ANZSCTS Cardiac Surgery Database Program

Annual Report

2023

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Acronyms

ANZSCTS	Australian and New Zealand Society for Cardiac and Thoracic Surgeons
ARL	Average run length
AVR	Aortic valve replacement
BITA	Bilateral internal thoracic artery
CABG	Coronary artery bypass graft
CCRET	Centre of Cardiovascular Research and Education in Therapeutics
CPB	Cardiopulmonary bypass
CUSUM	Cumulated sum
DM	Data Manager
DMAC	Data Management and Analysis Centre
dNRI	Derived new renal insufficiency
DoCS	Director of Cardiothoracic Surgery
DSWI	Deep sternal wound infection
EF	Ejection fraction
FFP	Fresh frozen plasma
ICU	Intensive care unit
IQR	Interquartile range
KPI	Key performance indicator
LITA	Left internal thoracic artery
LOS	Length of stay
LV	Left ventricular
LVF	Left ventricular function
MD	Medical Director
MI	Myocardial infarction
MV	Mitral valve
MVR	Mitral valve replacement
NSTEMI	Non-ST-elevation myocardial infarction
OM	Operative mortality
RA	Radial artery
RA-dNRI	Risk-adjusted derived new renal insufficiency
RA-OM	Risk-adjusted operative mortality
RBC	Red blood cell
RITA	Right internal thoracic artery
RTT	Return to theatre
SC	Steering Committee
SVG	Saphenous vein graft

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 Database is based in the Centre of Cardiovascular Research and Education in Therapeutics (CCRET) within the School of Public Health and Preventive Medicine at Monash University.

We acknowledge the contributions made by the ANZSCTS Database Steering and Research Committees, which oversee all registry activities including the quality assurance and research programs. We thank the Database Data Custodian, Prof Chris Reid, the Co-Director of the CCRET, Prof Dion Stub, the Steering Committee Chair and Deputy Chair, A/Prof Julie Mundy and A/Prof Siven Seevanayagam, and the Research Committee Chair, Prof Julian Smith, for their essential support of the Database. Prof Chris Reid is supported by a National Health and Medical Research Council Principal Research Fellowship and Prof Stub is supported by a National Heart Foundation Future Leader Fellowship.

We also acknowledge the Data Management and Analysis Centre staff at the CCRET (Dr Jenni Williams-Spence, Dr Lavinia Tran, Mr Noah Solman, Ms Jenna McLaren, Mrs Nicole Marrow, Mr Jonathan Ong and Mr Mark Lucas).

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. We sincerely thank these individuals for their participation.

Photograph by Mark Lucas 2018 ©

Foreword

This is the 17th Annual Report of the ANZSCTS Cardiac Surgery Database Program. There are currently 61 units both public and private across Australia and New Zealand that have subscribed and been granted access to submit data to the Database. This report includes data from 57 units and 17,875 cases from 2023, including 32 private hospitals. The information presented in this report underpins the importance of data in ensuring quality outcomes in cardiac surgery.

The main focus of the data presented in this report is on unit comparisons for surgery performed in the 2023 calendar year. Thirty-day follow-up dictates that surgical outcomes are collected to the end of January 2024. In some sections, information is also presented as pooled (four- or five-year) or five-year time-series data. The report displays unit performance compared to other contributing units and the group average. Units are anonymised by assignment of a random code for public reporting, but are re-identifiable to individual hospitals.

The Australian Committee on Safety and Quality in Health Care's Framework for Australian Clinical Quality Registries outlines the importance of capturing data for the entire eligible patient population to minimise selection bias and maximise the strength and coverage of quality assurance activities. Data completeness amongst the hospitals contributing to the ANZSCTS Database is excellent, however, there are a small number of cardiac surgical units not yet participating in the Program.

This report demonstrates that overall, most participating cardiac surgical units had satisfactory outcomes for the key performance indicators (mortality and complications). However, this report also shows that there is variability in practice and the knowledge gained from benchmarking units highlights opportunities for review and improvement.

Outside of the Annual Report, the Program has a Steering Committee that meets quarterly to review the most recent data and identify variation in performance. If there is a signal that a specific aspect of surgical performance needs attention then Directors of Cardiac Surgical Units at public hospitals and Medical Directors at private hospitals are notified in accordance with the ANZSCTS Database's *Special Cause Variation Management Policy*. This process continually reduces variation and improves patient care and an example of how it was recently expanded to cover a wider range of cases is presented in Section 5 of this report.

Clinical audits using institutional or other limited datasets cannot replicate the benefits of participation in a binational clinical quality registry. A core aim of the ANZSCTS Database is therefore to achieve total cardiac surgery patient population coverage in Australia and New Zealand to ensure all care is maintained at a high standard. We rely on the efforts of local government, surgeons and hospital administrators to support participation and help us reach this goal. We look forward to reporting on the entirety of cardiac surgical activity in Australia and New Zealand in future publications.

Associate Professor Julie Mundy
Chair, ANZSCTS Database Program Steering Committee

Introduction

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 since 2002 for Victorian units, and since 2007 at a national level. It expanded to include Aotearoa New Zealand in 2019 with the addition of Auckland City Hospital and reached full public hospital coverage of cardiac surgery in Australia in 2020.

The ANZSCTS Database 2023 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's report also includes an additional section summarising the methods used for the recent expansion of the peer review process to examine lower volume procedures. The report is presented as follows:

- Section 1: Isolated Coronary Artery Bypass Graft (CABG) Surgery
- Section 2: Isolated Valve Surgery
- Section 3: Combined Valve and CABG Surgery
- Section 4: Other Cardiac Surgery
- Section 5: Development of CUSUM Chart Reporting for AVR and combined AVR and CABG
- Section 6: Concluding Remarks

Key performance indicators

The Database collects and analyses data for a range of clinically relevant surgical outcomes for the purpose of monitoring cardiac surgical unit performance. These KPIs are:

- Unadjusted operative (in-hospital and 30-day) mortality (OM) and risk-adjusted OM (RA-OM)
- Permanent stroke
- Unadjusted derived new renal insufficiency (dNRI) and risk-adjusted dNRI (RA-dNRI)
- Deep sternal wound infection (DSWI)
- Return to theatre (RTT) for bleeding

The KPIs are defined in detail in Appendix A (pg. 77). Information about the ANZSCORE risk-adjustment models can be found in Appendix B (pg. 79). Units that fall outside the upper 99.7% control limit for any of these KPIs are supported in line with the Database *Special Cause Variation Management Policy*.

Data completeness and analysis

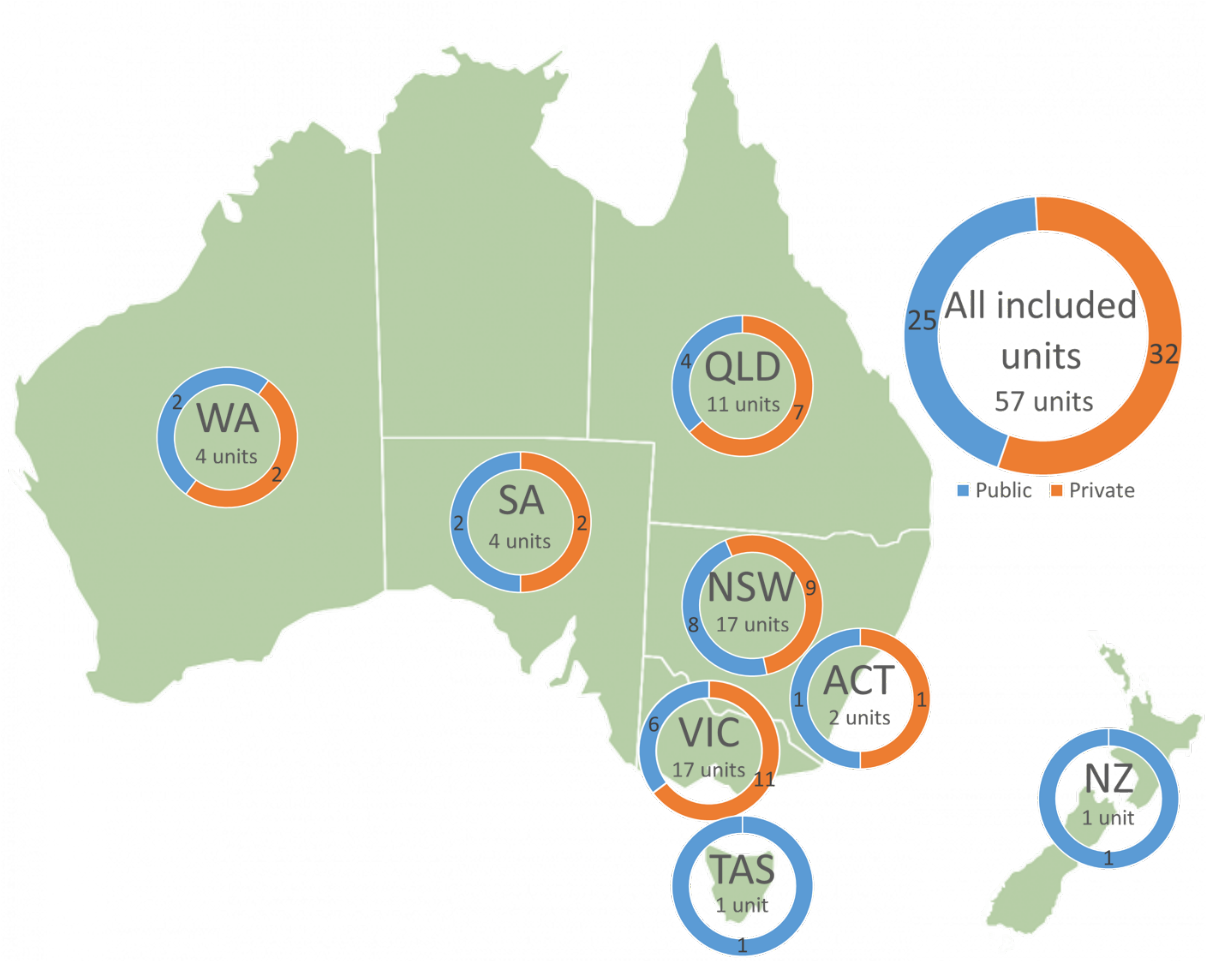
Of the cases submitted in 2023, 99.2% were flagged as complete. Incomplete cases miss one or more variables for a variety of reasons. The tables presented in this report include all available data. Accordingly, there are small variations in the total number of cases in each table due to the differing amount of missing data for each variable.

Where the number of cases in the current year is low (Sections 2 and 3), data is pooled with the preceding four years. Details of data preparation and key variable definitions are presented in Appendix C (pg. 81).

Contributing hospitals

Data from 57 cardiac surgery units are presented in this report, including from 32 private hospitals. Some hospitals joined the Program more recently, therefore have not provided data over the full period analysed. Only units that submitted at least three quarters worth of data (9 months; or equivalent for new units), in 2023 are included in the report. A list of hospitals included in the report and the proportion of cases contributed by each hospital can be found in Appendix D (pg. 83).

Figure 1. Participating hospitals featured in the 2023 Annual Report, by state and country



Overview of procedures

In 2023, 17,875 cardiac surgical procedures were performed at the 57 hospitals included in this report. Figure 2 and Table 1 show the frequency of the major procedure groups by unit and over the last five years, respectively.

Figure 2. Cardiac surgery cases by procedure group and unit, 2023

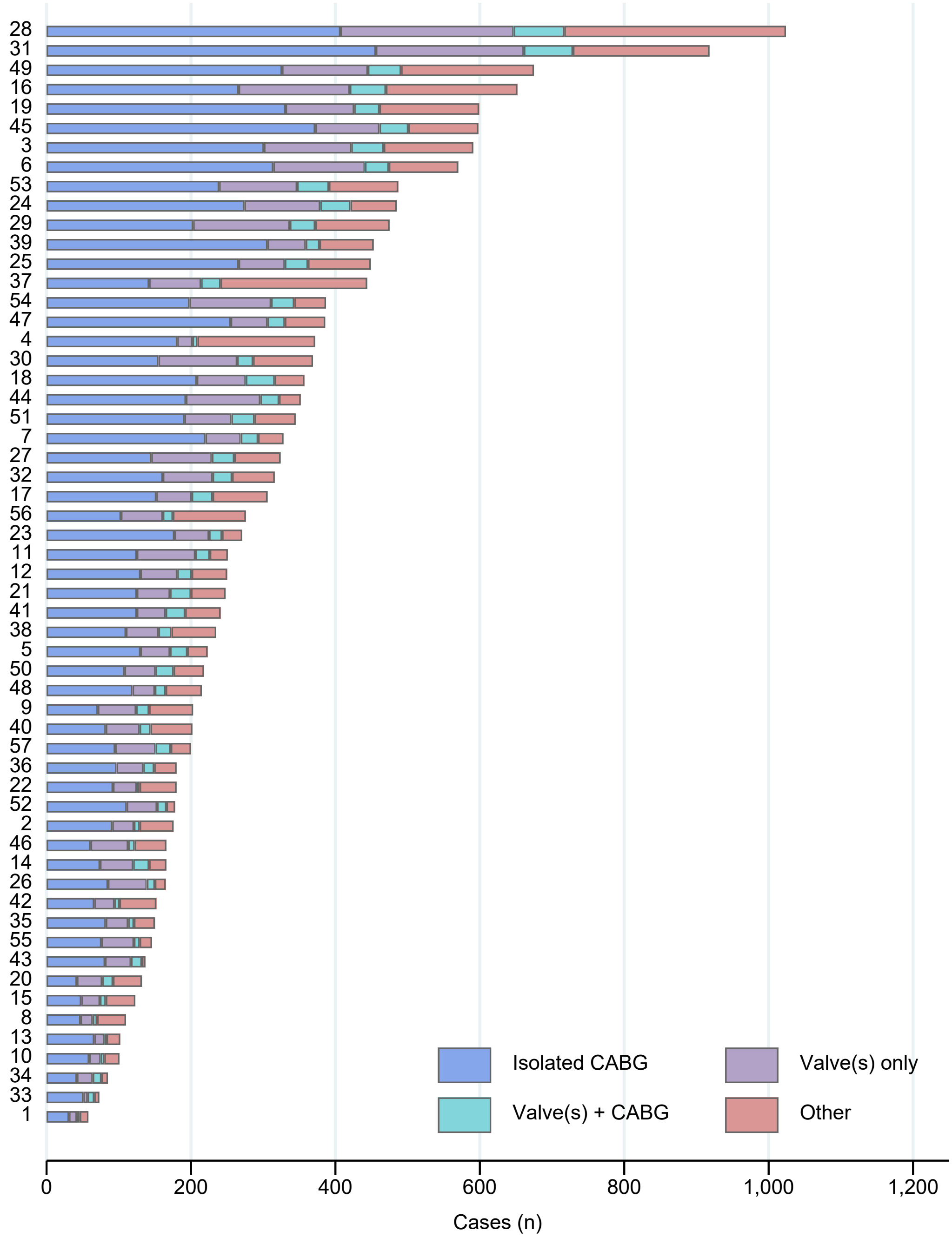
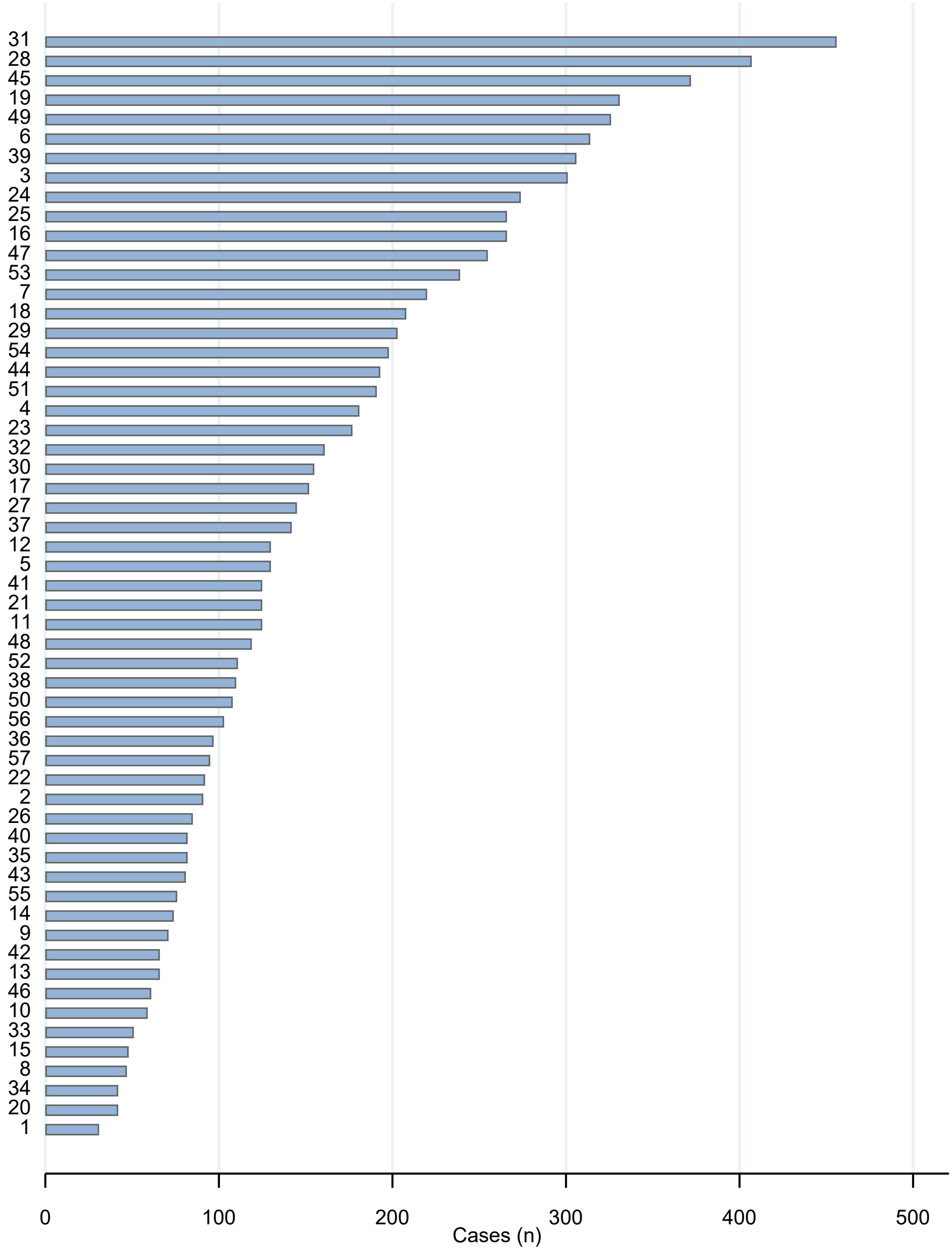


Table 1. Cardiac surgery procedure groups by year

	2019	2020	2021	2022	2023	Total
Hospitals (n)	40	47	52	55	57	57
Total cases (n)	15,102	15,078	16,111	16,326	17,875	80,492
Isolated CABG (%)	50.9	51.4	51.8	53.2	50.7	51.6
Valve(s) only (%)	20.3	20.9	20.2	19.2	20.6	20.2
Valve(s) + CABG (%)	8.6	8.4	8.4	7.9	7.4	8.1
Other (%)	20.1	19.4	19.7	19.7	21.2	20.1

1. Isolated CABG Surgery

Figure 3. Isolated CABG cases by unit, 2023



Summary of isolated CABG surgery activity

Isolated CABG surgery accounted for 50.7% of cases submitted to the ANZSCTS Database in 2023 (Table 1). There were 9,064 cases in total and case volume varied between units, with 21 performing fewer than 100 cases and 16 performing more than 200 (Figure 3).

Choice of conduits

There was large variation between units with the type of conduits used, particularly with radial arteries vs saphenous vein (Figure 12). Bilateral internal thoracic artery (BITA) grafts were associated with the most anastomoses (mean of 2.2), followed by saphenous vein graft (SVG) (mean of 1.7; Table 9). The mean number of grafts per patient did not notably vary between age groups; however, the proportion of patients having total arterial revascularisation generally decreased with increasing age, from 41.6% in the 18 to less than 50 years cohort to 24.9% in patients 80 years and older (Table 10). Total arterial revascularisation was more common in patients having off-pump surgery, compared to on-pump surgery (57.8 vs 26.7%), noting that off-pump procedures only accounted for 9.0% of isolated CABG cases in 2023 (Table 8 and Table 10). The proportion of cases involving total arterial revascularisation varied substantially between units (Figure 13).

Complications with risk factors

Consistent with expectations, complications varied for patients with key pre-operative risk factors. In particular, diabetic patients had a higher incidence of stroke while patients with markers of pre-operative renal dysfunction had a higher incidence of RTT for bleeding. Both cohorts had more cases involving DSWI (Table 11). Unsurprisingly, these patient cohorts also had a substantially higher post-operative incidence of dNRI (Table 14). For all isolated CABG patients, there were weak trends suggesting increasing incidence of permanent stroke and post-operative dNRI with increasing age group, on average, and new cardiac arrhythmias consistently increased between age groups. Age did not appear to affect DSWI and RTT for bleeding, overall (Table 12 and Table 14).

The mean OM for emergency and salvage surgery was close to 10-fold higher than elective surgery in 2023. Low ejection fraction (EF), myocardial infarction (MI) within 24 hours and pre-operative creatinine greater than 200 µmol/L or dialysis were associated with markedly increased OM, and OM was twice as high in females (Table 15).

KPIs

The majority of units performed comparably in 2023, and units with outcomes outside the 99.7% control limit on funnel plot analysis were engaged by the ANZSCTS Database Steering Committee (SC), in line with the *Special Cause Variation Management Policy*. The SC views a minimum of 100 cases as necessary for reliable interpretation of the results and discretion should be used for units that do not meet this threshold.

The OM for isolated CABG patients was 1.1% in 2023 and 2019-2022 (Figure 14a and Figure 14b), which is consistent with the various in-hospital and 30-day mortality rates reported by registries in the United States, Sweden, Germany, and the United Kingdom, which ranged from 0.8 – 2.5% for recent years (1-4). The RA-OM calculated using the Database's ANZSCORE model was 1.0% in 2023 (Figure 14c). In 2023, the incidences of other KPIs were consistent with previous years, including dNRI (2.4%), RA-dNRI (2.1%), permanent stroke (0.9%), DSWI (0.9%) and RTT for bleeding (2.4%; Figure 15-18). For the interpretation of funnel plots see Appendix E (pg. 85).

Resource utilisation

Almost half of patients (49.8%) were admitted the day before or day of their surgery, and the median pre-operative length of stay (LOS) was higher at public hospitals (two days) than private hospitals (one day; Figure 21 and Table 16). Approximately 76.8% of patients were discharged less than ten days after their surgery, with a median stay of seven days in the public hospitals and eight days in the private hospitals (Figure 22 and Table 17).

Almost one third (30.8%) of patients were extubated within six hours and 68.3% within 12 hours of surgery (Table 18). The length of intensive care unit (ICU) stay showed a cyclical pattern with patients frequently discharged at 24-hour intervals (Figure 24). Just under half of patients (46.0%) were discharged from the ICU within 48 hours (Table 20). The mean length of ICU LOS was lower in public hospitals (64.5 hours) compared to private hospitals (68.4 hours; Table 21). Overall, approximately 39% of isolated CABG patients received some type of blood product transfusion and there was similar use of red blood cell (RBC) and non-RBC products at public and private hospitals (Figure 25).

1.1 Patient characteristics

1.1.1 Clinical status

Figure 4. Clinical status of isolated CABG patients by unit, 2023

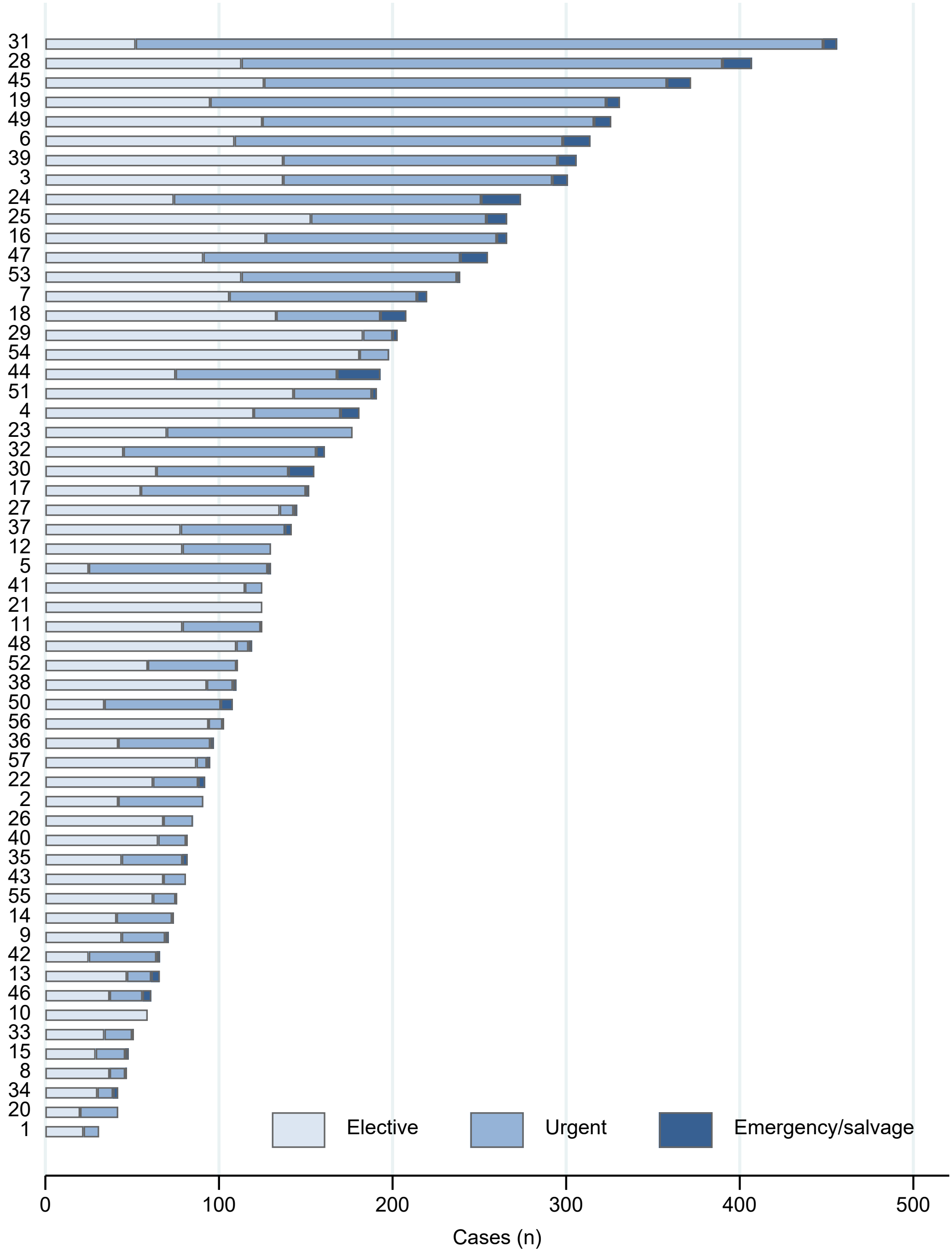


Table 2. Clinical status of isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
Elective (%)	56.2	51.6	50.0	48.9	50.9	51.4
Urgent (%)	40.3	45.2	46.5	47.8	45.8	45.2
Emergency/salvage (%)	3.5	3.2	3.5	3.3	3.2	3.3

1.1.2 Sex and age

Figure 5. Sex of isolated CABG patients by unit, 2023

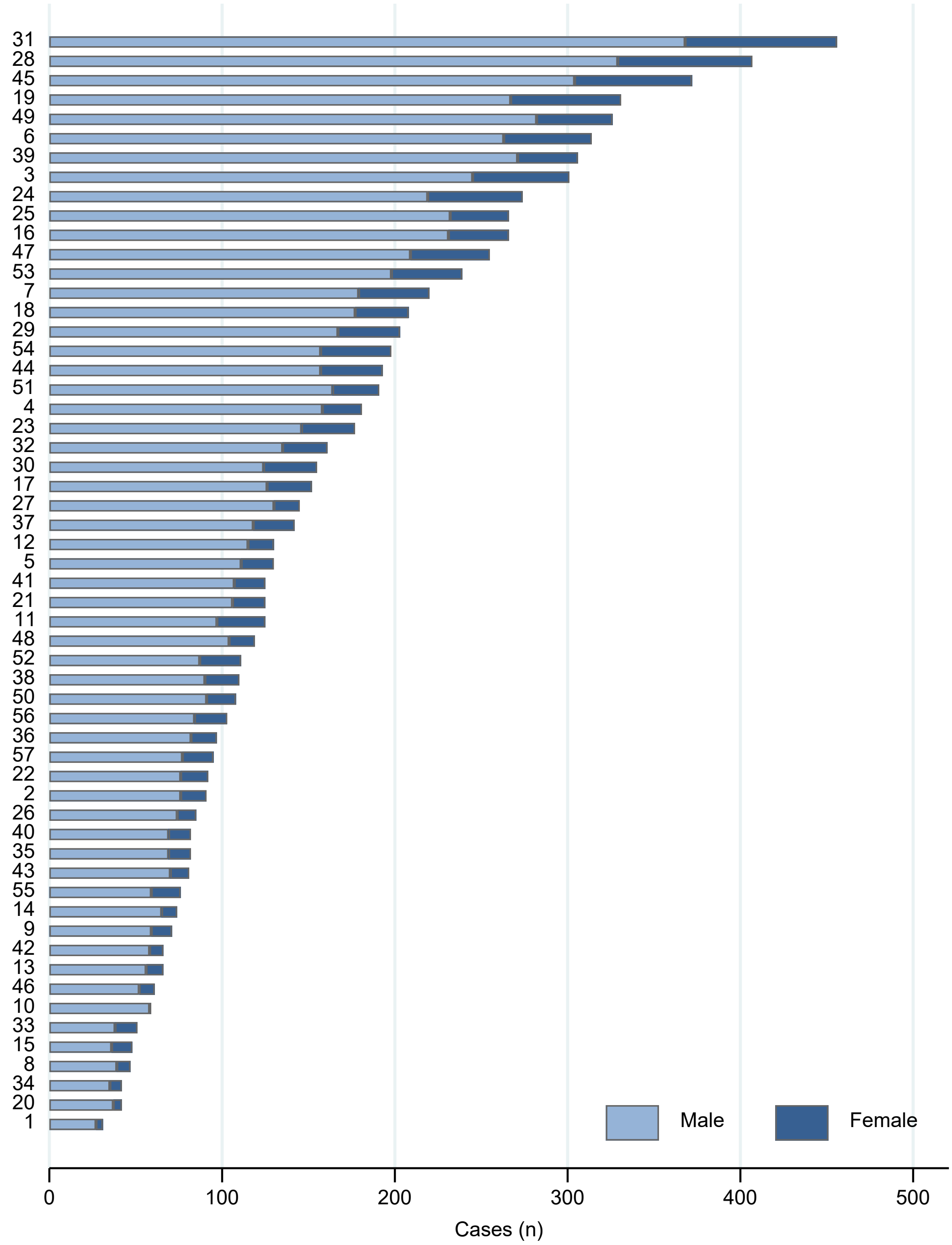
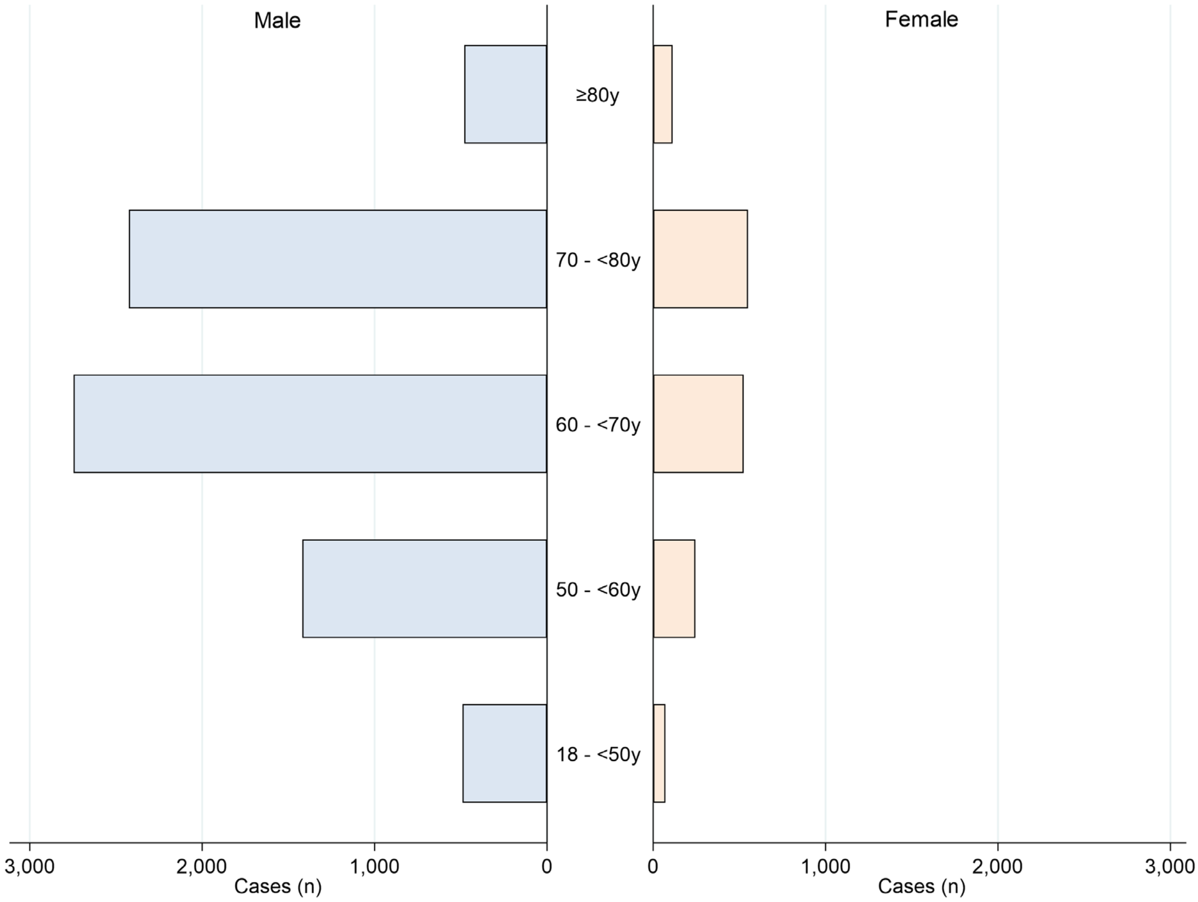


