TAVR). MV surgery includes any surgery performed in isolation on the MV, excluding transcatheter mitral valve replacement (TMVR) and MitraClip.

There are a number of variables collected by the Database that have been identified as potential risk factors when assessing differences in sex outcomes[15]. These factors are compared between the sexes in Table 13 for AoV and MV surgery. In general, females present with higher NYHA class. Females also appear to be slightly older and have a lower BSA. The age of presentation is examined further in Figures 32 and 33, which display the frequency of ages for all AoV and MV cases by sex.

Outcome differences between the sexes are described in Table 14. OM and RBC transfusion rates are higher in females.

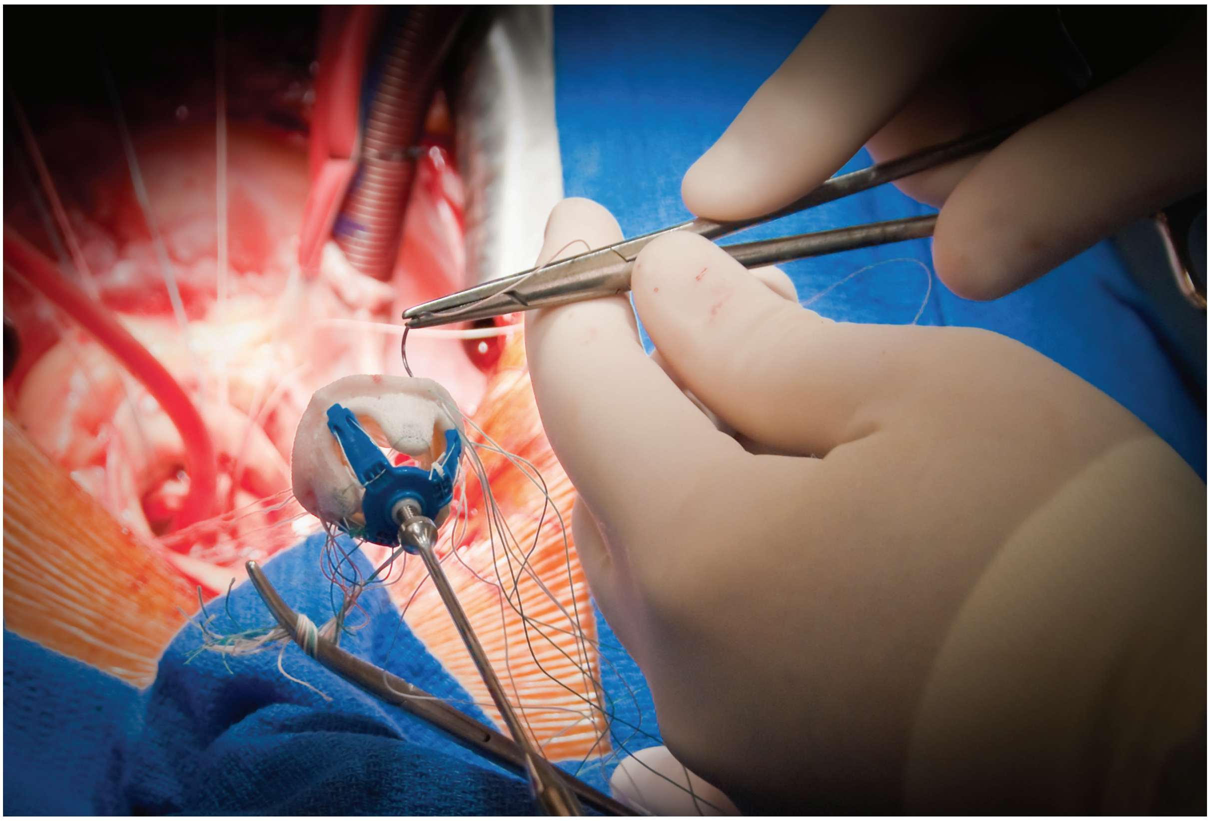


Table 13. Sex differences in clinical characteristics for isolated AoV and MV surgery, 2010-2019

	Isolated AoV surgery		Isolated MV surgery	
	Male	**Female**	**Male**	**Female**
n	8403	4646	4070	2744
Risk factors (%)				
Diabetes (oral therapy)	14.4	14.2	4.8	6.5
Hypertension	66.9	71.1	46.3	46.5
Hypercholesterolaemia	52.4	55.5	31.4	32.8
Current smoker	10.1	6.5	9.5	10.0
Peripheral vascular disease	6.2	4.1	2.2	2.9
Pre-op dialysis	1.8	0.9	1.3	1.6
Renal transplant	0.7	0.5	0.5	0.4
Arrhythmia	17.6	15.3	25.8	30.1
NYHA class				
I	28.2	21.1	30.4	19.7
II	40.0	40.1	39.3	37.3
III	27.1	33.8	24.5	34.0
IV	4.7	5.1	5.8	9.1
Clinical status				
Elective	85.4	89.9	85.0	84.7
Urgent	12.9	9.0	12.7	12.5
Emergency	1.6	1.1	2.2	2.7
Salvage	0.0	0.0	0.1	0.1
LVF				
Normal LVF (EF>60%)	56.5	67.8	59.2	62.0
Mild LVD (EF>45%-≤60%)	29.3	25.1	30.7	28.8
Moderate LVD (EF≥30%-≤45%)	10.6	5.4	8.7	8.0
Severe LVD (EF<30%)	3.6	1.7	1.4	1.1
Risk factors (means)				
Age	66.3	70.2	61.0	61.9
BMI	29.4	30.1	26.7	27.0
BSA	2.0	1.7	1.9	1.7
Pre-operative [Hb]	136.2	127.2	137.7	126.3
eGFR	84.2	71.3	84.9	73.2

Figure 32. Frequency distribution of age by sex for isolated AoV surgery, 2010-2019

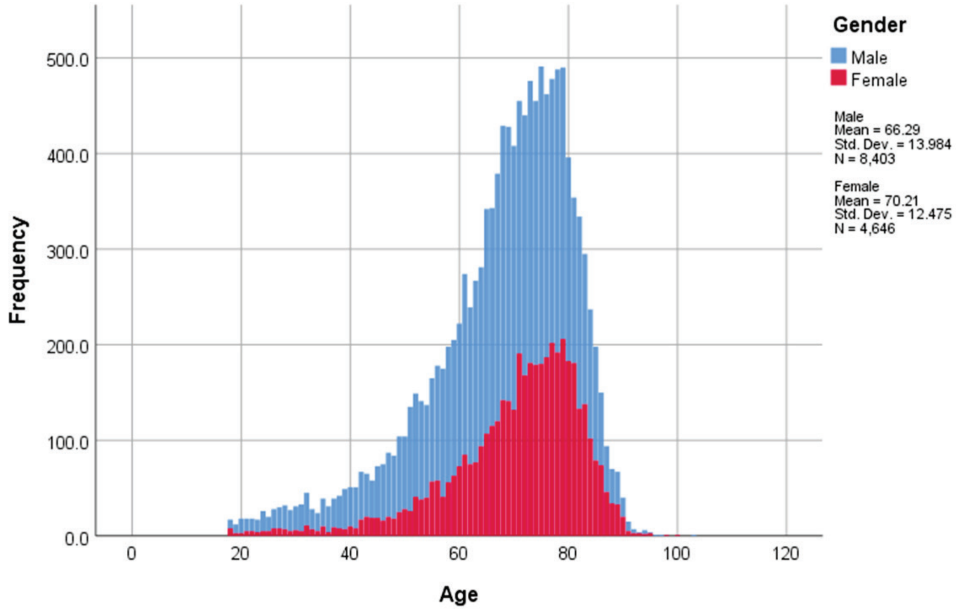


Figure 33. Frequency distribution of age by sex for isolated MV surgery, 2010-2019

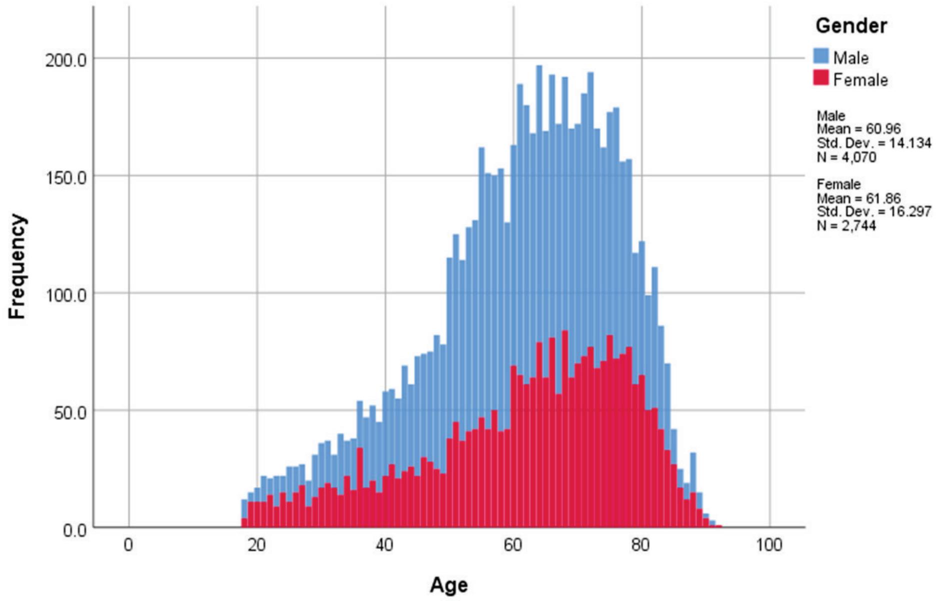


Table 14. Clinical outcomes by sex for isolated AoV and MV surgery, 2010-2019

	Isolated AoV surgery		Isolated MV surgery	
	Male	Female	Male	Female
n	8403	4646	4070	2744
Outcomes (%)				
OM	1.5	2.4	1.3	2.8
DSWI	0.8	0.6	0.5	0.4
Permanent stroke	1.1	1.0	1.3	2.0
DNRI	4.3	3.6	4.1	2.8
Re-op for bleeding	4.0	2.9	4.1	3.5
RBC transfused	25.6	40.9	23.7	40.9
NRBC transfused	23.8	20.5	22.2	23.7

It has been discussed in the literature that females tend to receive fewer MV repairs than their male counterparts[18]. This may be due to a different aetiologic spectrum and more advanced disease presentations.

Data from the ANZSCTS Database observes a similar trend, explored below in Figures 34-36.

Figure 34. MV surgery by sex, 2010-2019

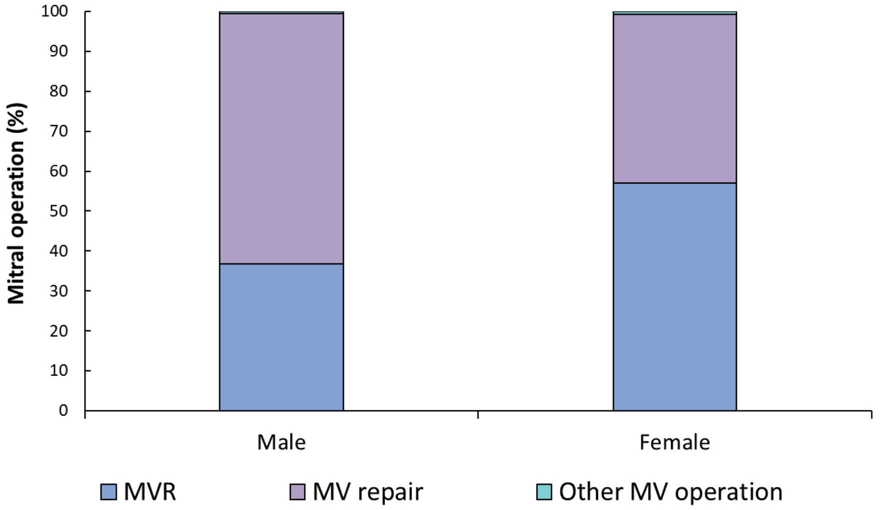


Table 15. MV surgery type by aetiology and sex, 2010-2019

	MVR (%)		MV repair (%)		Total MV surgery (n)	
	Male	Female	Male	Female	Male	Female
Rheumatic	84.3	91.4	15.7	8.6	204	614
Congenital	25.3	27.3	74.7	72.7	79	44
Ischaemic	38.8	56.1	61.2	43.9	121	57
Idiopathic calcific.	50.0	70.4	50.0	29.6	142	135
Myxomatous degen.	21.7	33.1	78.3	66.9	2140	1043
Failed prior repair	77.3	90.6	22.7	9.4	132	64
Active infection	70.4	74.8	29.6	25.2	378	206

Please note not all aetiologies captured by the ANZSCTS Database feature in this table

Table 15 describes the difference in the proportion of males and females receiving MV replacements (MVR) or MV repairs by aetiology. For the data shown in Table 15, females have a proportionally higher rate of MVR over MV repairs for the aetiologies presented.

Figures 35 and 36 describe the sex differences in the severity of MV disease among patients receiving MV surgery. It appears that while females present with a higher frequency of trivial to moderate regurgitation, males are more likely to present with severe regurgitation. Among patients having MV surgery, there is a higher proportion of females with clinically significant stenosis of the MV, compared to males.

It can be seen in Table 15 that women are more likely to present with rheumatic valve disease, which is associated more with stenosis than regurgitation. This could explain the data presented in Figures 35 and 36.

Figure 35. Mitral regurgitation severity in patients having MV surgery by sex, 2010-2019

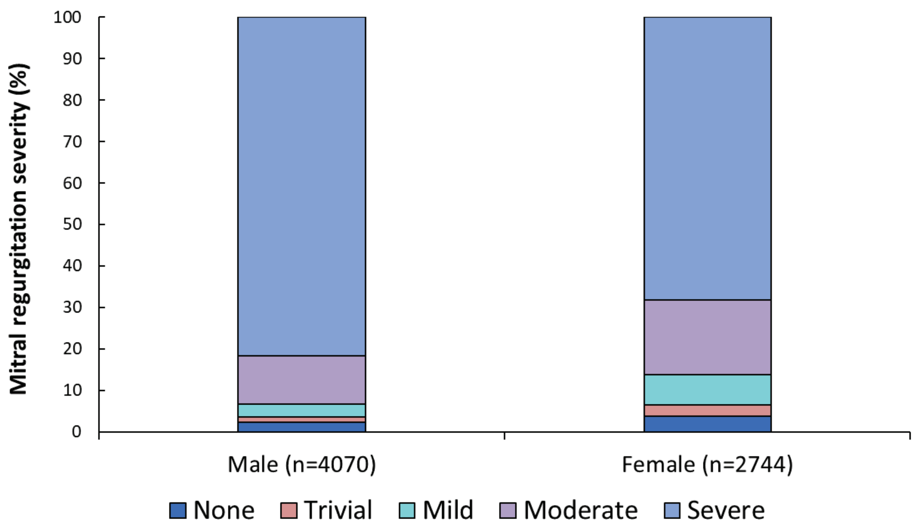


Figure 36. Clinically significant mitral stenosis in patients having MV surgery by sex, 2010-2019

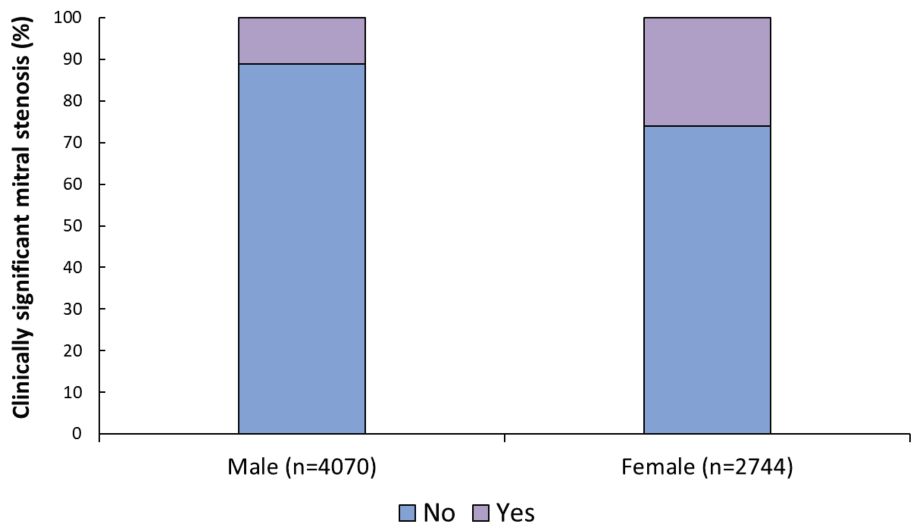
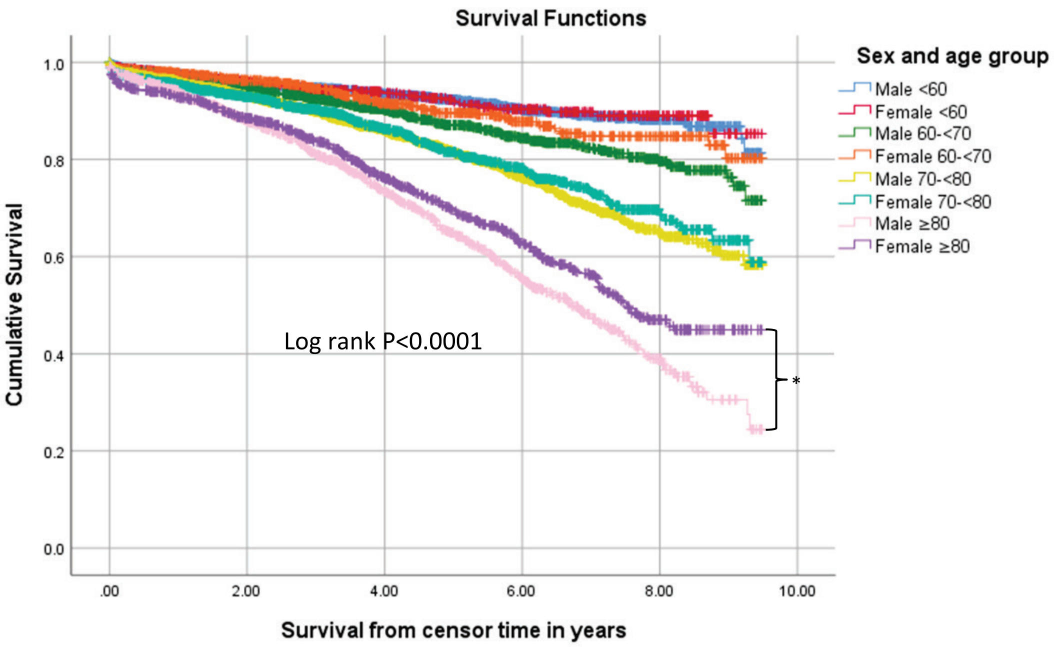


Figure 37. Long-term survival of patients having isolated AoV surgery by sex and age group, 2010-2019

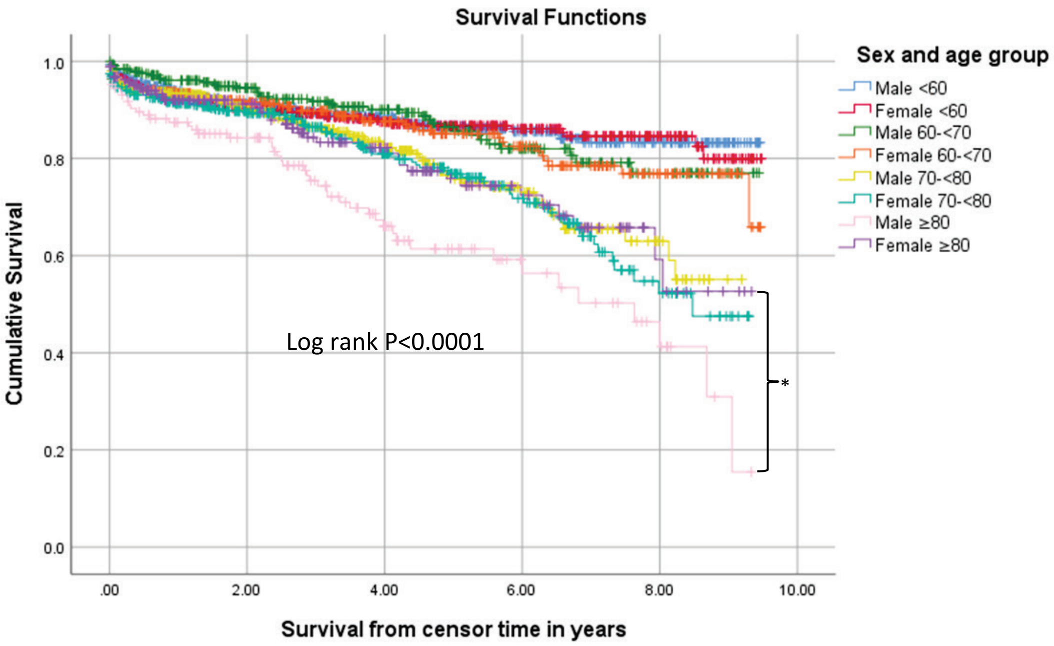


* P<0.01

Table 16. Cases remaining and survival (%) for isolated AoV surgery, at 1, 3, 5 and 7 years post-surgery by sex and age group, 2010-2019

	Cases remaining (n)				Survival (%)			
Time since surgery	1 year	3 year	5 year	7 year	1 year	3 year	5 year	7 year
Male <60	1702	1179	707	350	97.5	94.7	92.2	88.8
Female <60	599	405	246	118	97.2	94.2	91.9	89.0
Male 60-<70	1664	1157	622	166	96.9	92.3	86.9	79.6
Female 60-<70	803	547	273	144	97.7	94.5	89.3	84.7
Male 70-<80	2209	1403	770	326	95.9	89.9	81.4	69.9
Female 70-<80	1446	973	551	255	95.3	90.1	81.3	73.2
Male ≥80	999	665	368	138	93.9	81.0	64.7	47.2
Female ≥80	874	634	369	170	92.7	83.6	69.5	56.2