Table 3. Sex of isolated CABG patients by year

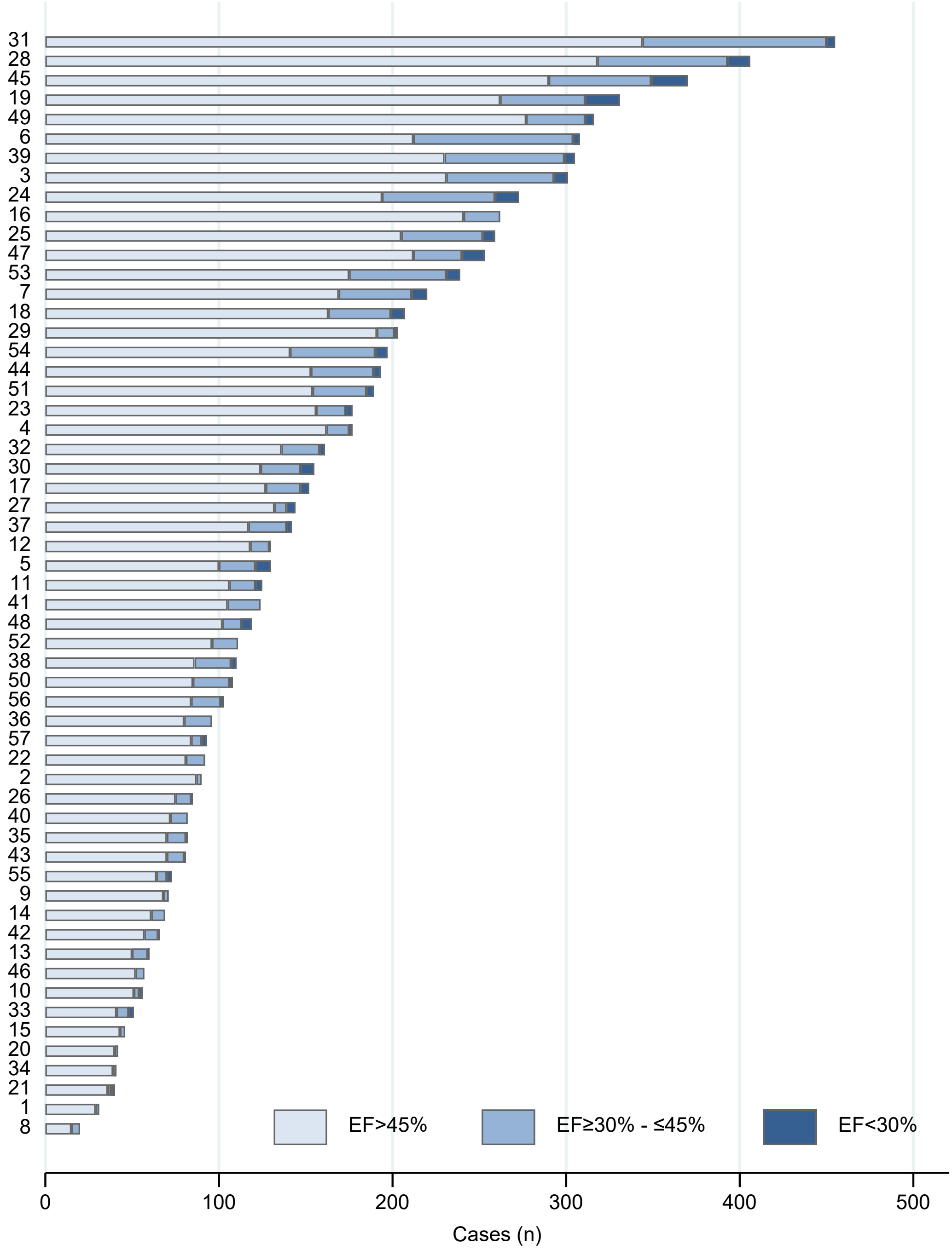
	2019	2020	2021	2022	2023	Total
Male (%)	82.3	82.8	83.4	83.5	83.4	83.1
Female (%)	17.7	17.2	16.6	16.5	16.6	16.9

Figure 6. Age of isolated CABG patients by sex, 2023



1.1.3 Left ventricular function

Figure 7. Pre-operative left ventricular function (LVF) of isolated CABG patients by unit, 2023



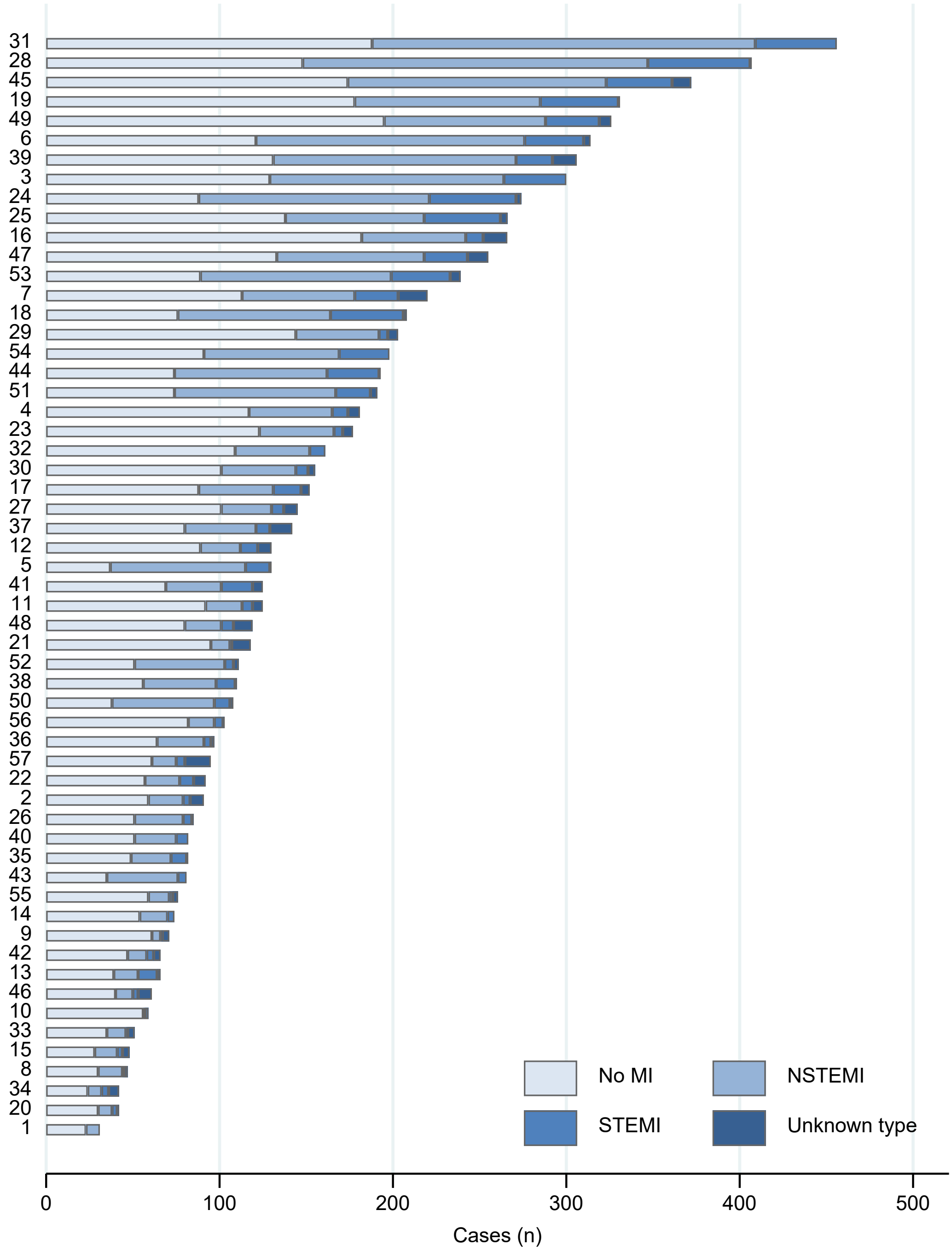
The ANZSCTS Database classifies an EF>45% as normal or mildly reduced, an EF≥30% - ≤45% as moderately reduced and an EF<30% as severely reduced LVF (Appendix C, pg. 81).

Table 4. Pre-operative LVF of isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
EF>45% (%)	81.2	80.3	81.1	81.2	81.8	81.1
EF≥30% - ≤45% (%)	15.7	16.5	15.9	15.8	15.6	15.9
EF<30% (%)	3.1	3.2	3.0	3.0	2.6	3.0

1.1.4 Previous myocardial infarction

Figure 8. Previous MI in isolated CABG patients by unit, 2023



NSTEMI, non-ST-elevation MI; STEMI, ST-elevation MI

Table 5. Previous MI in isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
No MI (%)	48.4	47.6	50.5	48.4	53.3	49.8
NSTEMI (%)	38.0	39.2	36.0	38.0	34.2	37.0
STEMI (%)	10.0	10.0	10.5	10.6	9.5	10.1
Unknown type (%)	3.6	3.1	3.0	3.0	3.0	3.1

1.1.5 Timing of previous myocardial infarction

Figure 9. Timing of previous MI in isolated CABG patients by unit, 2023

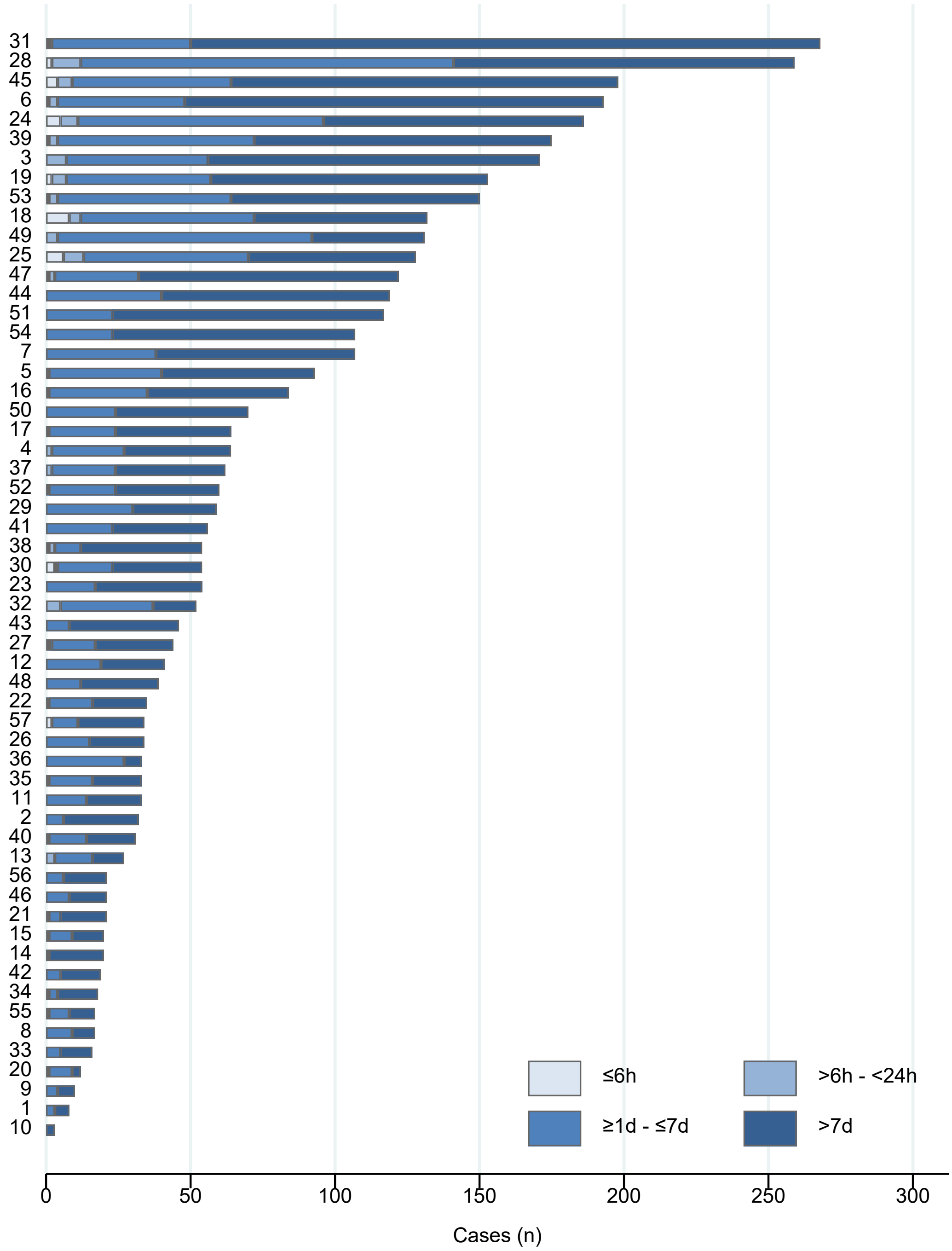


Table 6. Timing of previous MI in isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
≤6hr (%)	1.6	1.5	1.5	1.1	1.0	1.3
>6hr - <24hr (%)	2.3	2.0	1.6	2.2	2.0	2.0
≥1d - ≤7d (%)	31.5	36.4	36.9	35.7	35.9	35.3
>7d (%)	64.7	60.1	60.0	61.0	61.1	61.4

1.2 Previous cardiac surgery

Figure 10. Initial vs redo surgery in isolated CABG patients by unit, 2023

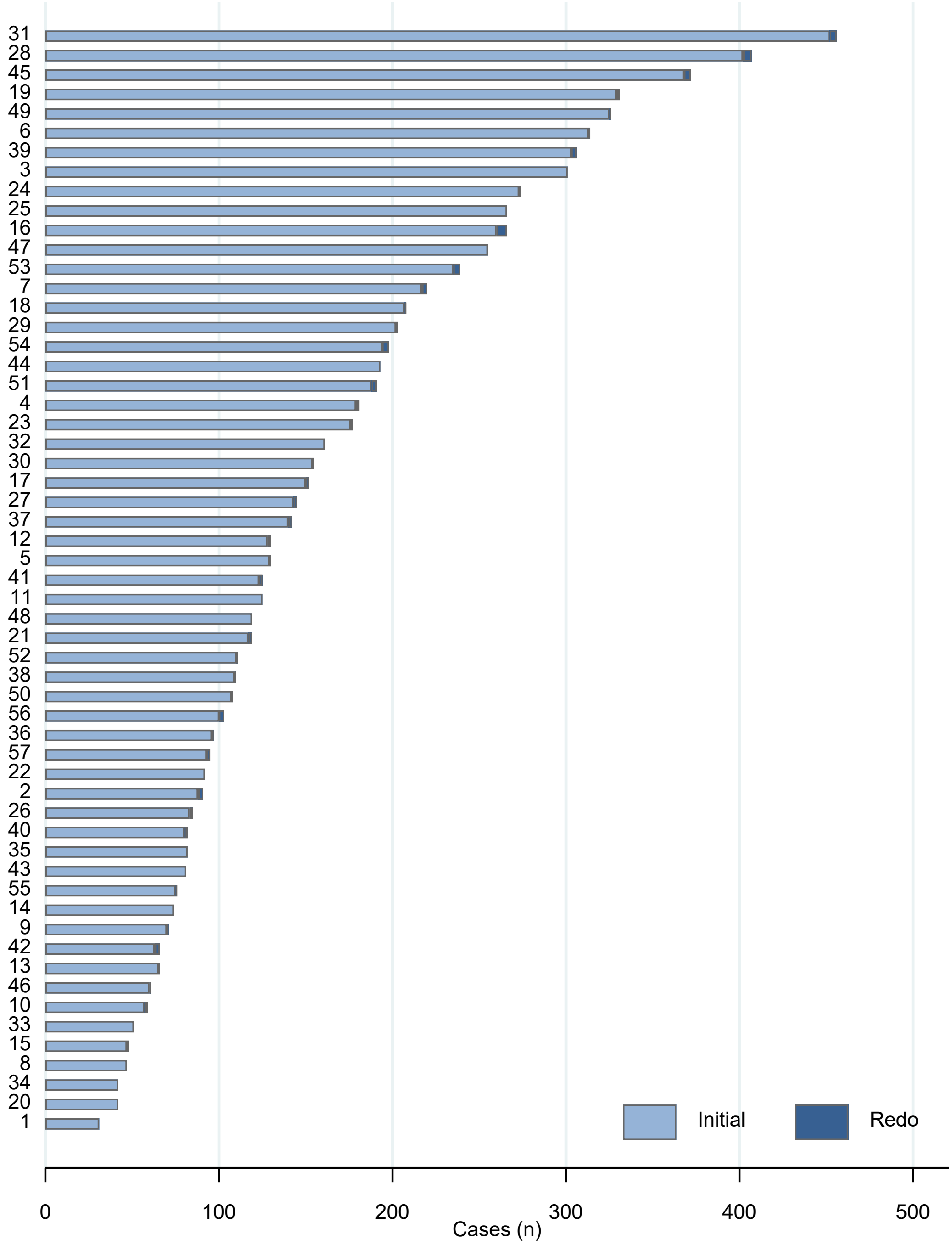


Table 7. Initial vs redo surgery in isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
Initial (%)	98.8	98.9	98.9	99.0	99.1	98.9
Redo (%)	1.2	1.1	1.1	1.0	0.9	1.1

1.3 On-pump and off-pump coronary surgery

Figure 11. On-pump vs off-pump surgery in isolated CABG patients by unit, 2023

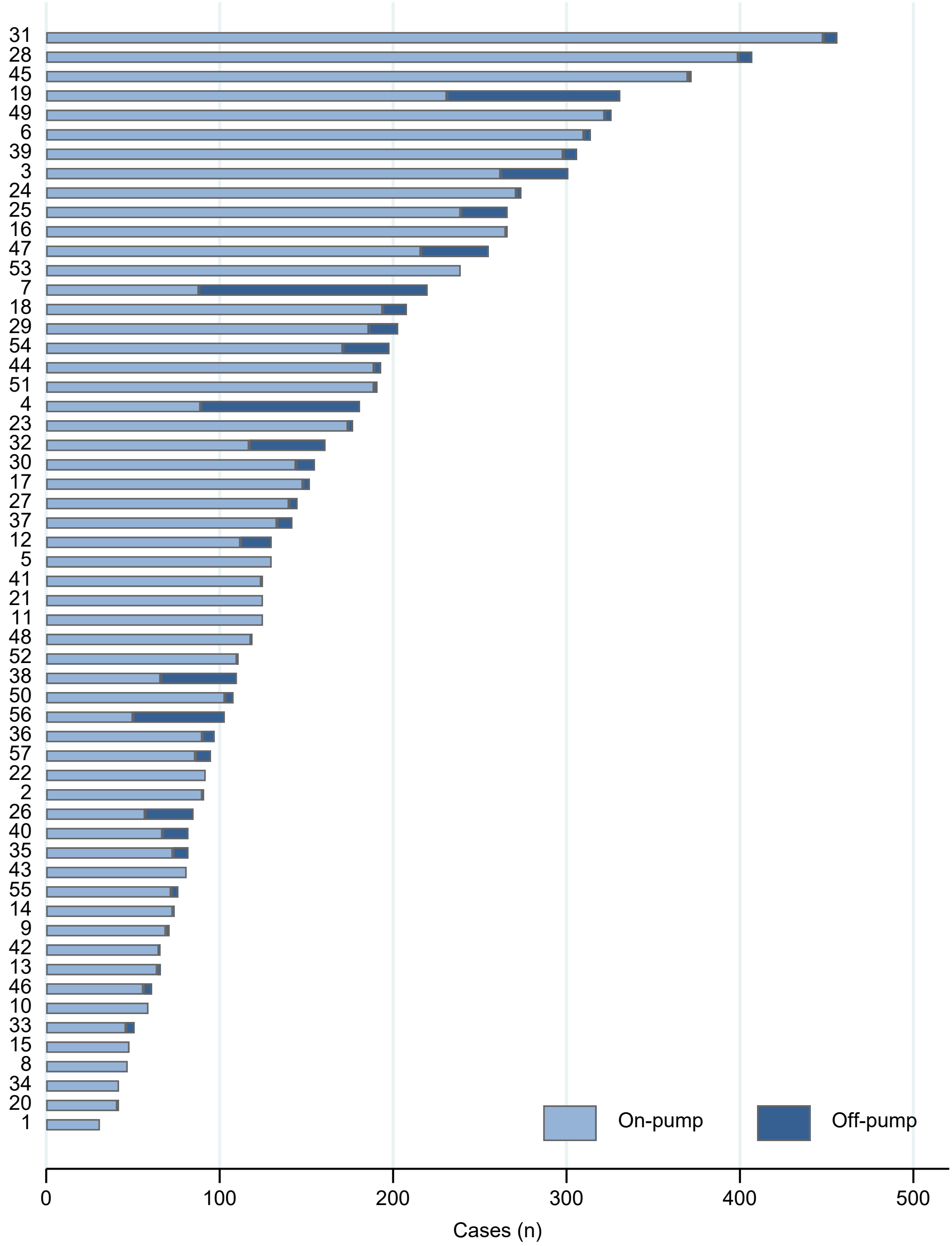


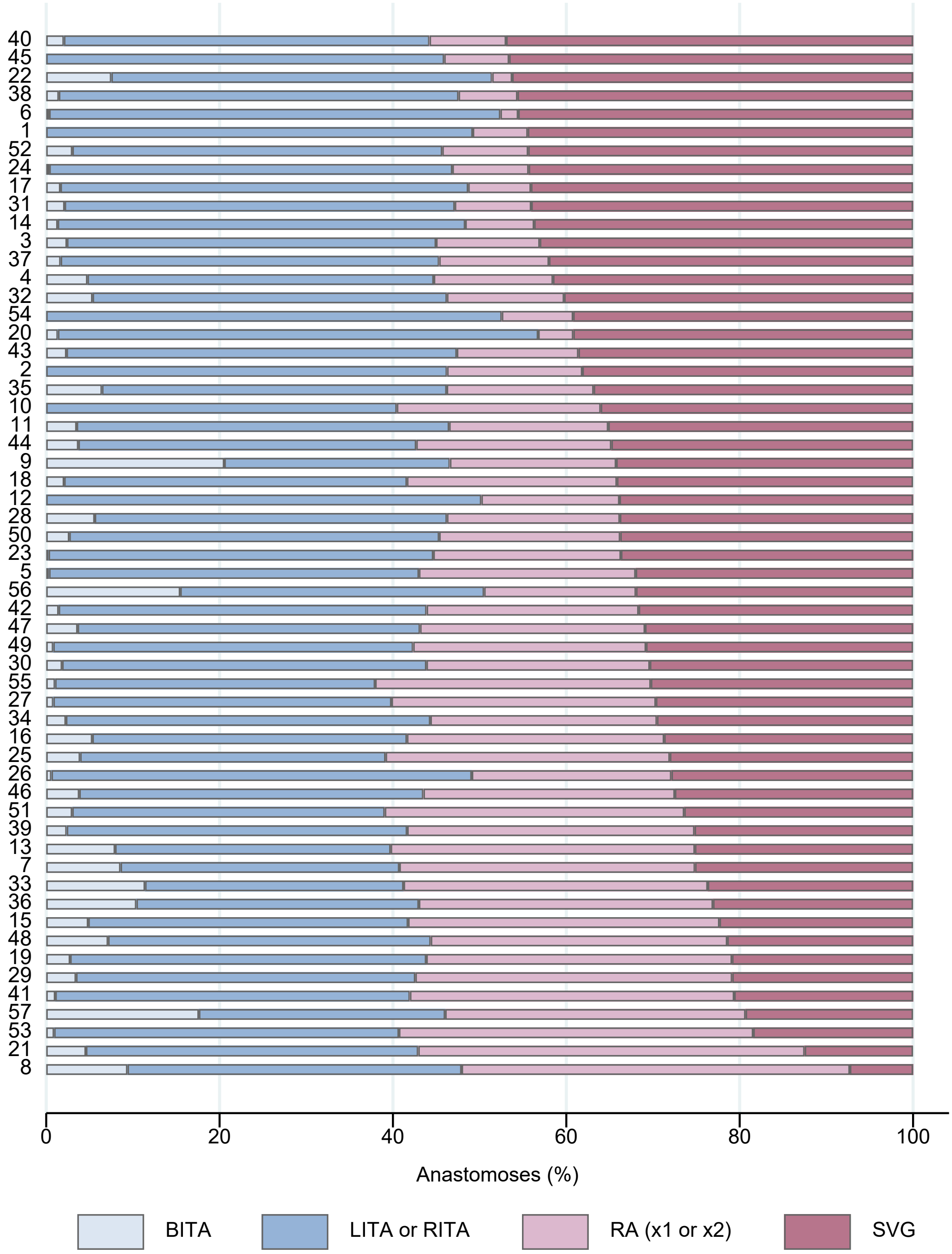
Table 8. On-pump vs off-pump surgery in isolated CABG patients by year

	2019	2020	2021	2022	2023	Total
On-pump (%)	93.3	94.2	94.1	91.7	91.0	92.8
Off-pump (%)	6.7	5.8	5.9	8.3	9.0	7.2

1.4 Conduit selection

1.4.1 Conduits used for anastomoses

Figure 12. Type of arterial and venous conduits harvested for isolated CABG surgery by unit, 2023



BITA indicates bilateral internal thoracic artery; LITA, left internal thoracic artery; RITA, right internal thoracic artery; RA, radial artery; SVG, saphenous vein graft

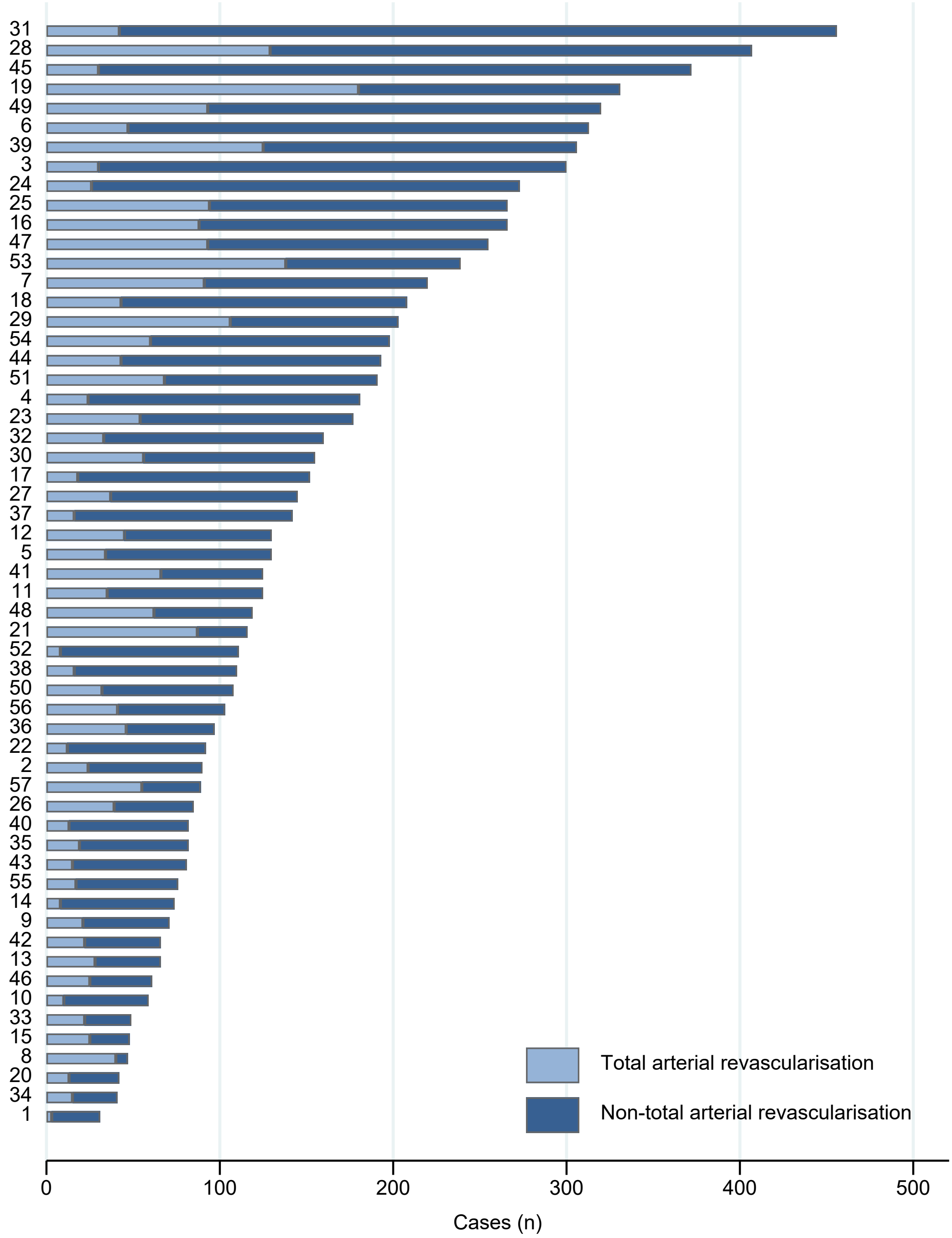
Table 9. Summary of the number of distal anastomoses based on conduit type used for isolated CABG surgery, 2023

	Mean	Median	IQR	Range
BITA	2.2	2	2 - 2	2 - 5
LITA or RITA	1.1	1	1 - 1	1 - 5
RA (x1 or x2)	1.4	1	1 - 2	1 - 6
SVG	1.7	2	1 - 2	1 - 5

Table 10. Grafts and multi-vessel disease in isolated CABG surgery by age and CPB, 2023

	Mean grafts (n)	Multi-vessel disease (%)	Total arterial revascularisation (%)
Age			
18 - <50y	3.0	90.9	41.6
50 - <60y	3.1	94.8	34.5
60 - <70y	3.1	95.7	29.8
70 - <80y	3.0	95.8	24.9
≥80y	2.8	96.1	24.9
CPB			
On-pump	3.0	96.3	26.7
Off-pump	2.7	85.1	57.8

Figure 13. Total arterial revascularisation vs non-total arterial revascularisation in isolated CABG surgery by unit, 2023



1.5 Influence of co-morbidities on complications

1.5.1 Pre-existing diabetes and renal impairment

Table 11. Complications following isolated CABG surgery, by pre-operative diabetes and renal function

		Insulin dependent diabetes		Pre-operative creatinine		Pre-operative eGFR	
		No	Yes	≤200 µmol/L	>200 µmol/L	>60 mL/ min/1.73m²	≤60 mL/ min/1.73m²
n	2023	8,126	932	8,813	243	7,475	1,576
	2019-2022	28,643	3,797	31,598	852	26,766	5,667
Permanent stroke (%)	2023	0.8	1.6	0.9	0.8	0.7	1.4
	2019-2022	0.9	1.5	1.0	2.2	0.9	1.5
DSWI (%)	2023	0.9	1.5	0.9	2.9	1.0	0.8
	2019-2022	0.8	2.3	1.0	2.7	1.0	1.2
RTT for bleeding (%)	2023	2.3	2.5	2.3	5.0	2.2	3.4
	2019-2022	2.3	2.3	2.2	5.4	2.0	3.5
New cardiac arrhythmia (%)	2023	28.1	24.4	27.7	29.8	27.1	30.8
	2019-2022	26.8	24.8	26.5	29.4	25.7	30.4

1.5.2 Age

Table 12. Complications following isolated CABG surgery, by age group

		Age				
		18 - <50y	50 - <60y	60 - <70y	70 - <80y	≥80y
n	2023	561	1,664	3,271	2,975	593
	2019-2022	2,073	6,310	11,403	10,597	2,090
Permanent stroke (%)	2023	0.5	0.6	0.6	1.1	1.9
	2019-2022	0.7	0.7	0.9	1.3	1.3
DSWI (%)	2023	1.8	1.0	0.7	0.9	1.0
	2019-2022	1.2	1.1	0.9	1.0	0.9
RTT for bleeding (%)	2023	2.3	1.8	2.6	2.5	2.2
	2019-2022	1.9	1.9	2.3	2.5	2.7
New cardiac arrhythmia (%)	2023	12.9	20.4	26.8	33.3	39.6
	2019-2022	11.8	18.2	26.0	32.8	37.5

1.5.3 Previous cardiac surgery or use of cardiopulmonary bypass

Table 13. Complications following isolated CABG surgery, by previous surgery and CPB

		Previous surgery		CPB	
		Initial	Redo	On-pump	Off-pump
n	2023	8,972	86	8,244	820
	2019-2022	32,111	350	30,284	2,181
Permanent stroke (%)	2023	0.9	0.0	0.9	0.9
	2019-2022	1.0	2.0	1.0	0.8
DSWI (%)	2023	0.9	3.5	0.9	1.0
	2019-2022	1.0	0.3	1.0	0.9
RTT for bleeding (%)	2023	2.3	4.7	2.4	2.2
	2019-2022	2.3	4.0	2.3	2.0
New cardiac arrhythmia (%)	2023	27.8	24.4	28.0	24.9
	2019-2022	26.5	26.1	26.7	23.9

1.5.4 Influence of comorbidities on derived new renal insufficiency

Table 14. Incidence of dNRI following isolated CABG surgery, by pre-operative demographics and risk factors

	2023		2019-2022	
	n	dNRI (%)	n	dNRI (%)
Insulin dependent diabetes				
No	8,009	2.2	28,265	2.2
Yes	867	3.9	3,566	5.0
Pre-operative creatinine				
≤200 µmol/L	8,776	2.2	31,478	2.3
>200 µmol/L	101	18.8	381	18.1
Pre-operative eGFR				
>60 mL/min/1.73m²	7,448	1.6	26,684	1.7
≤60 mL/min/1.73m²	1,427	6.6	5,161	6.7
Age				
18 - <50y	539	1.1	2,000	2.3
50 - <60y	1,624	2.0	6,160	1.7
60 - <70y	3,196	1.6	11,200	2.2
70 - <80y	2,933	3.3	10,441	2.9
≥80y	585	4.4	2,058	4.5
Previous surgery				
Initial	8,791	2.3	31,512	2.4
Redo	84	7.1	340	4.7
CPB				
On-pump	8,079	2.4	29,725	2.5
Off-pump	798	2.9	2,127	2.2

1.6 Influence of patient characteristics on operative mortality

Table 15. OM following isolated CABG surgery, by patient demographics and risk factors

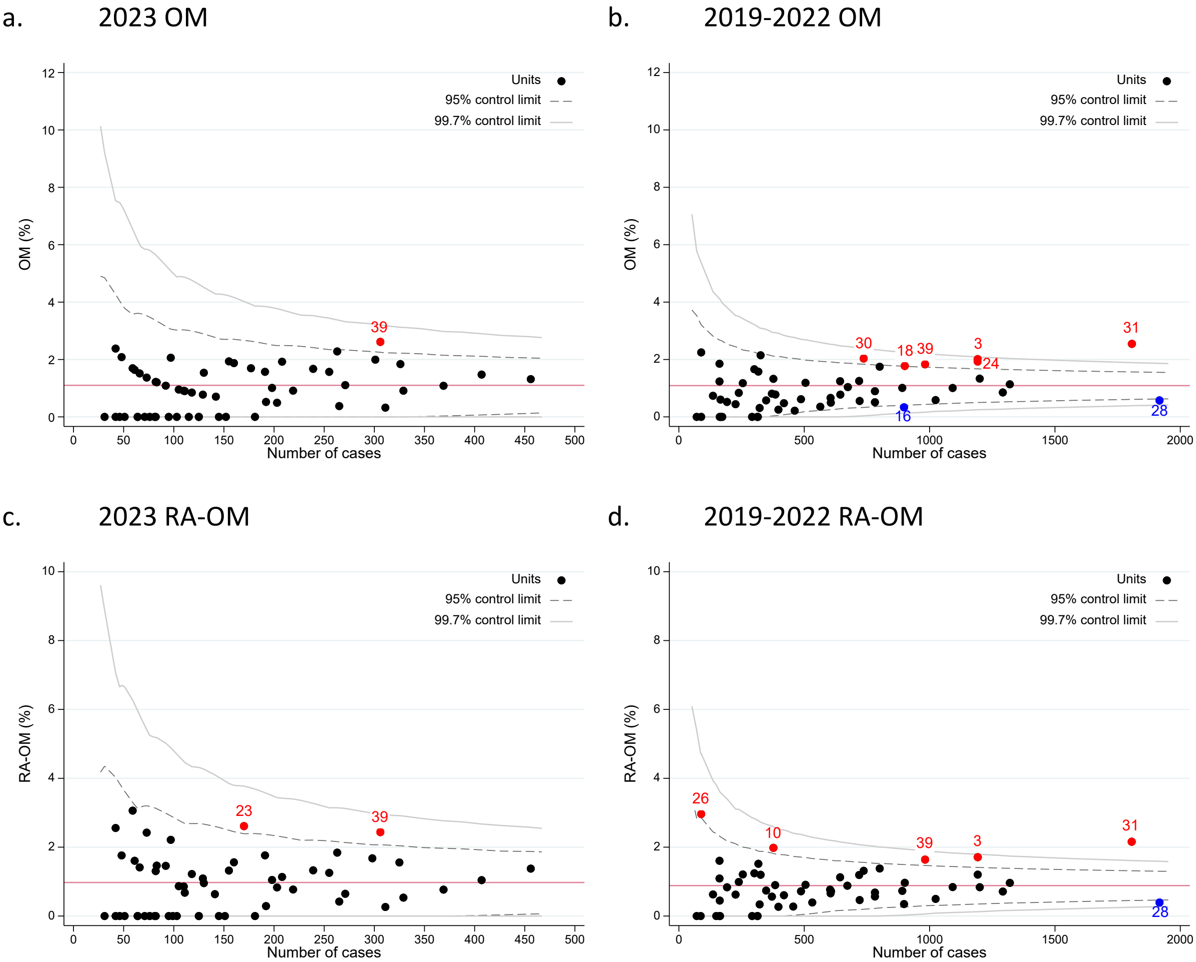
	2023		2019-2022	
	n	OM (%)	n	OM (%)
Clinical status				
Elective	4,588	0.6	16,589	0.5
Urgent	4,117	1.3	14,543	1.3
Emergency/salvage	293	5.8	1,081	6.8
Sex/age				
Male	7,504	0.9	26,738	0.9
18 - <50y	484	0.4	1,726	1.0
50 - <60y	1,411	0.5	5,356	0.4
60 - <70y	2,724	0.6	9,517	0.8
70 - <80y	2,409	1.1	8,539	1.3
≥80y	476	3.4	1,600	2.1
Female	1,494	2.0	5,475	1.8
18 - <50y	70	1.4	328	1.5
50 - <60y	244	1.2	912	1.4
60 - <70y	518	1.5	1,791	1.1
70 - <80y	549	2.0	1,967	2.2
≥80y	113	6.2	477	3.6
LVF				
EF>45%	7,215	0.7	25,690	0.7
EF≥30% - ≤45%	1,376	2.4	5,059	2.3
EF<30%	233	4.3	976	5.2
Previous MI				
No MI	4,792	0.6	15,684	0.6
NSTEMI	3,079	1.5	12,177	1.4
STEMI	851	2.2	3,319	2.1
Unknown type	268	1.9	1,021	0.8
Timing of previous MI				
≤6hr	41	17.1	225	10.7
>6hr - <24hr	86	5.8	335	5.7
≥1d - ≤7d	1,508	1.5	5,794	1.6
>7d	2,562	1.4	10,116	1.1
Previous surgery				
Initial	8,907	1.1	31,854	1.1
Redo	86	1.2	349	2.9
CPB				
On-pump	8,180	1.0	30,037	1.1
Off-pump	818	1.8	2,168	1.1
Dialysis				
No	8,829	1.0	31,663	1.0
Yes	164	8.5	544	7.4
Pre-operative creatinine				
≤200 µmol/L	8,751	0.9	31,340	1.0
>200 µmol/L	240	7.1	851	6.1

1.7 Unit outcomes – mortality, complications and resource utilisation

1.7.1 Operative mortality

A full summary of outcomes for all units is provided in Appendix F (pg. 86).

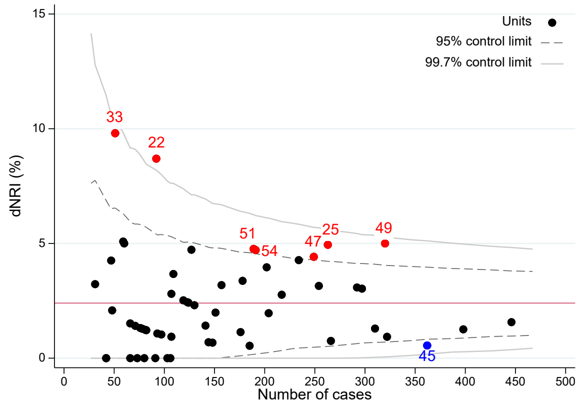
Figure 14. OM following isolated CABG surgery, by unit



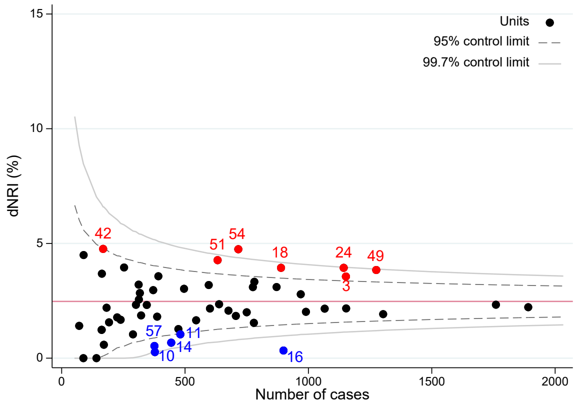
1.7.2 Complications

Figure 15. dNRI following isolated CABG surgery, by unit

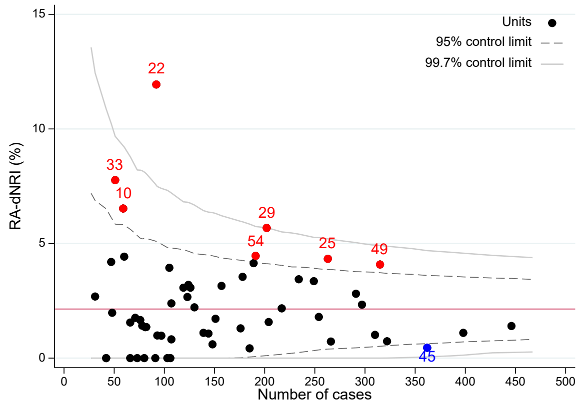
a. 2023 dNRI



b. 2019-2022 dNRI



c. 2023 RA-dNRI



d. 2019-2022 RA-dNRI

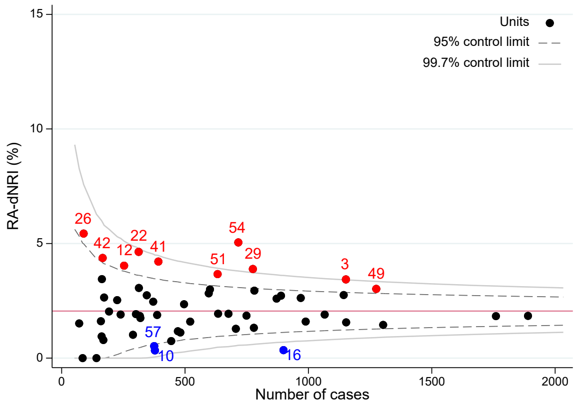
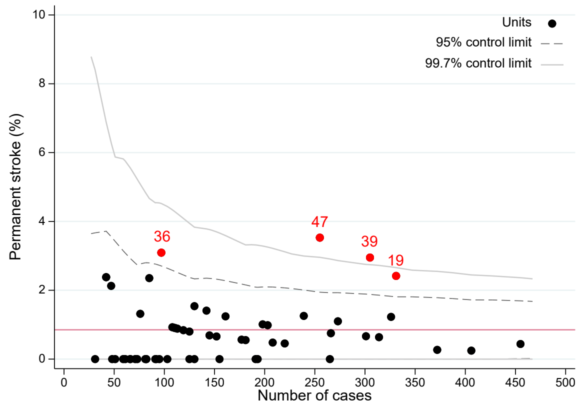


Figure 16. Permanent stroke following isolated CABG surgery, by unit

a. 2023 permanent stroke



b. 2019-2022 permanent stroke

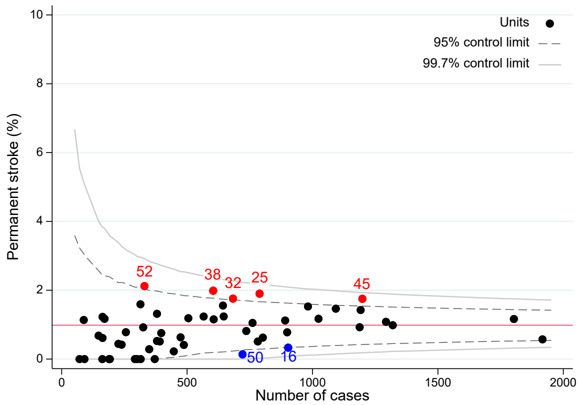
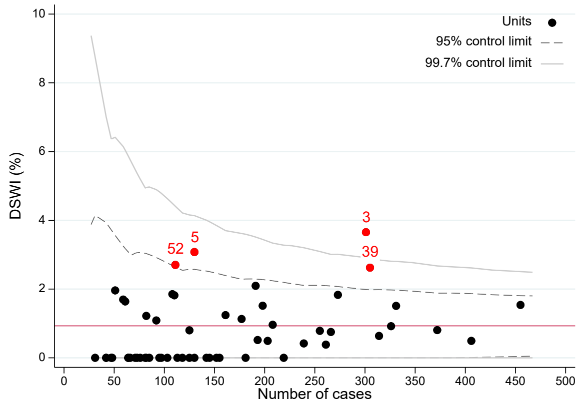


Figure 17. DSWI following isolated CABG surgery, by unit

a. 2023 DSWI



b. 2019-2022 DSWI

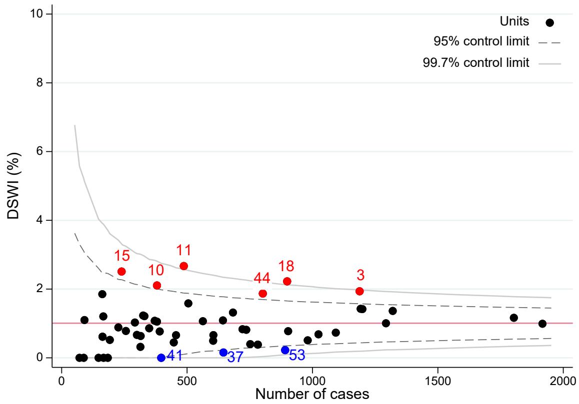
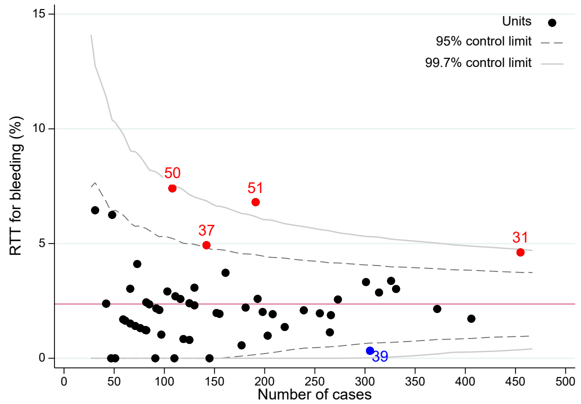


Figure 18. RTT for bleeding following isolated CABG surgery, by unit

a. 2023 RTT for bleeding



b. 2019-2022 RTT for bleeding

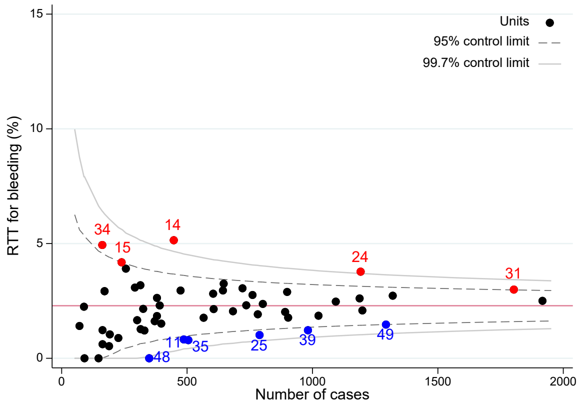
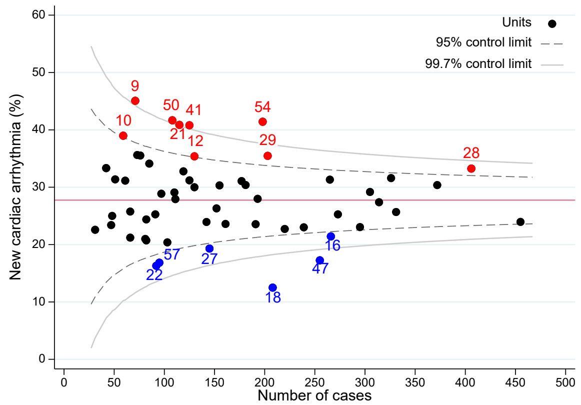


Figure 19. New cardiac arrhythmia following isolated CABG surgery, by unit

a. 2023 new cardiac arrhythmia



b. 2019-2022 new cardiac arrhythmia

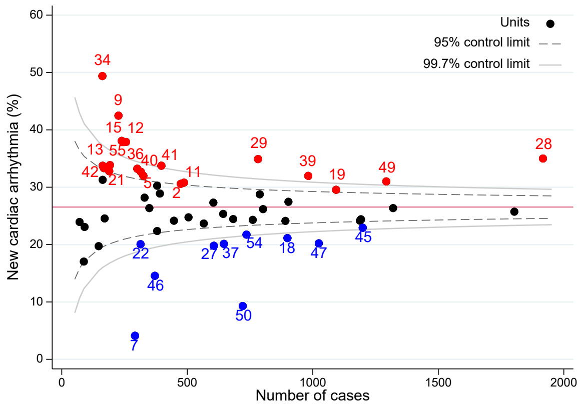
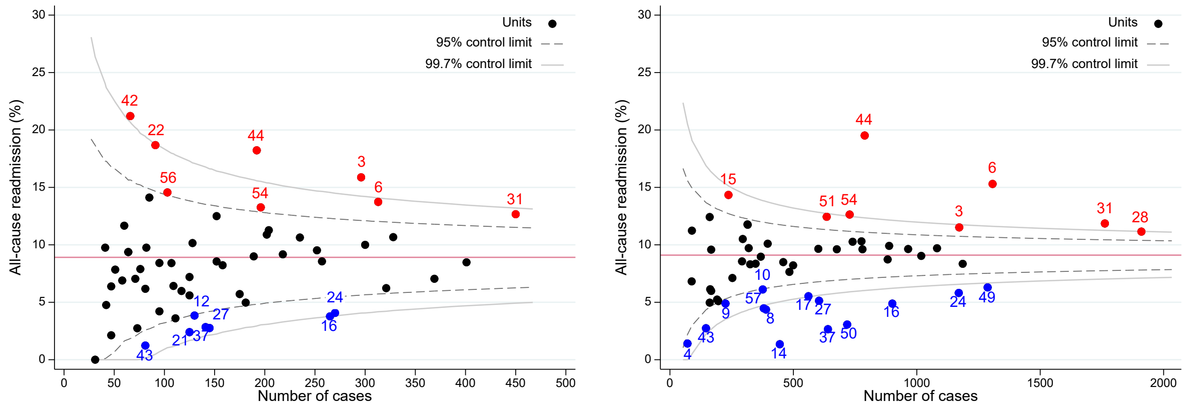


Figure 20. All-cause readmission following isolated CABG surgery, by unit

a. 2023 all-cause readmission

b. 2019-2022 all-cause readmission



1.7.3 Resource utilisation

Cases with a pre-operative LOS of more than 14 days were classified as clinical outliers and excluded from the analysis.

Figure 21. Distribution of pre-operative LOS for isolated CABG patients, 2023

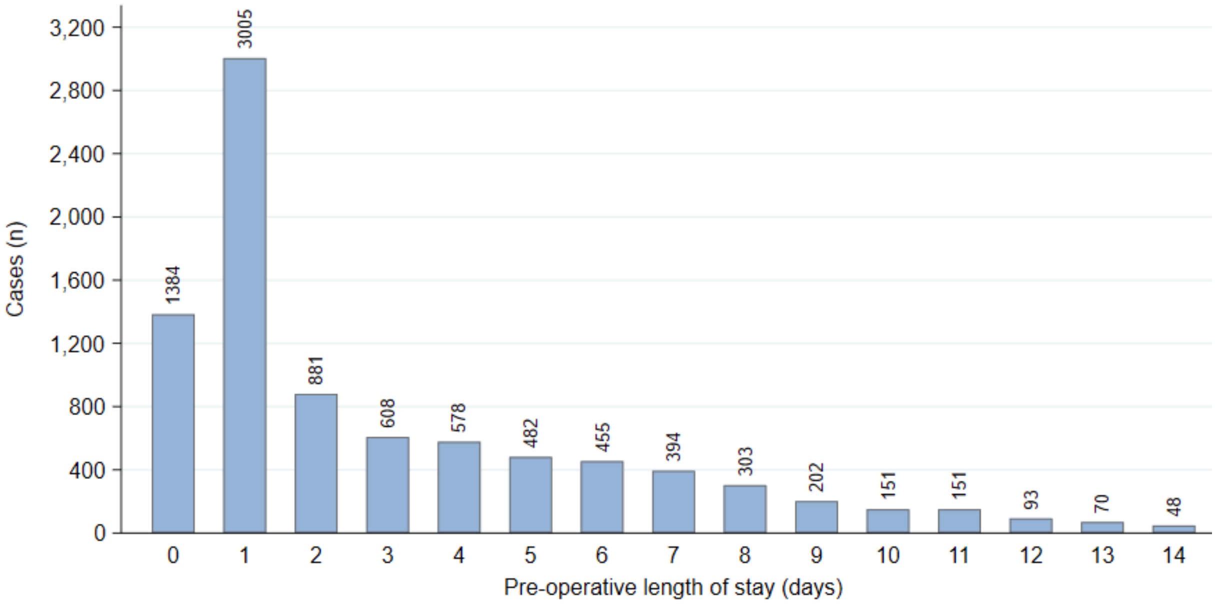


Table 16. Summary of pre-operative LOS for isolated CABG patients at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	3.4	2	1 - 6
Private	2.4	1	1 - 3
Total	3.1	2	1 - 5

Cases with a post-operative LOS of more than 90 days were classified as clinical outliers and excluded from the analysis.

Figure 22. Distribution of post-operative LOS for isolated CABG patients, 2023

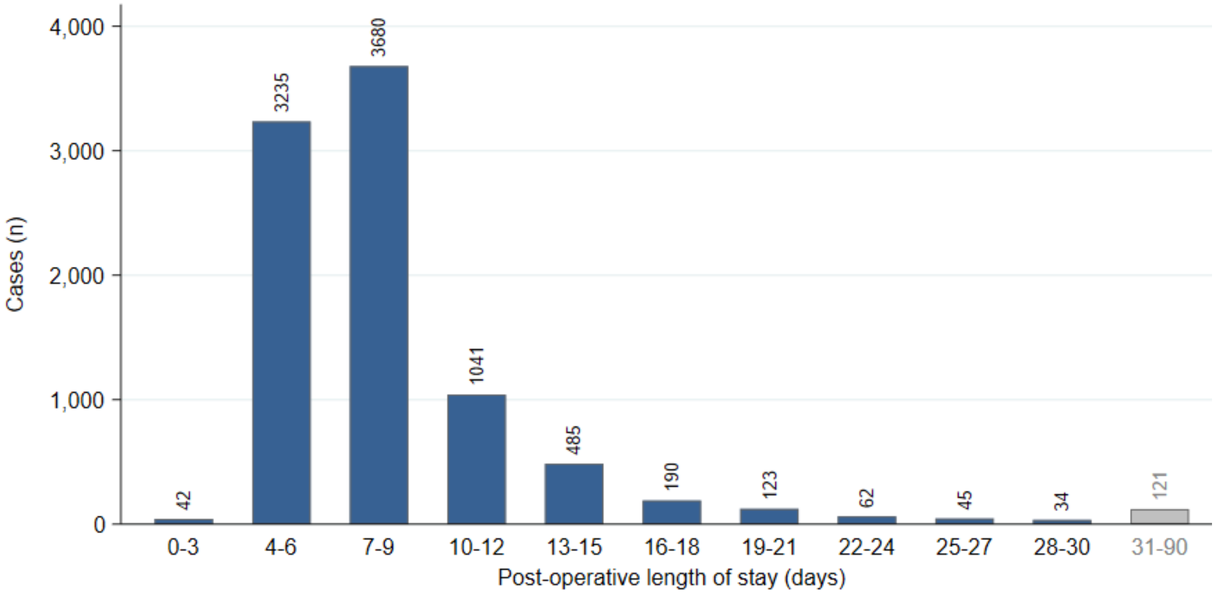


Table 17. Summary of post-operative LOS for isolated CABG patients at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	8.5	7	6 - 9
Private	8.9	8	7 - 10
Total	8.7	7	6 - 9

Cases with a ventilation time of more than four weeks (672 hours) were classified as clinical outliers and excluded from the analysis.

Figure 23. Distribution of initial post-operative ventilation time for isolated CABG patients, 2023

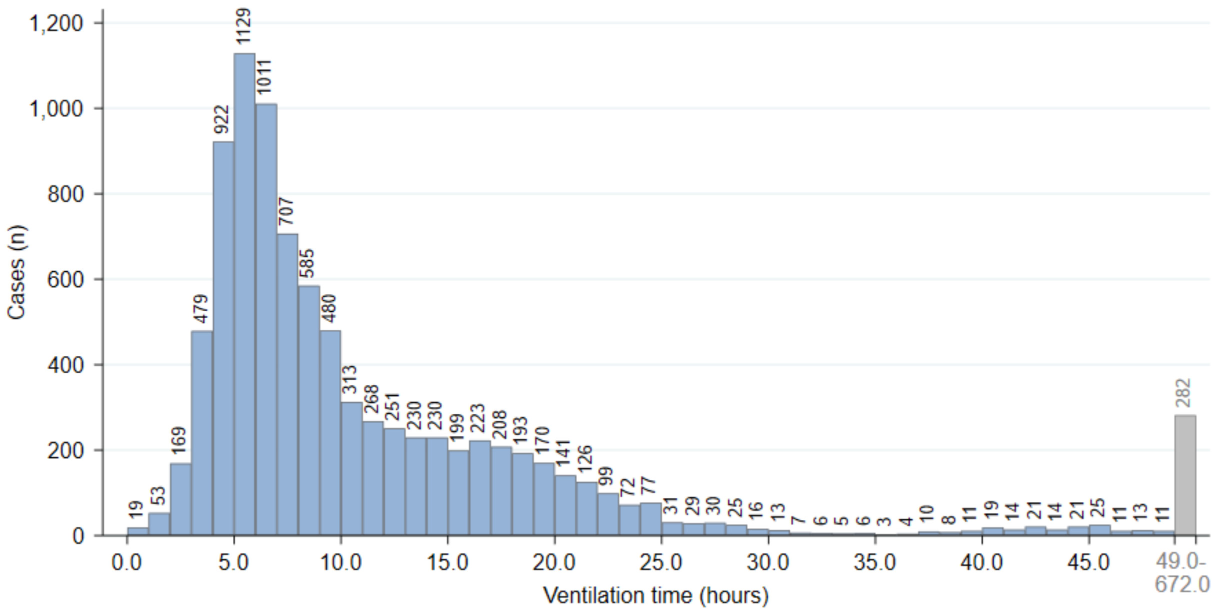


Table 18. Cumulative proportion of patients extubated over time for isolated CABG surgery, 2023

	<6h	<12h	<24h	<48h	<96h	<192h	<384h	≤672h
Cumulative patients (n)	2,771	6,135	8,277	8,696	8,867	8,952	8,980	8,989
Cumulative percentage (%)	30.8	68.3	92.1	96.7	98.6	99.6	99.9	100.0

Table 19. Summary of initial post-operative ventilation time for isolated CABG patients at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	15.2	8.3	5.8 - 15.4
Private	11.4	7.2	5.2 - 13.1
Total	13.8	8.0	5.5 - 14.4

Cases with an ICU LOS of more than six weeks (1,008 hours) were classified as clinical outliers and excluded from the analysis.