Figure 38. Long-term survival of patients having isolated MVR by sex and age group, 2010-2019



* P<0.01

Table 17. Cases remaining and survival (%) for isolated MVR at 1, 3, 5 and 7 years post-surgery by sex and age group, 2010-2019

	Cases remaining (n)				Survival (%)			
Time since surgery	1 year	3 year	5 year	7 year	1 year	3 year	5 year	7 year
Male <60	413	288	206	98	93.7	89.3	86.6	83.3
Female <60	429	290	203	111	92.4	88.9	86.7	84.6
Male 60-<70	272	182	105	55	96.1	91.7	85.6	79.2
Female 60-<70	270	178	123	48	93.5	89.3	85.1	76.9
Male 70-<80	297	186	96	25	93.1	86.0	75.8	63.0
Female 70-<80	312	186	117	38	91.4	86.0	76.8	62.4
Male ≥80	117	72	27	16	87.4	75.4	59.2	50.3
Female ≥80	143	85	51	27	92.0	83.3	75.9	65.8

Figure 39. Long-term survival of patients having isolated MV repair by sex and age group, 2010-2019

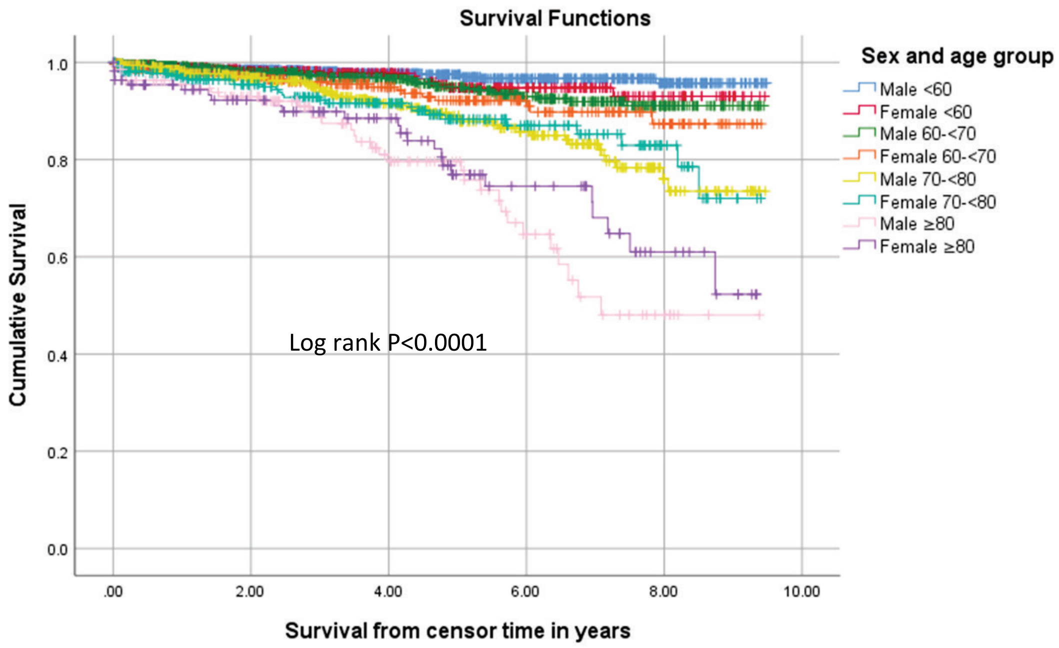


Table 18. Cases remaining and survival (%) for isolated MV repair at 1, 3, 5 and 7 years post-surgery by sex and age group, 2010-2019

	Cases remaining (n)				Survival (%)			
Time since surgery	1 year	3 year	5 year	7 year	1 year	3 year	5 year	7 year
Male <60	895	641	366	107	98.8	98.0	97.2	95.7
Female <60	328	224	150	54	98.9	97.8	94.8	93.0
Male 60-<70	598	403	257	161	99.1	96.9	94.6	91.9
Female 60-<70	274	196	124	36	97.7	95.5	92.2	87.3
Male 70-<80	389	255	147	71	97.9	94.4	88.4	82.0
Female 70-<80	219	155	97	48	96.4	92.2	88.3	85.2
Male ≥80	115	74	41	13	94.7	87.4	77.7	48.1
Female ≥80	92	65	41	20	94.4	88.5	76.9	64.8

For isolated valve surgery, as for isolated CABG, reported long-term survival is generally lower in females than males. This was examined using the ANZSCTS Database data for all patients who had such operations. Figures 37, 38 and 39 illustrate the trends for AoV surgery (P<0.0001), MVR (P<0.0001) and MV repair (P<0.0001), respectively.

There was no significant difference between sexes in any of the <80 years patient groups for AoV surgery. However, for both AoV surgery and MVR the graphs show a survival advantage in female patients 80 and older (P<0.01). This can be observed for both AoV (Figure 37/Table 16) and MV surgery (Figure 38-39/Table 17-18).

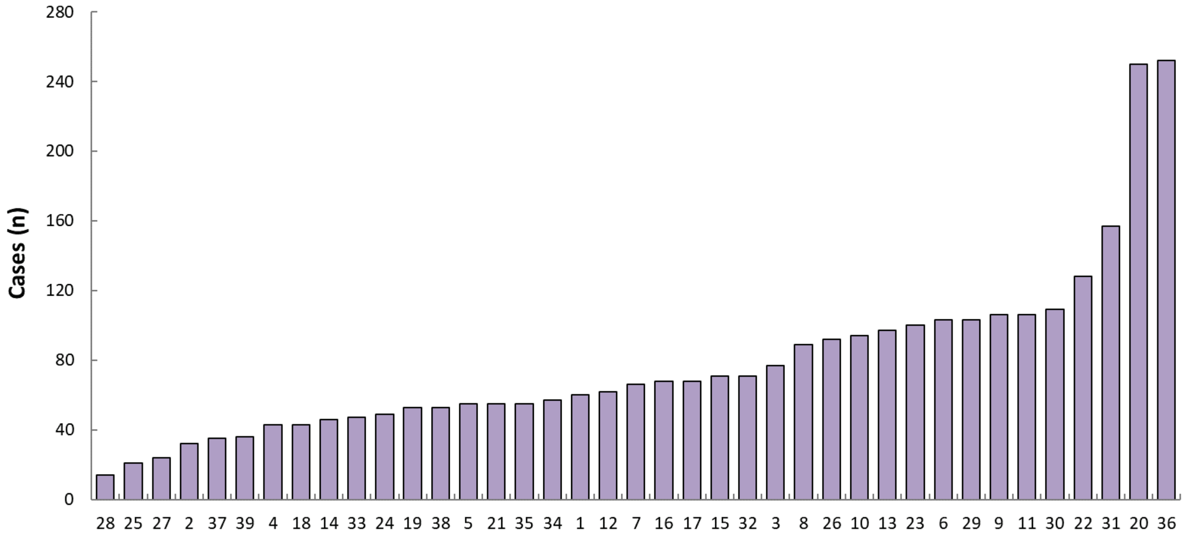
The LOTTERY study is an example of important research that utilises the ANZSCTS Database with the intent to provide a greater understanding of the effect of sex on cardiac surgical outcomes.

3. Isolated Valve Surgery

This section explores the patient population and outcomes for isolated valve surgery. TAVR, TMVR and MitraClip insertions are not included in the following grouped analyses.

In 2019, the number of isolated valve surgery performed by contributing units ranged from 14 to 252 (Figure 40).

Figure 40. Isolated valve surgery performed by unit, 2019



3.1 Patient characteristics

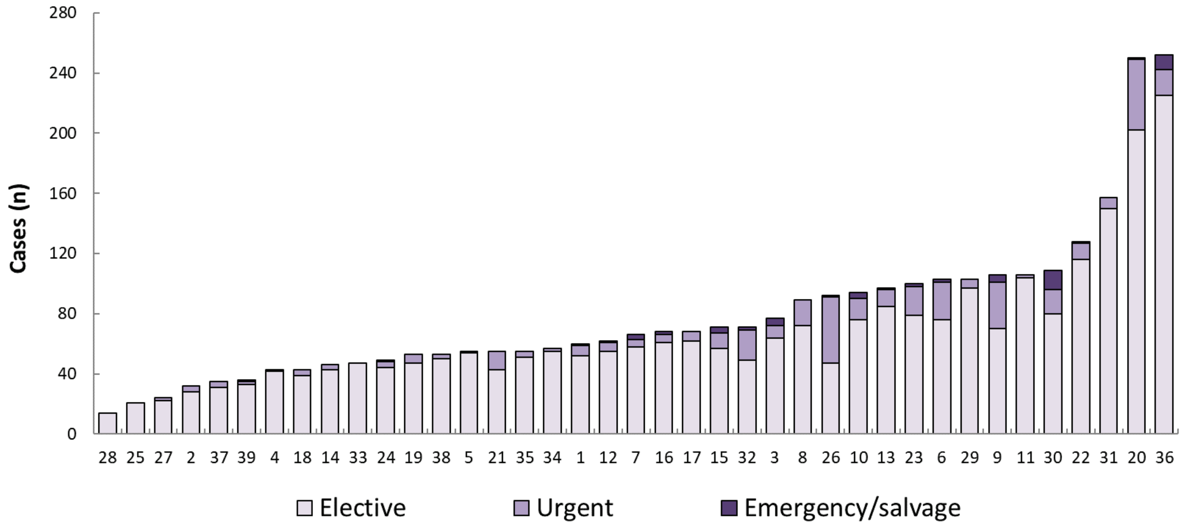
Since patient characteristics such as clinical status at presentation, age, sex, and other comorbidities can influence outcomes in the isolated valve surgery patient population, the distribution of those factors are explored in the following sections.

3.1.1 Clinical status

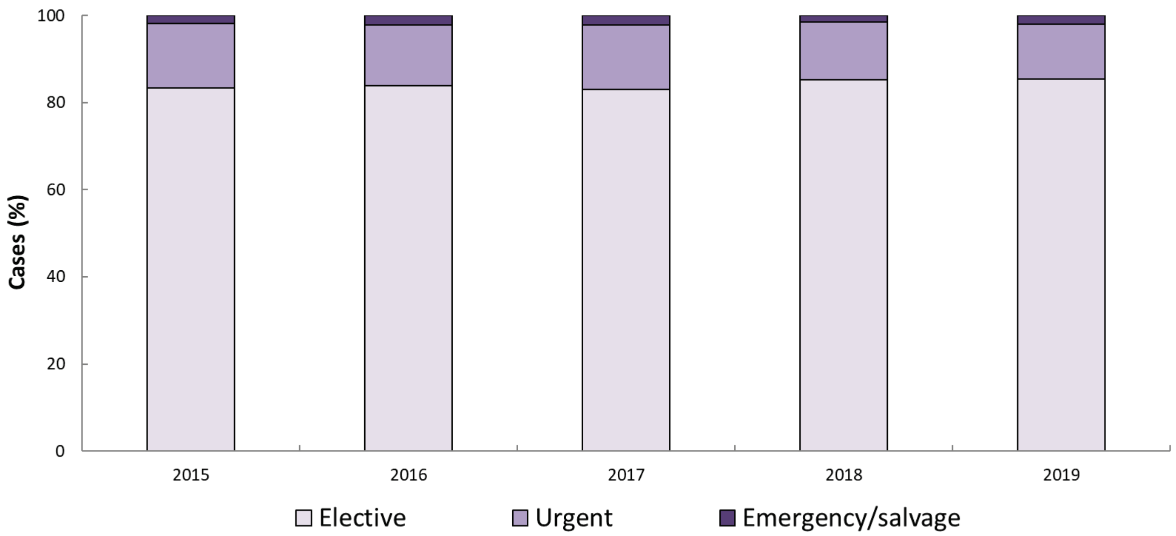
The proportion of reported urgent and emergency or salvage cases in 2019 varied between units (Figure 41a). The isolated valve patient groups reported clinical status has remained relatively consistent over the past five years, unlike isolated CABG which showed an increase in reported urgent cases after 2016. Isolated valve surgery had a higher proportion of reported elective surgery accounting for an average of 84.2% of cases (Figure 41b).

Figure 41. Clinical status of isolated valve patients

a. Units in 2019



b. Year

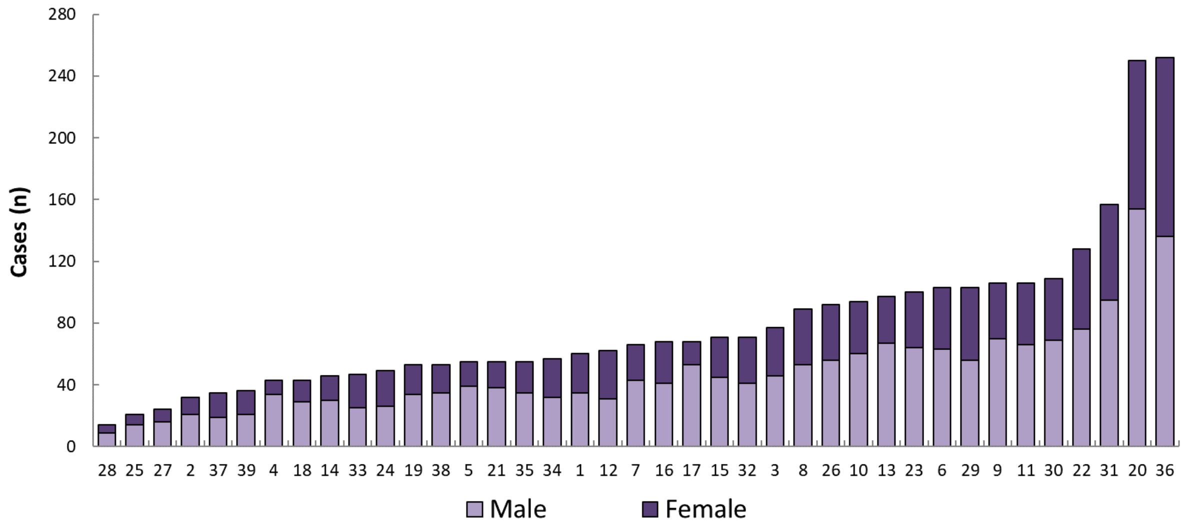


3.1.2 Sex and age

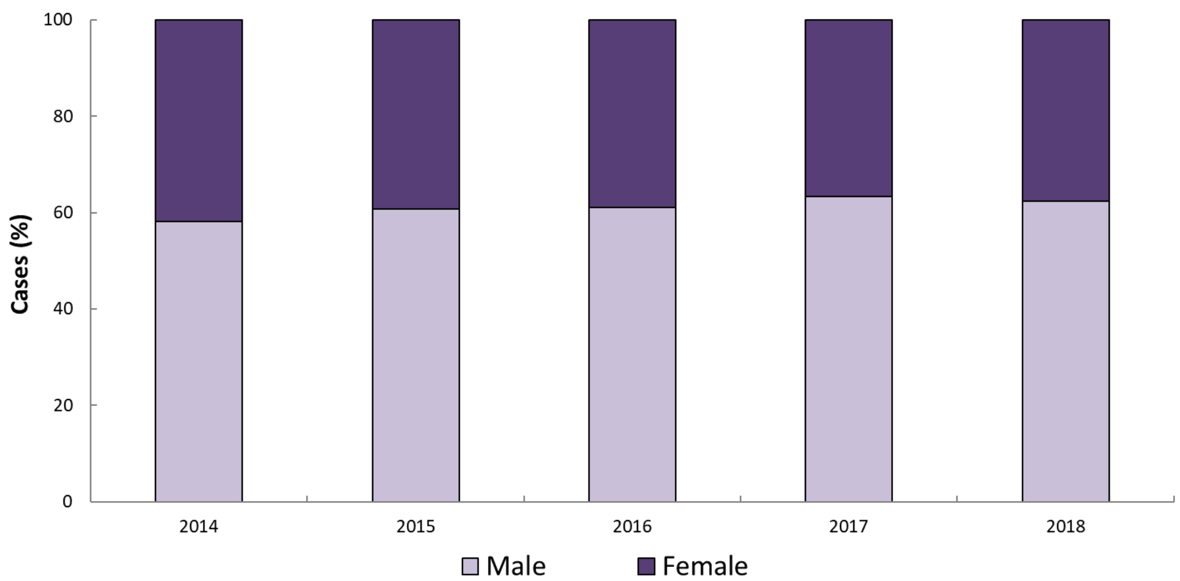
The ratio of male to female patients was largely consistent between units in 2019 (Figure 42a). The average proportion of male to female patients having isolated valve surgery in 2019 remained consistent with previous years, so that approximately 62% were male (Figure 42b).

Figure 42. Sex of isolated valve patients

a. Units in 2019

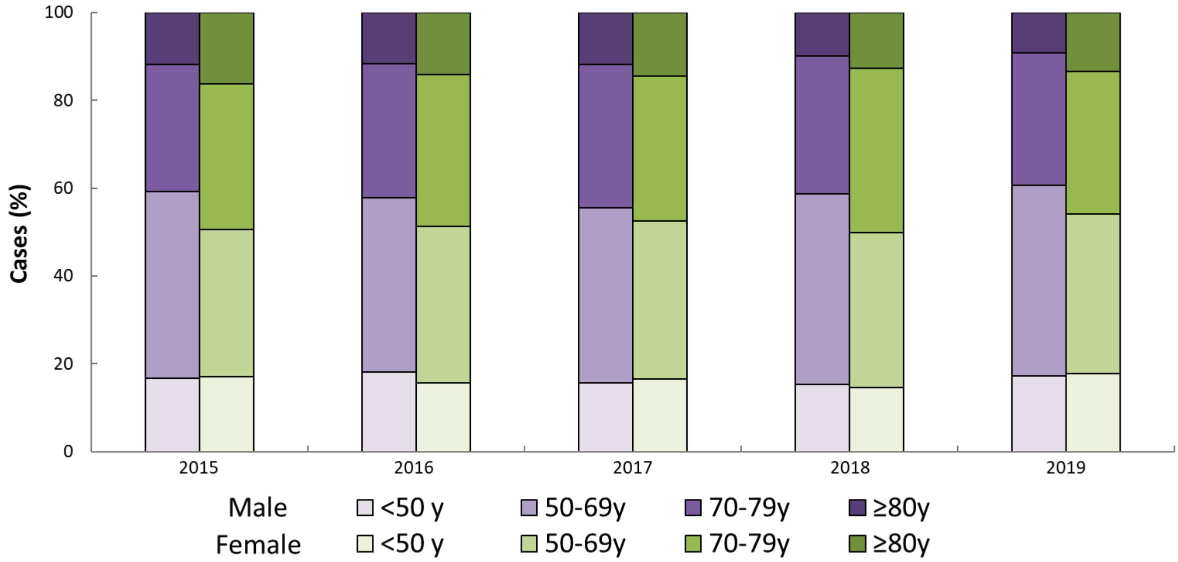


b. Year



As was the case with isolated CABG, a higher proportion of females having isolated valve surgery over the last five years were aged 70 years and over (Figure 43). Interestingly, this proportion decreased by approximately 5% in 2019, contrary to that observed for isolated CABG.

Figure 43. Age groupings for male and female isolated valve patients, 2015-2019

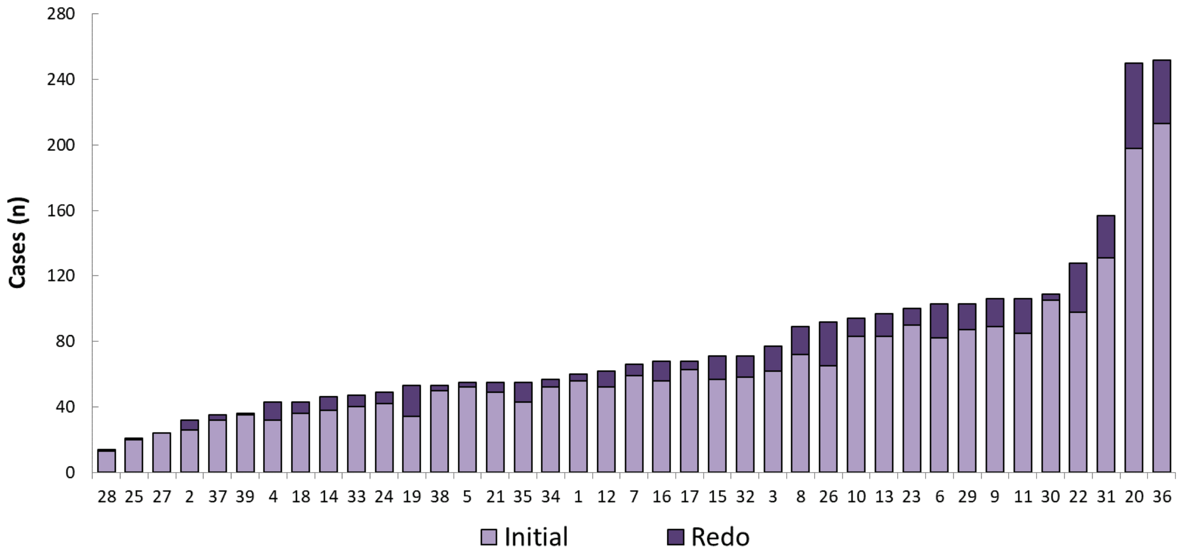


3.2 Previous surgery

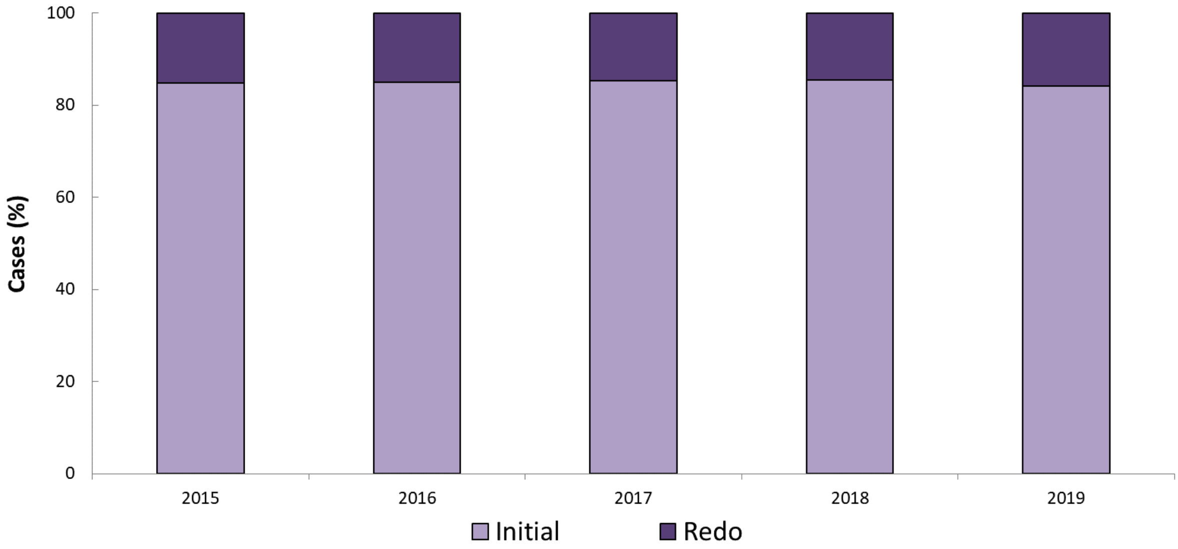
An operation is considered a redo if the patient had any prior cardiac surgery. In 2019, the proportion of isolated valve surgery patients who had previous cardiac surgery varied between units from 0 to 35.8% (Figure 44a). The overall proportion of cases in 2019 that had redo surgery remained similar to previous years at 15.9%, being 14- and 4-fold higher than isolated CABG and combined valve and CABG, respectively (Figure 44b).