Figure 24. Distribution of ICU LOS for isolated CABG patients, 2023

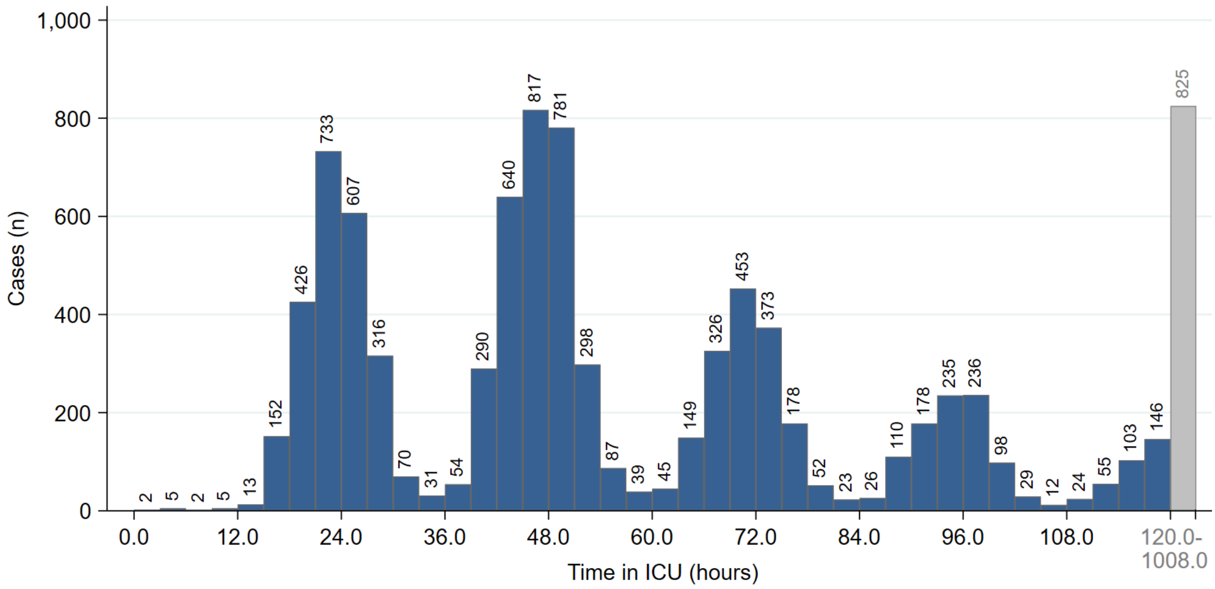


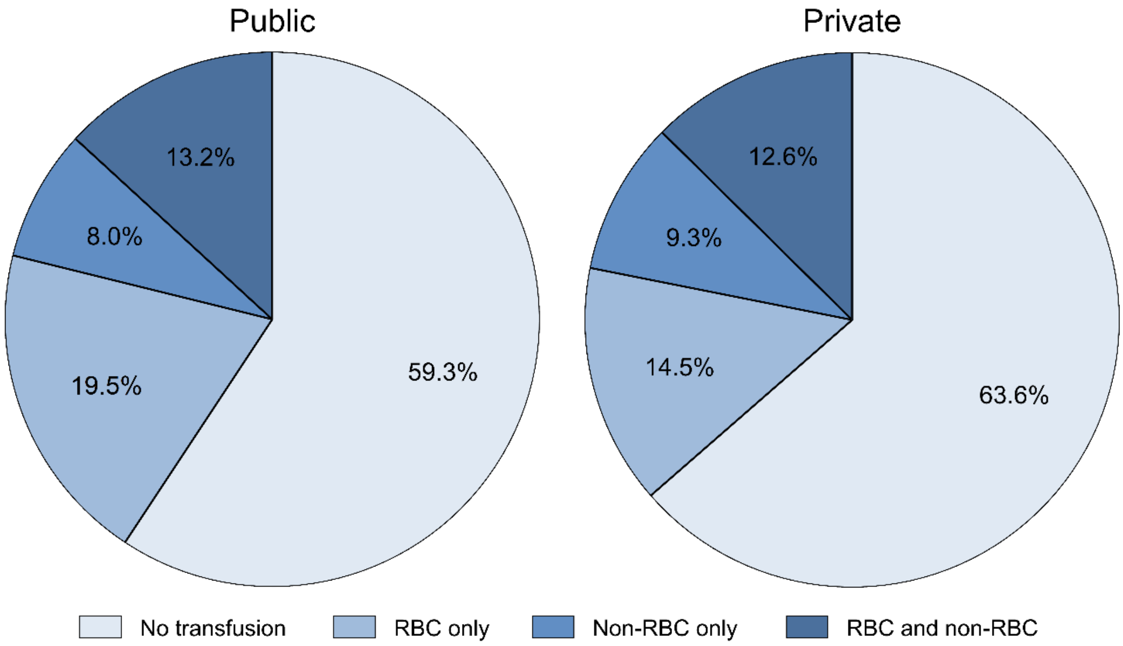
Table 20. Cumulative proportion of patients discharged from ICU over time for isolated CABG surgery, 2023

	<12h	<24h	<48h	<72h	<144h	<288h	<576h	≤1008h
Cumulative patients (n)	14	1,338	4,163	6,341	8,550	8,955	9,025	9,044
Cumulative percentage (%)	0.2	14.8	46.0	70.1	94.5	99.0	99.8	100.0

Table 21. Summary of ICU LOS for isolated CABG patients at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	64.5	47.3	25.0 - 76.7
Private	68.4	50.6	45.6 - 74.9
Total	65.9	49.2	30.0 - 75.9

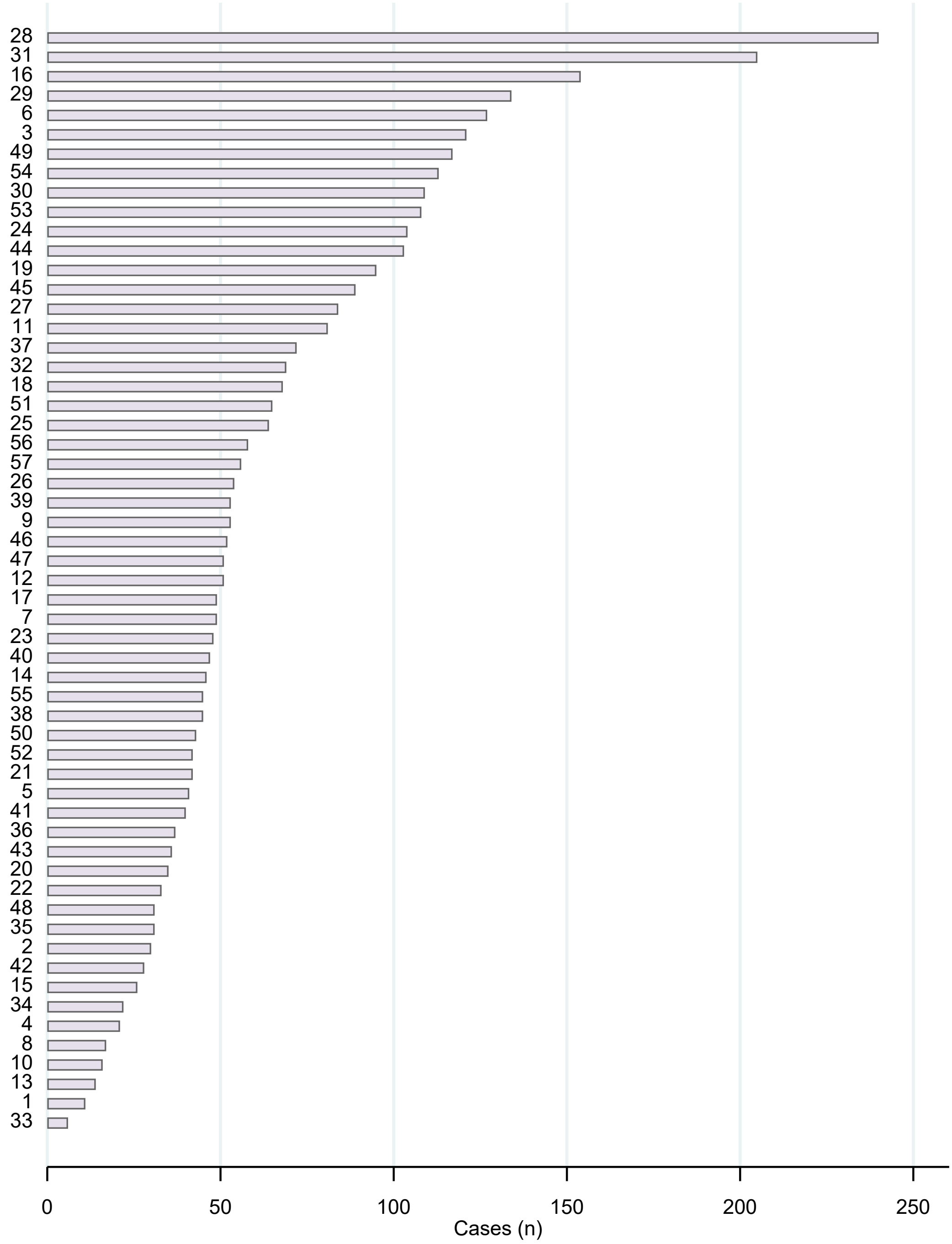
Figure 25. Blood product usage for isolated CABG patients at public and private hospitals, 2023



Note: non-RBC consists of platelets, NovoSeven, cryoprecipitate and fresh frozen plasma (FFP)

2. Isolated Valve Surgery

Figure 26. Isolated valve cases by unit, 2023



Summary of isolated valve surgery activity

Case volume and patient characteristics

There were 3,681 isolated valve procedures performed in 2023 and case volume varied largely between units. Half of the participating units performed fewer than 50 procedures (Figure 26).

All isolated valve procedures: Type and mortality

There has been a reduction in the proportion of isolated aortic valve replacement (AVR) surgery, relative to all isolated valve surgery, in the last ten years. In contrast, the procedures with the most notable percentage increases between 2013 and 2023 were mitral valve replacement (MVR), MV repair and double valve procedures (Figure 31). In-hospital mortality and total OM for all isolated valve patients were 1.4 and 1.6%, respectively, in 2023 (Table 25).

Single valve procedures: Valve choice and mortality

Bioprosthetic valves were used in 84.7% of AVR procedures in 2023, compared to 70.5% in MVR procedures. Homo- or allo-grafts were rarely used (<1% of cases) for AVR and MVR procedures (Figure 33).

For single valve surgery, the incidence of OM doubled for urgent AVR and MVR cases, relative to elective surgery. Emergency or salvage procedures were associated with substantial further increases in OM; however, the interpretation of this data is limited by the small sample sizes. There did not appear to be a notable survival benefit for either sex or a consistent association between age and OM. Patients with low EF, having redo procedures, or with pre-operative markers of renal issues had higher OM than their counterparts for AVR and MVR (Table 27).

Isolated AVR: Case volume and outcomes

AVR is the most common valve procedure, though greater than 95% of participating units had a case volume of fewer than 50 procedures in 2023 (Figure 34). Data for the last five years was pooled to provide sufficient case numbers for analysis of outcomes.

The majority of units performed comparably with respect to outcomes of AVR surgery. The OM for isolated AVR patients was 1.3% in 2019-23 (Figure 35a). Comparisons to the most recently published data from overseas registries is limited by differences in patient cohorts, such as the inclusion of AV replacements, and slight variations in the definitions for mortality, but these range between 1.3 – 2.7%. (1-4). The RA-OM calculated using the Database's ANZSCORE model was 0.9% for 2019-23 (Figure 35b). The incidences of the other key performance indicators were: dNRI (2.8%), RA-dNRI (1.8%), permanent stroke (1.2%), DSWI (0.5%) and RTT for bleeding (3.9%; Figure 36 and Figure 37).

Isolated AVR: Resource utilisation

Most patients (74.3%) were admitted the day before or day of their surgery, and the median pre-operative LOS was one day at public and private hospitals (Figure 38 and Table 28). The majority of patients (71.5%) were discharged less than ten days after their surgery (Figure 39), with a slightly higher median post-operative LOS at the private hospitals (eight days), compared to the public hospitals (seven days; Table 29).

Almost one third of patients (31.8%) were extubated within six hours and 89.8% within 24 hours of surgery (Figure 40 and Table 30). Mean ventilation time was higher in public hospitals, compared with private hospitals (17.9 vs. 12.3 hours, respectively; Table 31). ICU LOS showed a cyclical pattern with patients often discharged at 24-hour intervals (Figure 41). Almost half of patients were discharged from the ICU within 48 hours (45.8%; Table 32). The mean length of ICU stay was lower in public hospitals (65.0 hours) compared to private hospitals (70.5 hours; Table 33).

Blood product transfusions were given to approximately 42% of AVR patients, with higher usage of RBC and/or non-RBC products at public hospitals (44.8% of patients transfused) compared to private hospitals (37.1%; Figure 42).

2.1 Patient characteristics

2.1.1 Clinical status

Figure 27. Clinical status of isolated valve patients by unit, 2023

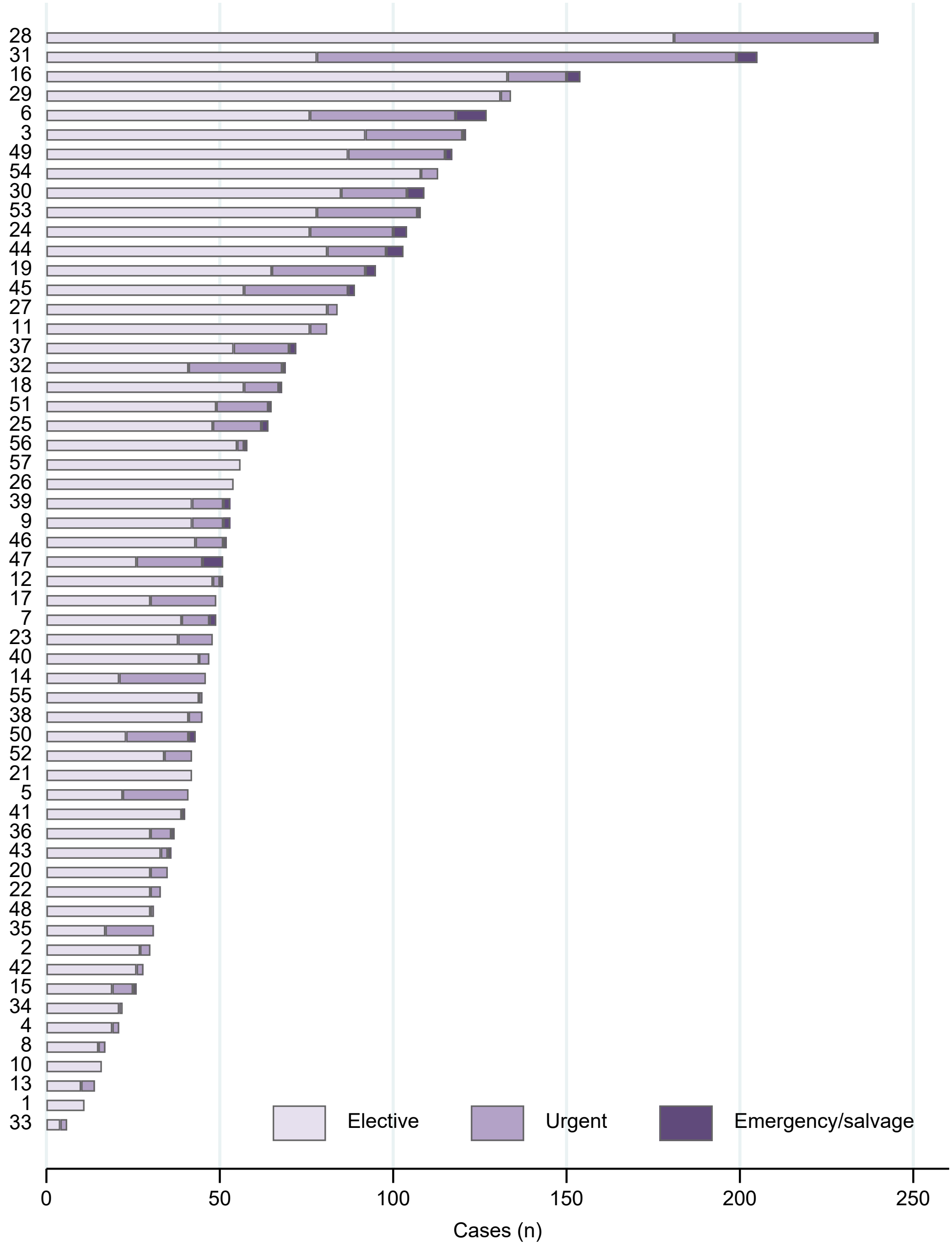


Table 22. Clinical status of isolated valve patients by year

	2019	2020	2021	2022	2023	Total
Elective (%)	82.0	78.5	78.2	76.3	77.6	78.5
Urgent (%)	16.1	19.7	19.7	21.9	20.5	19.6
Emergency/salvage (%)	2.0	1.8	2.1	1.8	1.9	1.9

2.1.2 Sex and age

Figure 28. Sex of isolated valve patients by unit, 2023

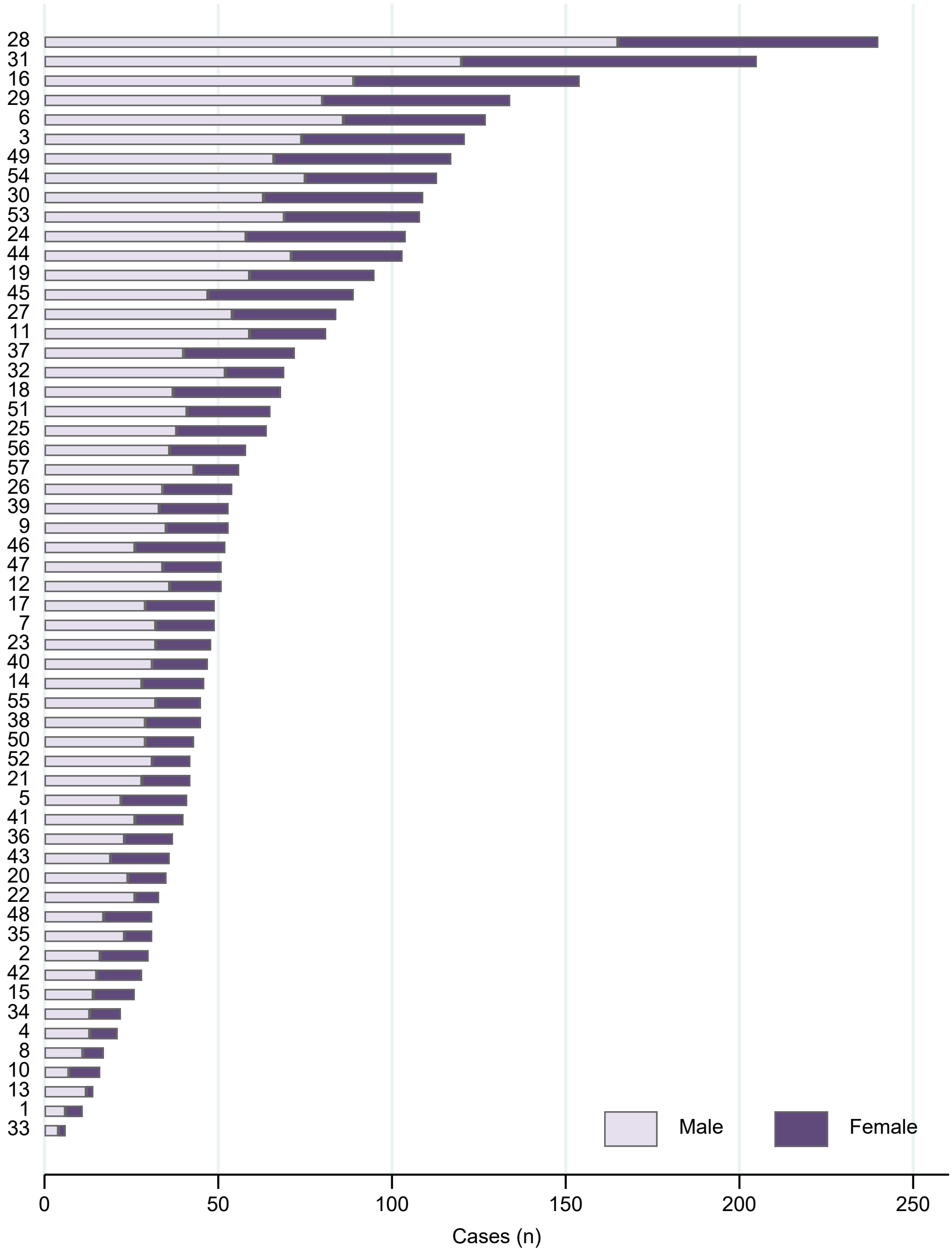
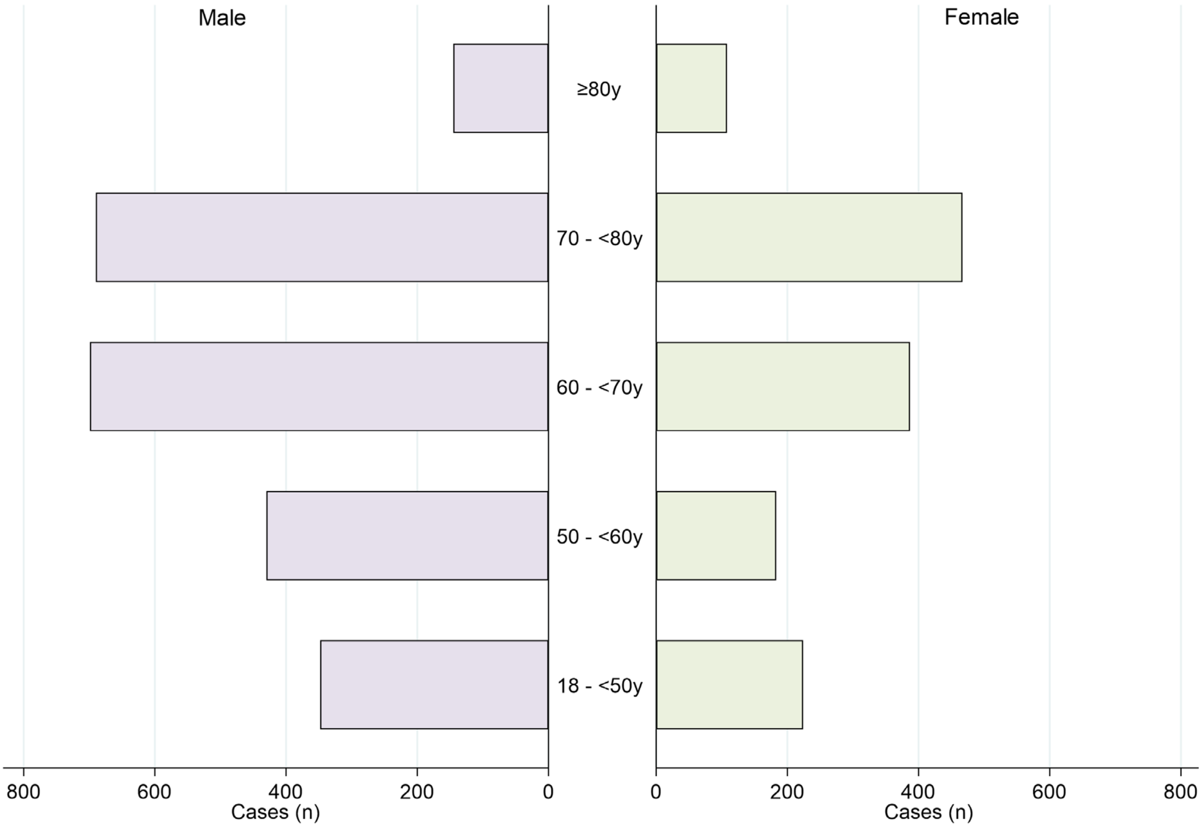


Table 23. Sex of isolated valve patients by year

	2019	2020	2021	2022	2023	Total
Male (%)	61.6	62.2	62.2	62.7	62.8	62.3
Female (%)	38.4	37.8	37.8	37.3	37.2	37.7

Figure 29. Age of isolated valve patients by sex, 2023



2.2 Previous cardiac surgery

Figure 30. Initial vs redo surgery in isolated valve patients by unit, 2023

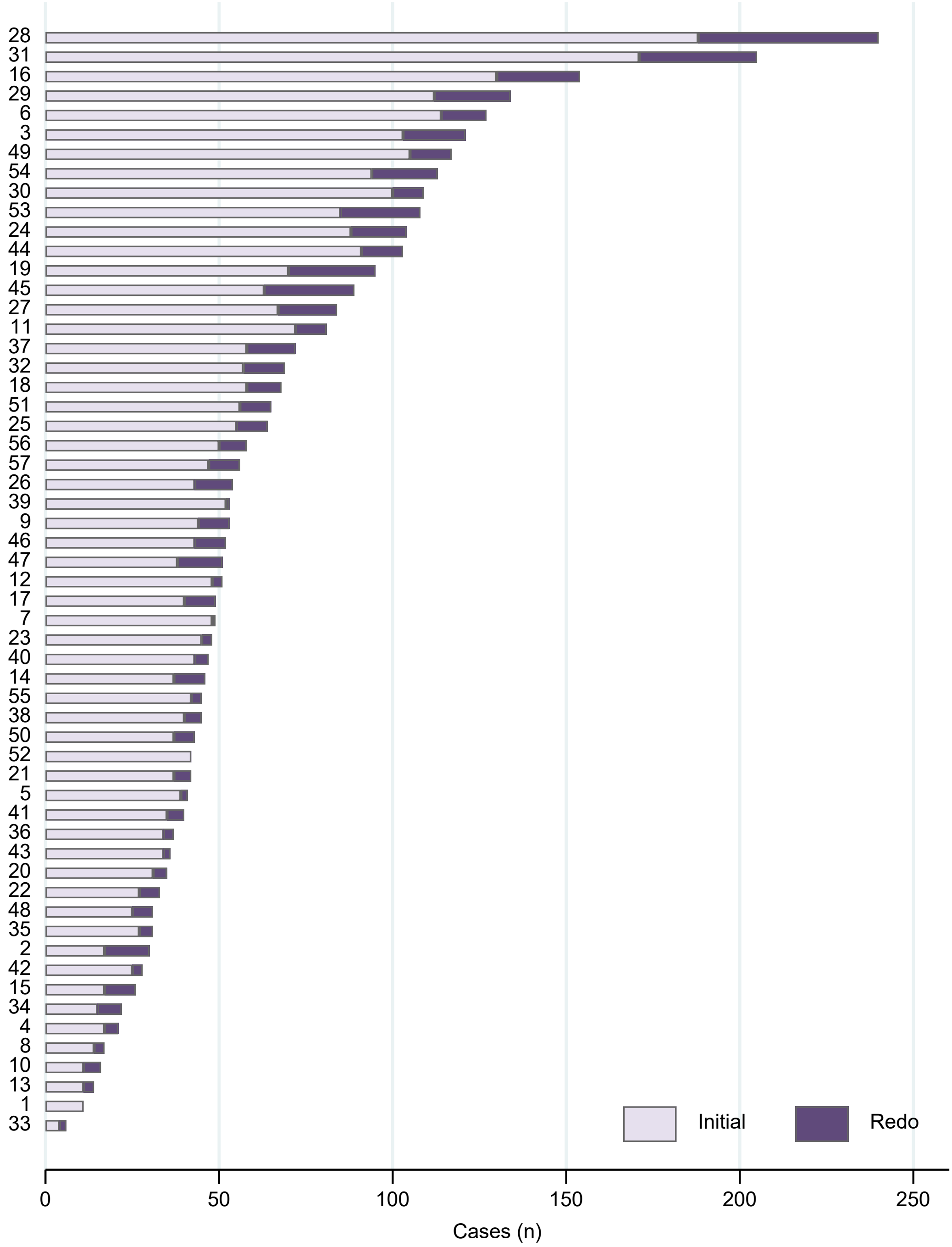
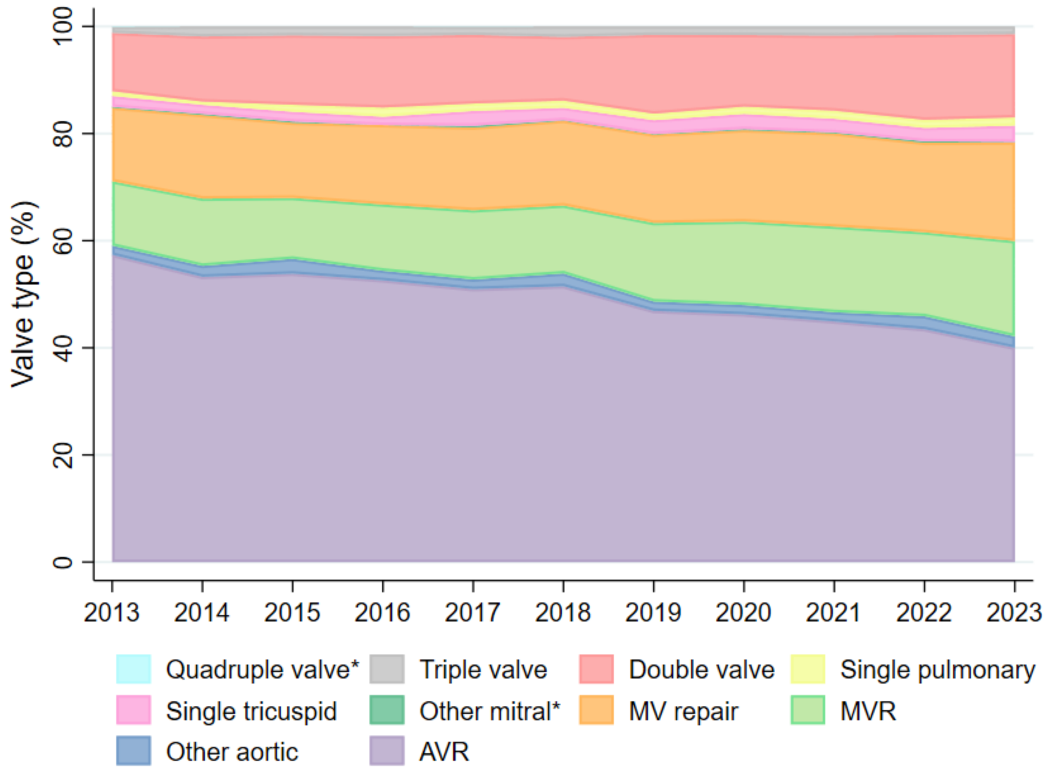


Table 24. Initial vs redo surgery in isolated valve patients by year

	2019	2020	2021	2022	2023	Total
Initial (%)	84.2	85.6	84.2	84.7	84.4	84.6
Redo (%)	15.8	14.4	15.8	15.3	15.6	15.4

2.3 Overview of all valve surgery

Figure 31. Isolated valve surgery by year, 2013-2023



*Not visible on the figure as these categories represent a total of 54 out of 31,140 cases, combined, between 2013 and 2023

MV repair indicates mitral valve repair; MVR, mitral valve replacement; AVR, aortic valve replacement

Table 25. In-hospital mortality and total OM in isolated valve patients, 2023

	Total cases		In-hospital mortality		Total OM	
Valve surgery type	n	%	n	%	n	%
Single aortic	1,538	42.1	20	1.3	22	1.4
AVR	1,460	39.9	18	1.2	20	1.4
Other aortic	78	2.1	2	2.6	2	2.6
Single mitral	1,332	36.4	16	1.2	19	1.4
MVR	653	17.9	15	2.3	18	2.8
MV repair	674	18.4	0	0.0	0	0.0
Other mitral	5	0.1	1	20.0	1	20.0
Single tricuspid	111	3.0	1	0.9	1	0.9
Single pulmonary	56	1.5	0	0.0	0	0.0
Aortic and mitral	221	6.1	7	3.2	7	3.2
Mitral and tricuspid	296	8.1	5	1.7	5	1.7
Aortic and tricuspid	26	0.7	1	3.8	1	3.8
Other double valve	25	0.7	1	4.0	1	4.0
Triple valve	51	1.4	1	2.0	1	2.0
Quadruple valve	0	0.0	0	-	0	-
Total valve surgery	3,656	100.0	52	1.4	57	1.6

2.4 Single valve surgery

Figure 32. Types of isolated single valve surgery performed by unit, 2023

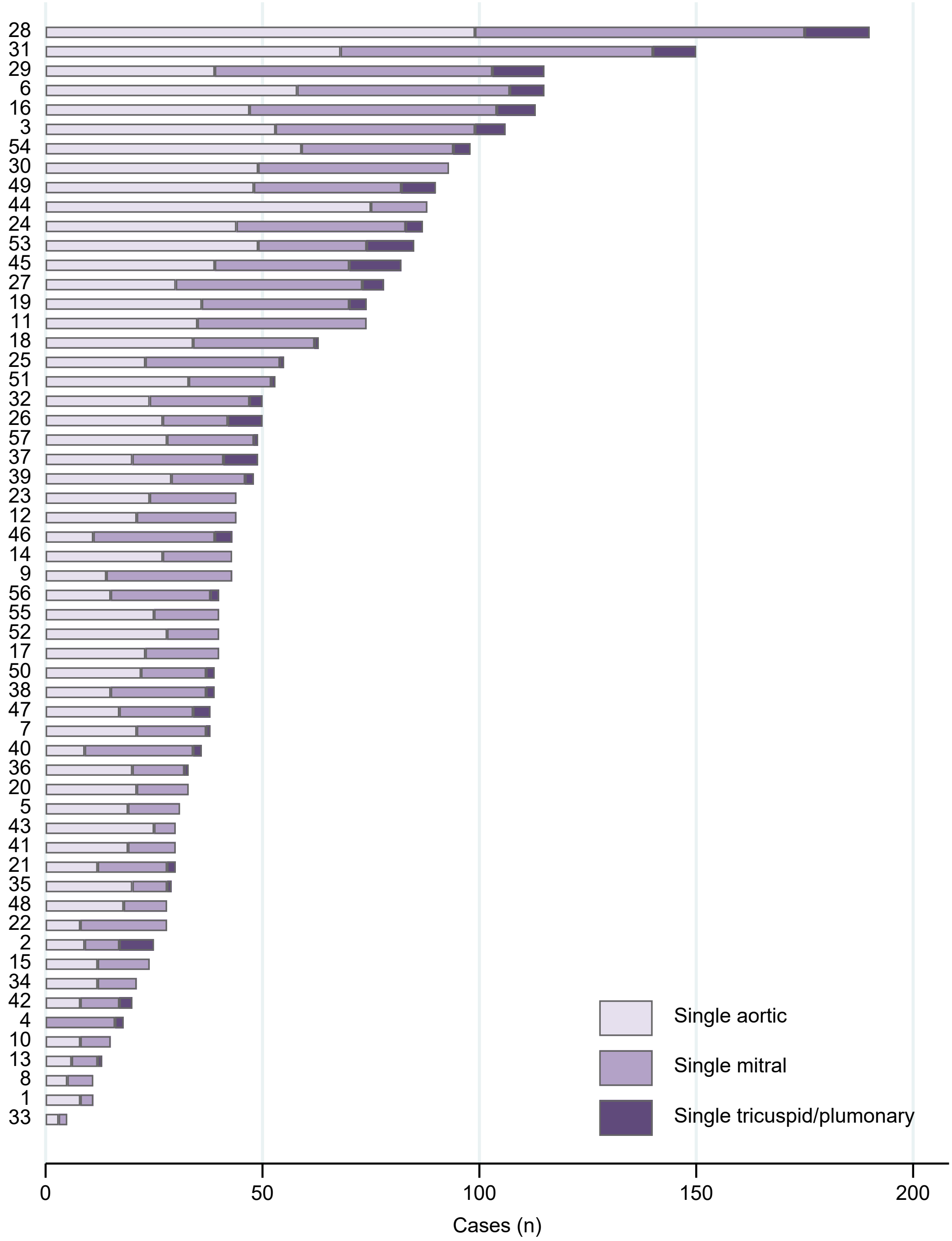
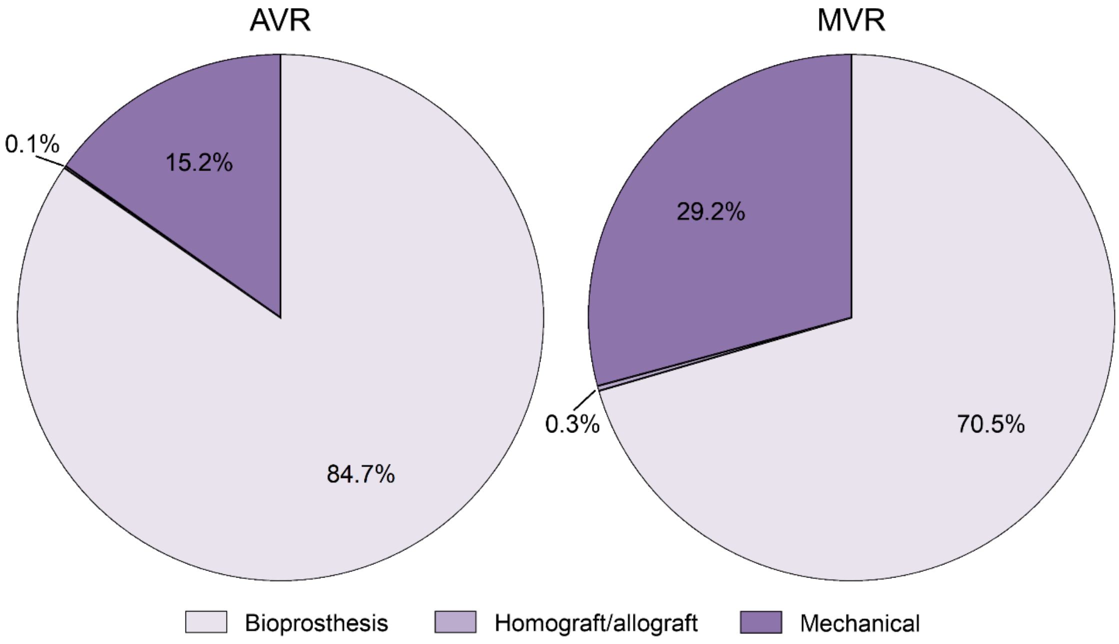


Table 26. Types of isolated single valve surgery performed by year

	2019	2020	2021	2022	2023	Total
Single aortic (%)	58.1	56.5	55.4	55.6	50.7	55.1
Single mitral (%)	37.3	38.6	39.8	39.5	43.7	39.9
Single tricuspid/pulmonary (%)	4.6	4.9	4.8	4.8	5.5	5.0

2.4.1 Prosthesis type

Figure 33. Prosthesis type used for single AVR or MVR surgery, 2023



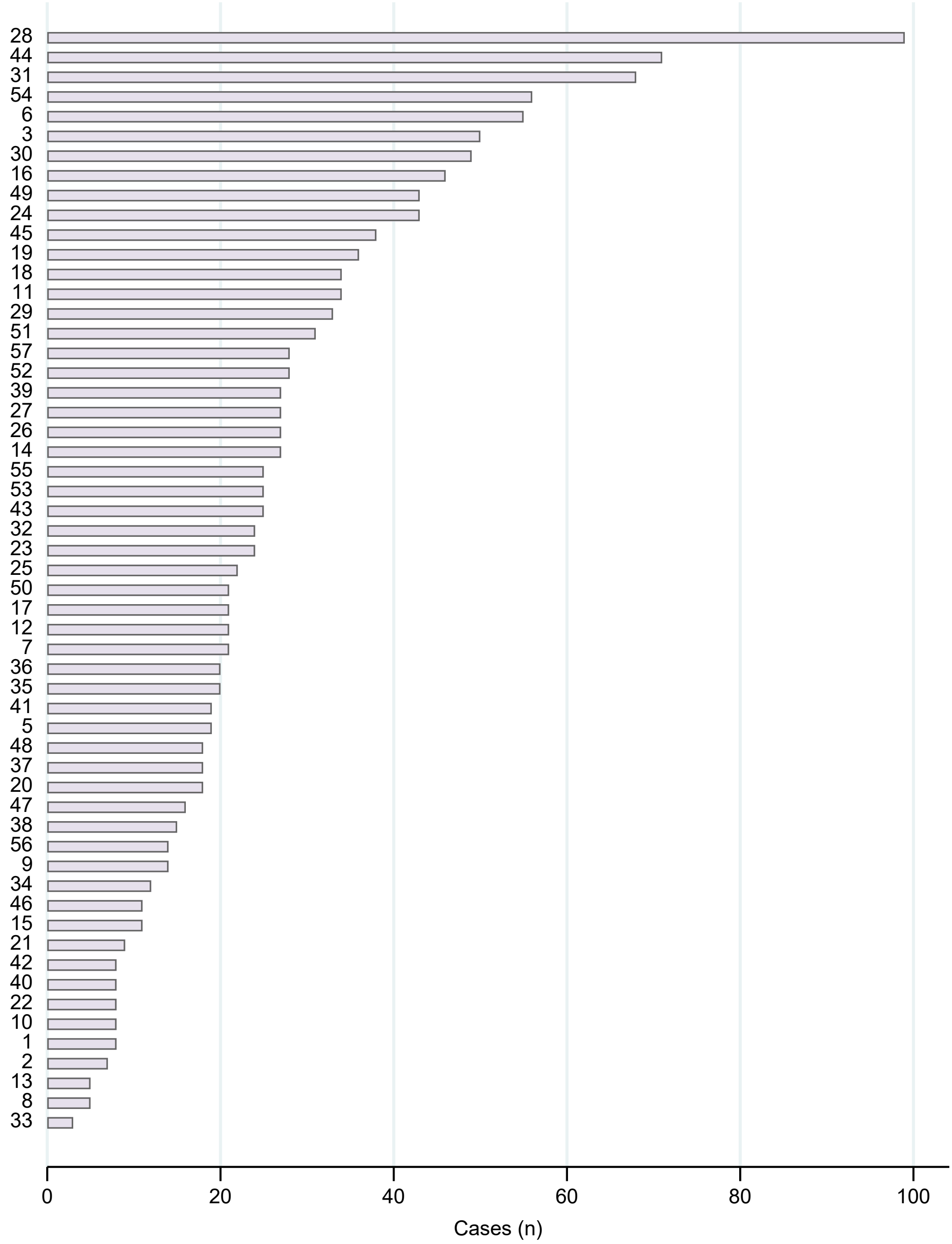
2.5 Influence of patient characteristics on operative mortality

Table 27. OM following the three most common isolated single valve surgeries, by patient demographics and risk factors, 2019-2023

	AVR		MVR		MV repair	
	n	OM (%)	n	OM (%)	n	OM (%)
Clinical status						
Elective	5,726	0.9	1,787	1.8	2,428	0.2
Urgent	1,296	2.2	680	3.7	337	0.9
Emergency/salvage	105	9.5	103	8.7	21	0.0
Sex/age						
Male	4,854	1.2	1,311	2.6	1,852	0.1
18 - <50y	527	0.8	217	0.9	363	0.0
50 - <60y	787	1.1	217	1.8	429	0.0
60 - <70y	1,571	0.9	323	4.3	550	0.0
70 - <80y	1,650	1.0	419	2.9	423	0.2
≥80y	319	4.4	135	1.5	87	1.1
Female	2,273	1.5	1,259	2.5	934	0.6
18 - <50y	180	2.2	283	1.8	154	0.0
50 - <60y	294	1.4	184	2.2	157	0.0
60 - <70y	724	1.0	268	2.2	291	0.7
70 - <80y	878	1.7	371	3.0	269	0.7
≥80y	197	2.5	153	3.9	63	3.2
LVF						
EF>45%	6,113	1.2	2,230	2.3	2,595	0.3
EF≥30% - ≤45%	703	2.1	266	3.0	140	0.0
EF<30%	196	3.6	29	10.3	8	0.0
Previous MI						
No MI	6,654	1.2	2,377	2.1	2,717	0.3
NSTEMI	313	3.5	106	2.8	33	3.0
STEMI	69	1.4	57	19.3	14	0.0
Unknown type	91	2.2	29	6.9	22	0.0
Previous surgery						
Initial	6,302	1.1	1,965	2.2	2,707	0.3
Redo	825	3.0	604	3.6	78	0.0
Dialysis						
No	7,040	1.2	2,522	2.3	2,776	0.3
Yes	87	9.2	47	17.0	10	0.0
Pre-operative creatinine						
≤200 µmol/L	6,964	1.2	2,463	2.4	2,768	0.3
>200 µmol/L	156	5.8	103	6.8	16	0.0

2.6 AVR

Figure 34. Isolated AVR surgery by unit, 2023



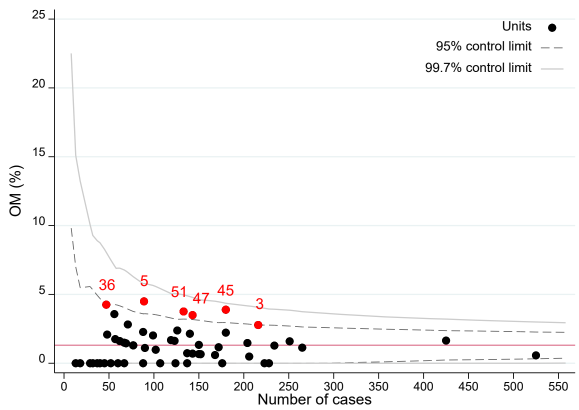
2.6.1 Unit outcomes – mortality, complications and resource utilisation

2.6.1.1 Operative mortality

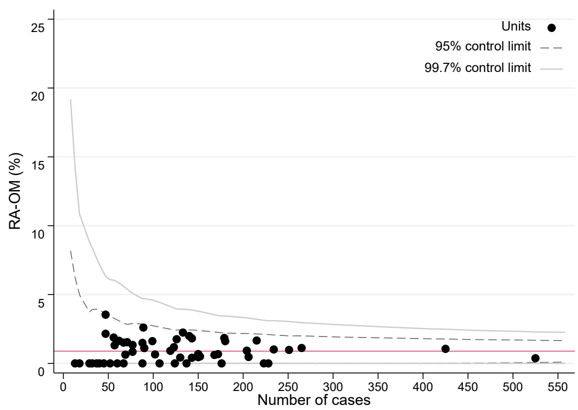
To enhance the visibility of the individual unit outcomes on the funnel plots, units with very low case numbers (<10 in the five-year pooled data) were excluded. A full summary of outcomes for all units is provided in Appendix F (pg. 86).

Figure 35. OM following isolated AVR surgery 2019-2023, by unit

a. OM



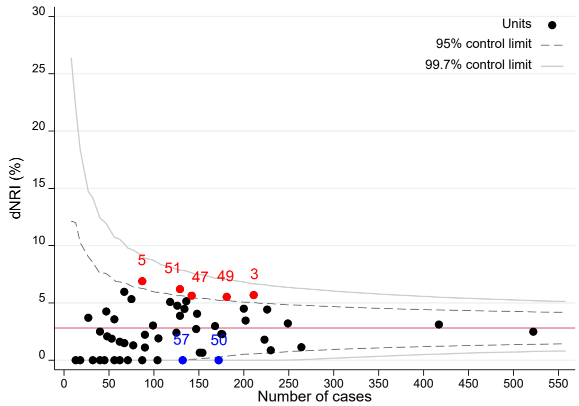
b. RA-OM



2.6.1.2 Complications

Figure 36. dNRI following isolated AVR surgery 2019-2023, by unit

a. dNRI



b. RA-dNRI

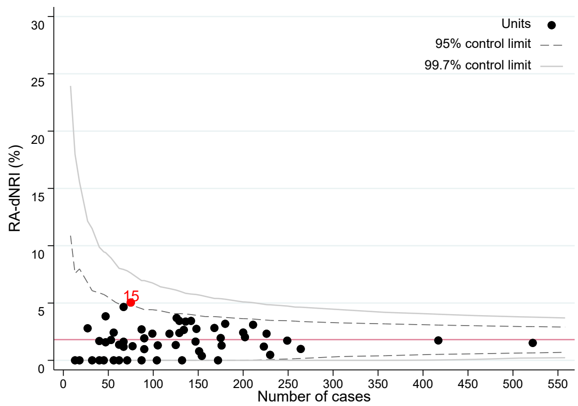
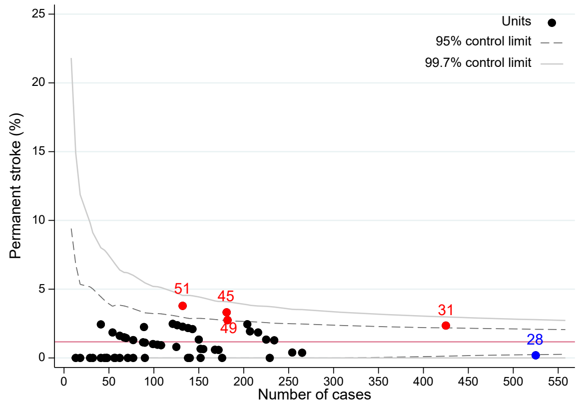
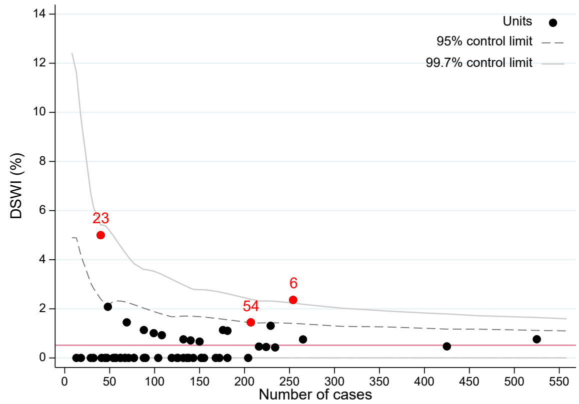


Figure 37. Complications following isolated AVR surgery 2019-2023, by unit

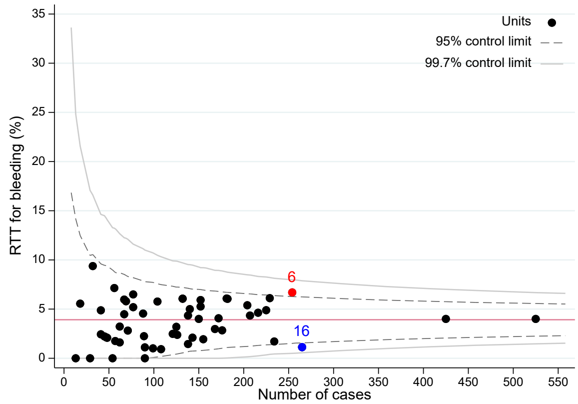
a. Permanent stroke



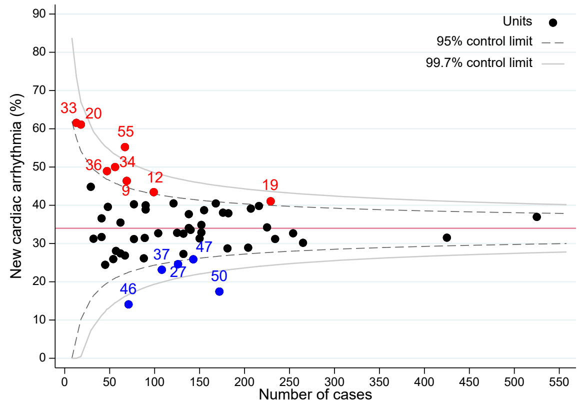
b. DSWI



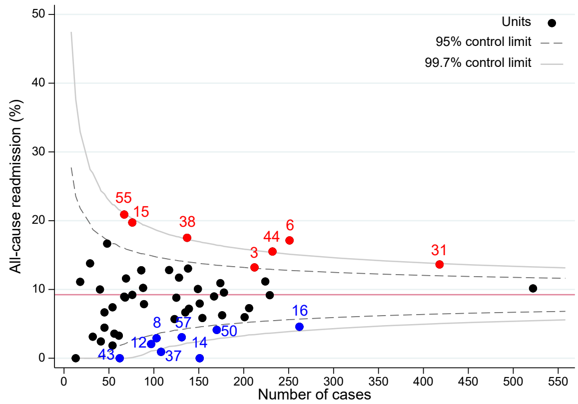
c. RTT for bleeding



d. New cardiac arrhythmia



e. All-cause readmission



2.6.1.3 Resource utilisation

Cases with a pre-operative LOS of more than 14 days were classified as clinical outliers and excluded from the analysis.

Figure 38. Distribution of pre-operative LOS for isolated AVR patients, 2023

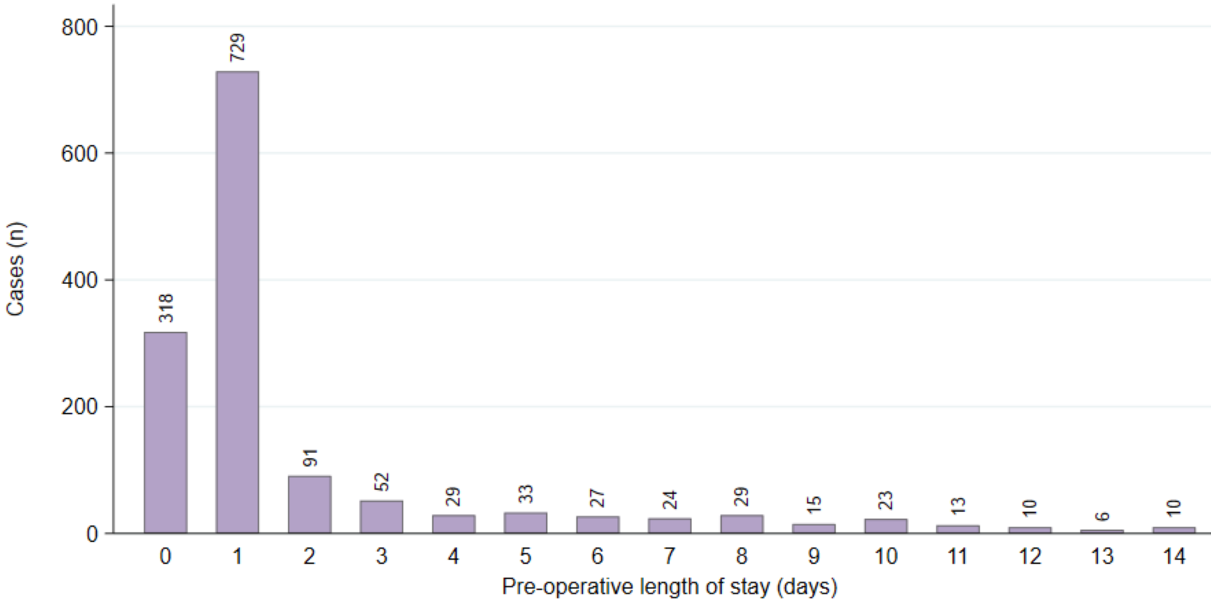


Table 28. Summary of pre-operative LOS for isolated AVR patients at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	2.1	1	0 - 2
Private	1.6	1	1 - 1
Total	2.0	1	1 - 2

Cases with a post-operative LOS of more than 90 days were classified as clinical outliers and excluded from the analysis.

Figure 39. Distribution of post-operative LOS for isolated AVR patients, 2023

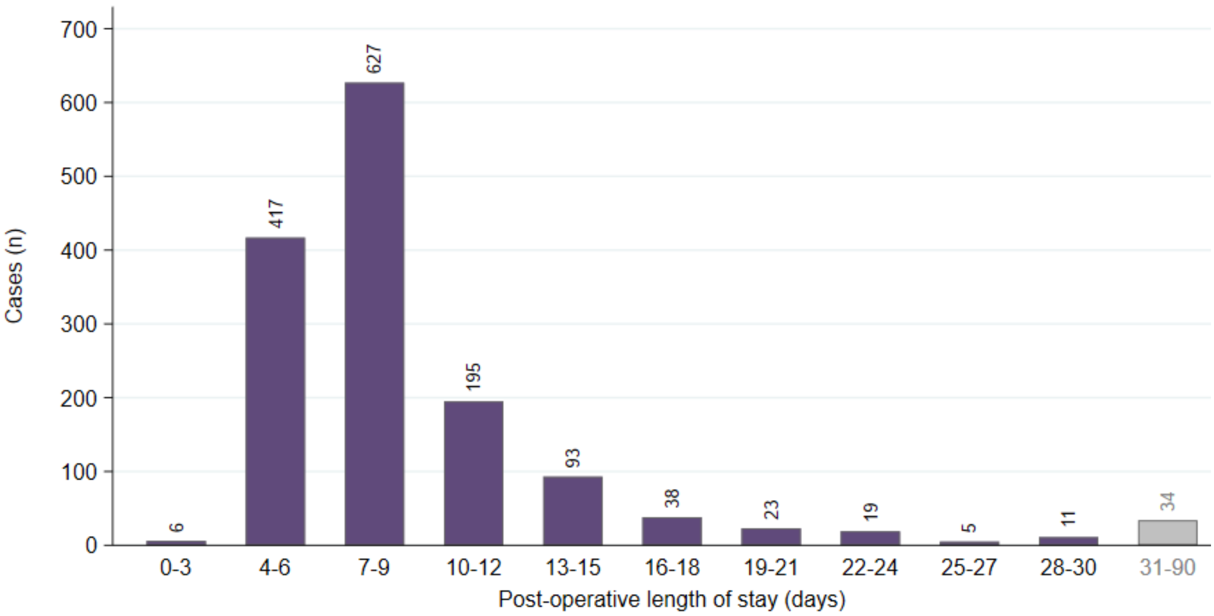


Table 29. Summary of post-operative LOS for isolated AVR patients at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	9.6	7	6 - 10
Private	9.4	8	7 - 10
Total	9.5	8	6 - 10

Cases with a ventilation time of more than four weeks (672 hours) were classified as clinical outliers and excluded from the analysis.

Figure 40. Distribution of initial post-operative ventilation time for isolated AVR patients, 2023

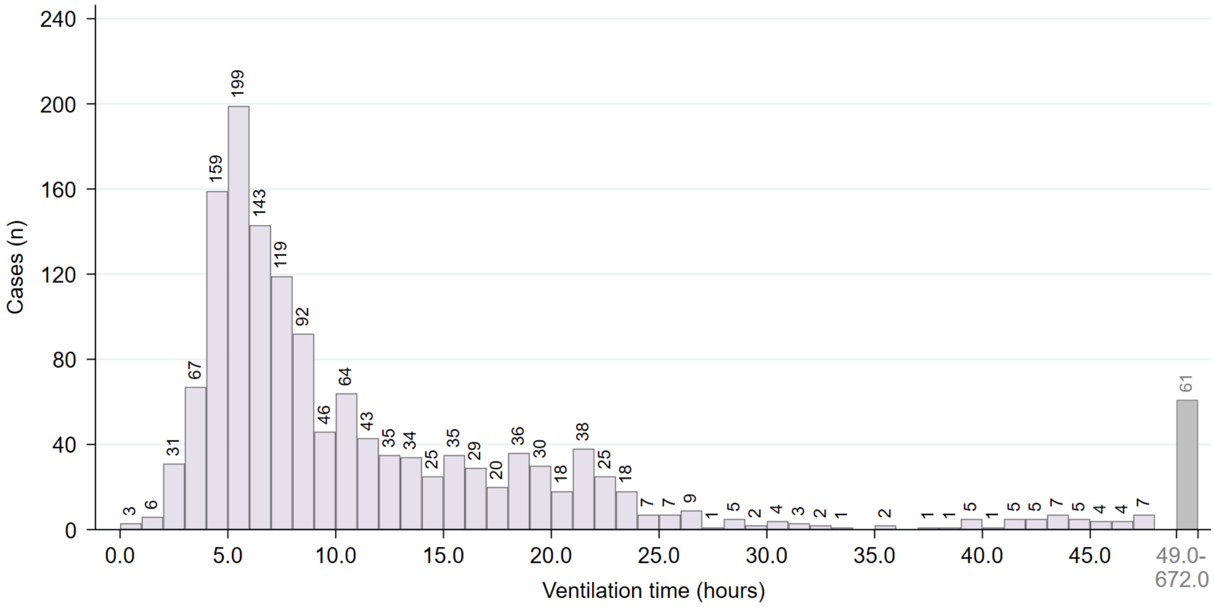


Table 30. Cumulative proportion of patients extubated over time for isolated AVR surgery, 2023

	<6h	<12h	<24h	<48h	<96h	<192h	<384h	≤672h
Cumulative patients (n)	465	972	1,315	1,403	1,437	1,454	1,463	1,464
Cumulative percentage (%)	31.8	66.4	89.8	95.8	98.2	99.3	99.9	100.0

Table 31. Summary of initial post-operative ventilation time for isolated AVR patients at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	17.9	8.2	5.5 - 16.6
Private	12.3	7.6	5.3 - 15.3
Total	15.9	8.0	5.5 - 15.8

Cases with an ICU LOS of more than six weeks (1,008 hours) were classified as clinical outliers and excluded from the analysis.