Figure 44. Isolated valve: initial and redo surgery

a. Units in 2019



b. Year



3.3 Overview of all valve surgery

Case numbers and OM for single and multiple valve surgery is detailed in Table 19. We emphasise that OM is not risk-adjusted, therefore takes no account of clinical nor patient characteristics. Since annual incidence is generally low, apparently large differences between 2019 OM and 2015-2018 OM rates may not reflect significant changes in that outcome, however, it is clear that tricuspid surgery, alone or in combination, increases OM.

A full list of valve surgery is available in the ANZSCTS Database Data Definitions Manual version 4 (available on request to the ANZSCTS Database Team).

Combined valve and CABG surgery is presented in Section 4 (Table 23). TAVR cases are reported in Table 20. The ANZSCTS Database released a specific TAVR module in September 2016 and receive a small proportion of the TAVRs performed in Australia.

The most common isolated valve surgery performed in 2019 and in the preceding four years were single aortic, which predominantly involve AoV replacements (AVR), followed by single mitral (Table 19).

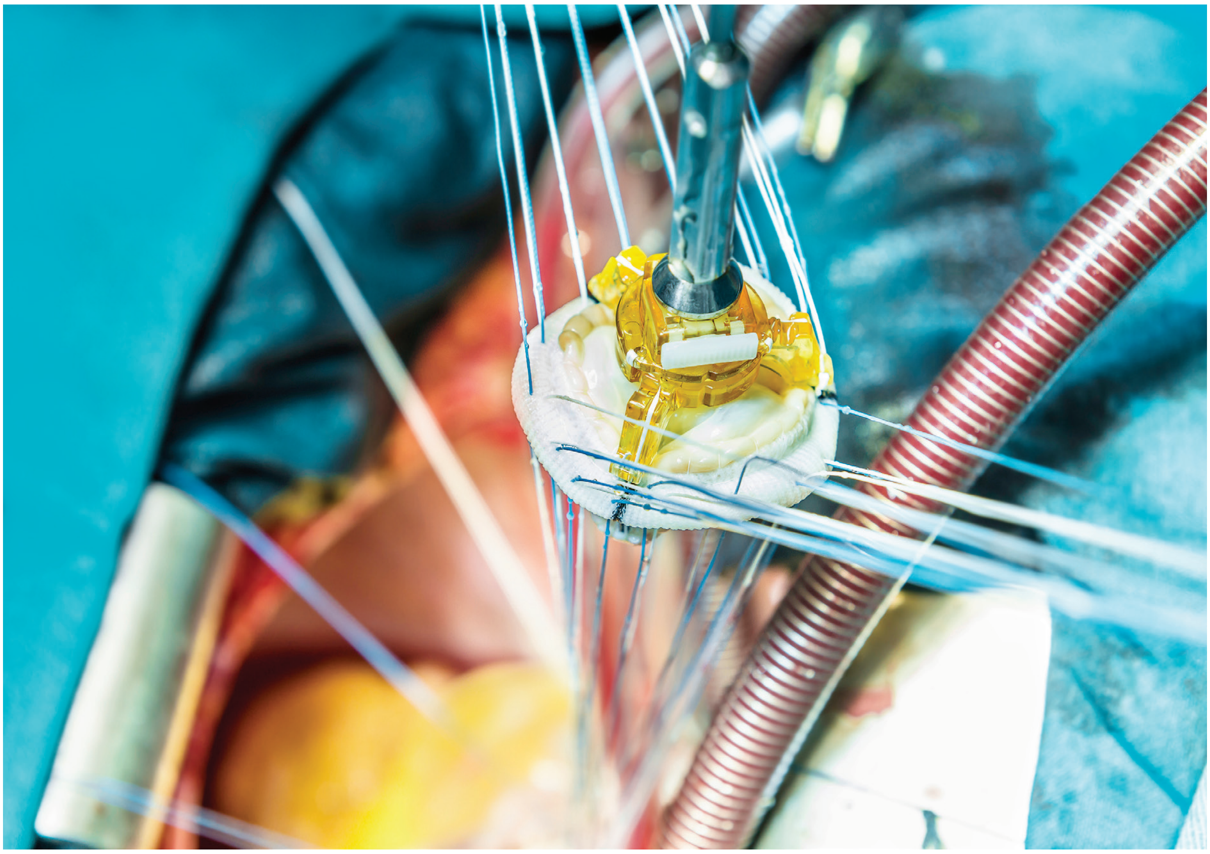


Table 19. OM (%) for valve surgery, 2019 and 2015-2018^

Valve surgery	Year	n	OM (%)
Single aortic[#]	2019	1475	1.4
	2015-2018	6056	1.6
AVR	2019	1420	1.4
	2015-2018	5786	1.6
Other aortic	2019	55	1.8
	2015-2018	270	1.5
Single mitral*	2019	955	1.0
	2015-2018	3111	1.7
MVR	2019	450	1.8
	2015-2018	1369	3.3
Repair	2019	502	0.2
	2015-2018	1722	0.3
Single tricuspid	2019	81	7.4
	2015-2018	247	5.3
Single pulmonary	2019	40	0.0
	2015-2018	166	1.2
Aortic and mitral	2019	165	3.6
	2015-2018	685	5.0
Aortic and tricuspid	2019	31	6.5
	2015-2018	74	4.1
Mitral and tricuspid	2019	238	2.5
	2015-2018	610	3.9
Other double	2019	16	0.0
	2015-2018	50	4.0
Triple	2019	46	0.0
	2015-2018	195	7.7
Quadruple	2019	0	-
	2015-2018	2	0.0
Total valve surgery	**2019**	**3047**	**1.7**
	2015-2018	**11196**	**2.2**

[#]AoV surgery excludes TAVR
*MV surgery excludes TMVR and insertion of MitraClip device
^3 cases excluded from table due to missing data

Table 20. OM (%) for TAVR, 2019 and 2015-2018

Valve surgery	Year	n	OM (%)
TAVR	2019	493	0.8
	2015-2018	993	1.7
Transapical	2019	1	0.0
Transfemoral	2019	340	1.2
Transaortic	2019	10	0.0
Transsubclavian	2019	10	0.0
Unknown access route^	2019	132	0.0
Total other valve surgery	2019	536	0.9
	2015-2018	1270	1.6

^132 cases had missing access route data

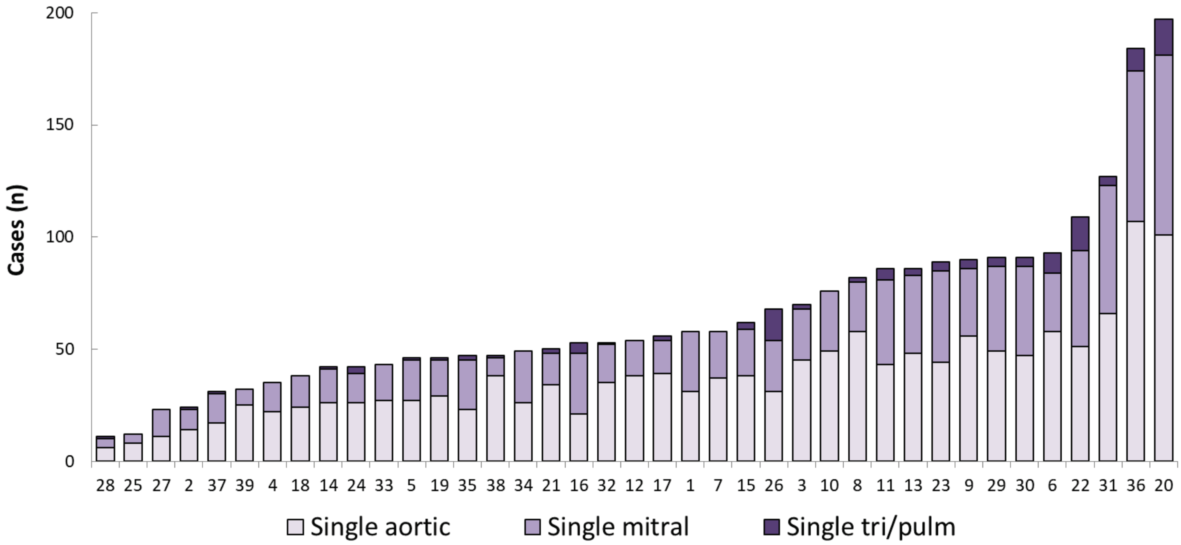
3.4 Single valve surgery

3.4.1 Type of surgery

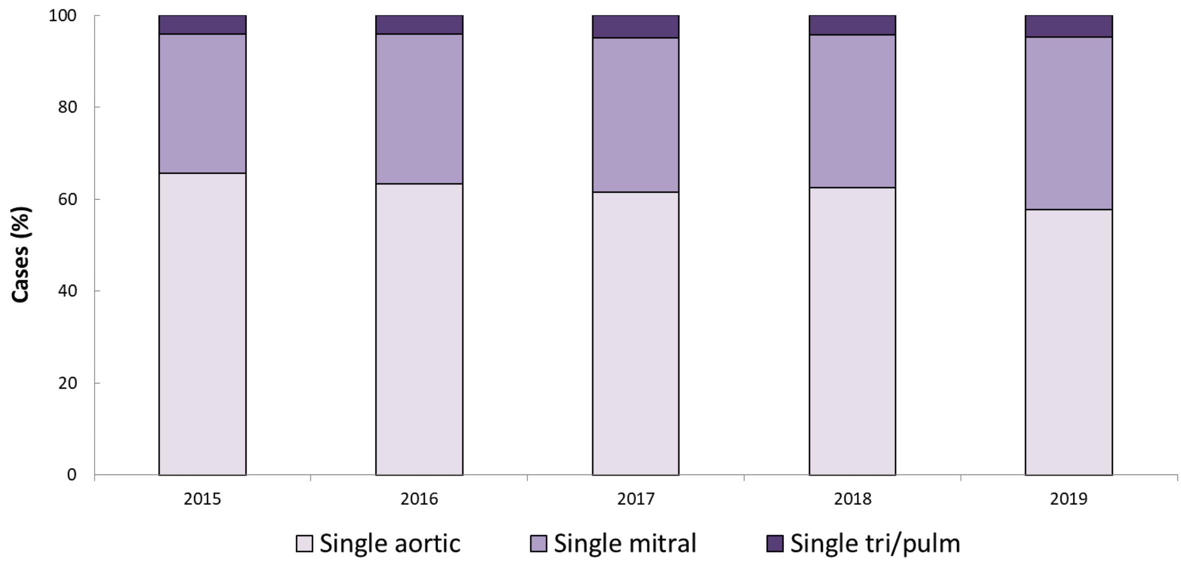
The relative proportions of the types of single valve surgery were consistent between units in 2019, apart from a small number of units that showed a larger proportion of single tricuspid or pulmonary valve surgery (tri/pulm; Figure 45a). In 2019, the proportion of patients having single AoV surgery decreased to 57.8% from 65.7% in 2015 (Figure 45b). There was a proportionate increase in single MV surgery from 30.3% in 2015 to 37.4% in 2019, while isolated tricuspid and pulmonary valve surgery remained consistent at approximately 4%.

Figure 45. Type of isolated single valve surgery performed

a. Units in 2019



b. Year



3.4.2 Influence of patient characteristics on 30-day mortality

Generally, OM was higher for patients with more exigent clinical status or redo operations (Table 21). The relationship between mortality and age, LVF, and previous MI was less consistent, particularly for MVR and MV repair, which may be related to lower case numbers. It should be noted that OM is not risk-adjusted and therefore does not account for differences in patient characteristics.

The table below refers to surgical valve replacement. Non-invasive percutaneous valve replacements such as TAVR and TMVR insertion have been excluded. Insertion of a MitraClip device has also been excluded.

Table 21. Influence of patient characteristics on OM (%) for the three most common isolated single valve operations, 2015-2019

	AVR		MVR		MV repair	
	n	OM (%)	n	OM (%)	n	OM (%)
Clinical status						
Elective	6219	1.1	1399	1.9	2000	0.3
Urgent	891	3.7	342	5.0	207	1.0
Emergency/salvage	96	13.5	78	11.5	17	0.0
Sex/age						
Male	4709	1.4	896	2.3	1559	0.1
<50y	480	0.0	169	4.1	324	0.0
50-69y	1901	1.2	358	2.0	838	0.1
70-79y	1721	1.7	275	1.1	317	0.3
≥80y	607	2.5	94	4.3	80	0.0
Female*	2497	1.9	923	3.5	665	0.8
<50y	142	2.1	218	2.3	133	0.0
50-69y	881	0.8	332	3.6	303	0.7
70-79y	1027	2.1	257	5.1	169	1.2
≥80y	446	3.6	116	1.7	60	1.7
LVF						
Normal LVF (EF>60%)	4107	1.0	1004	3.0	1362	0.3
Mild LVD (EF>45%-≤60%)	2139	2.1	552	3.3	699	0.4
Moderate LVD (EF≥30%-≤45%)	632	2.8	185	1.6	127	0.0
Severe LVD (EF<30%)	207	3.9	45	4.4	15	0.0
Previous MI						
No MI	6662	1.5	1671	2.8	2172	0.3
NSTEMI	360	3.3	71	7.0	30	3.3
STEMI	85	0.0	54	1.9	9	0.0
Unknown type	99	5.1	23	0.0	13	0.0
Previous surgery						
Initial	6426	1.3	1396	2.4	2145	0.3
Redo	780	4.0	423	4.5	79	0.0

*1 case missing female age group data for AVR

^121, 33 and 21 cases either did not have their LVEF measured or have a missing/unknown EF entered for AVR, MVR and MV repair, respectively.

3.5 Aortic Valve Replacement

Due to the differences in outcomes for the various valve categories, isolated AVR being the largest group, is analysed in the following section. The number of AVRs performed by units in 2019 varied from 6 to 106 (Figure 46). Since 2015, the numbers of limited access surgery has slowly and marginally increased to 10.8% of isolated AVRs in 2019 (Figure 47).

Figure 46. Isolated AVR performed by unit, 2019

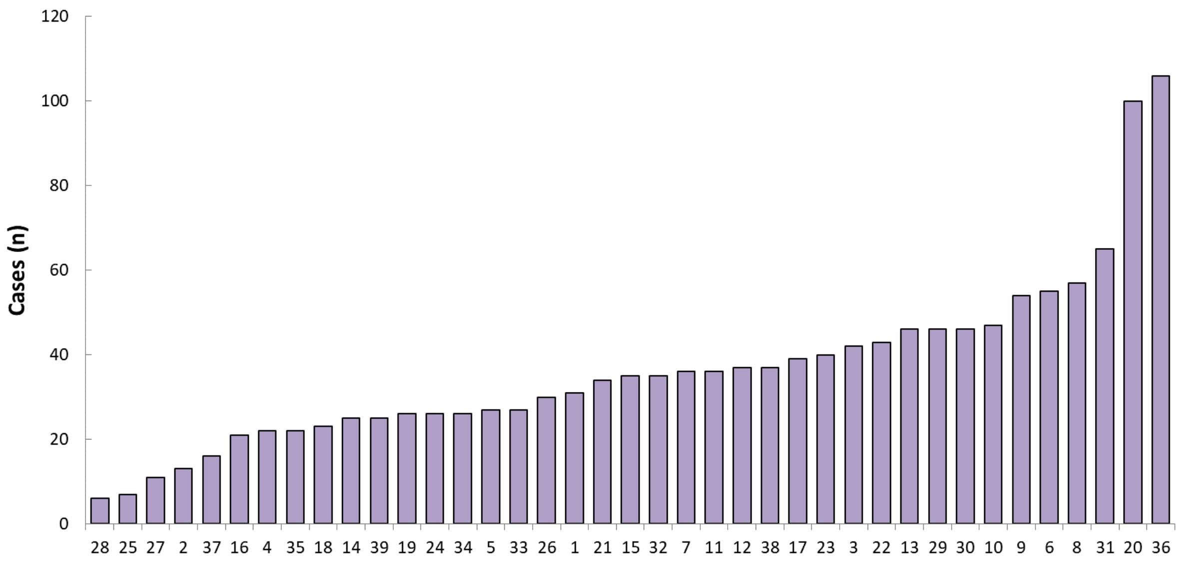
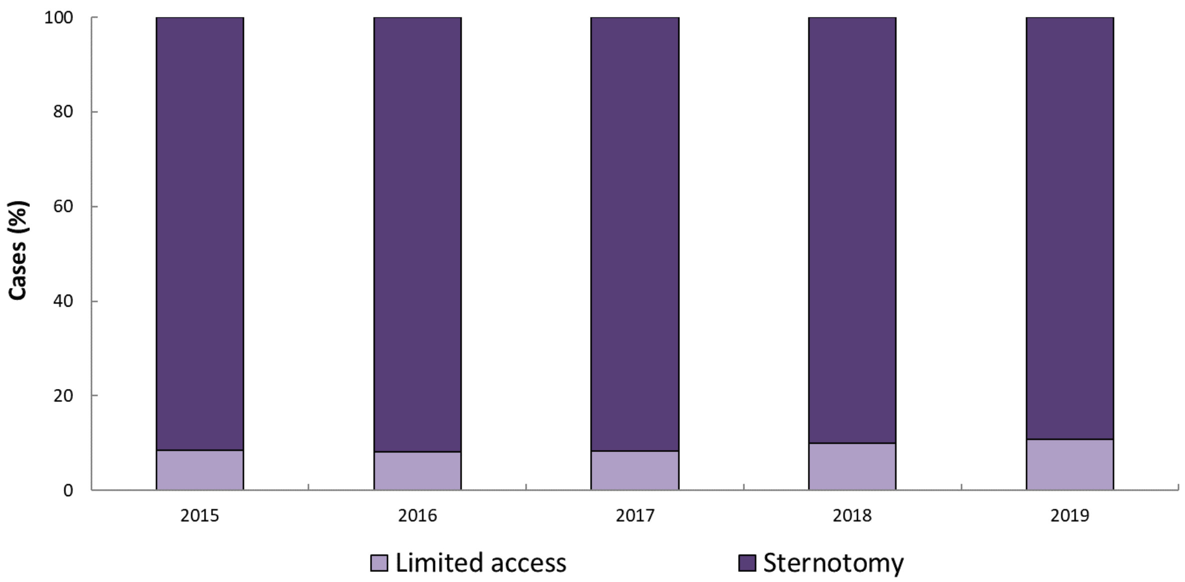


Figure 47. Surgical access for isolated AVR, 2015-2019



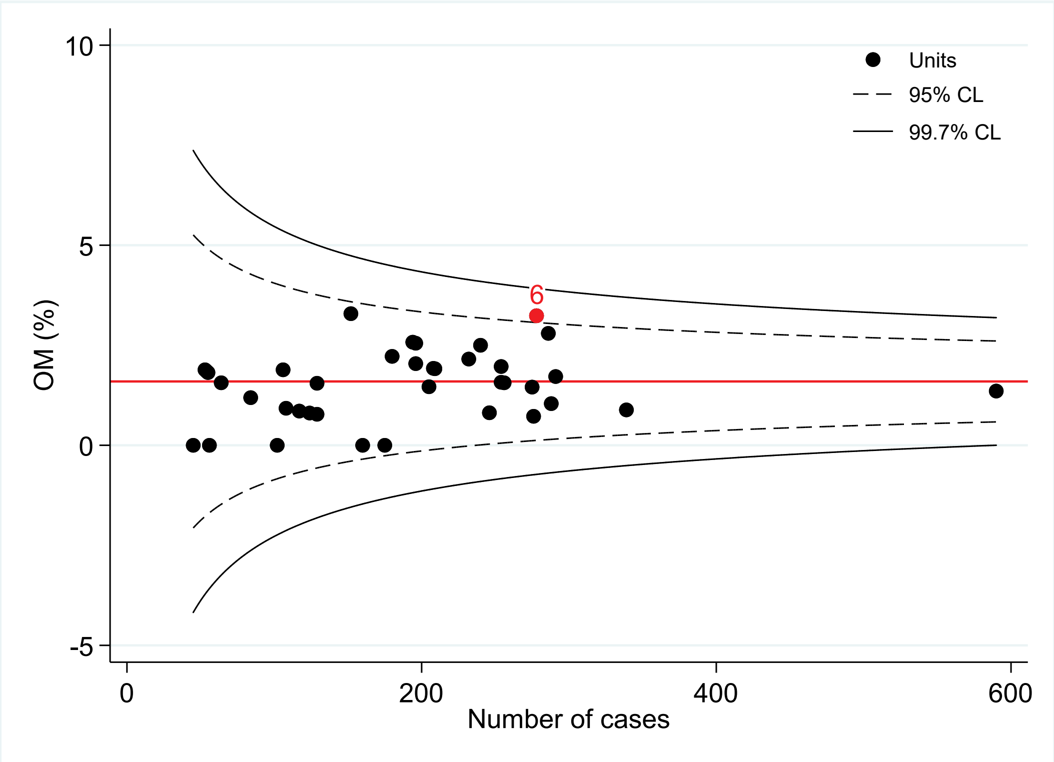
3.5.1 Unit outcomes – mortality, complications and resource utilisation

Unit outcomes are reported for the pooled 2015-2019 period for isolated AVR due to low surgical numbers making individual year outcome data difficult to interpret.

3.5.1.1 30-day mortality

Between 2015 and 2019, the average OM for all isolated surgical AVR cases submitted to the Database was 1.60%, a slight decrease from that in the 2018 annual report[8] (Figure 48). In comparison, the most recent data by the SWEDEHEART registry, reported 30-day mortality for isolated AVR at 2.04% in 2019; the American STS operative mortality for isolated AVR was 2.2% from their 2018 annual report; and the New Zealand mortality for first-time isolated AVR in 2017 was 1.2%[5-6,10]. All units were within the upper 99.7% CL.

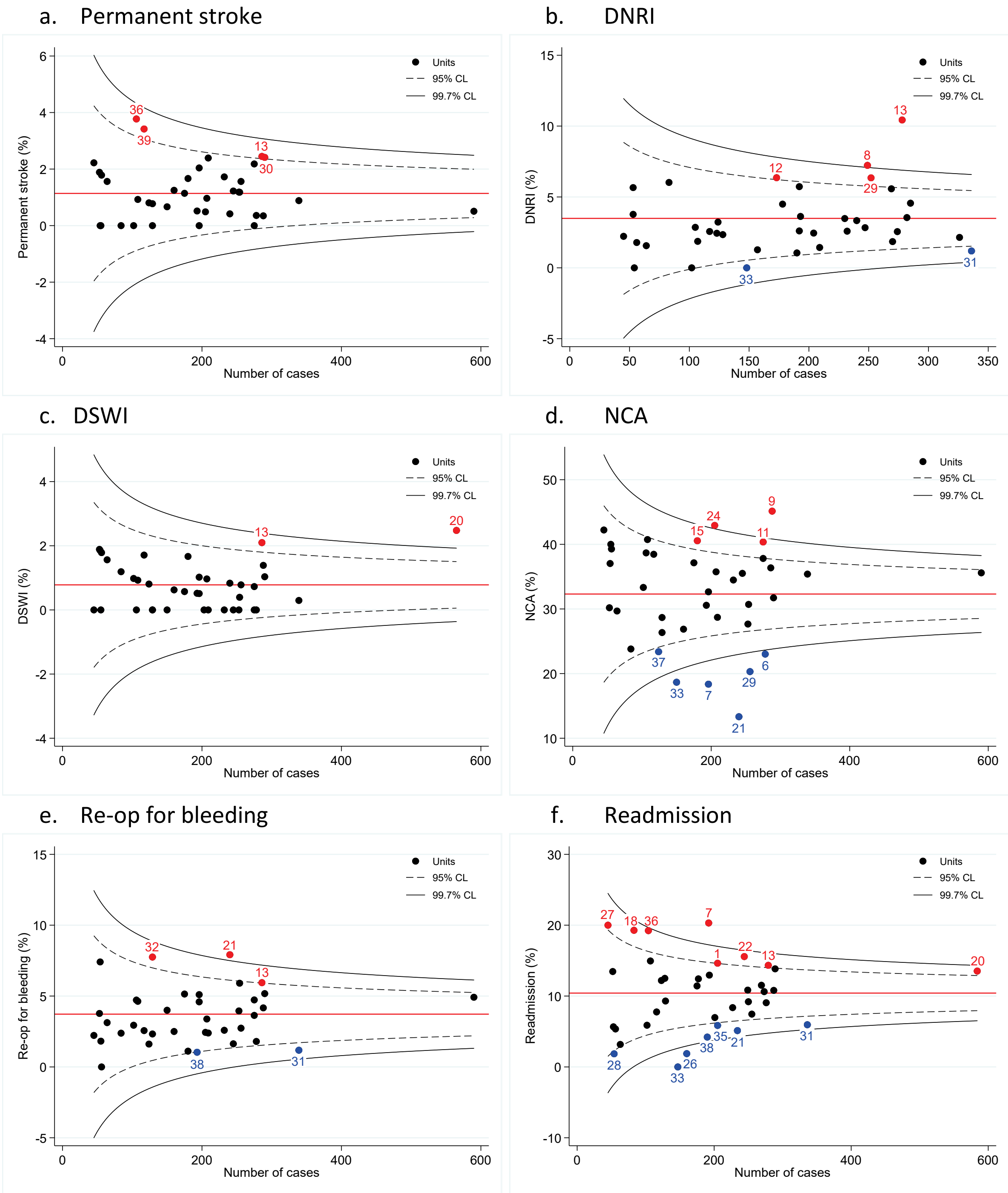
Figure 48. OM by unit following AVR, 2015-2019



3.5.1.2 Complications

While the mean incidences of permanent stroke (1.14%) and DSWI (0.78%) were similar for most units, there was notable variation for DNRI (3.49%), NCA (32.3%), re-op for bleeding (3.72%), and readmission (10.4%; Figure 49). These values remained consistent with those reported in the 2018 annual report[8]. The data for incidence of DNRI excludes patients who received pre-operative dialysis (Figure 49b).

Figure 49. Complications by unit following AVR, 2015-2019



3.5.1.3 Resource utilisation

As for Section 1, due to the skewed distribution of the ICU length of stay and ventilation data, the GMs are presented. The GM is defined as the nth root of a product of n numbers. It is less sensitive to outlying values, therefore describes the central tendency of a skewed data-set more precisely.

The pooled data shows marked variation between units for the time patients spent in the ICU, the duration of ventilation, and the percentage of patients who received RBC or NRBC transfusions (Table 22). The ICU length of stay and ventilation times were similar to those for isolated CABG cases, as were the proportion of cases involving transfusions.

Table 22. Resource utilisation by unit for isolated AVR patients, 2015-2019

	2015-2019			
Unit	ICU (GM, h)	Ventilation (GM, h)	RBC usage (%)	NRBC usage (%)
1	33.4	10.5	28.4	28.4
2	34.5	6.3	13.2	39.6
3	38.2	9.2	36.7	26.5
4	57.9	8.9	38.9	29.6
5	75.5	15.2	4.9	2.0
6	106.1	10.9	34.9	21.6
7	38.1	10.4	22.4	19.9
8	72.0	13.6	36.6	25.2
9	81.5	8.7	31.3	19.4
10	59.2	9.7	25.3	19.4
11	54.3	8.9	36.6	17.0
12	37.8	11.2	32.0	25.1
13	52.7	9.3	32.9	28.0
14	52.4	13.5	26.6	51.6
15	38.0	8.6	14.4	8.9
16	37.8	7.8	20.9	22.5
17	30.8	10.1	26.3	14.7
18	64.3	6.5	26.2	15.5
19	62.2	7.9	14.3	35.7
20	31.4	8.7	25.1	20.2
21	37.7	14.0	39.2	38.8
22	29.7	8.9	25.2	11.8
23	25.1	9.0	17.8	6.5
24	43.8	12.2	38.2	23.0
26	38.6	8.0	18.1	24.4
27	71.3	7.4	15.6	4.4
28	32.2	9.8	14.5	12.7
29	48.2	13.4	30.1	17.2
30	42.3	7.9	26.8	15.5
31	53.3	8.8	9.4	4.4
32	65.8	13.1	20.9	17.1
33	82.1	15.8	17.1	7.2
34	59.2	8.3	22.2	30.6
35	38.0	6.0	21.1	21.1
36	38.5	9.5	34.0	17.0
37	66.3	13.7	49.2	43.5
38	34.1	8.4	15.0	8.8
39	62.7	12.4	26.5	13.7
Total	**46.1**	**9.8**	**26.4**	**19.5**

As described in Section 1, median is used for pre- and post-PLOS as GM excludes 0 values, which is a valid data point for these variables. In 2015-2019, there was variability between units in the pre- and post-PLOS data for isolated AVR cases (Figures 50 and 51). The medians ranged from 0-1 days for pre-PLOS and 5-10 days for post-PLOS.

Figure 50. Pre-procedural length of stay for isolated AVR patients by unit, 2015-2019

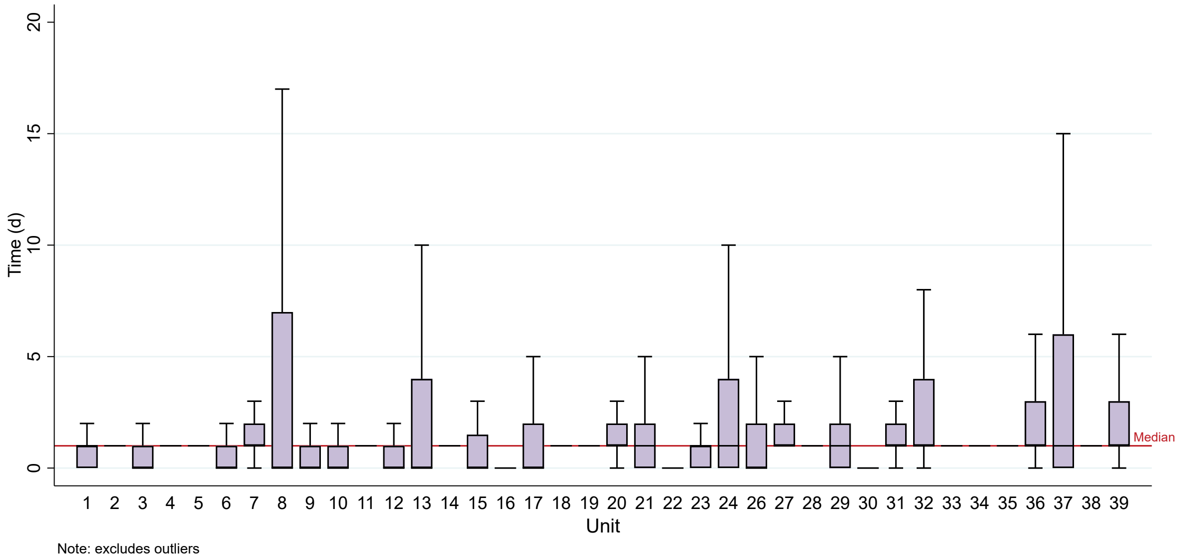
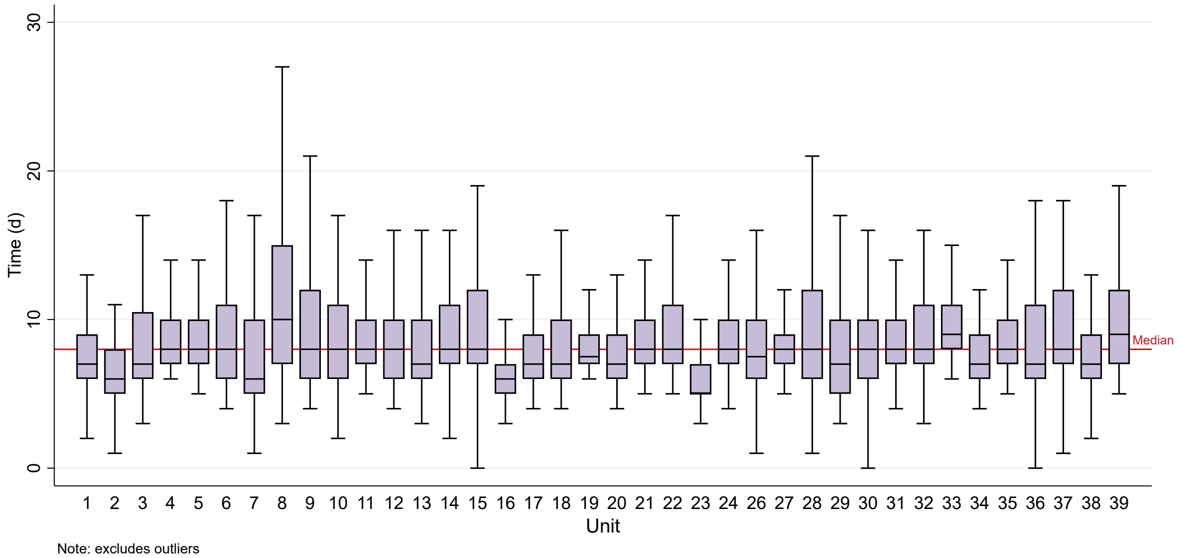


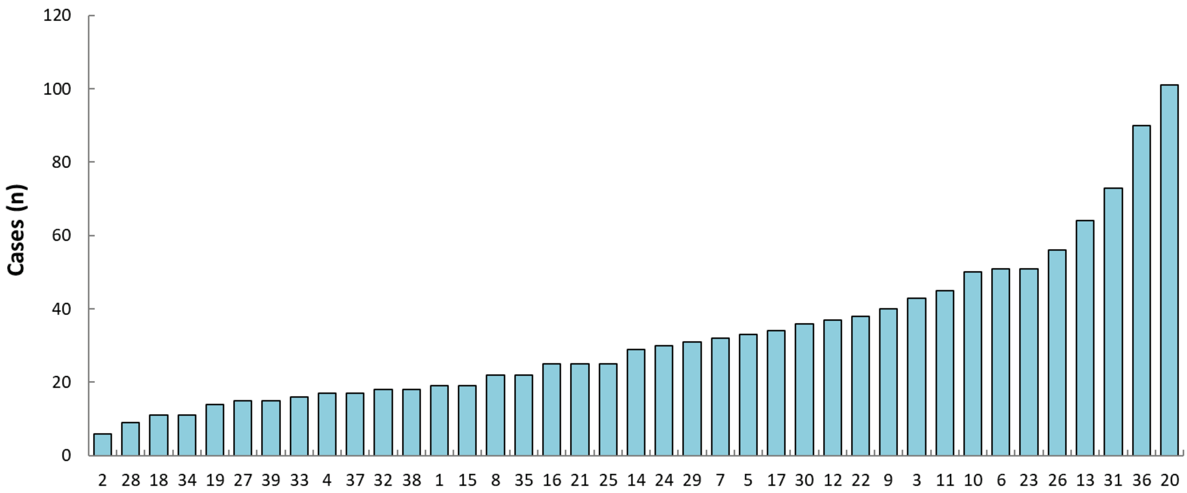
Figure 51. Post-procedural length of stay for isolated AVR patients by unit, 2015-2019



4. Combined Valve and CABG Surgery

Combined valve and CABG surgery is the smallest group analysed in the annual report, with 1288 cases in 2019. The lowest number performed in a unit was 6, the highest 101 (Figure 52).

Figure 52. Combined valve and CABG surgery performed by unit, 2019



4.1 Patient characteristics

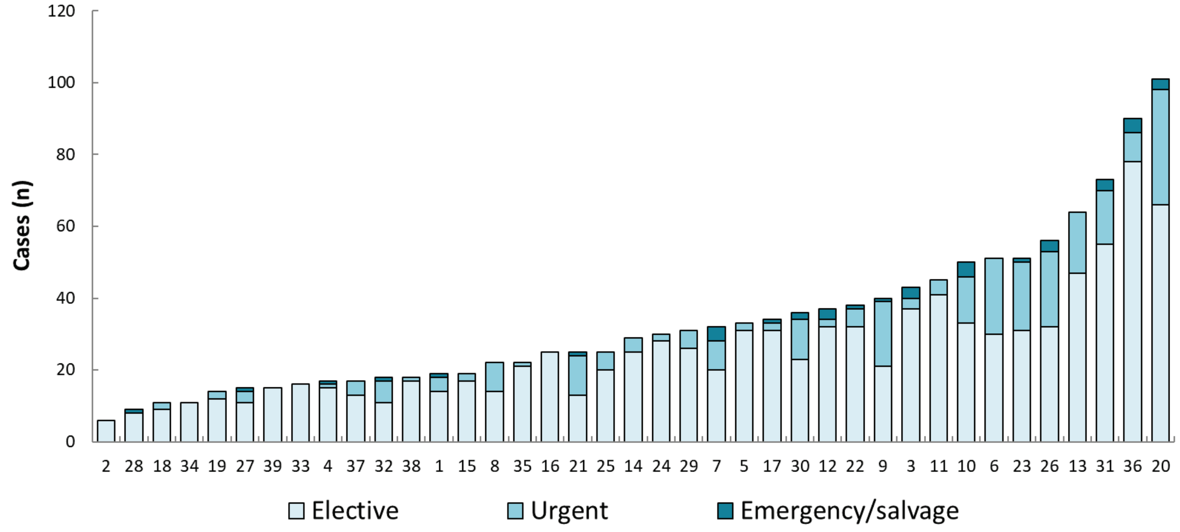
The incidence and influence of patient characteristics that may affect the outcomes of surgery include clinical status, sex, age and comorbidities. These are explored in the following section.

4.1.1 Clinical status

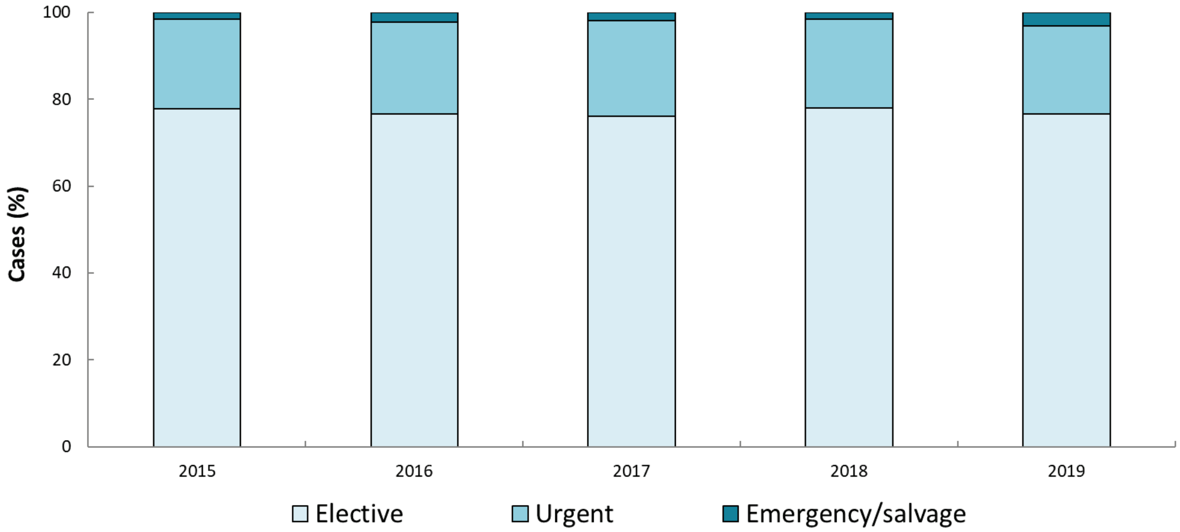
As for isolated CABG and isolated valve, the distribution of reported clinical status in each unit varied for combined valve and CABG in 2019. Reported emergency and salvage cases were the smallest proportion in each unit (Figure 53a). The distribution of clinical status remained broadly consistent over the last five years, however, there was a higher proportion of elective cases (average 77.0%) than for isolated CABG (Figure 53b). It is interesting to note that the number of reported emergency and salvage cases doubled in 2019 (3.03%) compared to 2018 (1.45%), and is at its highest proportion overall compared to previous years.