Figure 41. Distribution of ICU LOS for isolated AVR patients, 2023

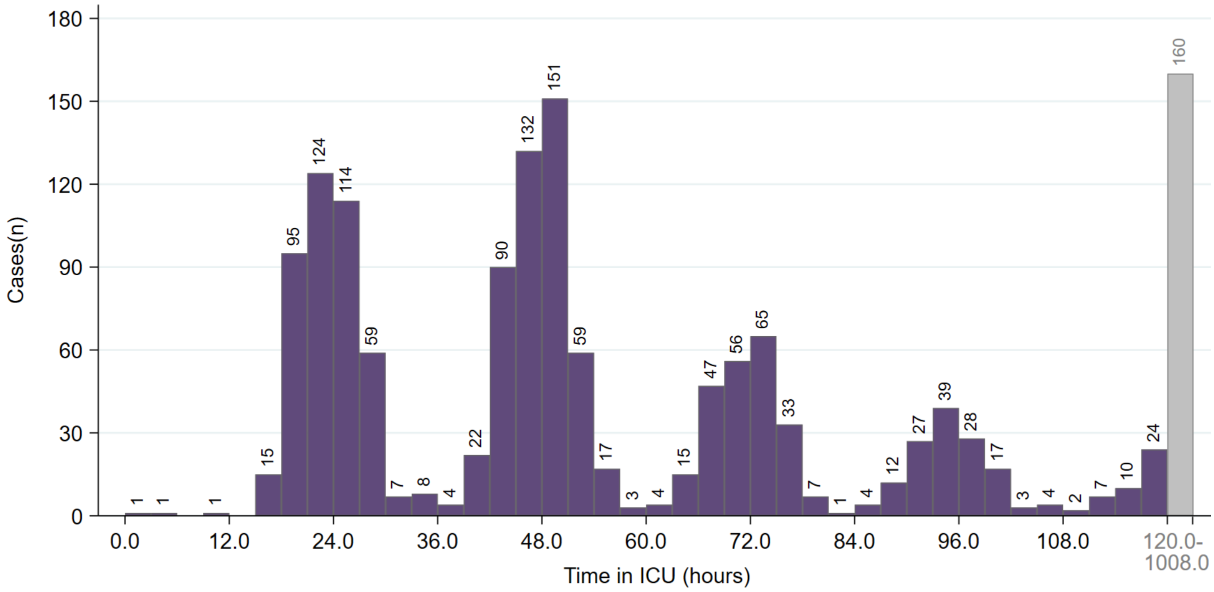


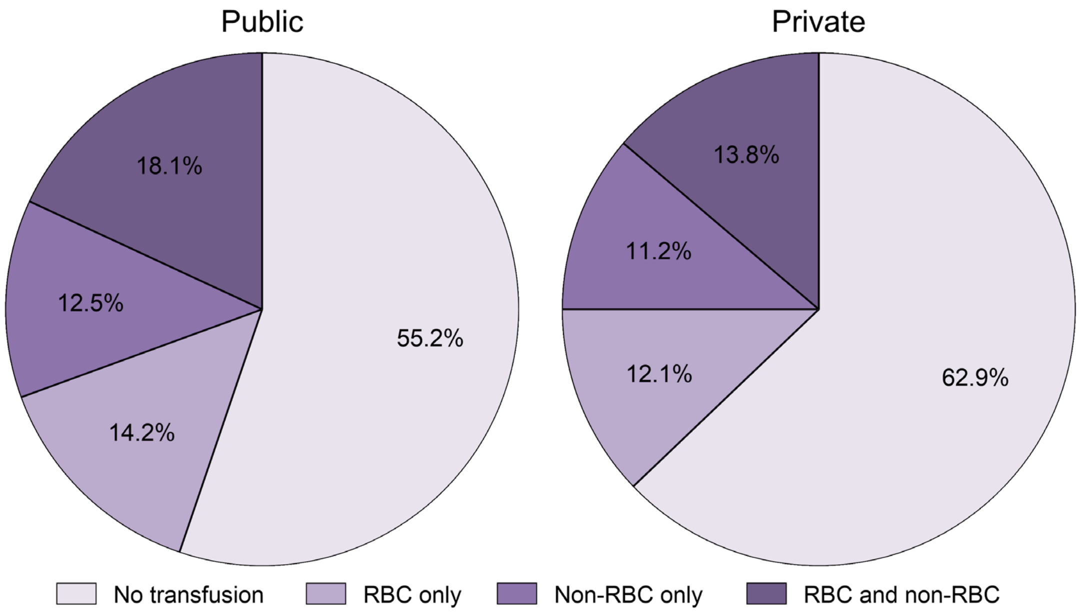
Table 32. Cumulative proportion of patients discharged from ICU over time for isolated AVR surgery, 2023

	<12h	<24h	<48h	<72h	<144h	<288h	<576h	≤1008h
Cumulative patients (n)	3	237	673	1,025	1,370	1,446	1,465	1,468
Cumulative percentage (%)	0.2	16.1	45.8	69.8	93.3	98.5	99.8	100.0

Table 33. Summary of ICU LOS for isolated AVR patients at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	65.0	46.2	24.1 - 75.0
Private	70.5	51.1	46.8 - 76.8
Total	67.0	48.9	27.4 - 76.0

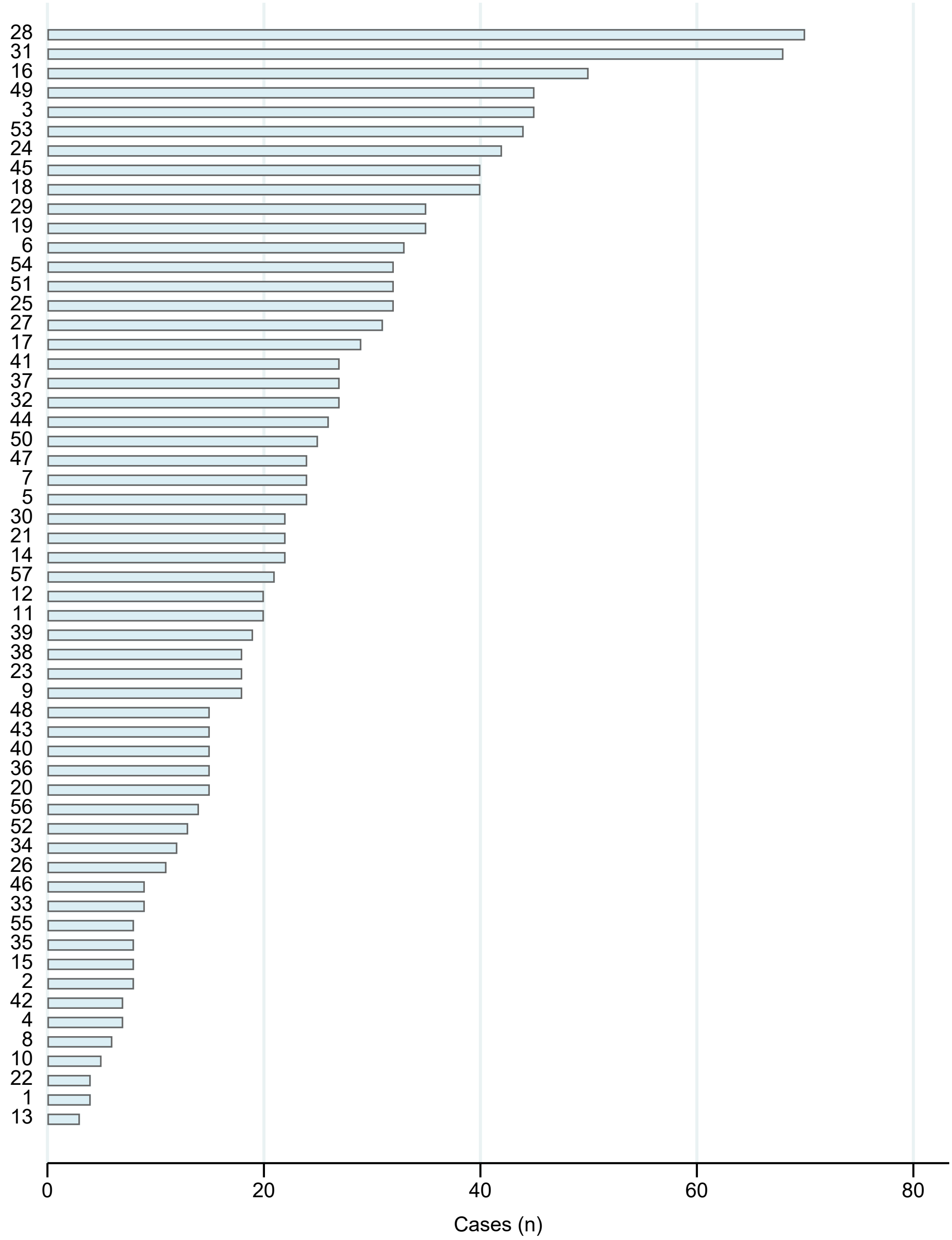
Figure 42. Blood product usage for isolated AVR patients at public and private hospitals, 2023



Note: non-RBC consists of platelets, NovoSeven, cryoprecipitate and FFP

3. Combined Valve and CABG Surgery

Figure 43. Combined valve and CABG cases by unit, 2023



Summary of valve and CABG activity

All combined valve and CABG procedures: Type and mortality

The most common type of combined valve and CABG surgery in the last ten years has been AVR and CABG, despite a decrease from 69.8% of all valve and CABG procedures in 2013 to 63.7% in 2023. In 2023, the second and third most frequent procedures were MVR and CABG, followed by MV repair and CABG, which accounted for approximately 24.9% of valve and CABG surgery cases, combined (Figure 51). In-hospital mortality and total OM for all valve and CABG patients were 2.3 and 2.4%, respectively (Table 40).

Combined AVR and CABG: Case volume and outcomes

Despite combined AVR and CABG being the most common valve and CABG procedure, close to three quarters of participating units had a case volume of 20 or fewer procedures in 2023 (Figure 54). Data for the last five years was pooled to provide sufficient case numbers for analysis of outcomes.

The majority of units performed comparably in 2019-2023 and the OM for combined AVR and CABG patients was 2.6% for this period (Figure 55a). The ability to benchmark the Australian and New Zealand outcomes internationally is limited by the lack of standardised definitions and reporting of unadjusted OM. The closest comparisons are seen with the in-hospital mortality incidences of 2.8% in non-emergency combined AVR and CABG cases in the United Kingdom for 2022/23, and 3.8% for all combined AVR and CABG cases in Germany in 2023 (3, 4). The RA-OM calculated using the Database's ANZSCORE model was 2.2% for 2019-2023 (Figure 55b). The incidences of the other key performance indicators were dNRI (5.0%), RA-dNRI (2.2%), permanent stroke (1.7%), DSWI (1.0%) and RTT for bleeding (4.9%; Figure 56 and Figure 57).

Combined AVR and CABG: Resource utilisation

Most patients (61.7%) were admitted the day before or day of their surgery, and the median pre-operative LOS was one day at public and private hospitals (Figure 58 and Table 47). The majority of patients (57.5%) were discharged less than ten days following their surgery, with a median post-operative LOS at public and private hospitals of nine days (Figure 59 and Table 48).

Patients at public hospitals had a higher mean duration of ventilation (22.3 hours), compared to private hospitals (17.2 hours; Table 50), and 6.9% of all patients were ventilated for more than 48 hours (Table 49). As was also seen with the other major procedure types, ICU LOS showed a cyclical pattern with patients often discharged at 24-hour intervals (Figure 61). Only 35.7% of patients were discharged from ICU in less than 48 hours and the mean ICU LOS was lower for public hospitals (85.0 hours) compared to private hospitals (92.2 hours; Table 51 and Table 52).

The proportion of patients receiving blood transfusions for combined AVR and CABG patients was broadly similar at public hospitals (65.3%) and private hospitals (61.0%), as was the distribution of the types of transfusion. The most common type of transfusion included both RBC and non-RBC products (Figure 62).

3.1 Patient characteristics

3.1.1 Clinical status

Figure 44. Clinical status of combined valve and CABG patients by unit, 2023

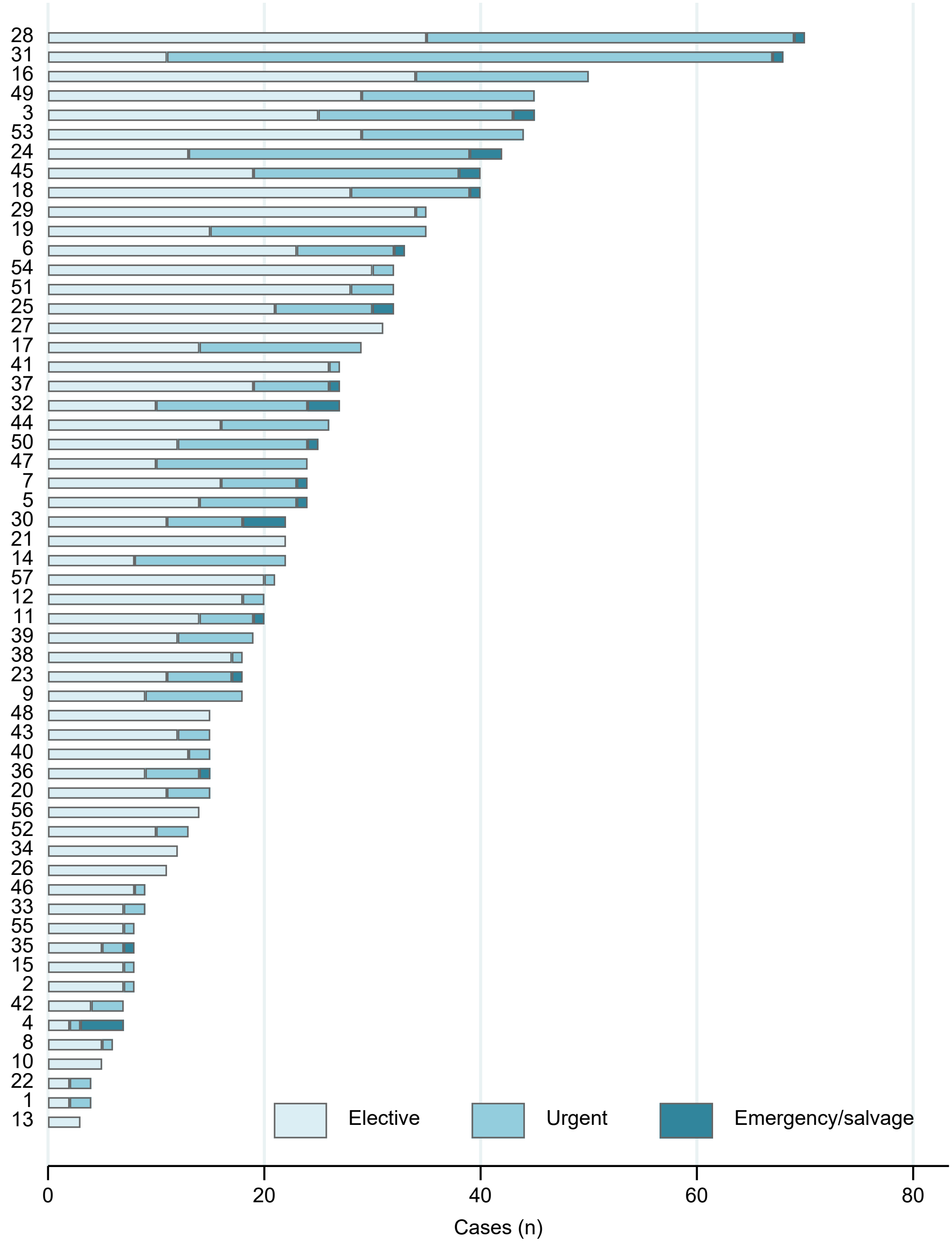


Table 34. Clinical status of combined valve and CABG patients by year

	2019	2020	2021	2022	2023	Total
Elective (%)	72.7	68.5	64.7	65.6	64.9	67.3
Urgent (%)	24.3	29.7	33.1	31.6	32.7	30.3
Emergency/salvage (%)	3.0	1.7	2.2	2.8	2.4	2.4

3.1.2 Sex and age

Figure 45. Sex of combined valve and CABG patients by unit, 2023

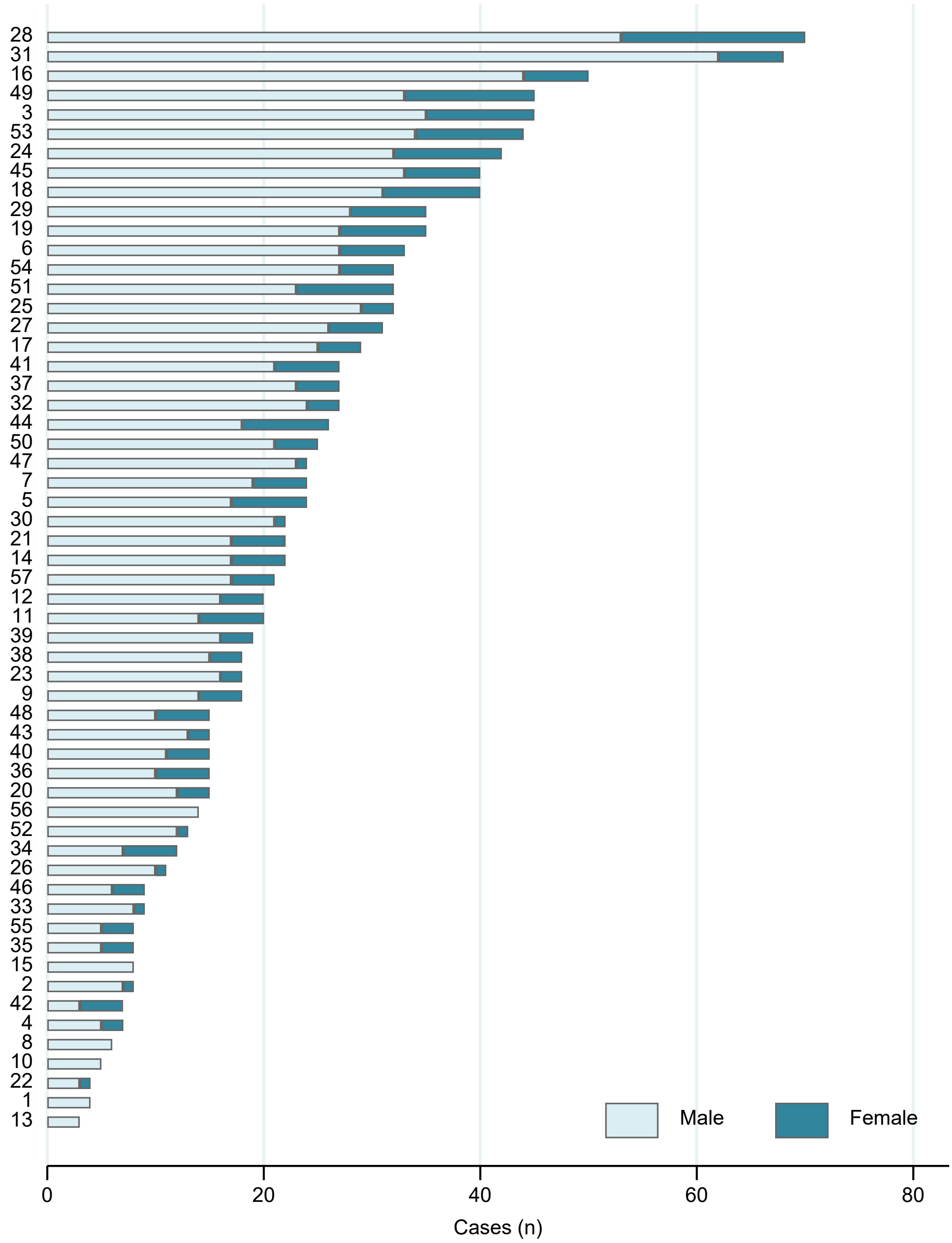
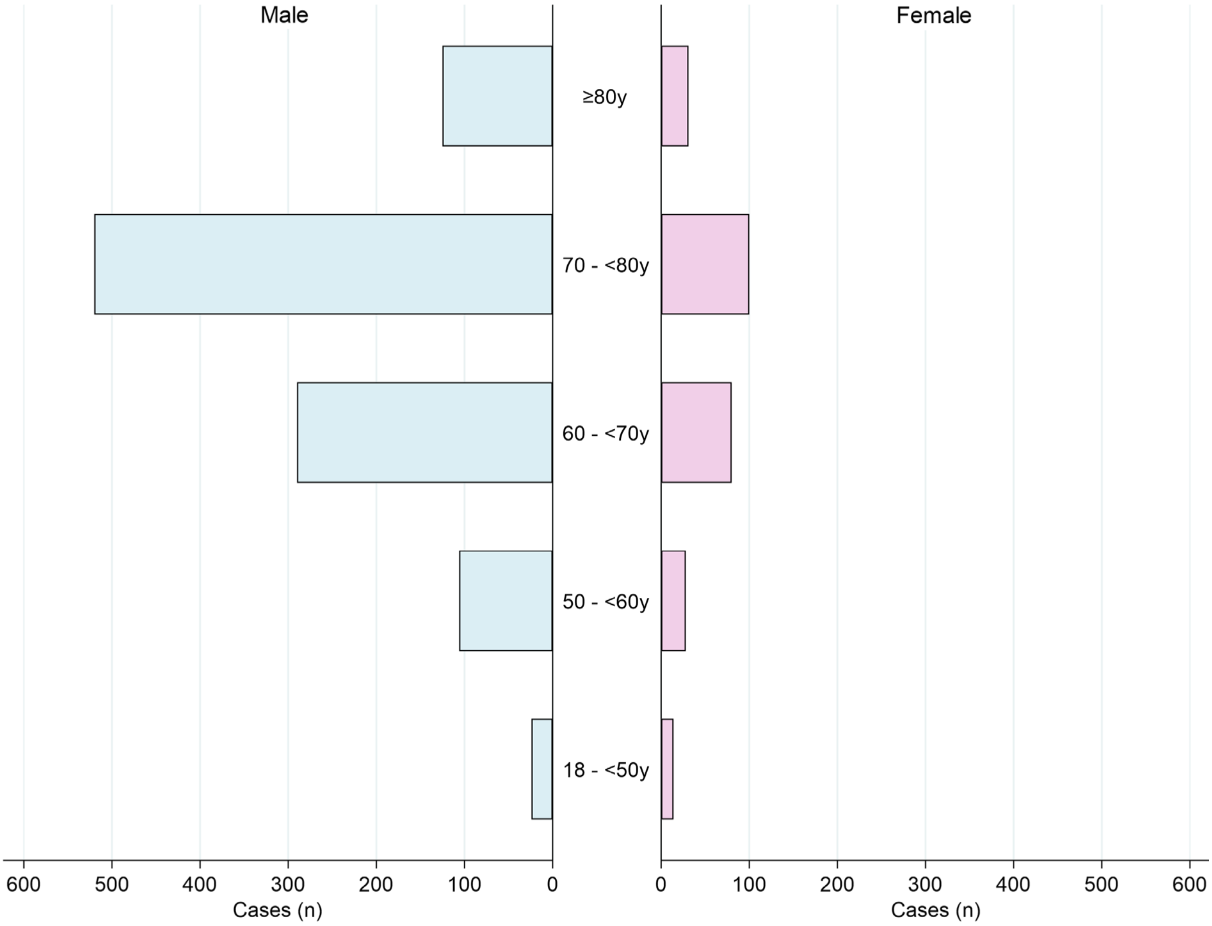


Table 35. Sex of combined valve and CABG patients by year

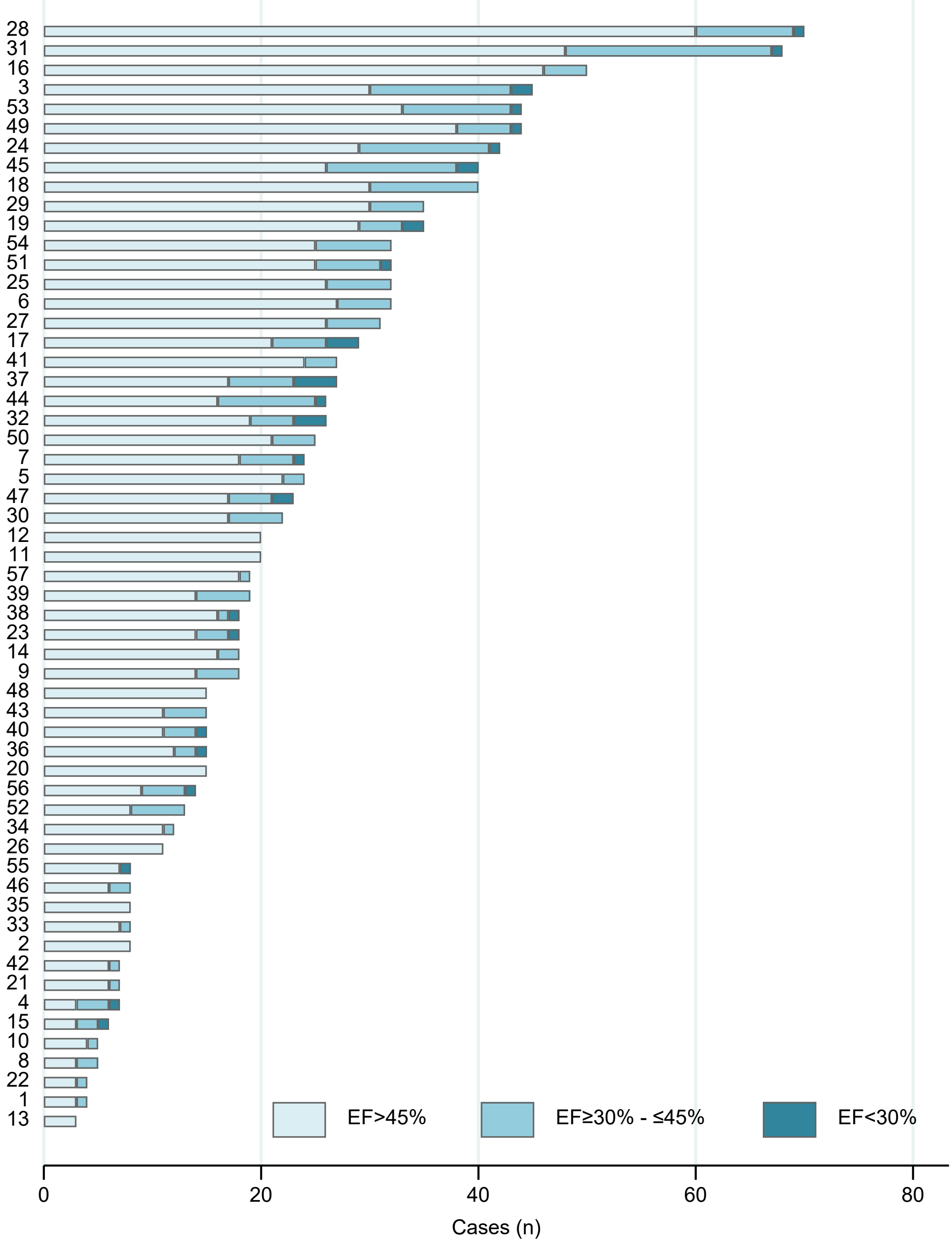
	2019	2020	2021	2022	2023	Total
Male (%)	81.5	80.6	80.4	81.3	80.8	80.9
Female (%)	18.5	19.4	19.6	18.7	19.2	19.1

Figure 46. Age of combined valve and CABG patients by sex, 2023



3.1.3 Left ventricular function

Figure 47. Pre-operative LVF of combined valve and CABG patients by unit, 2023



The ANZSCTS Database classifies an EF>45% as normal or mildly reduced, an EF≥30% - ≤45% as moderately reduced and an EF<30% as severely reduced LVF, respectively (Appendix C, pg. 81).

Table 36. Pre-operative LVF of combined valve and CABG patients by year

	2019	2020	2021	2022	2023	Total
EF>45% (%)	79.6	79.6	80.4	77.2	79.6	79.3
EF≥30% - ≤45% (%)	16.3	16.1	15.3	18.9	17.8	16.9
EF<30% (%)	4.1	4.3	4.3	3.9	2.6	3.8

3.1.4 Previous myocardial infarction

Figure 48. Previous MI in combined valve and CABG patients by unit, 2023

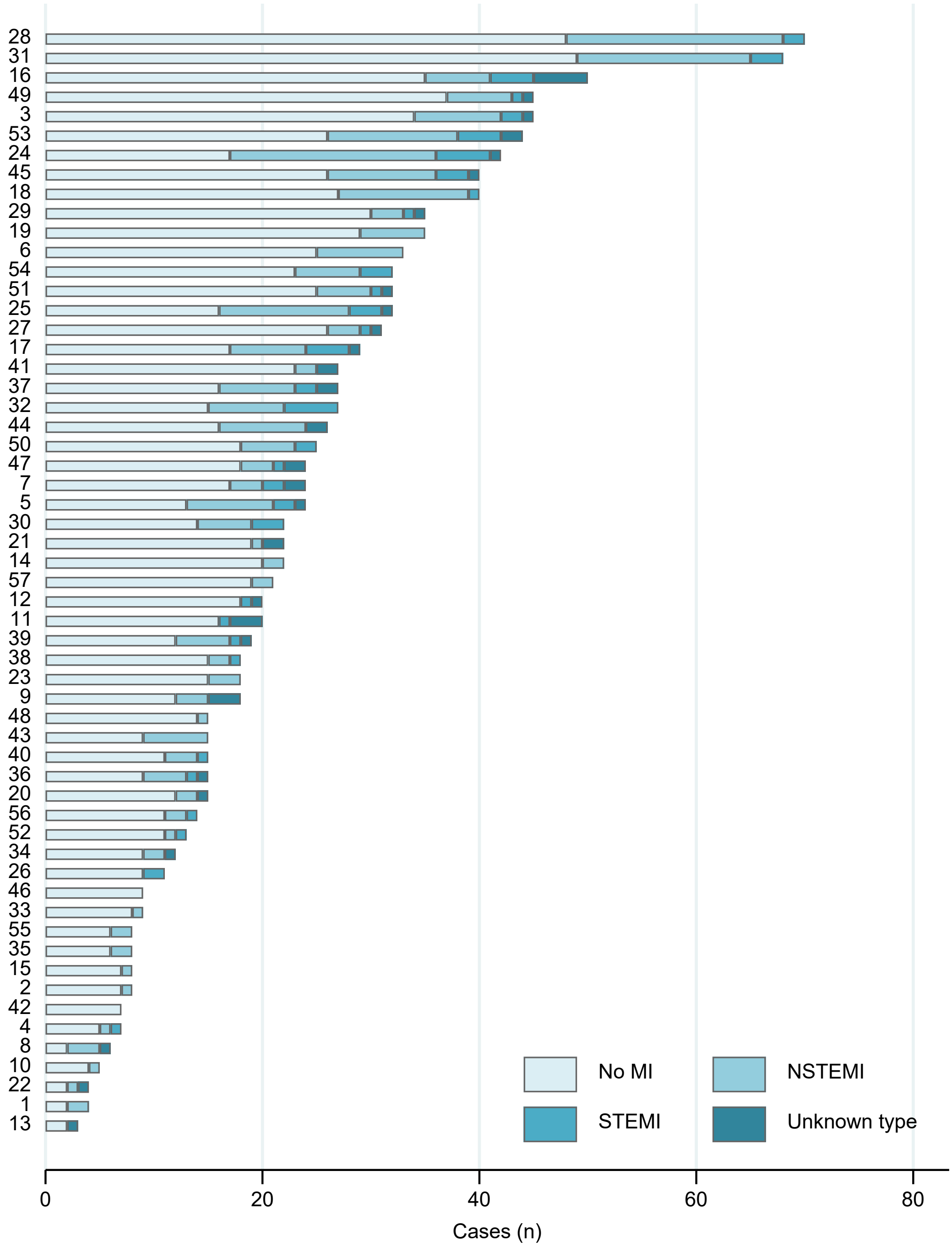


Table 37. Previous MI in combined valve and CABG patients by year

	2019	2020	2021	2022	2023	Total
No MI (%)	73.2	71.4	70.3	71.3	71.9	71.6
NSTEMI (%)	19.7	21.0	20.6	20.6	19.8	20.3
STEMI (%)	3.7	3.9	5.8	5.3	5.0	4.8
Unknown type (%)	3.4	3.7	3.3	2.8	3.3	3.3

3.1.5 Timing of previous myocardial infarction

Figure 49. Timing of previous MI in combined valve and CABG patients by unit, 2023

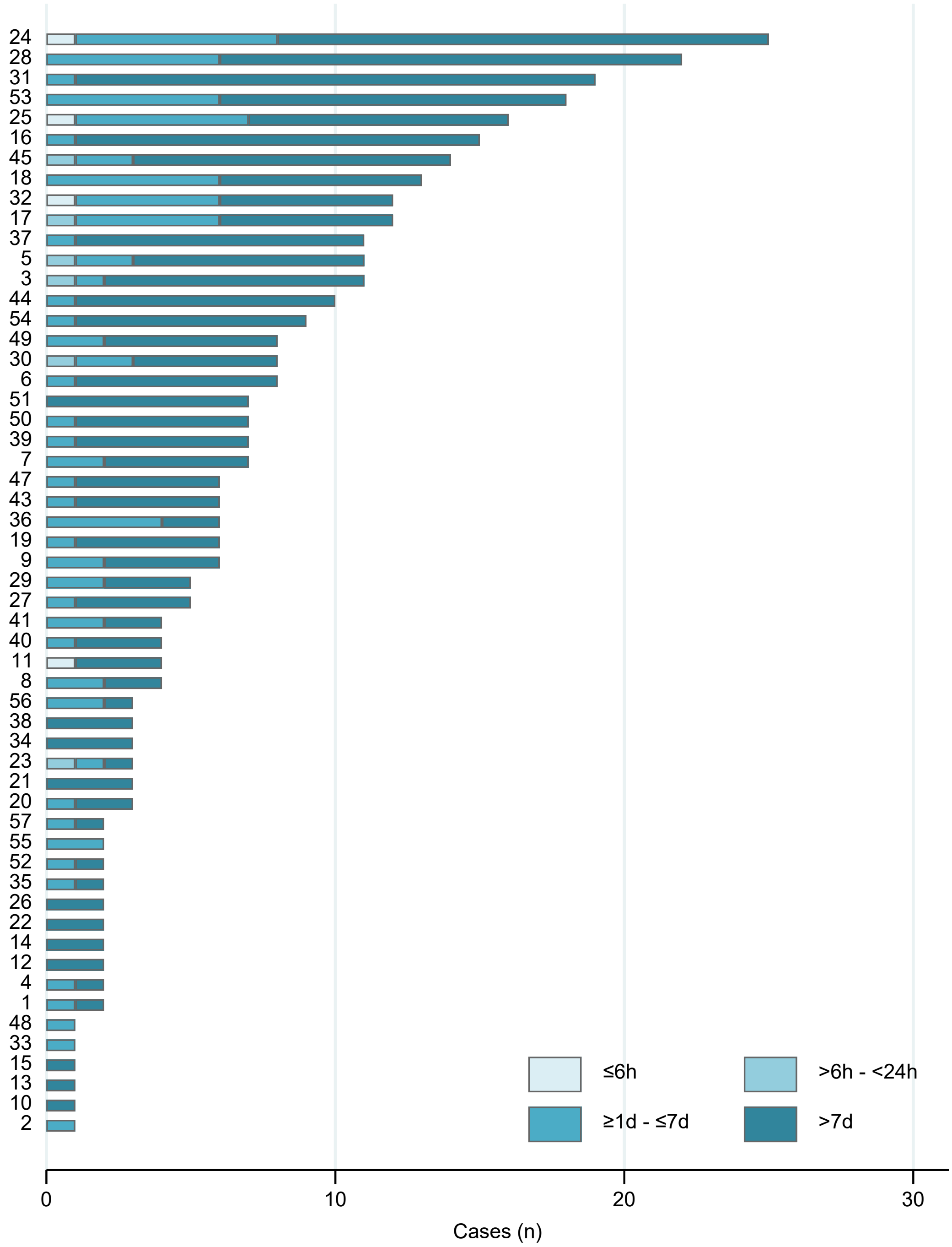


Table 38. Timing of previous MI in combined valve and CABG patients by year

	2019	2020	2021	2022	2023	Total
≤6hr (%)	1.7	0.6	1.3	0.5	1.1	1.0
>6hr - <24hr (%)	0.9	1.4	2.0	1.1	1.6	1.4
≥1d - ≤7d (%)	22.1	24.5	26.5	27.2	24.6	25.1
>7d (%)	75.3	73.5	70.2	71.2	72.7	72.5