Figure 53. Clinical status of combined valve and CABG patients

a. Units in 2019



b. Year

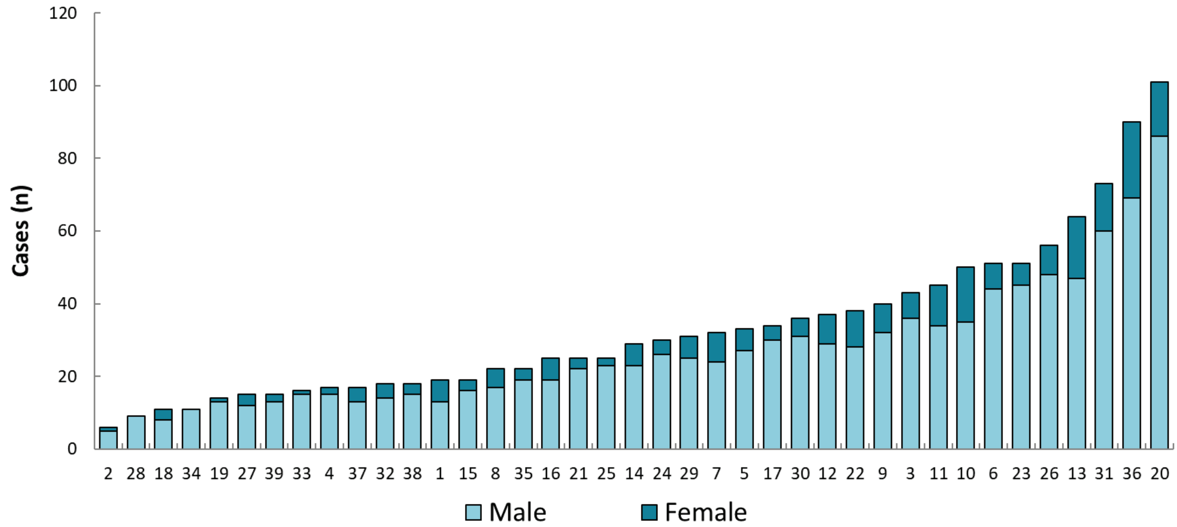


4.1.2 Sex and age

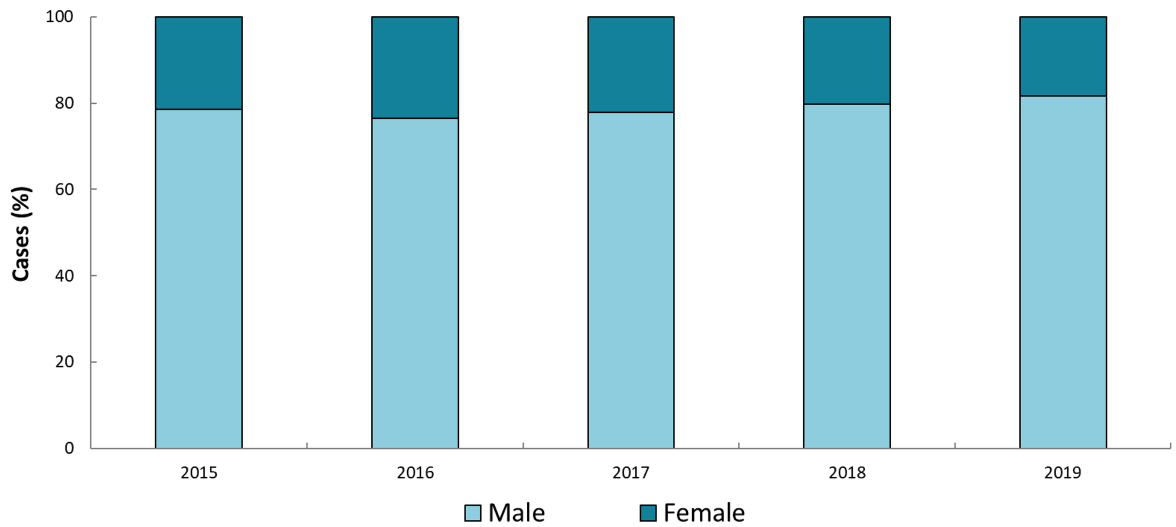
The ratio of male to female in combined valve and CABG patients was similar between units in 2019 (Figure 54a). Males consistently constitute the majority of cases. The proportion of male patients having combined valve and CABG surgery annually has gradually increased since 2015, from 76.4% in 2016 to 81.6% in 2019 (Figure 54b).

Figure 54. Sex of combined valve and CABG patients

a. Units in 2019

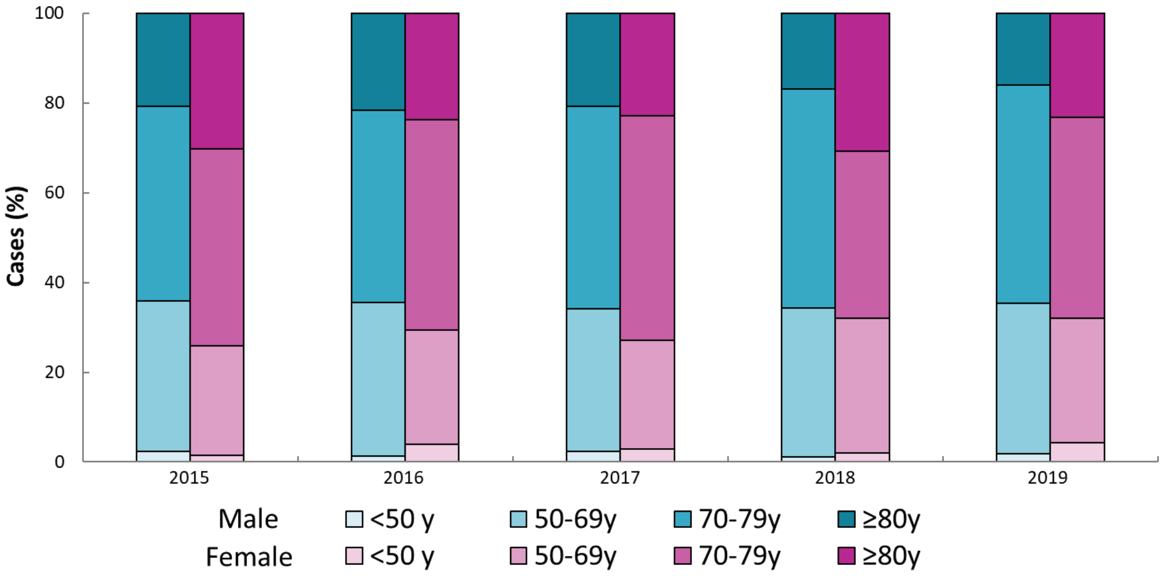


b. Year



Between 2015 and 2019 the proportion of female patients aged 70 years and older who had combined valve and CABG surgery was higher, compared to male patients, which is consistent with the proportions seen in isolated CABG and isolated valve surgery (Figure 55). It is interesting to note that patients who have combined valve and CABG surgery tend to be 70 years or older with 64.9% of males and 70.9% of females compared to isolated CABG (38.0% and 46.4%, respectively) and isolated valve (41.6% and 48.3%, respectively).

Figure 55. Age groupings for male and female combined valve and CABG patients, 2015-2019

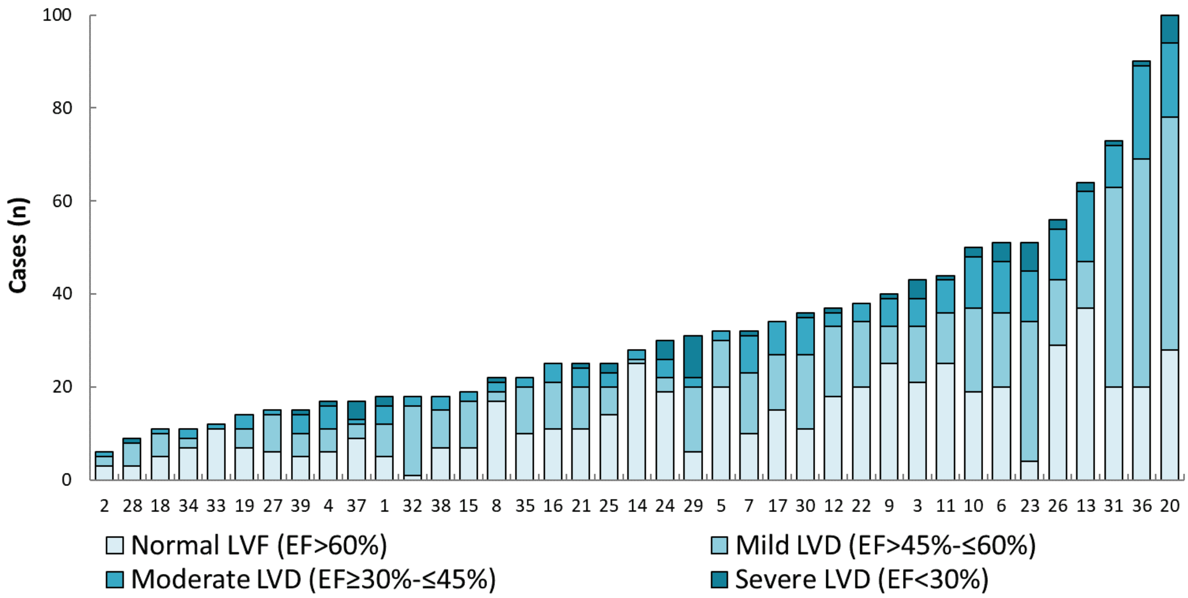


4.1.3 Left ventricular function

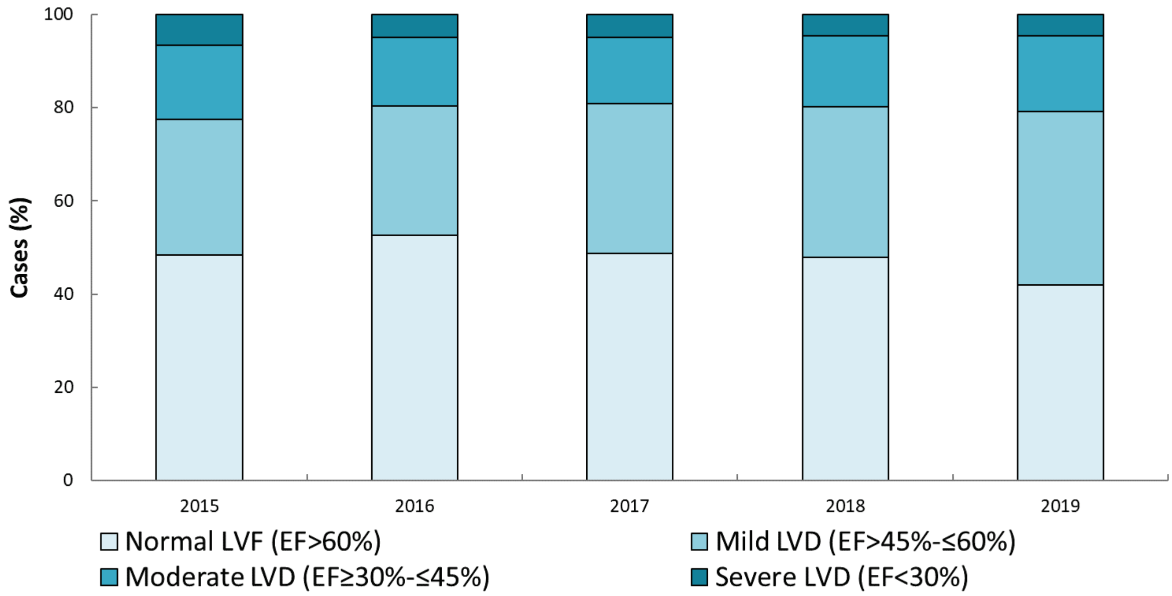
There was large variation between units in 2019 for LVF. In most units, more than half of combined valve and CABG patients present with some form of LVD (Figure 56a). The proportion of patients with moderate LVD and severe LVD remained consistent with previous years (Figure 56b). Patients presenting with normal LVF or mild LVD accounted for approximately 80% of cases in 2019 a similar trend to that observed for isolated CABG.

Figure 56. Combined valve and CABG: pre-operative LV function

a. Units in 2019



b. Year

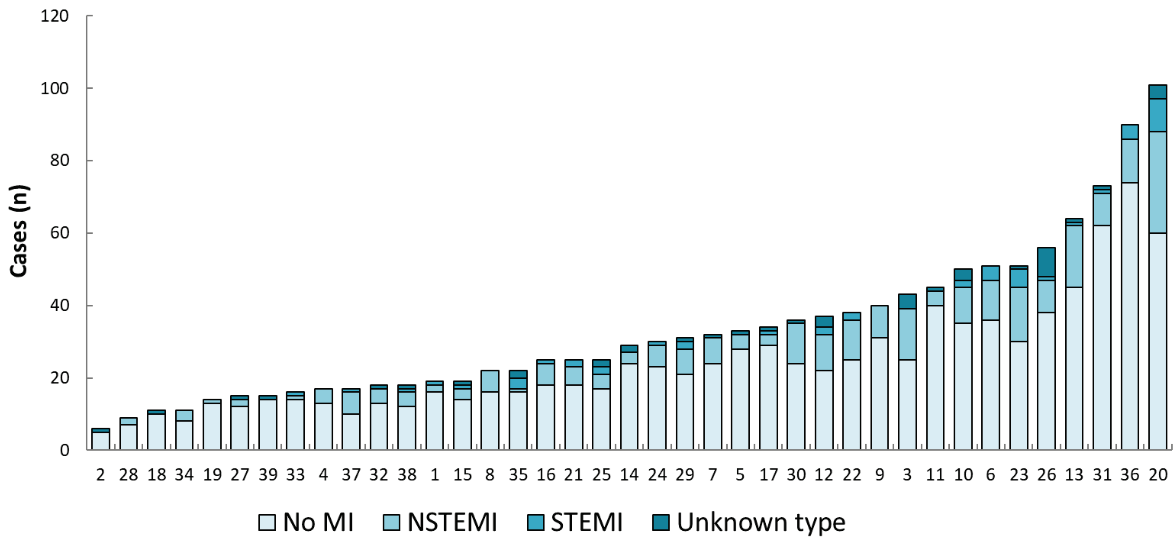


4.1.4 Previous myocardial infarction

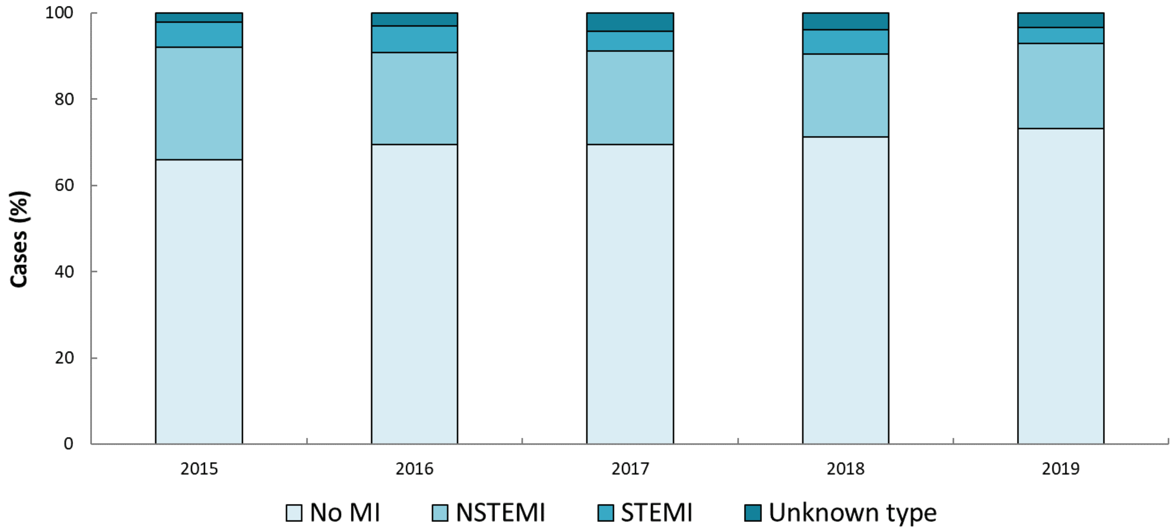
In 2019, the majority of combined valve and CABG patients did not have a MI prior to surgery, and this was fairly consistent between units (Figure 57). The proportion of patients with no MI prior to surgery has slowly increased over the past five years from 69.9% in 2015 to 73.1% in 2019 (Figure 57b).

Figure 57. Combined valve and CABG: prior MI

a. Units in 2019



b. Year

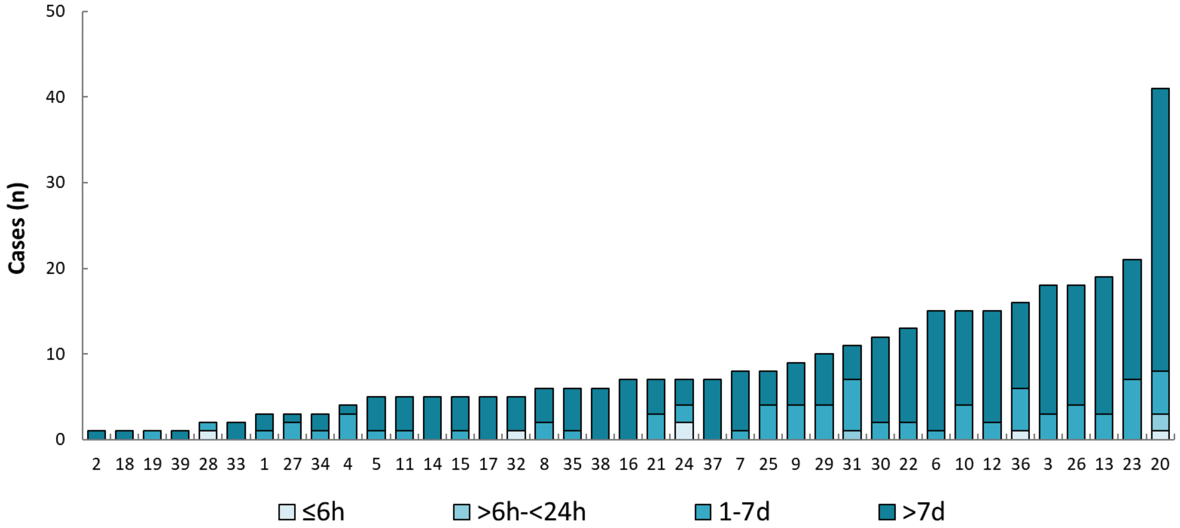


4.1.5 Timing of pre-operative myocardial infarction

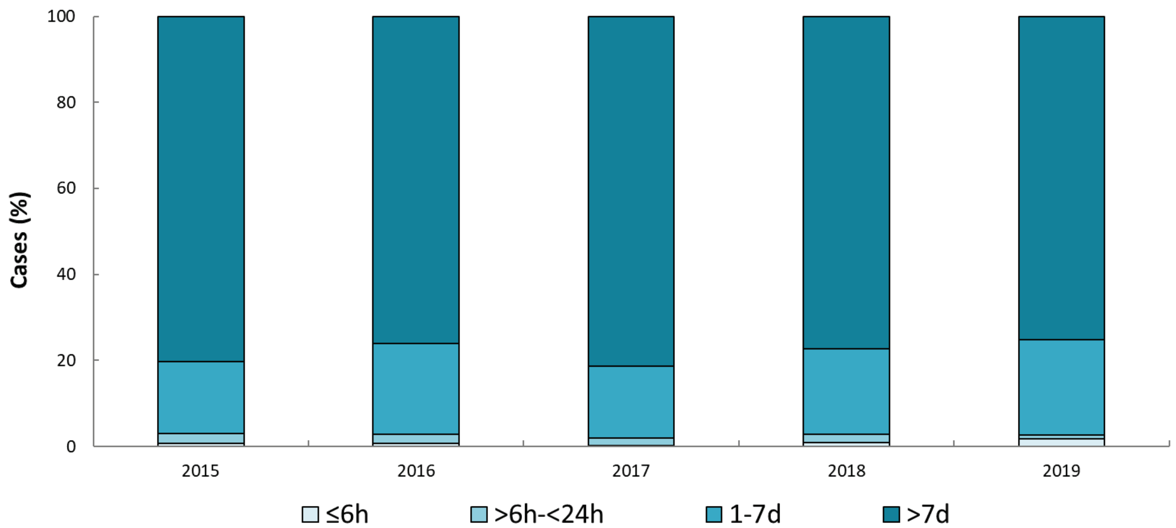
For the majority of units, MI occurred more than seven days prior to surgery (Figure 58a). This is consistent with the pooled data over the last five years, however the small proportion of patients who had a MI within 6 hours of surgery doubled in 2019 compared to previous years (Figure 58b).