3.2 Previous cardiac surgery

Figure 50. Initial vs redo surgery in combined valve and CABG patients by unit, 2023

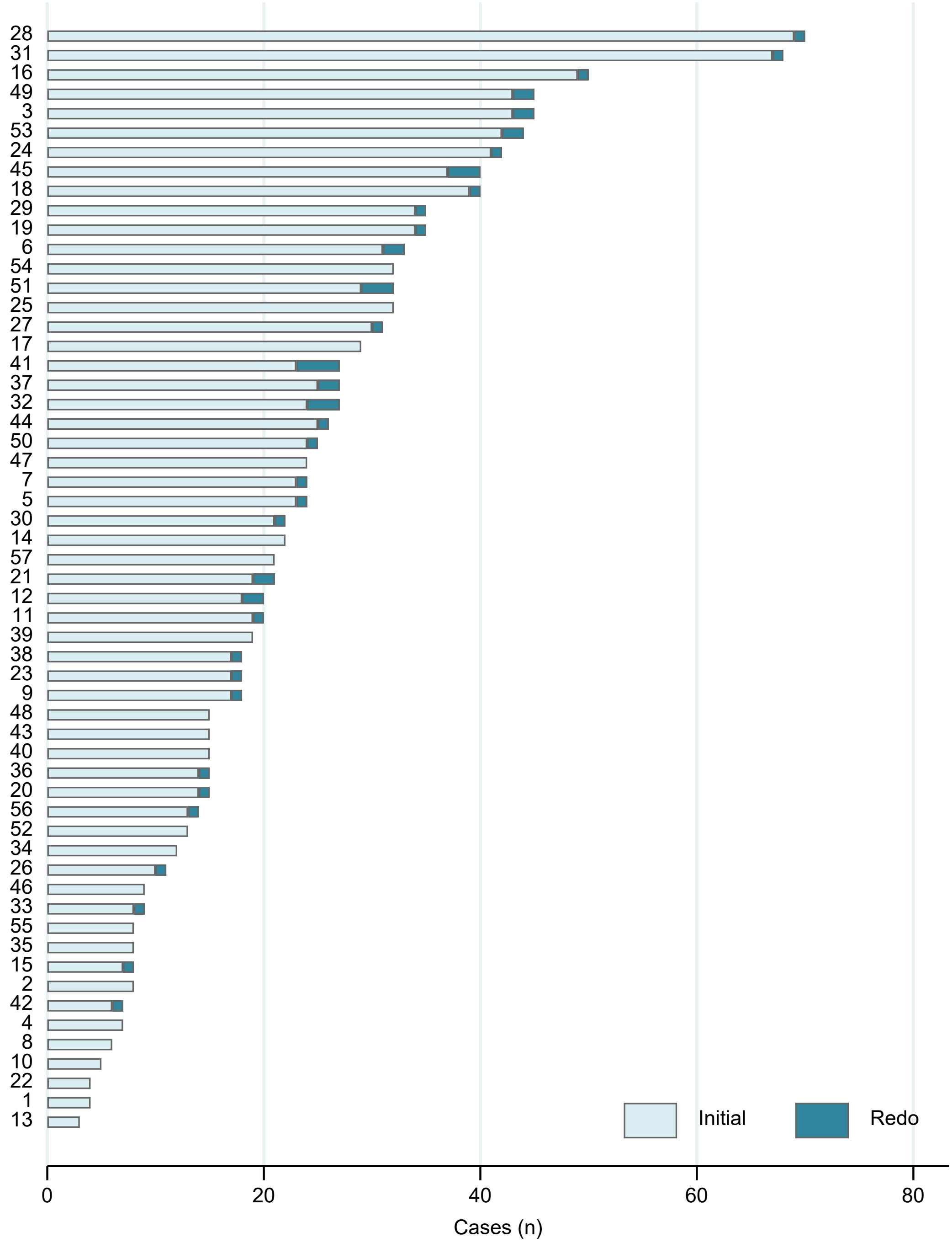
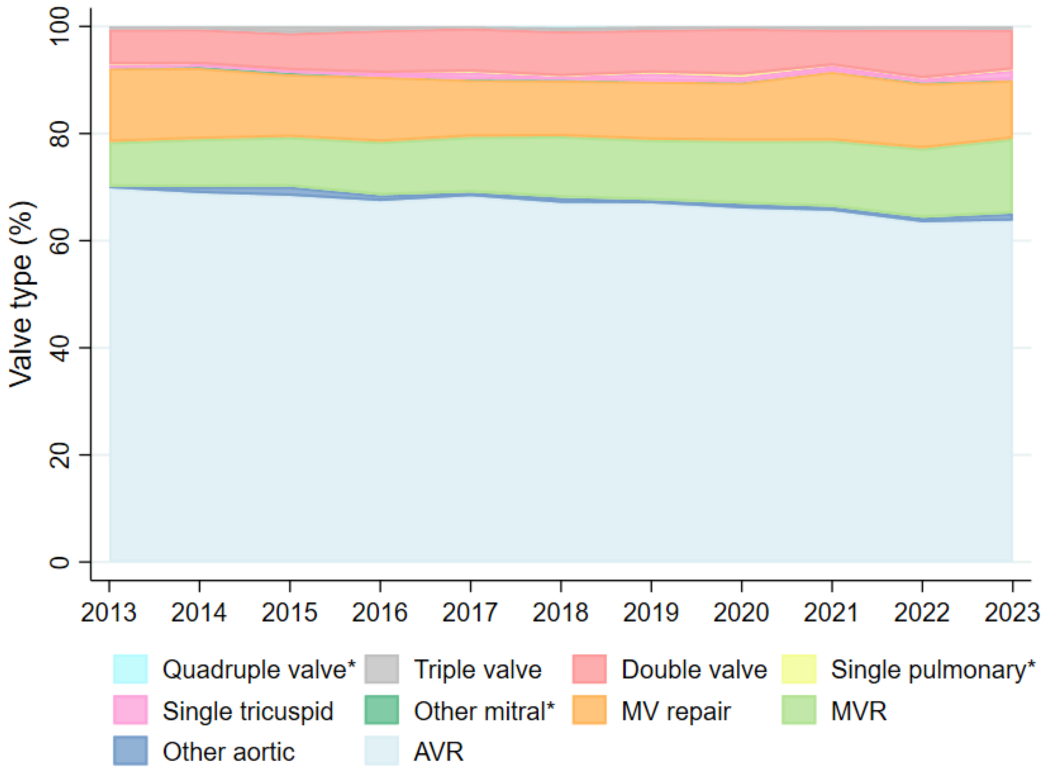


Table 39. Initial vs redo surgery in combined valve and CABG patients by year

	2019	2020	2021	2022	2023	Total
Initial (%)	95.5	94.5	95.6	95.7	96.1	95.5
Redo (%)	4.5	5.5	4.4	4.3	3.9	4.5

3.3 Overview of all combined valve and CABG surgery

Figure 51. Combined valve and CABG surgery by year, 2013-2023



*Not visible on the figure as these categories represent a total of 27 out of 13,534 cases, combined, between 2013 and 2023

Table 40. In-hospital mortality and total OM in combined valve and CABG patients, 2023

	Total cases		In-hospital mortality		Total OM	
Valve surgery type	n	%	n	%	n	%
Single aortic	851	65.1	12	1.4	13	1.5
AVR	834	63.8	10	1.2	11	1.3
Other aortic	17	1.3	2	11.8	2	11.8
Single mitral	326	24.9	10	3.1	10	3.1
MVR	183	14.0	7	3.8	7	3.8
MV repair	142	10.9	3	2.1	3	2.1
Other mitral	1	0.1	0	0.0	0	0.0
Single tricuspid	23	1.8	1	4.3	1	4.3
Single pulmonary	2	0.1	0	0.0	0	0.0
Aortic and mitral	48	3.7	4	8.3	4	8.3
Mitral and tricuspid	39	3.0	2	5.1	2	5.1
Aortic and tricuspid	8	0.6	1	12.5	1	12.5
Other double valve	3	0.2	0	0.0	0	0.0
Triple valve	8	0.6	0	0.0	0	0.0
Quadruple valve	0	0.0	0	-	0	-
Total valve surgery	1,308	100.0	30	2.3	31	2.4

3.4 Combined single valve and CABG surgery

Figure 52. Types of combined single valve and CABG surgery performed by unit, 2023

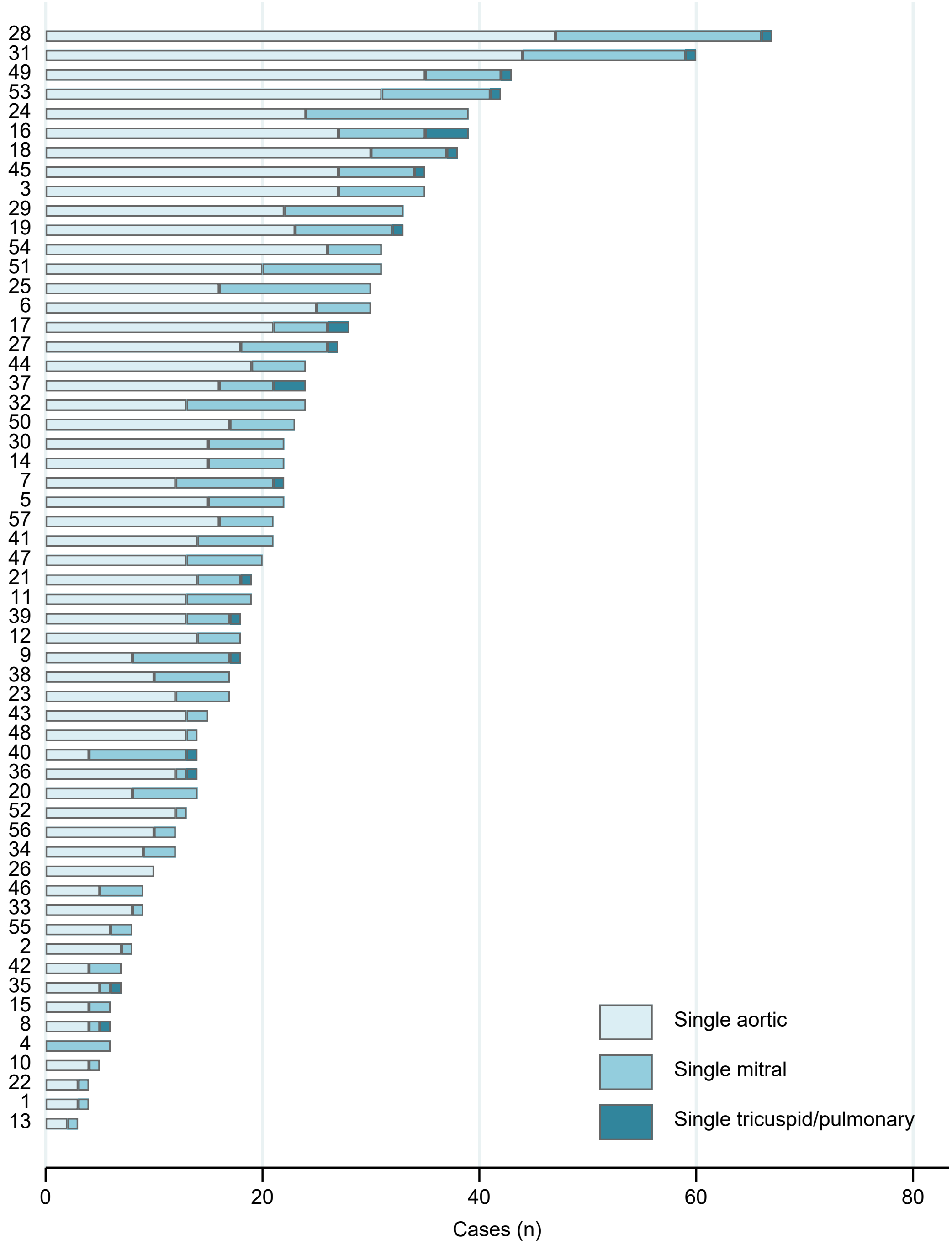
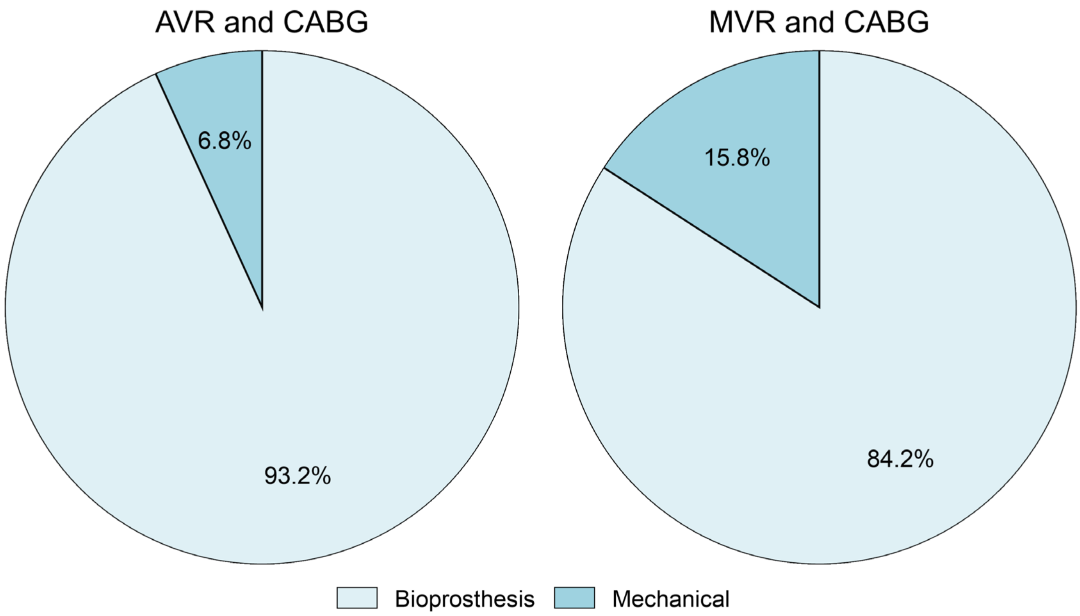


Table 41. Types of combined single valve and CABG surgery performed by year

	2019	2020	2021	2022	2023	Total
Single aortic (%)	74.0	73.6	71.5	71.2	70.8	72.2
Single mitral (%)	24.2	24.9	27.3	27.9	27.1	26.3
Single tricuspid/pulmonary (%)	1.8	1.5	1.2	0.9	2.1	1.5

3.4.1 Prosthesis type

Figure 53. Prosthesis type used for AVR or MVR, combined with CABG surgery, 2023



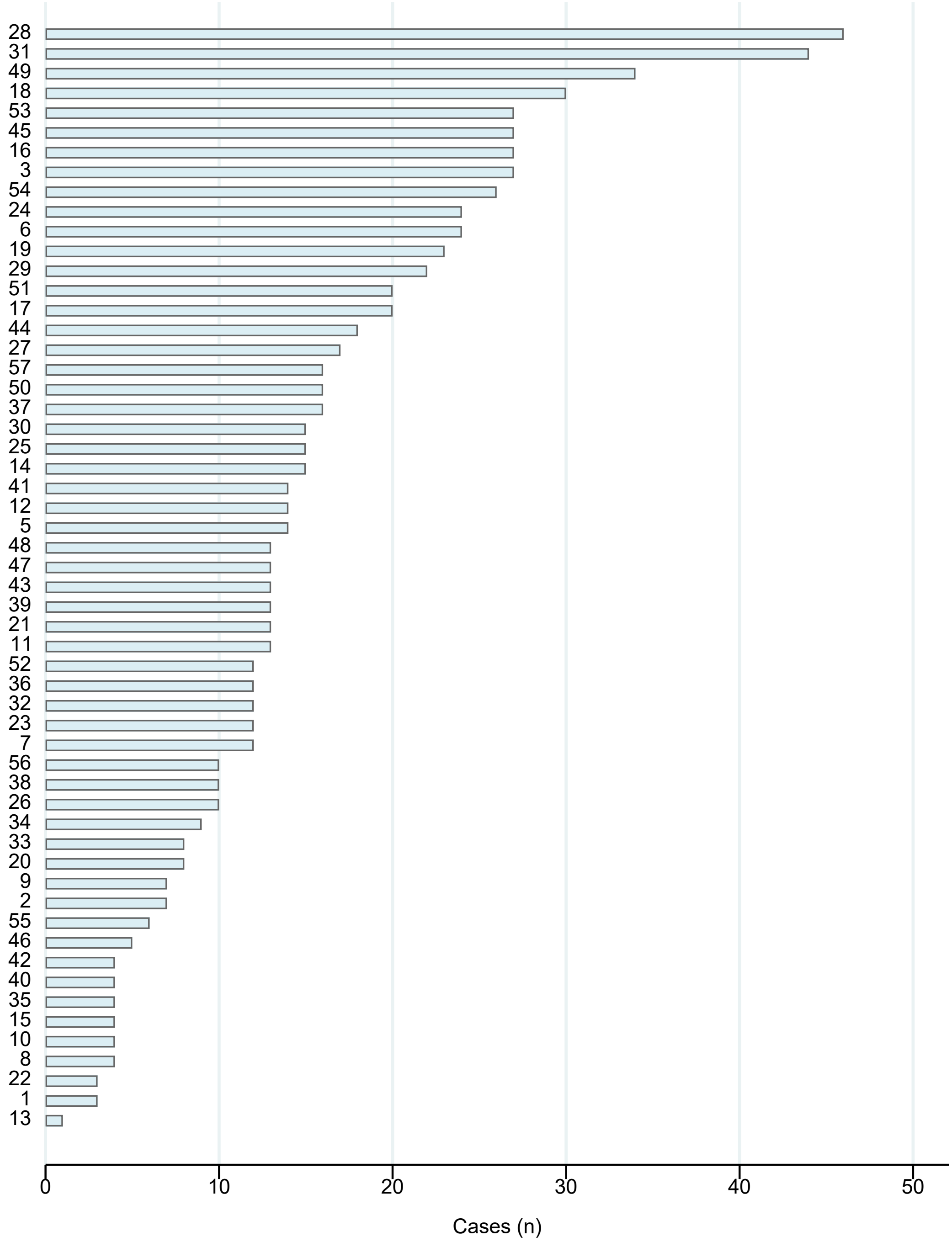
3.5 Influence of patient characteristics on operative mortality

Table 42. OM following the three most common combined single valve and CABG operations, by patient demographics and risk factors

	AVR and CABG		MVR and CABG		MV repair and CABG	
	n	OM (%)	n	OM (%)	n	OM (%)
Clinical status						
Elective	2,926	1.9	460	1.7	480	1.9
Urgent	1,216	3.2	298	8.4	242	3.3
Emergency/salvage	67	19.4	46	23.9	21	9.5
Sex/age						
Male	3,505	2.2	563	4.4	617	1.9
18 - <50y	41	0.0	21	0.0	28	0.0
50 - <60y	249	2.4	68	1.5	90	4.4
60 - <70y	928	2.2	166	4.8	197	1.0
70 - <80y	1,792	2.1	239	5.4	246	2.4
≥80y	495	3.0	69	4.3	56	0.0
Female	704	4.4	241	7.9	126	5.6
18 - <50y	15	0.0	17	0.0	5	0.0
50 - <60y	43	2.3	28	3.6	18	5.6
60 - <70y	177	2.8	56	12.5	38	7.9
70 - <80y	354	4.2	105	7.6	55	5.5
≥80y	115	8.7	35	8.6	10	0.0
LVF						
EF>45%	3,457	2.1	562	4.1	522	1.5
EF≥30% - ≤45%	594	4.9	173	8.1	161	3.7
EF<30%	102	5.9	54	13.0	55	9.1
Previous MI						
No MI	3,118	1.7	507	2.6	485	1.9
NSTEMI	842	5.9	188	10.1	162	3.1
STEMI	130	3.1	82	12.2	66	6.1
Unknown type	119	2.5	27	7.4	30	3.3
Timing of previous MI						
≤6hr	8	25.0	8	37.5	1	0.0
>6hr - <24hr	13	0.0	7	28.6	2	0.0
≥1d - ≤7d	287	7.0	68	10.3	67	4.5
>7d	781	4.4	213	8.9	187	3.7
Previous surgery						
Initial	4,063	2.5	759	5.1	731	2.5
Redo	146	4.1	44	11.4	12	8.3
Dialysis						
No	4,143	2.5	773	5.4	734	2.3
Yes	66	9.1	31	6.5	9	22.2
Pre-operative creatinine						
≤200 µmol/L	4,102	2.4	749	4.8	721	1.9
>200 µmol/L	104	9.6	55	14.5	22	22.7

3.6 Combined AVR and CABG

Figure 54. Combined AVR and CABG surgery by unit, 2023



3.6.1 Influence of co-morbidities on complications

3.6.1.1 Pre-existing diabetes and renal impairment

Table 43. Complications following combined AVR and CABG surgery, by pre-operative diabetes and renal function

		Insulin dependent diabetes		Pre-operative creatinine		Pre-operative eGFR	
		No	Yes	≤200 µmol/L	>200 µmol/L	>60 mL/ min/1.73m²	≤60 mL/ min/1.73m²
n	2023	767	73	821	18	620	219
	2019-2022	3,096	305	3,312	87	2,548	851
Permanent stroke (%)	2023	1.8	0.0	1.7	0.0	1.5	2.3
	2019-2022	1.6	2.3	1.7	3.4	1.4	2.6
DSWI (%)	2023	0.7	4.1	1.0	0.0	1.0	0.9
	2019-2022	0.8	3.3	1.0	3.4	0.9	1.4
RTT for bleeding (%)	2023	4.2	5.5	4.1	11.1	3.5	6.4
	2019-2022	4.9	6.6	4.8	12.6	4.7	6.1
New cardiac arrhythmia (%)	2023	42.0	35.6	41.7	33.3	39.5	47.2
	2019-2022	39.7	36.7	39.4	42.5	38.6	41.9

3.6.1.2 Age

Table 44. Complications following combined AVR and CABG surgery, by age group

		Age				
		18 - <50y	50 - <60y	60 - <70y	70 - <80y	≥80y
n	2023	12	69	233	416	110
	2019-2022	44	224	880	1,751	502
Permanent stroke (%)	2023	0.0	0.0	1.3	1.9	2.7
	2019-2022	0.0	0.9	1.5	1.5	3.4
DSWI (%)	2023	0.0	1.4	1.7	0.7	0.0
	2019-2022	2.3	0.4	1.1	0.9	1.4
RTT for bleeding (%)	2023	0.0	5.8	4.7	3.4	6.4
	2019-2022	6.8	3.1	5.3	4.9	5.6
New cardiac arrhythmia (%)	2023	16.7	29.0	39.5	45.3	41.8
	2019-2022	15.9	31.7	36.6	41.3	43.6

3.6.1.3 Surgical history

Table 45. Complications following combined AVR and CABG surgery, by previous surgery

		Previous surgery	
		Initial	Redo
n	2023	815	25
	2019-2022	3,278	123
Permanent stroke (%)	2023	1.7	0.0
	2019-2022	1.7	1.6
DSWI (%)	2023	1.0	0.0
	2019-2022	1.1	0.0
RTT for bleeding (%)	2023	4.3	4.0
	2019-2022	5.1	3.3
New cardiac arrhythmia (%)	2023	41.2	52.0
	2019-2022	39.7	32.8

3.6.1.4 Influence of comorbidities on derived new renal insufficiency

Table 46. Incidence of dNRI following combined AVR and CABG surgery, by pre-operative demographics and risk factors

	2023		2019-2022	
	n	dNRI (%)	n	dNRI (%)
Insulin dependent diabetes				
No	756	4.6	3,049	4.7
Yes	68	5.9	294	8.5
Pre-operative creatinine				
≤200 µmol/L	817	4.8	3,303	4.8
>200 µmol/L	7	0.0	40	20.0
Pre-operative eGFR				
>60 mL/min/1.73m²	619	2.4	2,543	3.4
≤60 mL/min/1.73m²	205	11.7	800	10.1
Age				
18 - <50y	11	0.0	40	2.5
50 - <60y	66	3.0	217	5.1
60 - <70y	230	2.6	861	5.3
70 - <80y	408	5.4	1,727	4.6
≥80y	109	8.3	498	6.0
Previous surgery				
Initial	799	4.5	3,224	5.0
Redo	25	12.0	119	6.7

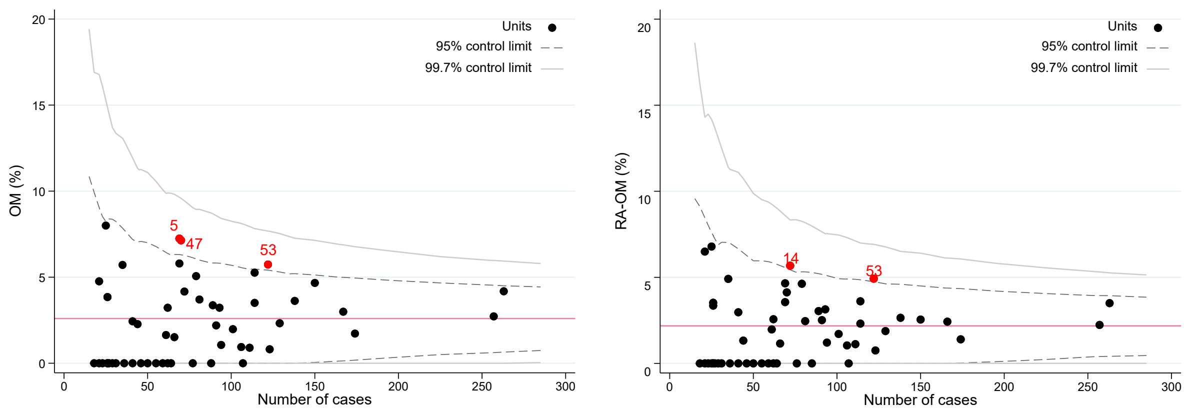
3.6.2 Unit outcomes – mortality, complications and resource utilisation

3.6.2.1 Operative mortality

To enhance the visibility of the individual unit outcomes on the funnel plots, units with very low case numbers (<10 in the five-year pooled data) were excluded. A full summary of outcomes for all units is provided in Appendix F (pg. 86).

Figure 55. OM following combined AVR and CABG surgery 2019-2023, by unit

a. OM b. RA-OM



3.6.2.2 Complications

Figure 56. dNRI following combined AVR and CABG surgery 2019-2023, by unit

a. dNRI b. RA-dNRI

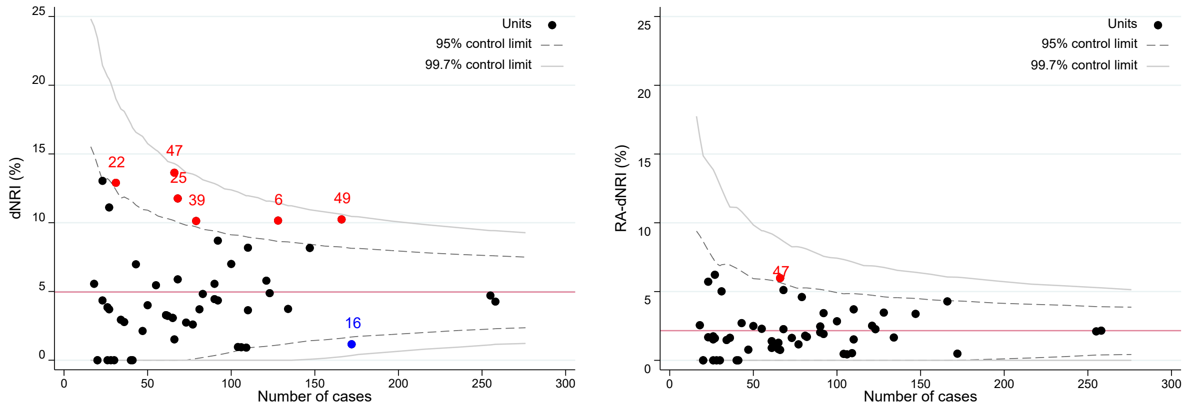
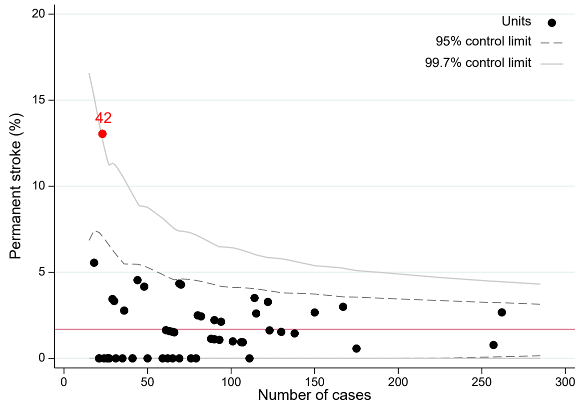
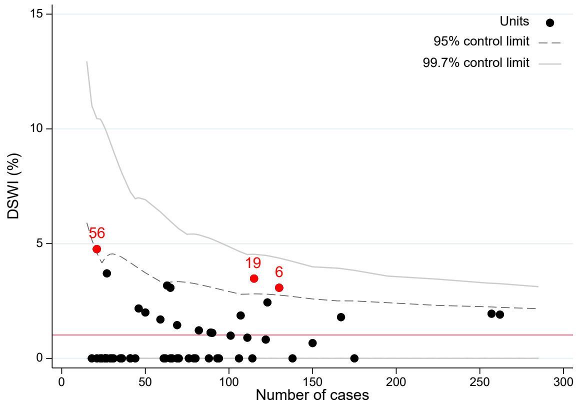


Figure 57. Complications following combined AVR and CABG surgery 2019-2023, by unit

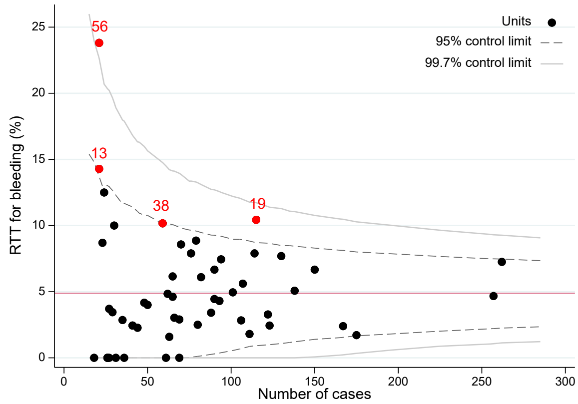
a. Permanent stroke



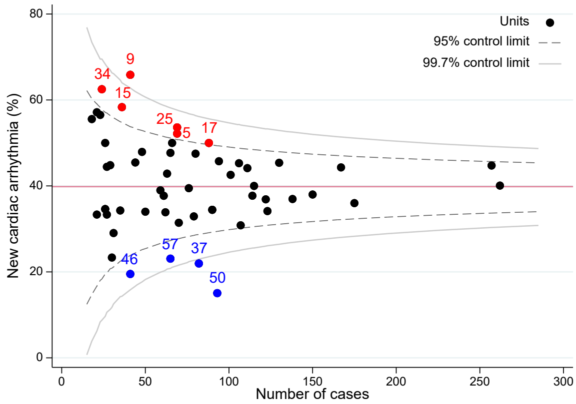
b. DSWI



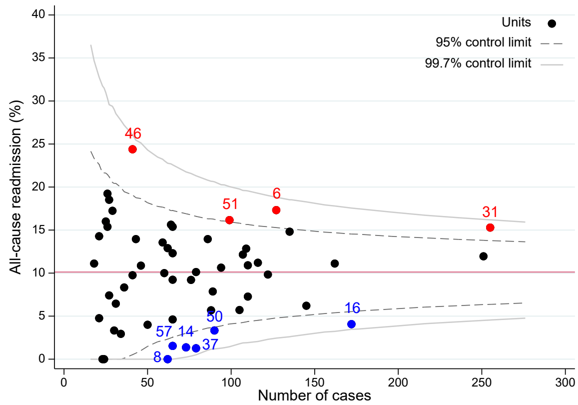
c. RTT for bleeding



d. New cardiac arrhythmia



e. All-cause readmission



3.6.2.3 Resource utilisation

Cases with a pre-operative LOS of more than 14 days were classified as clinical outliers and excluded from the analysis.