Figure 58. Combined valve and CABG: timing of pre-operative MI

a. Units in 2019



b. Year

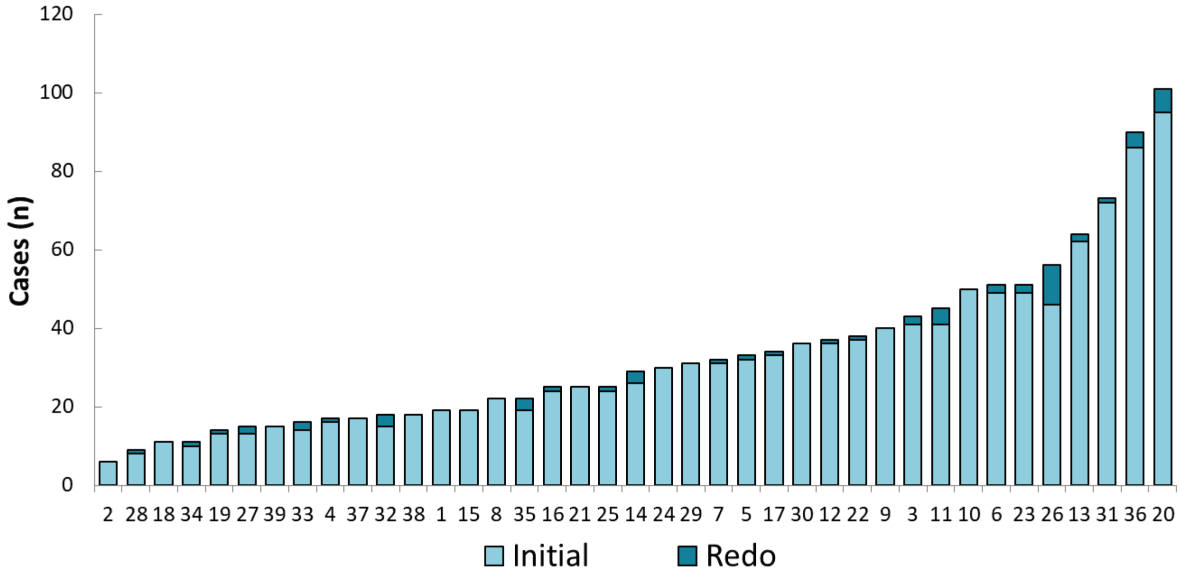


4.2 Previous surgery

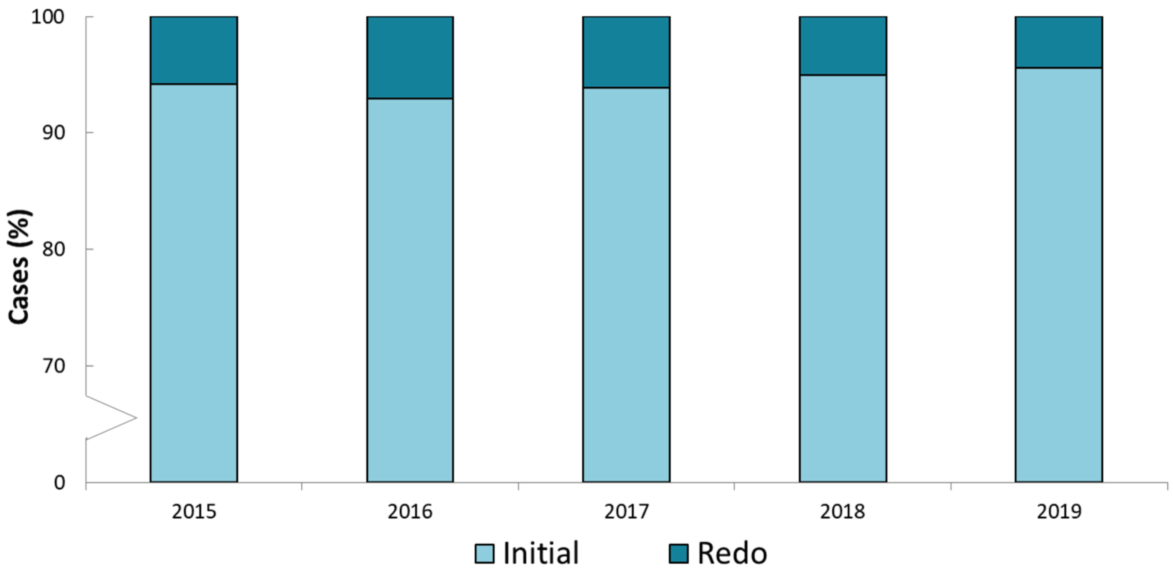
An operation is considered a redo if the patient had any prior cardiac surgery. The number of redo cases constitute a small and consistent proportion of combined valve and CABG surgery per unit (Figure 59). As was the case with isolated CABG, the number of redo operations in the combined valve and CABG surgical group has declined slowly over the past four years, from 7.01% in 2016 to 4.43% in 2019.

Figure 59. Combined valve and CABG: initial and redo surgery

a. Unit in 2019



b. Year

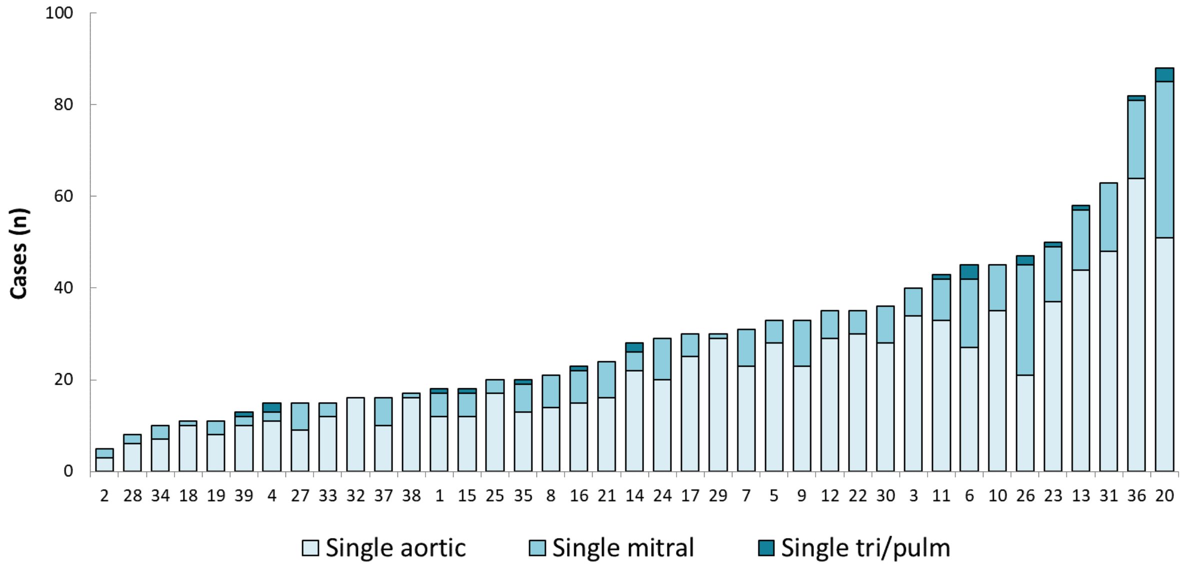


4.3 Single valve surgery combined with CABG

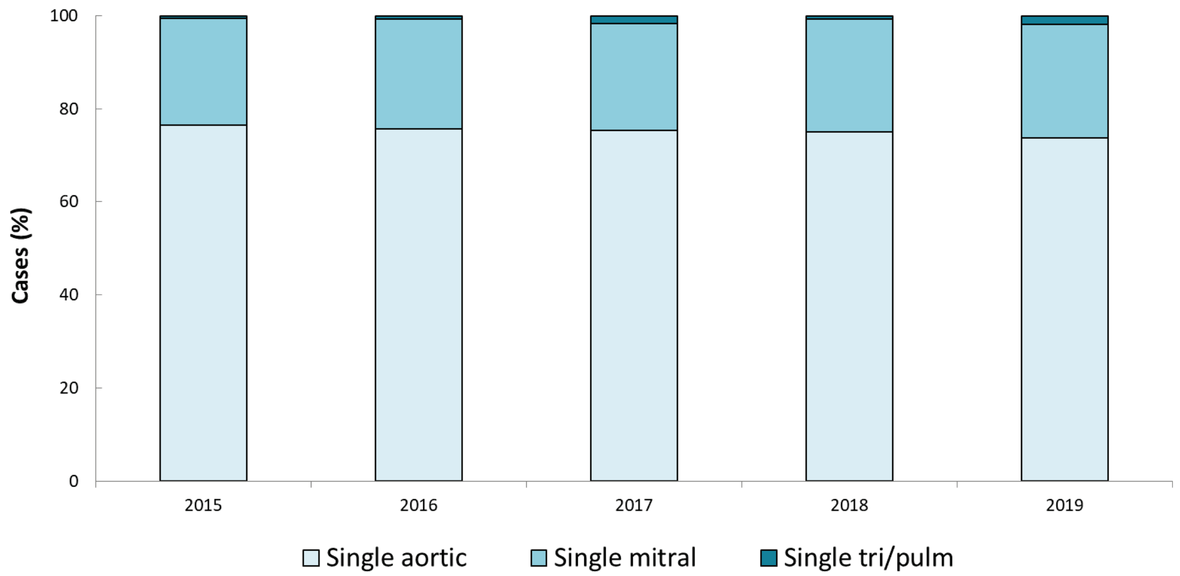
Single AoV and CABG is consistently the most commonly performed combined surgery, with the exception of two units (Figure 60a). The proportion of valve types remained relatively consistent over the previous five years with a small increase in tri/pulm valve surgery in 2019 (1.78%) similar to 2017 (Figure 60b). Overall, combined single AoV and CABG accounted for the majority of cases with an average of 75.2%.

Figure 60. Type of single valve surgery combined with CABG

a. Units in 2019



b. Year



Of the three common valve and CABG combinations, MV repair and CABG had the lowest OM in 2019 and combined AVR and CABG had the lowest OM for the preceding four years. In comparison combined MVR and CABG had a consistently high OM (Table 23). The OM for other surgical groups was widely variable, as expected with low frequency data. The average OM for all combined valve and CABG surgery was 3.42% in 2019, similar to 3.61% in 2015-2018.

Table 23. OM (%) for combined valve and CABG surgery, 2019 and 2015-2018

Valve surgery	Year	n	OM (%)
Single aortic	2019	868	2.8
	2015-2018	3498	2.5
AVR	2019	860	2.8
	2015-2018	3440	2.4
Other aortic	2019	8	0.0
	2015-2018	58	5.2
Single mitral	2019	288	4.2
	2015-2018	1085	5.3
MVR	2019	146	7.5
	2015-2018	511	7.6
Repair	2019	142	0.7
	2015-2018	567	3.2
Single tricuspid	2019	19	0.0
	2015-2018	39	7.7
Single pulmonary	2019	2	0.0
	2015-2018	3	0.0
Aortic and mitral	2019	62	8.1
	2015-2018	248	6.9
Aortic and tricuspid	2019	2	0.0
	2015-2018	26	19.2
Mitral and tricuspid	2019	39	5.1
	2015-2018	130	7.7
Other double	2019	0	-
	2015-2018	3	0.0
Triple	2019	8	12.5
	2015-2018	39	10.3
Quadruple	2019	0	-
	2015-2018	1	0.0
Total valve surgery	2019	**1288**	**3.4**
	2015-2018	**5072**	**3.6**

4.4 Influence of patient characteristics on 30-day mortality

Generally, OM for all combined valve and CABG surgery increased with reported urgency, advancing age, severity of LVD, previous MI and redo surgery (Table 24).

Table 24. Influence of patient characteristics on OM (%) for combined AVR and CABG and all other combined valve and CABG surgery, 2015-2019

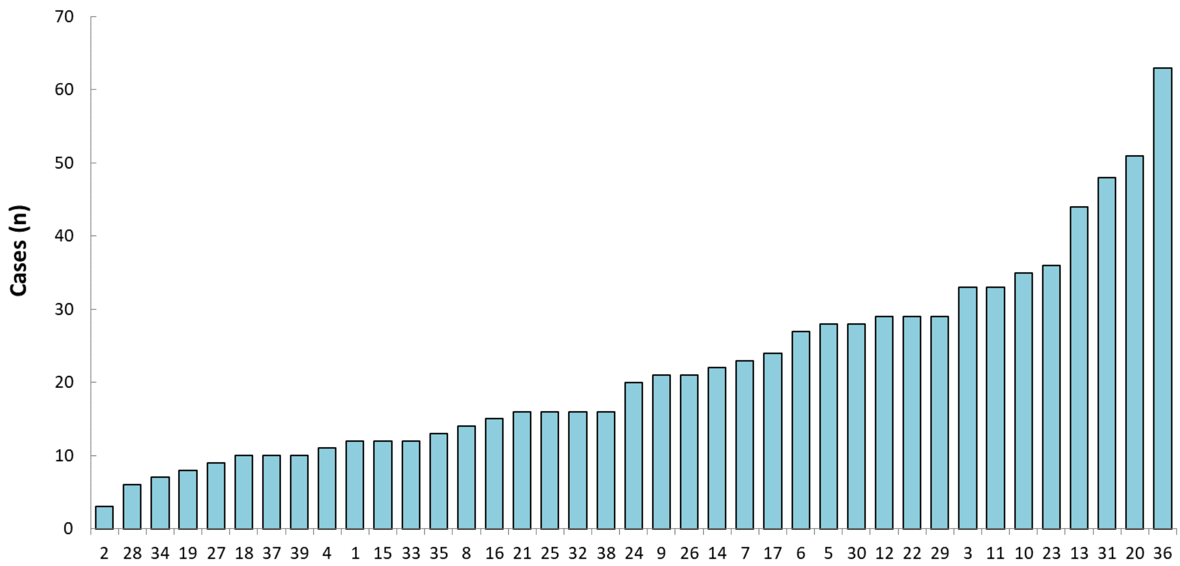
	AVR with CABG		All other valve with CABG	
	n	OM (%)	n	OM (%)
Clinical status				
Elective	3416	1.9	1483	3.6
Urgent	830	4.0	502	9.6
Emergency/salvage	54	16.7	75	24.0
Sex/age				
Male	3453	2.2	1562	5.2
<50y	33	0.0	56	1.8
50-69y	1011	1.7	658	5.0
70-79y	1685	1.9	610	5.4
≥80y	724	3.9	238	5.9
Female	847	3.5	498	7.8
<50y	13	0.0	26	3.8
50-69y	183	2.2	170	7.1
70-79y	412	3.6	190	8.4
≥80y	239	4.6	112	8.9
LVF^				
Normal LVF (EF>60%)	2232	1.8	782	4.0
Mild LVD (EF>45%-≤60%)	1346	2.7	646	4.6
Moderate LVD (EF≥30%-≤45%)	520	4.4	441	8.8
Severe LVD (EF<30%)	156	5.1	169	10.1
Previous MI				
No MI	3108	1.8	1334	4.3
NSTEMI	903	4.2	472	7.0
STEMI	154	5.8	177	13.6
Unknown type	135	2.2	77	6.5
Timing of prior MI				
≤6h	8	0.0	8	37.5
>6h-<24h	14	0.0	21	9.5
1-7d	211	5.7	157	12.1
>7d	959	4.0	539	6.9
Previous surgery				
Initial	4108	2.4	1891	5.2
Redo	192	4.2	169	13.0

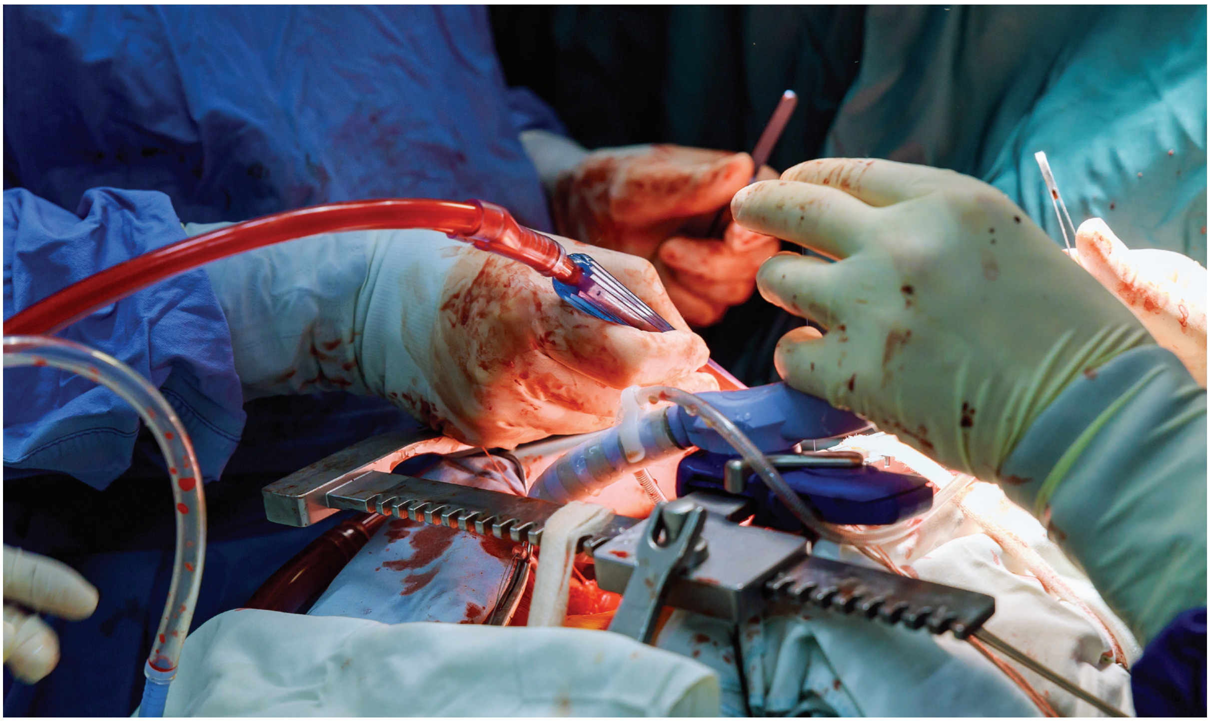
^46 and 20 cases missing EF data for AVR and CABG and all other combined valve and CABG, respectively

4.5 Combined AVR and CABG

Due to the differences in outcomes for the various valve categories, combined AVR and CABG being the largest group, is analysed in the following section. The lowest volume unit submitted 3 cases and highest submitted 63 (Figure 61).

Figure 61. Combined AVR and CABG performed by unit, 2019





4.5.1 Influence of co-morbidities on complications

4.5.1.1 Diabetes or renal impairment

This report compares two parameters of renal impairment: patients with a pre-operative creatinine level of ≥200 µmol/L or those with a pre-operative eGFR ≤60 mL/min/1.73m^2.

Patients with diabetes had a higher incidence of post-operative permanent stroke and re-op for bleeding in 2019, whereas in the pooled data permanent stroke and DSWI were higher. Patients with an eGFR of ≤60ml/min/1.73m^2 tended to have a higher incidence of complications in 2019, however, the pooled data did not show the same (Table 25).

Table 25. Influence of pre-operative diabetes and of renal function on complications (%) for combined AVR and CABG patients

		Diabetes*^		Pre-op creatinine		Pre-op eGFR¥	
		No	Yes	<200 µmol/L	≥200 µmol/L	>60mL /min/1.73m²	≤60mL /min/1.73m²
n	2019	550	310	839	21	635	224
	2015-2018	2183	1256	3324	116	2340	1099
Permanent stroke#	2019	1.3	1.9	1.4	4.8	1.1	2.7
	2015-2018	1.4	2.4	1.8	1.7	1.6	2.2
DSWI~	2019	0.9	0.6	0.8	0.0	0.8	0.9
	2015-2018	1.1	2.1	1.4	2.6	1.5	1.3
NCA†	2019	38.8	35.2	37.6	33.3	36.1	41.3
	2015-2018	37.9	36.4	37.3	39.7	37.1	37.9
Re-op for bleeding‡	2019	4.6	5.8	5.0	4.8	4.3	7.2
	2015-2018	4.2	4.2	4.1	6.0	4.4	3.8

*1 case missing diabetes data in 2015-2018
^Refers to all diabetes, regardless of type of therapy
¥1 case missing eGFR data in both 2019 and 2015-2018
#1 and 7 cases missing permanent stroke data in 2019 and 2015-2018, respectively
~2 and 25 cases missing DSWI data in 2019 and 2015-2018, respectively
†1 and 7 cases missing NCA data in 2019 and 2015-2018, respectively
‡1 and 6 cases missing re-op bleeding data in 2019 and 2015-2018, respectively

Note: eGFR data was updated in the second edition, July 2021

4.5.1.2 Age

Increasing age appears to be associated with an increasing incidence of NCA and stroke, although inconsistent, which is potentially due to low case numbers and low frequency data (Table 26).

Table 26. Influence of patient age~ on complications (%) for combined AVR and CABG patients

		Age			
		<50 y	50-69 y	70-79 y	≥80 y
n	2019	10	248	444	158
	2015-2018	36	946	1653	805
Permanent stroke	2019	0.0	0.8	1.4	3.2
	2015-2018	2.8	1.2	2.1	1.7
DSWI	2019	0.0	1.2	0.5	1.3
	2015-2018	2.8	2.3	0.9	1.6
NCA	2019	30.0	35.5	36.6	43.7
	2015-2018	16.7	32.9	39.3	39.8
Re-op for bleeding	2019	0.0	2.4	6.1	6.3
	2015-2018	8.3	4.3	4.1	4.1

~Same missing data for complications applies as for Table 25

4.5.1.3 Surgical history

In combined AVR and CABG patients, redo surgery was associated with higher rates of DSWI, NCA and re-op for bleeding in the pooled data (2015-2018; Table 27).

Table 27. Influence of redo surgery~ on complications (%) for combined AVR and CABG patients

		Surgery	
		Initial	Redo
n	2019	835	25
	2015-2018	3273	167
Permanent stroke	2019	1.6	0.0
	2015-2018	1.8	1.8
DSWI	2019	0.8	0.0
	2015-2018	1.4	3.6
NCA	2019	37.4	40.0
	2015-2018	37.3	40.4
Re-op for bleeding	2019	5.2	0.0
	2015-2018	4.1	5.4

~Same missing data for complications applies as for Table 25

4.5.1.4 Influence of comorbidities on derived new renal impairment

Patients with pre-operative renal impairment or diabetes had an increased incidence of DNRI following combined AVR and CABG surgery, as did those having redo surgery (Table 28). Increasing age was less consistently associated with an increased incidence of DNRI. This data excludes patients who were on pre-operative dialysis.

Table 28. DNRI (%) for combined AVR and CABG patients on the basis of diabetes, renal insufficiency, age and surgical history

	2019		2015-2018	
	n	DNRI (%)‡	n	DNRI (%)‡
Diabetes				
No	540	3.5	2063	4.4
Yes	303	11.9	1160	5.5
Pre-op creatinine				
<200 µmol/L	836	6.3	3166	4.3
≥200 µmol/L	7	28.6	57	31.6
Pre-op eGFR				
>60mL/min/1.73m²	634	4.9	2231	3.1
≤60mL/min/1.73m²	209	11.5	992	8.7
Age				
<50y	8	0.0	34	5.9
50-69y	243	7.4	872	4.6
70-79y	436	6.0	1552	3.7
≥80y	156	7.1	765	7.2
Previous surgery				
Initial	820	6.5	3069	4.6
Redo	23	8.7	154	9.1

‡2 and 143 cases missing DNRI data in 2019 and 2015-2018, respectively

Note: the amount of missing data for DNRI in 2015-2018 is largely due to a lack of post-operative creatinine data from one hospital for a portion of this period.

^Refers to all diabetes, regardless of type of therapy

Note: eGFR data was updated in the second edition, July 2021

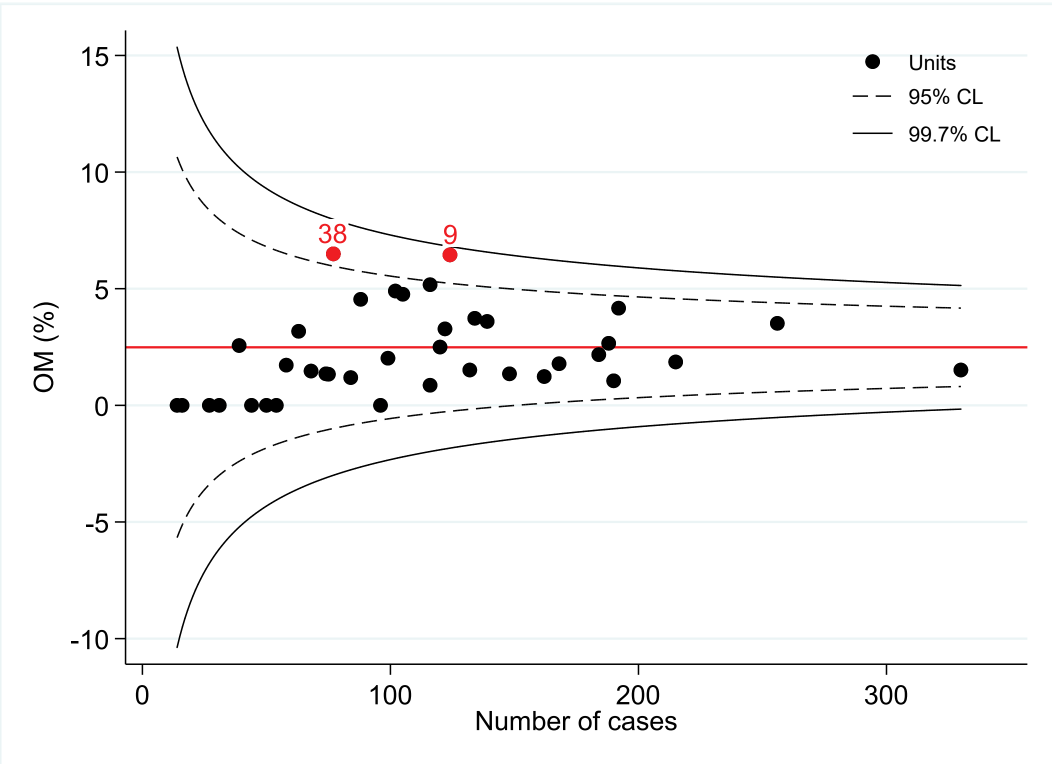
4.5.2 Unit outcomes – mortality, complications and resource utilisation

Due to low surgical numbers, the unit outcome data for combined AVR and CABG is presented for the pooled 2015-2019 period.

4.5.2.1 30-day mortality

The average OM for all units was 2.49% for combined AVR and CABG patients in the 2015-2019 period (Figure 62). This is favourably comparable to the 3.3% mortality rate reported by the STS in the 2018 annual report[10]. All units were within the upper 99.7% CL for OM.

Figure 62. OM by unit following combined AVR and CABG, 2015-2019

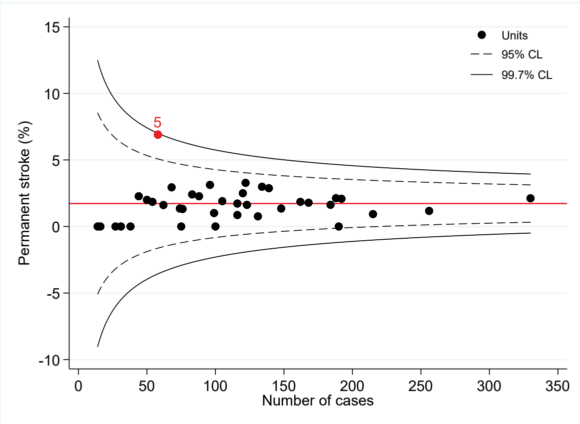


4.5.2.2 Complications

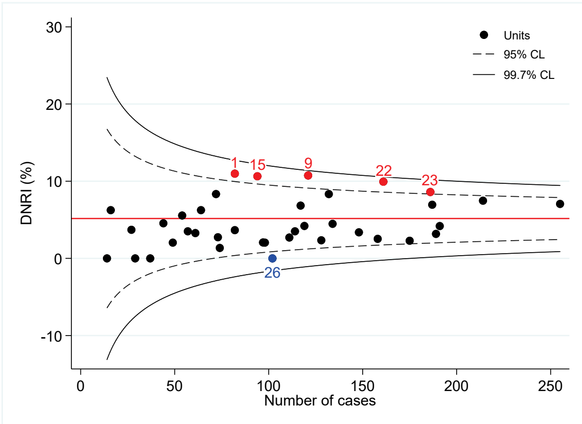
The outcomes for most units were within the 95% CL from the mean for permanent stroke (1.72%) and DSWI (1.33%). There was notable variation from the mean of DNRI (5.16%), NCA (37.4%), re-op for bleeding (4.36%), and readmission (10.9%; Figure 63). Again, data for DNRI excludes patients who received pre-operative dialysis (Figure 63b).

Figure 63. Complications by unit following combined AVR and CABG, 2015-2019

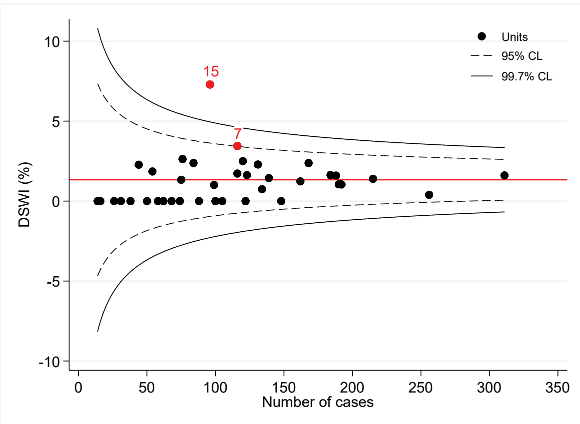
a. Permanent stroke



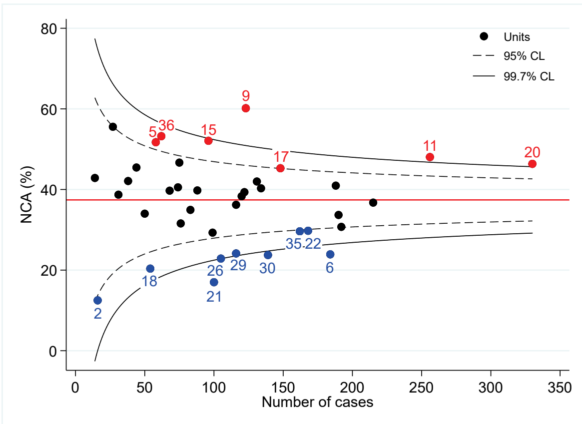
b. DNRI



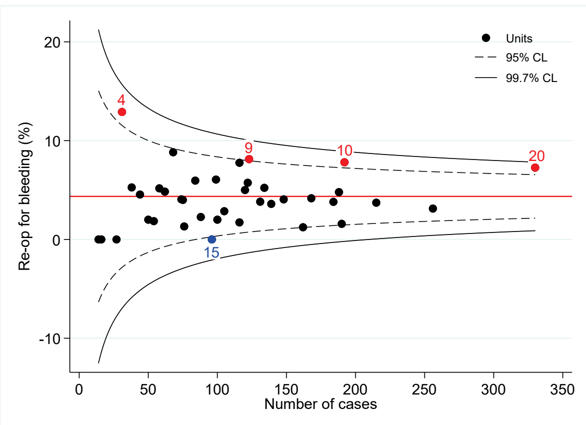
c. DSWI



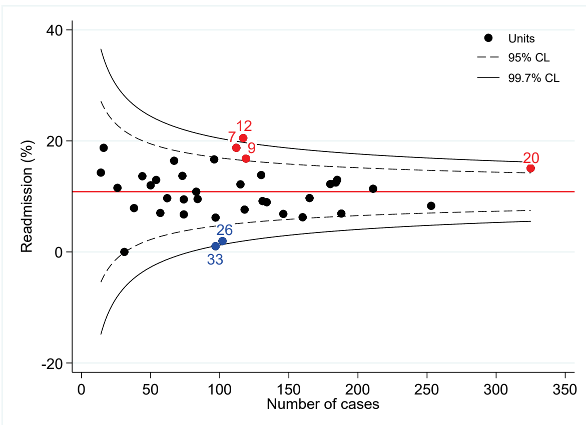
d. NCA



e. Re-op for bleeding



f. Readmission



4.5.2.3 Resource utilisation

As for previous sections, ICU length of stay and ventilation data is presented as GM, which is defined as the nth root of a product of n numbers. It is less sensitive to outlying values, so portrays the central tendency of a set of skewed data more accurately.

The pooled data shows marked variation between units for the time patients spent in the ICU, the duration of ventilation, and the percentage of patients who received RBC or NRBC transfusions (Table 29). These times and rates are significantly higher than for isolated CABG and isolated valve.

Table 29. Resource utilisation by unit for combined AVR and CABG patients, 2015-2019

	2015-2019			
Unit	ICU (GM, h)	Ventilation (GM, h)	RBC usage (%)	NRBC usage (%)
1	42.2	13.8	46.4	45.2
2	37.5	5.4	43.8	43.8
3	57.9	13.6	63.4	50.0
4	67.2	9.9	54.8	45.2
5	94.7	21.5	37.9	15.5
6	122.9	16.3	62.5	41.3
7	48.4	19.1	45.7	30.2
8	82.5	15.8	45.1	34.4
9	103.6	15.6	57.3	37.9
10	75.7	13.4	51.0	40.1
11	67.7	11.8	56.3	32.8
12	49.4	14.1	55.8	39.2
13	60.0	11.1	50.2	33.0
14	58.4	15.5	27.3	81.8
15	48.2	13.4	26.0	17.7
16	41.1	9.0	36.5	39.2
17	33.9	12.8	50.0	23.0
18	66.0	6.3	29.6	18.5
19	78.8	8.3	33.3	51.9
20	41.5	10.6	42.7	32.7
21	37.3	12.3	39.2	39.2
22	40.8	11.4	54.2	20.8
23	30.2	11.9	25.0	14.4
24	55.4	13.7	65.2	34.1
26	44.8	10.0	40.0	35.2
27	75.2	8.3	42.9	14.3
28	34.9	10.4	20.5	12.8
29	58.3	15.0	45.7	22.4
30	46.2	8.9	39.6	23.7
31	61.8	11.1	20.0	10.5
32	82.5	16.0	36.8	29.4
33	95.4	16.8	26.3	17.2
34	67.7	10.3	44.0	28.0
35	43.7	7.7	39.5	40.7
36	47.7	13.5	52.4	36.5
37	79.4	19.4	87.5	72.7
38	39.2	9.7	27.6	9.2
39	64.6	13.5	36.0	20.0
Total	**55.7**	**12.4**	**45.3**	**31.6**

As described in the other sections, median is used for pre- and post-PLOS as GM excludes 0 values, which is a valid data point for these variables. In the 2015-2019 period, there was variability between units in the pre- and post-PLOS data for combined AVR and CABG cases (Figures 64 and 65). The medians ranged from 0-4 days for pre-PLOS and 6-11 days for post-PLOS.

Figure 64. Pre-procedural length of stay for combined AVR and CABG patients by unit, 2015-2019

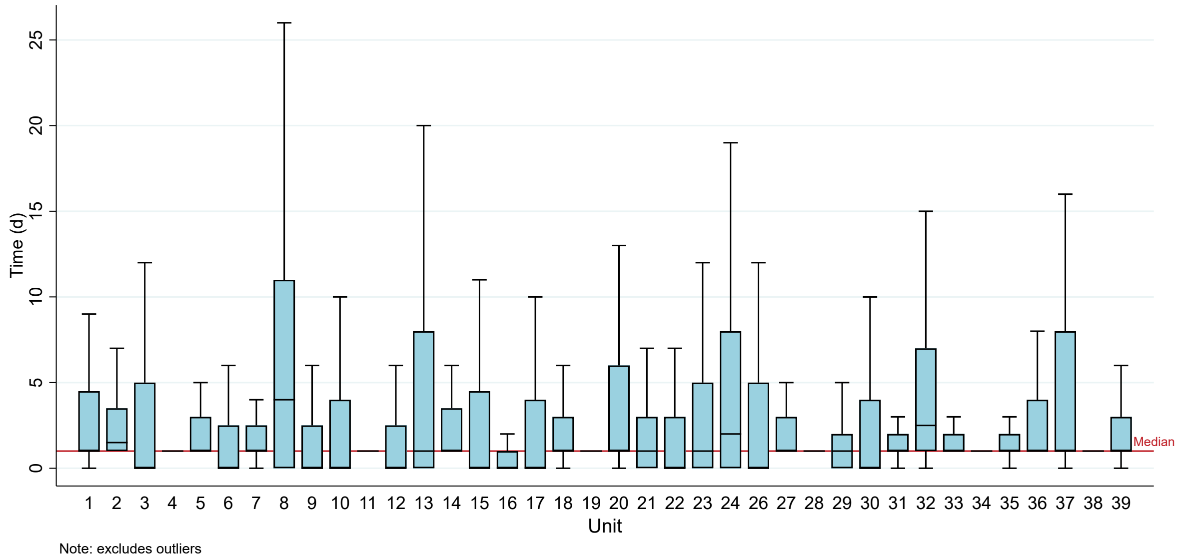
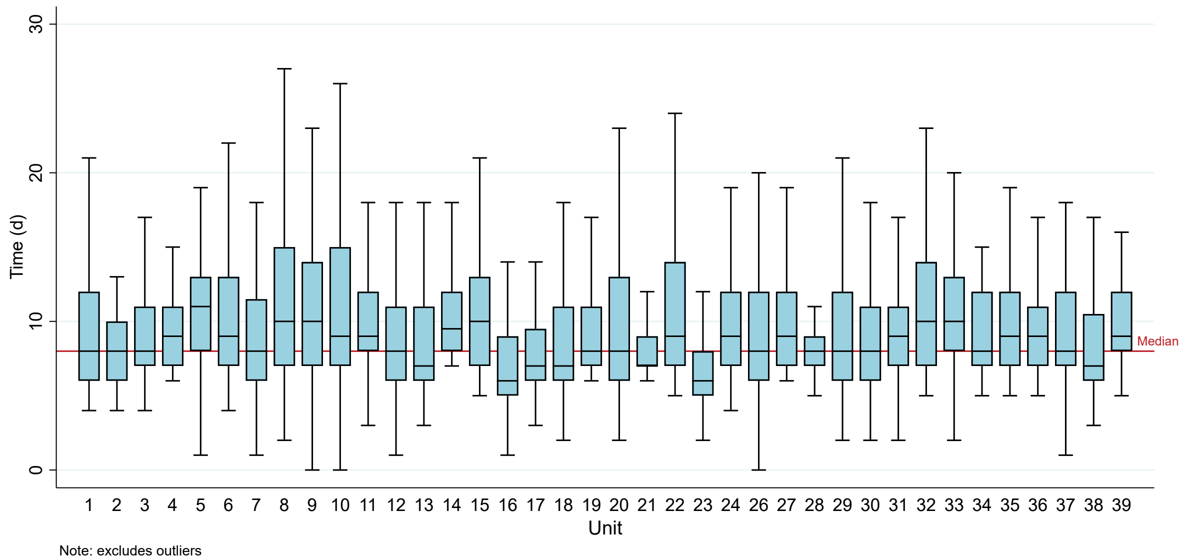


Figure 65. Post-procedural length of stay for combined AVR and CABG patients by unit, 2015-2019



5. Other Cardiac Surgery

Table 30 lists the 2019 case numbers for cardiac surgery not covered in Sections 1, 3 or 4. Many of these operations are not performed in isolation, therefore OM is not necessarily indicative of that specific surgery, so is not presented.

Table 30. Case numbers for other uncommon cardiac surgery, 2019

Surgery type (not mutually exclusive)	n
LV aneurysm	22
Acquired ventricular septal defect	32
Aortic replacement^	1290
Ascending only	953
Ascending + arch	245
Arch only	35
Descending	11
Thoraco-abdominal	4
Arch + descending	4
Descending + thoraco-abdominal	12
Ascending + arch + descending	7
Arch + descending + thoraco-abdominal	1
Other	16
Aortic repair*	285
Endarterectomy	17
Patch repair	176
Endarterectomy + patch repair	4
Indication for aortic procedure~	
Aneurysm	939
Dissection	332
Traumatic transection (<2 weeks)	3
Calcification	81
Other	211
Cardiac trauma	7
LV outflow tract myectomy	147
LV rupture repair	6
Pericardiectomy	36
Pulmonary thrombo-endarterectomy	17
Carotid endarterectomy	7
LV reconstruction	5
Pulmonary embolectomy	9
Cardiac tumour	91
Congenital	
Atrial septal defect	220
Other	158
Permanent LV epicardial lead	30
Atrial arrhythmia surgery	392
Left atrial appendage closure	333
Other	383

^2 cases missing aortic surgery type data
*88 cases missing aortic repair type data
~3 cases missing aetiology/pathology type data

Table 31 provides case numbers for valve surgery that was performed in isolation or in conjunction with other types of cardiac surgery.

Table 31. Case numbers for other AoV surgery performed without and with CABG, 2019 and 2015-2018

Valve surgery (not mutually exclusive)		Without CABG	With CABG
Aortic root replacement with valved conduit	2019	334	65
	2015-2018	894	202
Pulmonary autograft aortic root replacement (Ross)	2019	44	1
	2015-2018	122	2
Root reconstruction with valve sparing (David)	2019	62	2
	2015-2018	210	32
Total other valve surgery	**2019**	**440**	**68**
	2015-2018	**1226**	**236**

Table 32 presents case numbers and OM for transplants performed without any concomitant surgery.

Table 32. Case numbers and OM (%) for transplants, 2019

Surgery type (performed in isolation)	n	OM (%)
Cardiac transplant	94	5.3
Cardiopulmonary transplant	43	2.3

Concluding Remarks

The ANZSCTS Database has greater than 95% data completeness for all reported KPIs, assuring minimal to no selection bias in analyses. Compliance with the data definitions and completeness of case entry is assessed via triennial site audits, which consistently show the data submitted to the Database is of very high quality. We strive toward the ideal of including all adult patients from every cardiac surgical unit so that the performance of all units may be evaluated.

Some of the significant activities for the Program in 2019-2020 have been to:

- continually improve and update our web system, including the addition of variables to capture COVID-19 positive patients, enhance the online reports, and institute better search capabilities;
- progressively recruit more hospitals, so that with the addition of Royal Hobart Hospital, all Australian public units are involved, also accreting an additional 13 private units in Australia and a further public unit in New Zealand;
- addition of quarterly monitoring and reporting of data completeness for variables related to the KPIs;
- continued engagement with Data Managers through biannual meetings, memos, surveys, and newsletters;
- hold a Research Summit at the ANZSCTS Annual Scientific Meeting 2019 in Hobart.

The vital research program continues to grow. At the time of publication of this Report, 26 projects are in progress. Several research projects underway involve linkage to other rich datasets, including the Australian and New Zealand Intensive Care Society (ANZICS) Adult Patient Database and the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA). These projects will address questions about the pathway of care and longer-term outcomes that neither registry can answer independently. The Database also updated linkage with the Australian Institute of Health and Welfare's National Death Index. It now has long-term mortality data available up to the end of 2018, which can be accessed for research projects approved by the Database Research Committee.

Our goals for the remainder of 2020 and early 2021 are to: finalise the development and implementation of new risk adjustment models to improve the analyses used for 30-day and in hospital mortality; explore the capacity to factor-in case-mix to create standards for DNRI and re-op for bleeding; to expand the scope of our peer review process to potentially include surgical categories with lower case numbers; update the Data Definitions Manual, refining some definitions and adding new variables to reflect changes in clinical practice; continue to enhance the web system data entry portal for efficient data entry; engage with further sites in Australia and New Zealand to work towards total bi-national coverage; and continue linkage activities to answer pertinent research questions.

Long-term goals for the ANZSCTS Database will focus on extending the scope of the information collected through linkage of our data with other external administrative data sources; establishing a Cardiac Surgical Prosthesis Registry; evaluation of quality of life through collecting longitudinal Patient Reported Outcome Measures (PROMs); collecting twelve-month follow-up data; and improving our reporting processes to health professionals and to the public.

We take this opportunity to thank contributors for their dedicated efforts with data collection and for their financial support, both of which are integral to the continuing success of the Database.

Appendix A

Management of Unit Outliers – Review Timeline

Units sitting above the 99.7% control limit (CL) are managed according to the following timeline.

Week 0: Identification of an outlier during the SC Clinical Quality Meeting (CQM).

Week 2: The Head of Department (HOD) is written to by the Chair of the SC and asked to undertake an internal review of the data, particularly with respect to potential data definition or data entry issues. The ANZSCTS Database offers to collaborate with the site to assist with identifying any data discrepancies.

Week 12: SC reviews the results of that review and the current data at the CQM.

- If the results are within control limits, no further action is taken.
- If the KPI remains outside of range, the Chair will write to the HOD, Medical Director and/or hospital Safety and Quality Committee and recommend they conduct an investigation, and communicate their plans to address the situation to the SC. For Victorian public hospitals, Safer Care Victoria will be notified at this time. The ANZSCTS Database will provide a list of the data elements that may be relevant to their investigations, and offer to supply supplementary data to the unit to assist with the investigation, if requested.

Week 24: SC–CQM reviews the report from the unit regarding their plans and activity to correct the situation. It also reviews the unit's current quarterly data.

- If results are within control limits, unit is informed, and no further specific action is taken.
- If the outcome for the KPI remains outside of range and the SC believe, based on correspondence, that the unit are on track for addressing the issue, the unit continues to be monitored.
- If the KPI remains outside of range and the SC believe the unit needs further engagement, the Peer Review and Quality Assurance Committee (PRQAC) is involved and asked to conduct an external review.
- If the KPI remains outside of range and the unit has not responded to the SC thus far, a meeting with the PRQAC, hospital administration, and HOD is set up.
- If relevant, SCV will be updated on progress and/or included in meetings.

Week 36: SC reviews correspondence from unit and/or PRQAC and the current data at the CQM.

- If the results have fallen back within control limits, the Chair will write to the HOD to request a report about the processes put in place to remedy the situation, because that information may inform improved procedures that may be promulgated. No further specific action will be taken.
- If the KPI remains out of range, a meeting with the PRQAC (regardless of whether they have been previously engaged), the hospital administration, HOD and SCV, if relevant, is set up.

If, at any time period, there is insufficient data to determine whether the unit has returned to within the control limits, the unit will in any case, be monitored until 36 weeks, at which time, if the KPI outcome is outside CL, a meeting with the PRQAC, hospital administration, and HOD will be convened. Should a unit be detected an outlier for a KPI it had previously been an outlier for, the SC will, at its discretion, expedite the initial stages of the escalation policy.

Appendix B

Key Performance Indicator Definitions

The KPIs presented in this report are based on the ANZSCTS Cardiac Surgery Database Data Definitions Manual, as follows:

In-hospital and 30-day mortality or observed mortality

- *Observed mortality*
  Includes all in-hospital mortality and any post discharge mortalities that occurred within 30 days of the procedure.
- *Risk-adjusted mortality*
  Derived based on the ANZSCTS Database Program's risk model (Appendix E), and used to account for the degree of risk associated with the surgery and patient profile.

Re-operation for bleeding

Did the patient return to theatre for bleeding/tamponade?

Derived* new renal insufficiency

Acute post-operative renal insufficiency is characterised by one of the following:

a. Increased serum creatinine to >0.2mmol/L (>200µmol/L) AND a doubling or greater increase in creatinine over the baseline pre-operative value AND the patient did not require pre-operative dialysis/haemofiltration, or

c. A new post-operative requirement for dialysis/haemofiltration (when the patient did not require this pre-operatively).

*Indicator is calculated based on reported renal data

Deep sternal wound infection (DSWI)

Did the patient develop infection of sternal bone, muscle and/or mediastinum? The patient must have **wound debridement and** one of the following:

a. Positive cultures
b. Treatment with antibiotics

Includes all in-hospital DSWI events and any readmissions due to DSWI within 30 days of procedure.

Permanent stroke

Did the patient experience a stroke or new central neurologic deficit (persisting for >72 hours) peri- or post-operatively?

New cardiac arrhythmia (NCA)

NCA is any new form of cardiac arrhythmia that occurred post-procedurally that required treatment. This includes:

a. Heart block requiring permanent pacemaker
b. New other bradyarrhythmia requiring permanent pacemaker
c. Cardiac arrest documented by one of the following:
   - Ventricular fibrillation OR
   - Rapid ventricular tachycardia with haemodynamic instability OR
   - Asystole OR
   - Pulseless electrical activity (PEA)*
d. New atrial arrhythmia (requiring treatment) - atrial fibrillation or flutter
e. New ventricular tachycardia

*This type of cardiac arrest was not specified prior to the change in the Data Definitions Manual on September 1st 2016.

Duration of ICU stay (initial stay only)

Number of hours spent by the patient in the ICU prior to transfer to the high dependency unit or general ward (does not include readmission to ICU). Calculated by subtracting the ICU admission date and time from ICU discharge date and time, where both values are available.

Duration of ventilation (initial post-operative ventilation only)

Number of hours post-operation for which the patient was ventilated. Calculated by subtracting ICU admission time from the ICU extubation time, where both values are available. If the patient was extubated on the operating table, duration of ventilation is zero. Delayed re-intubation time is not counted.

Red blood cell transfusions

Were allogeneic red blood cells transfused during the intra-operative or post-operative period? Does not include:

a) Pre-donated blood
b) Cell saver blood
c) Pump residual blood
d) Chest tube recirculated blood

Non-red blood cell transfusions

Were blood products other than RBC (e.g. FFP and Platelets) transfused during the intra-operative or post-operative period? Does not include albumin.

Appendix C

Data Preparation and Key Variable Definitions

Data preparation and presentation

Data includes operative details and outcomes of cardiac surgery performed in 39 participating units in 2019, and from 2015-2018 (Sections 1 and 5) or 2015-2019 (Sections 3 and 4) for pooled analyses.

Final data related to this report was received by the ANZSCTS Database Program Data Management Team in the Centre of Cardiovascular Research and Education in Therapeutics (CCRET) of the Department of Epidemiology and Preventive Medicine, Monash University, on April 6th, 2020. Submitted data was checked for completeness and Data Managers in each unit were given opportunities to amend any errors. Any changes to the data after April 6th, 2020 are not reflected in this report.

Variable definitions

All definitions are based on the ANZSCTS Database Data Definitions Manual. Version 3.0 applies to all patients with admission dates prior to September 1st, 2016 and version 4.0 applies to patients with admission dates on and after September 1st, 2016.

Key variables presented in this report are defined below.

- Clinical status

Elective
The procedure could be deferred without risk of compromised cardiac outcome.

Urgent

a. Within 72 hours of angiography if initial operation was performed in the same admission as angiography ('same admission' includes where angiography was performed in another unit prior to direct transfer to unit where initial operation is performed); or
b. Within 72 hours of an unplanned admission (patient who had a previous angiogram and was scheduled for surgery but was admitted acutely); or
c. Procedure required during same hospitalisation in a clinically compromised patient in order to minimise chance of further clinical deterioration.^

^Additional criteria in version 4.0

Emergency*
Unscheduled surgery required in the next available theatre on the same day (as admission) due to refractory angina or haemodynamic compromise.

Salvage*
The patient underwent cardiopulmonary resuscitation *en route* to, or in the operating room, prior to surgical incision.

** Due to low number of cases, emergency and salvage patients are combined within the report, and labelled as emergency.*

- Left ventricular ejection fraction (LVEF)

Record the percentage of blood emptied from the left ventricle at the end of the contraction. Use the most recent determination prior to intervention. If unknown enter LVEF estimate.

This data gets converted to a measure of left ventricular function (LVF) or dysfunction (LVD) as follows;

EF (%)	Measure of function/dysfunction
LVEF > 60%	Normal LVF
LVEF 46-60%	Mild LVD
LVEF 30-45%	Moderate LVD
LVEF <30%	Severe LVD

- Readmission ≤ 30 days from surgery

Patient readmitted as an in-patient within 30 days from the date of surgery for ANY reason to general hospital; not emergency, short-stay wards or planned transfer to rehabilitation facility. Date of surgery counts as day zero.

- Redo operation

Operation performed on a patient who has undergone any prior cardiac surgery.

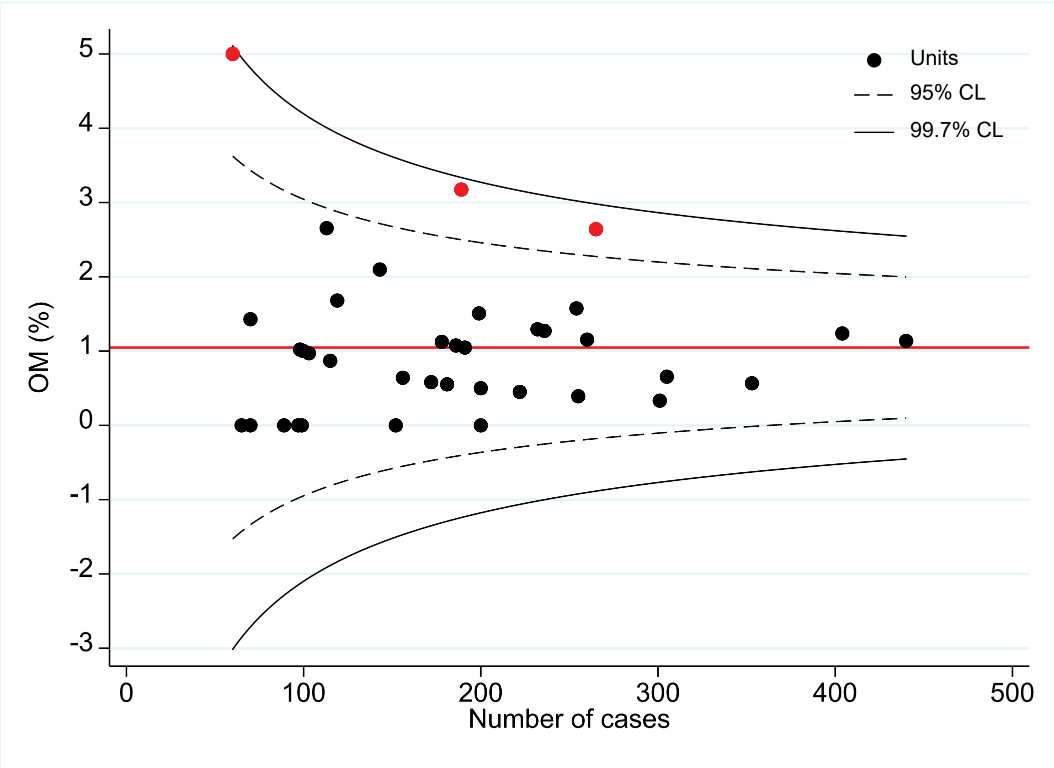
Appendix D

Appendix D-I - Interpretation of Funnel Plots

Funnel plots are an approach to compare performance standards of hospital units. They are especially useful in this situation as there is usually a difference in the numbers of operations (sample size) included in the data plot. For example, Figure D-1 below illustrates the OM after coronary artery bypass surgery in Australia in 2018.

The solid red line represents the average OM, the two-dashed lines are the 95% CL and the solid black lines are the 99.7% CLs. The funnel plot allows the CLs to narrow as the number of operations increases. This representation supports the 95% CL plot to illustrate the invalidity of ranking all of those units from “best” to “worst” as only three were worse than the majority, all of which had statistically similar outcomes.

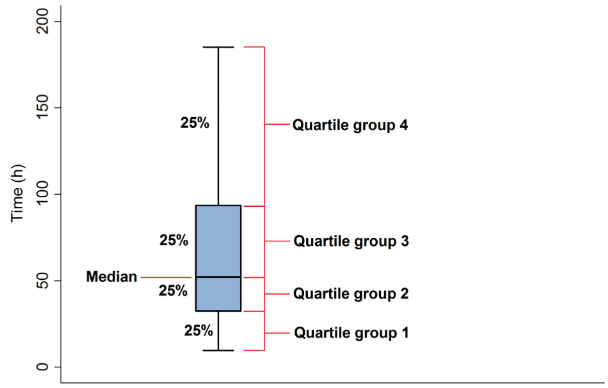
Figure D-I. OM following isolated CABG by unit



Appendix D-II - Interpretation of Box Plots

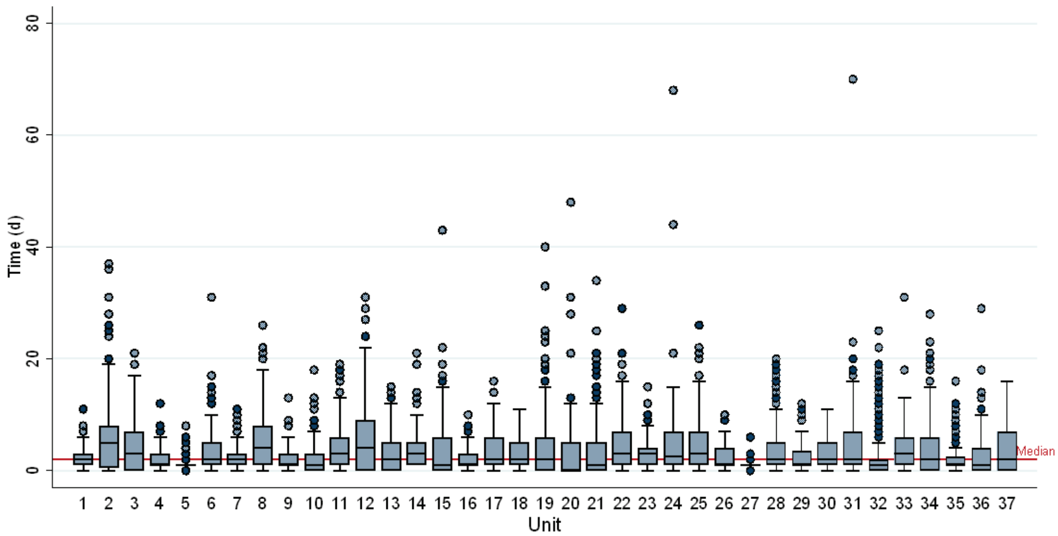
A Box Plot is a demonstration of statistical information that illustrates the maximum and minimum values (the upper and lower whiskers), the second and third quartiles (the lower and upper limits of the box, so that the box contains the middle half of the observations) and the median value (the line within the box), for a set of observations.

Figure D-II. Box plot example



The box plots presented in this report do not include observations that the statistical software package (Stata 15) has determined to be outliers (i.e. those that significantly deviate from where the majority of the observations lie). Where data is clustered particularly tightly, exclusion of outliers means the data may look compressed. For instance, in the length of stay data presented in Figure D-IIA, unit 27 has a number of outliers (represented by black circles) clustered around the median. When the outliers are removed, it looks as though all patients in unit 27 had a length of stay of one day, with no variation. Removing the outliers improves the readability of the graph, but does result in a small loss of information.

Figure D-IIA. Box Plot example: length of stay data with outliers



Appendix E

All Procedures Risk Adjustment Model

The All Procedures Score (Billah, *et. al.*, 2010) is a validated pre-operative risk prediction model, used for risk-adjustment for 30-day mortality for all cardiac surgery, in Australia[19]. The model was developed based on a large number of operations using standardised data collection methodology. Subsequent validation of the model showed that it is a good fit for Australian data and correctly classified the risk of a large number of operations.

The Risk Adjusted Mortality Rate (RAMR) takes into account a number of risk factors listed in Table E-I. The ratio of the observed mortality (OM) rate to the predicted mortality rate indicates the relative performance adjusted for the severity of illness or risk. A ratio of 1 indicates results as expected, less than 1 indicates results better than expected, and greater than 1 indicates results worse than expected. This ratio is then multiplied by the Observed Average Mortality Rate to yield a RAMR which normalises the individual unit for its case mix.

RAMR is calculated as follows:

$$\text{RAMR} = \left(\frac{\text{OM Rate}}{\text{Predicted Mortality Rate}} \right) \times \text{Average OM Rate}$$

RAMR is therefore, a predictor of mortality for a given patient set which takes into account the risks for those patients.

Table E-I. Variables that define overall patient risk in the All Procedures Risk-Adjustment Model

Age	Sex	Clinical Status
Procedure type	Previous Cardiac Surgery	NYHA* class
EF Grade	Pre-operative Dialysis	Hypercholesterolaemia
Previous vascular disease	BMI>25kg/m^2	Inotropes at time of surgery

* New York Heart Association functional classification for dyspnoea

References

1. McNeely, C., Markwell, S. & Vassileva, C. Trends in Patient Characteristics and Outcomes of Coronary Artery Bypass Grafting in the 2000 to 2012 Medicare Population. *The Annals of Thoracic Surgery* **102**, 132–138 (2016).

2. Dinh, D. T. *et al.* Trends in coronary artery bypass graft surgery in Victoria, 2001–2006: findings from the Australasian Society of Cardiac and Thoracic Surgeons database project. *The Medical Journal of Australia* **188**, 214–217 (2008).

3. Ferguson, T. B. *et al.* A decade of change--risk profiles and outcomes for isolated coronary artery bypass grafting procedures, 1990-1999: a report from the STS National Database Committee and the Duke Clinical Research Institute. Society of Thoracic Surgeons. *Ann. Thorac. Surg.* **73**, 480–489; discussion 489-490 (2002).

4. ElBardissi, A. W. *et al.* Trends in isolated coronary artery bypass grafting: An analysis of the Society of Thoracic Surgeons adult cardiac surgery database. *The Journal of Thoracic and Cardiovascular Surgery* **143**, 273–281 (2012).

5. *Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART). SWEDEHEART Annual report 2019*. Available online at https://www.ucr.uu.se/swedeheart/dokument-sh/arsrapporter-sh/1-swedeheart-annual-report-2019 (2020).

6. *Ministry of Health. 2020. New Zealand Cardiac Surgery National Report: 2017. National Cardiothoracic Surgery Clinical Network (NCSCN)*. Available online at https://www.health.govt.nz/system/files/documents/publications/new_zealand_cardiac_surgery_national_report_2017.pdf (2020).

7. Worrall-Carter, L., McEvedy, S., Wilson, A. & Rahman, M. A. Gender Differences in Presentation, Coronary Intervention, and Outcomes of 28,985 Acute Coronary Syndrome Patients in Victoria, Australia. *Women's Health Issues* **26**, 14–20 (2016).

8. Shardey, G *et al. The Australian and New Zealand Society of Cardiac and Thoracic Surgeons Cardiac Surgery Database Program National Annual Report 2018*. (2019).

9. *National Institute for Cardiovascular Outcomes Research (NICOR). National Cardiac Audit Programme (NCAP) 2019 Annual Report – Improving cardiovascular outcomes: timely, specialist, evidence-based care*. Available online at https://www.nicor.org.uk/wp-content/uploads/2019/09/NCAP-Annual-Report-2019-final.pdf (2019).

10. Jacobs, J. P. *et al.* The Society of Thoracic Surgeons National Database 2018 Annual Report. *The Annals of Thoracic Surgery* **106**, 1603–1611 (2018).

11. Johnston, A., Mesana, T. G., Lee, D. S., Eddeen, A. B. & Sun, L. Y. Sex Differences in Long-Term Survival After Major Cardiac Surgery: A Population-Based Cohort Study. *J Am Heart Assoc* **8**, (2019).

12. Blasberg, J. D., Schwartz, G. S. & Balaram, S. K. The role of gender in coronary surgery. *Eur J Cardiothorac Surg* **40**, 715–721 (2011).

13. Gombotz, H., Schreier, G., Neubauer, S., Kastner, P. & Hofmann, A. Gender disparities in red blood cell transfusion in elective surgery: a post hoc multicentre cohort study. *BMJ Open* **6**, e012210 (2016).

14. Neugarten, J., Sandilya, S., Singh, B. & Golestaneh, L. Sex and the Risk of AKI Following Cardio-thoracic Surgery: A Meta-Analysis. *Clin J Am Soc Nephrol* **11**, 2113–2122 (2016).

15. Filardo, G. *et al.* Excess short-term mortality in women after isolated coronary artery bypass graft surgery. *Open Heart* **3**, e000386 (2016).

16. Hogue Charles W. *et al.* Sex Differences in Neurological Outcomes and Mortality After Cardiac Surgery. *Circulation* **103**, 2133–2137 (2001).

17. Blankstein, R. *et al.* Female gender is an independent predictor of operative mortality after coronary artery bypass graft surgery: contemporary analysis of 31 Midwestern hospitals. *Circulation* **112**, I323-327 (2005).

18. Vassileva, C. M., Stelle, L. M., Markwell, S., Boley, T. & Hazelrigg, S. Sex differences in procedure selection and outcomes of patients undergoing mitral valve surgery. *Heart Surg Forum* **14**, E276-282 (2011).

19. Billah, B., Reid, C. M., Shardey, G. C. & Smith, J. A. A preoperative risk prediction model for 30-day mortality following cardiac surgery in an Australian cohort. *Eur J Cardiothorac Surg* **37**, 1086–1092 (2010).

2019 Research Publications

1. Irving, A. H. *et al.* Impact of patient blood management guidelines on blood transfusions and patient outcomes during cardiac surgery. *J. Thorac. Cardiovasc. Surg.* **160**, 437-445.e20 (2020).

2. Tran, L. *et al*. The Australian and New Zealand Society of Cardiac and Thoracic Surgeons Database Program - Two Decades of Quality Assurance Data. *Heart Lung Circ* **28**, 1459–1462 (2019).

3. Si, S. *et al.* Surgical aortic valve replacement in Australia, 2002-2015: temporal changes in clinical practice, patient profiles and outcomes. *ANZ J Surg* **89**, 1061–1067 (2019).

4. Zhu, M. Z. L. *et al.* On-Pump Beating Heart Versus Conventional Coronary Artery Bypass Grafting Early After Myocardial Infarction: A Propensity-Score Matched Analysis From the ANZSCTS Database. *Heart Lung Circ* **28**, 1267–1276 (2019).

5. Nag, N. *et al.* Structured Feedback: Acceptability and Feasibility of a Strategy to Enhance the Role of a Clinical Quality Registry to Drive Change in Cardiac Surgical Practice. *Heart Lung Circ* **28**, 1253–1260 (2019).

Contact Details

Postal Address:
ANZSCTS Database
Monash University
Level 4, 553 St Kilda Road
Melbourne 3004

Web: www.anzscts.org/database
Email: anzscts@monash.edu
Telephone: +61 3 9903 0518
Facsimile: +61 3 9903 0556