Figure 58. Distribution of pre-operative LOS for combined AVR and CABG patients, 2023

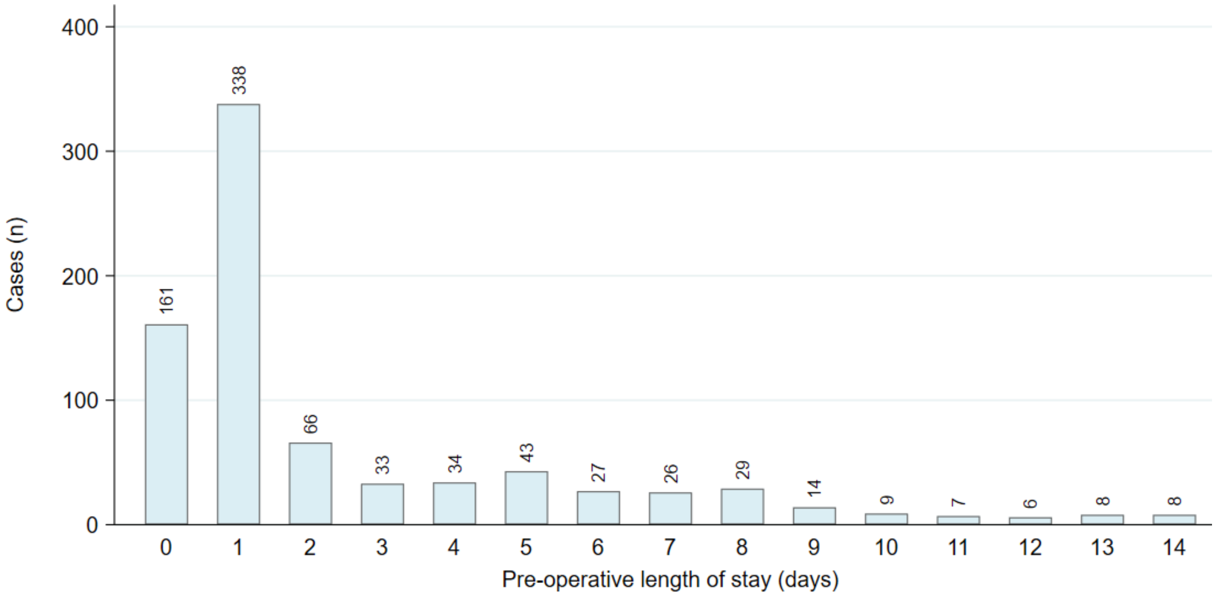


Table 47. Summary of pre-operative LOS for combined AVR and CABG patients at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	2.8	1	0 - 5
Private	2.2	1	1 - 2
Total	2.6	1	1 - 4

Cases with a post-operative LOS of more than 90 days were classified as clinical outliers and excluded from the analysis.

Figure 59. Distribution of post-operative LOS for combined AVR and CABG patients, 2023

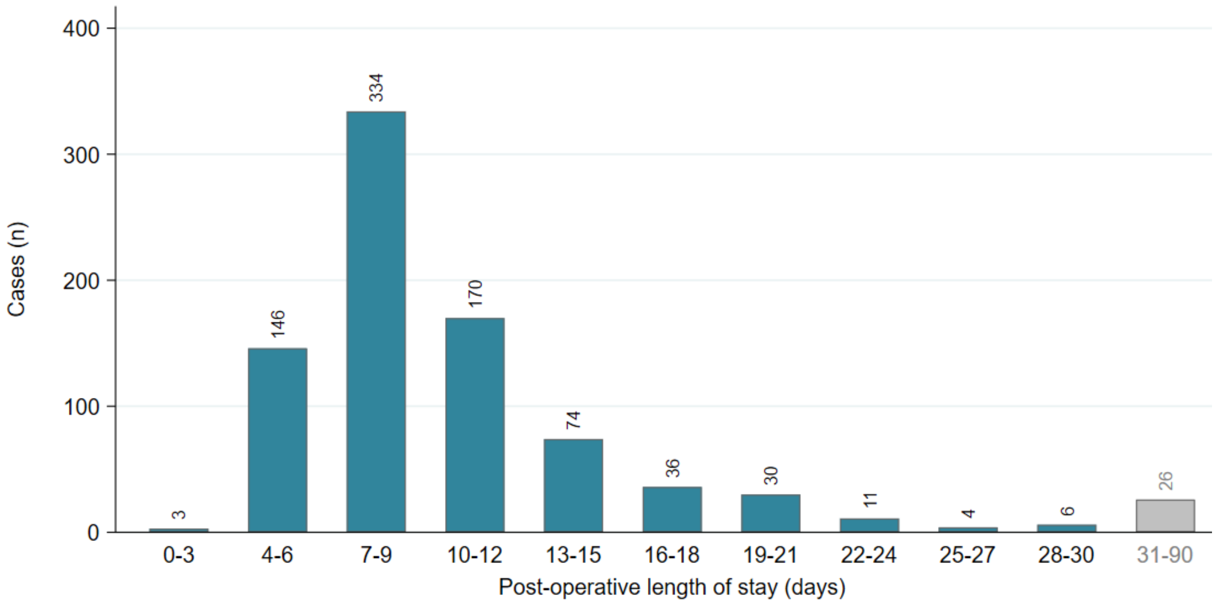


Table 48. Summary of post-operative LOS for combined AVR and CABG at public and private hospitals, 2023

	Mean (d)	Median (d)	IQR (d)
Public	10.8	9	7 - 12
Private	11.0	9	7 - 12
Total	10.9	9	7 - 12

Cases with a ventilation time of more than four weeks (672 hours) were classified as clinical outliers and excluded from the analysis.

Figure 60. Distribution of initial post-operative ventilation time for combined AVR and CABG patients, 2023

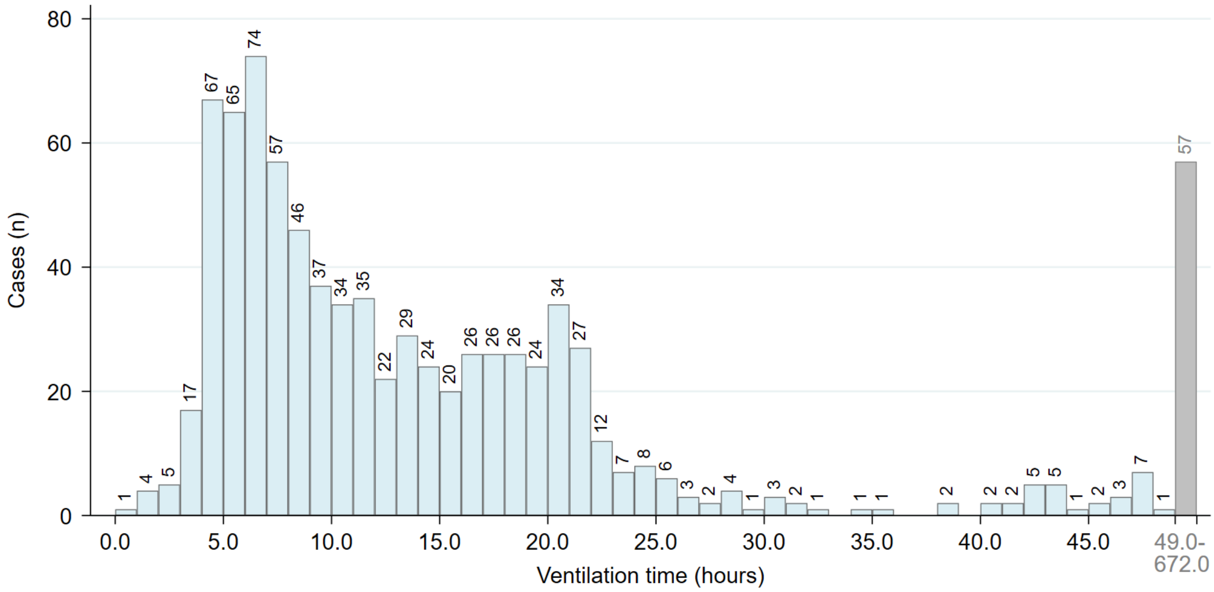


Table 49. Cumulative proportion of patients extubated over time for combined AVR and CABG surgery, 2023

	<6h	<12h	<24h	<48h	<96h	<192h	<384h	≤672h
Cumulative patients (n)	159	442	719	780	812	830	837	838
Cumulative percentage (%)	19.0	52.7	85.8	93.1	96.9	99.0	99.9	100.0

Table 50. Summary of initial post-operative ventilation time for combined AVR and CABG at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	22.3	11.5	6.8 - 20.3
Private	17.2	10.7	6.3 - 18.0
Total	20.4	11.2	6.6 - 19.6

Cases with an ICU LOS of more than six weeks (1,008 hours) were classified as clinical outliers and excluded from the analysis.

Figure 61. Distribution of ICU LOS for combined AVR and CABG patients, 2023

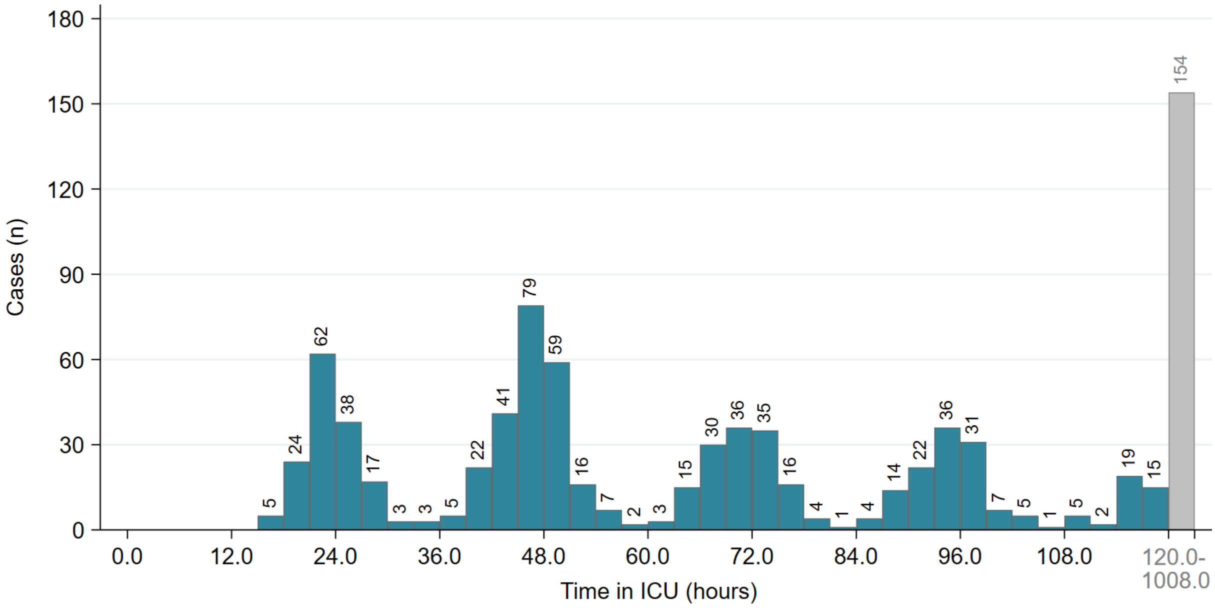


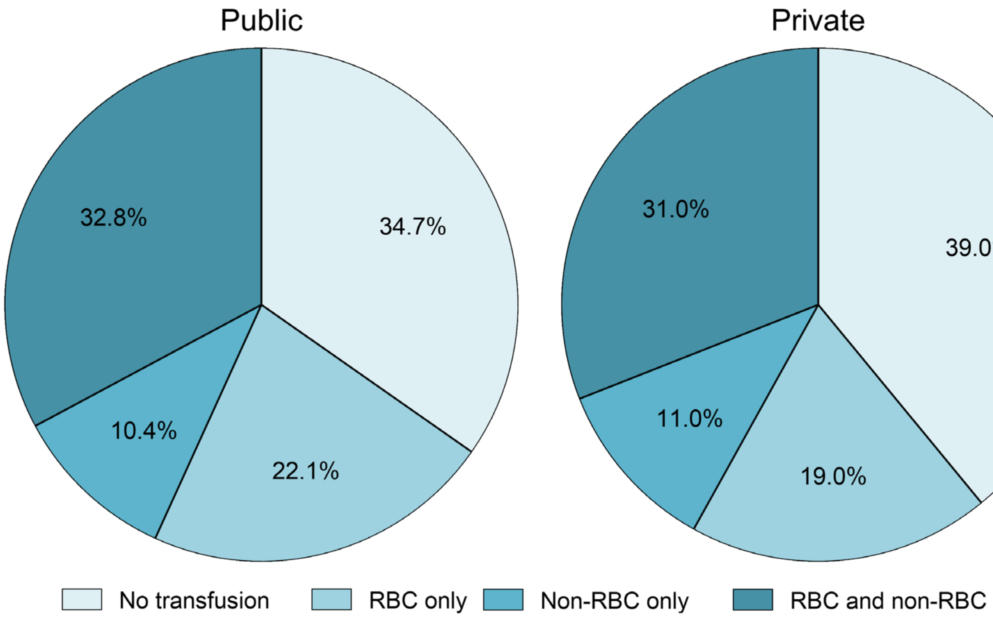
Table 51. Cumulative proportion of patients discharged from ICU over time for combined AVR and CABG surgery, 2023

	<12h	<24h	<48h	<72h	<144h	<288h	<576h	≤1008h
Cumulative patients (n)	0	91	299	467	735	815	830	838
Cumulative percentage (%)	0.0	10.9	35.7	55.7	87.7	97.3	99.0	100.0

Table 52. Summary of ICU LOS for combined AVR and CABG patients at public and private hospitals, 2023

	Mean (h)	Median (h)	IQR (h)
Public	85.0	65.9	29.1 - 98.5
Private	92.2	70.2	47.8 - 99.2
Total	87.7	68.0	44.1 - 98.7

Figure 62. Blood product usage for combined AVR and CABG patients at public and private hospitals, 2023



Note: non-RBC consists of platelets, NovoSeven, cryoprecipitate and FFP

4. Other Cardiac Surgery

The following section describes the frequency of the other types of cardiac procedures submitted to the ANZSCTS Database. Outcome data is not included due to the small sample sizes.

Table 53. Case numbers for isolated and concomitant aortic surgery, combined, 2023

Surgery type	n
Aortic replacement	1,655
Ascending only	1,177
Ascending + arch	364
Arch only	33
Descending only	20
Thoraco-abdominal only	11
Arch + descending	7
Descending + thoraco-abdominal	11
Ascending + arch + descending	20
Arch + descending + thoraco-abdominal	0
Other	11
Aortic repair	322
Endarterectomy	15
Patch repair	173
Endarterectomy + patch repair	3
Indication for aortic procedure	
Aneurysm	1,193
Dissection	428
Traumatic transection (<2 weeks)	3
Calcification	112
Other	244

Table 54. Case numbers for other isolated and concomitant uncommon cardiac surgery, combined, 2023

Surgery type	n
LV aneurysm	16
Acquired ventricular septal defect	27
Atrial septal defect	259
Other congenital	136
Cardiac trauma	9
LV outflow tract myectomy	131
LV rupture repair	10
Pericardiectomy	32
Pulmonary thrombo-endarterectomy	36
LV reconstruction	8
Pulmonary embolectomy	5
Cardiac tumour	131
Permanent LV epicardial lead	25
Left atrial appendage closure	860
Atrial arrhythmia surgery	623
Carotid endarterectomy	8
Other	405

LV indicates left ventricular

Table 55. Case numbers and OM for isolated transplant surgery, 2023

Surgery type	n	OM (%)
Cardiac transplant	109	4.6
Cardiopulmonary transplant	43	4.7

Table 56. Case numbers for other aortic valve surgery performed without and with CABG

Valve surgery		Without CABG	With CABG
Aortic root replacement with valved conduit	2023	367	64
	2019-2022	1,238	246
Pulmonary autograft aortic root replacement (Ross)	2023	49	1
	2019-2022	132	3
Aortic root reconstruction with valve sparing (David)	2023	61	9
	2019-2022	232	18
Total other valve surgery	2023	477	74
	2019-2022	1,602	267

5. Development of CUSUM Chart Reporting for AVR and combined AVR and CABG

Introduction

Isolated AVR and combined AVR and CABG account for 9% and 6% of the total cases in the Database, respectively, second only to isolated CABG surgery at 50%. Due to the large decrease in case volume between the most common procedure types, the gold-standard funnel plots used for unit benchmarking in isolated CABG surgery do not perform the same way in other cohorts. Efforts to combine procedure groups to increase statistical power were investigated but were unworkable due to the heterogeneity in outcomes and procedure mix between units. In order to reliably display and interpret outcome data for non-isolated CABG surgery, the ANZSCTS Database therefore introduced a new process to review isolated AVR and combined AVR and CABG procedures in 2024 for risk-adjusted operative mortality (RA-OM) and risk-adjusted derived new renal insufficiency (RA-dNRI) outcomes in the form of cumulative sum (CUSUM) charts.

What are CUSUM charts?

CUSUM charts are a type of statistical control chart that provide useful visual information on a unit's good (downward) or poor (upward) trends in outcomes over time. These types of charts were originally developed to monitor industrial processes but have subsequently been adapted for healthcare applications. They are ideal to use for reviewing low volume procedures and can monitor small shifts from the average after each case in chronological time-sequence order and plot the cumulative sum of these deviations.

The ANZSCTS Database also has a suite of risk-adjustment models (Appendix B, pg. 79) that are factored into the CUSUM charts to account for each patient's pre-operative risk factors. The CUSUM chart plots the difference between observed and expected outcomes on the y-axis and risk adjustment allows the expected outcome for an individual case to be determined by the estimated patient risk, rather than utilising a constant reference value as the expected outcome for all cases. This method ensures the size of the signal (good or poor) takes into account the factors outside of a surgeon or unit's control, to the extent permitted with the available data, and therefore peer review of AVR and combined AVR and CABG data is limited to the two KPIs the Database has risk-adjustment models for: RA-OM (30-day + in-hospital mortality) and RA-dNRI.

How are CUSUM charts useful?

CUSUM charts are useful for individual units to monitor performance for specific procedures over time. If a unit is performing well, the plotted points should fluctuate randomly around zero, showing that the process (surgical outcome) is "in control". However, if there is an upward or downward trend, it means the process has started to shift and units should pay special attention to correct upward deviations before they become "out of control".

CUSUM charts can include a defined threshold limit which is set for each procedure type and outcome using a combination of clinical input and statistical simulations. If the CUSUM reaches the threshold limit, an "alert" is signalled on the chart to show that the unit has met the definition of "special cause variation", which is defined as unexpected or non-random variance. This provides the unit with a prompt to review its data.

Development process

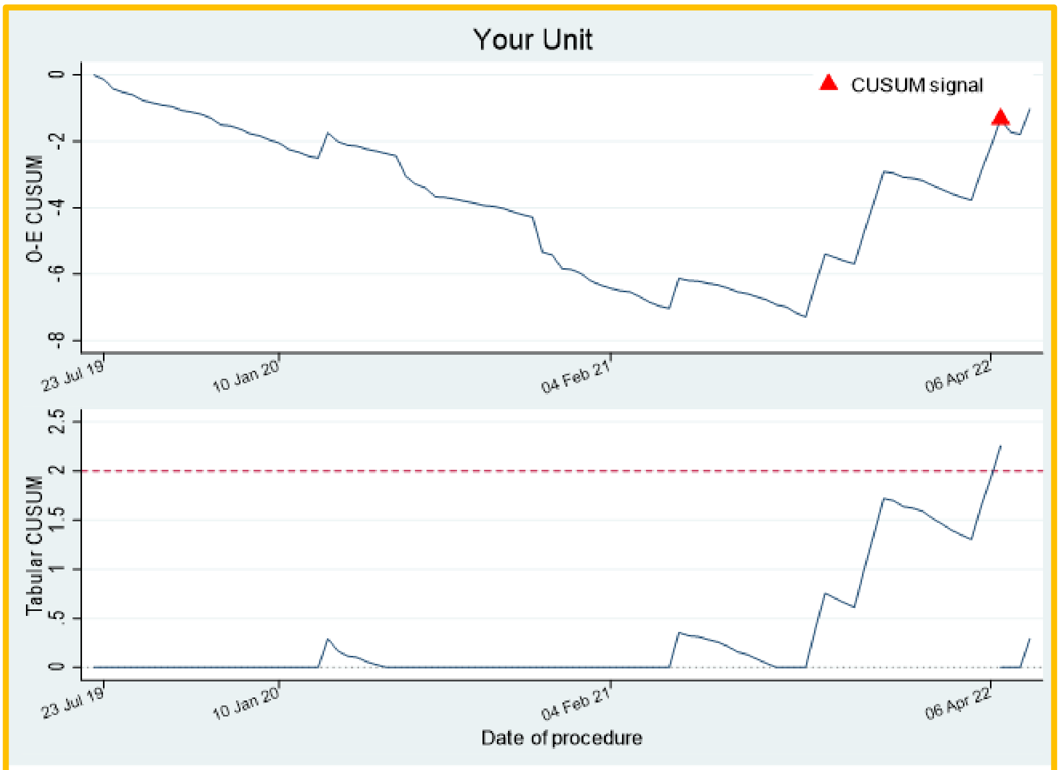
The development, testing, finalisation and implementation of CUSUM charts in the ANZSCTS Database was a process which involved contribution from various stakeholders including the Data Management and Analysis Centre (DMAC), biostatisticians, surgeons, web-system developers, and individual unit participants.

The DMAC consulted with a biostatistics professor at Monash University regarding the methodology and development of the CUSUM charts for peer review. The statistical package selected was Stata (version 17; StataCorp [5]) and the TABCUSUM (6) module was specifically chosen for its ability to plot the observed minus expected (O-E) type of CUSUM chart vertically aligned with a tabular CUSUM chart, which provide complementary information (Figure 63).

The O-E CUSUM chart displays the outcome of every case and is ideal for viewing overall performance at a unit over time. The tabular CUSUM chart is one-sided and does not cross into negative values. For this reason, a unit cannot accumulate “credit” from stretches of good performance and this chart is therefore more appropriate for identifying significant upward changes in outcomes (7). Significant changes are detected through the inclusion of a threshold.

A minimum number of 30 cases over a 36-month period was considered an appropriate volume for a unit to receive feedback via an annual Site CUSUM Chart Report.

Figure 63. Example CUSUM charts for RA-dNRI data developed using Stata



Note: these data are representative of outcomes for RA-dNRI in combined AVR and CABG cases at a single unit. The red dashed line represents the threshold limit set by clinical and statistical inputs, and the red triangle appears when the tabular CUSUM crosses the threshold, after which it resets to baseline.

Surgeon members of the ANZSCTS Database Steering Committee (SC) were consulted to assist with the generation of appropriate CUSUM chart alert thresholds for each procedure type and outcome. The surgeons were sent a survey seeking their input about the size of change in OM and dNRI (relative to the average) that would be of significance to the surgical community and should prompt an alert of a deviation. These results were collated and used in simulation studies to obtain the appropriate thresholds for the CUSUM charts.

The SC surgeons were also asked about how the CUSUM should reset following an alert. Typically, the CUSUM is either restarted at baseline or halfway between the baseline and threshold, which reduces the time to a secondary alert if the trend continues. The surgeons elected to reset the CUSUM to baseline, acknowledging that the SC would be monitoring any units with identified deviations.

Simulation studies

The simulation studies were used to determine average run lengths (ARL) to evaluate the reliability and sensitivity of the CUSUM charts and assist with determining the appropriate thresholds.

The first ARL simulation assessed the expected average number of consecutive samples required to obtain a signal when the process was still "in control" (i.e. a false alert). We aim to have a large ARL in this situation. This is denoted as ARL_0 which is equivalent to a type I error or a false positive rate.

The simulation studies were also performed to ascertain the ARL for when the process was "out of control" (i.e. when the outcome rate was substantially greater, or lesser, than the expected rate), which we would want to identify promptly and therefore aim to keep small. This is denoted as ARL_1 and is equivalent to a type II error or false negative rate.

Once the simulation studies were completed, the generated thresholds were applied to the CUSUM charts, which were combined into a Site CUSUM Chart Report.

Pilot study and finalisation

Fifteen public and private units were randomly selected and invited to participate in reviewing two draft versions of the Site CUSUM Chart Report, which contained four CUSUM charts to present data for the two procedure types and KPIs. Medical Directors (MD), Directors of Cardiothoracic Surgery (DoCS), Data Managers (DM), and other unit staff who routinely review ANZSCTS Database data at their unit were invited to participate in the review. Two rounds of questionnaires were completed which covered aspects such as comprehension, interpretation, usefulness, level of detail, frequency of dissemination, and formatting. The DMAC received 34 questionnaire responses from a variety of participants and the results were collated and reviewed (Figure 64-66). The key feedback was implemented into the final report.

Figure 64. Distribution of questionnaire responses based on hospital type

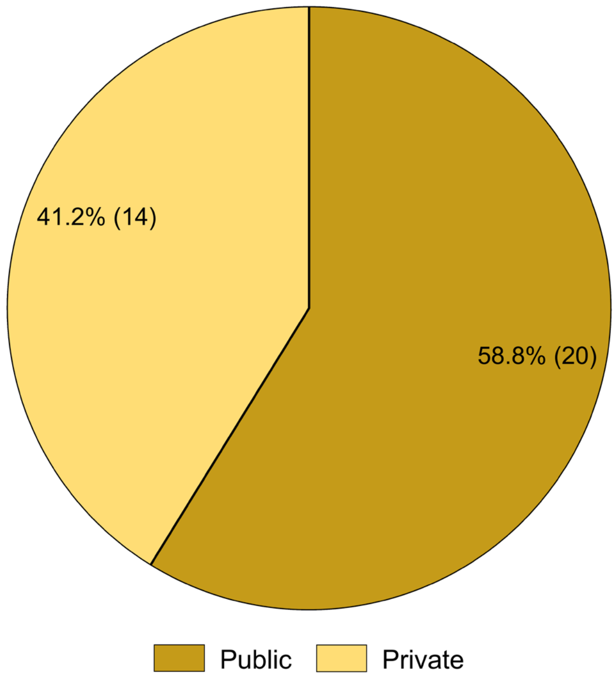


Figure 65. Distribution of questionnaire responses based on respondent's role

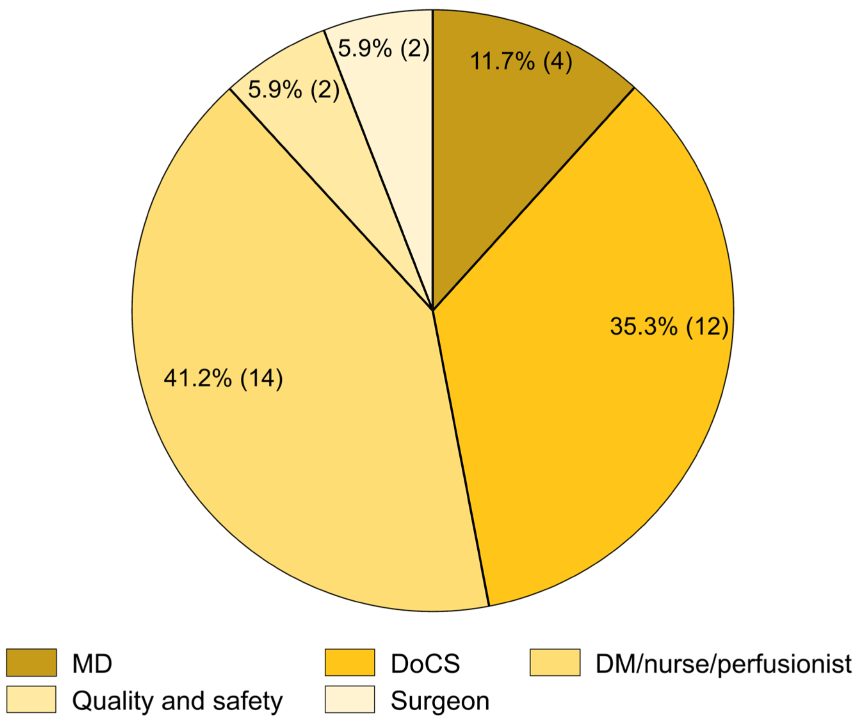
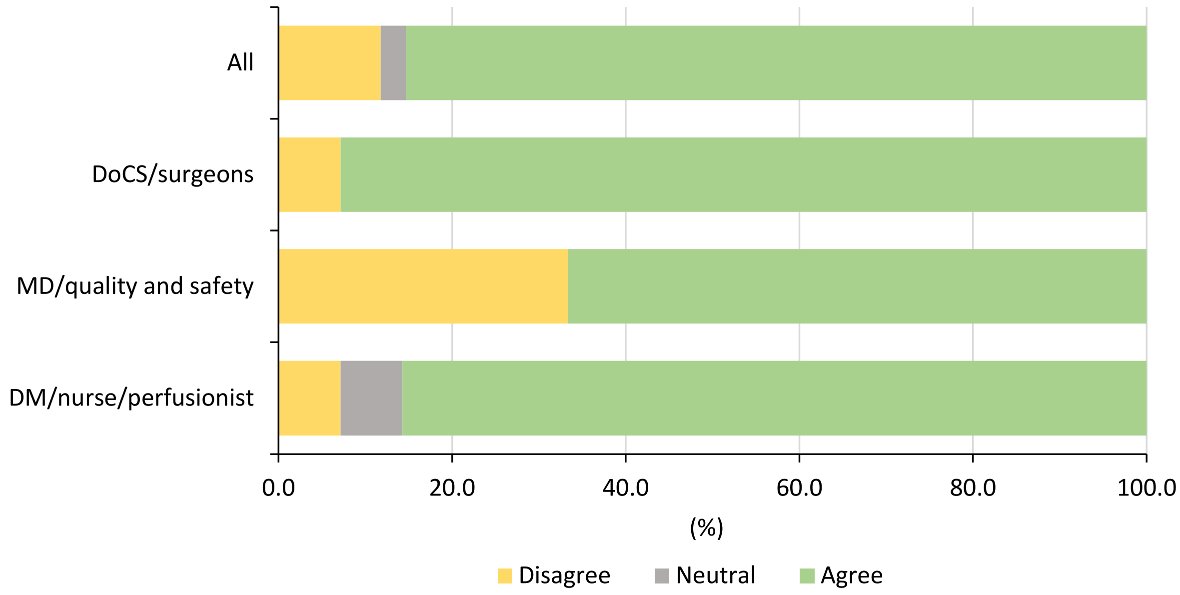
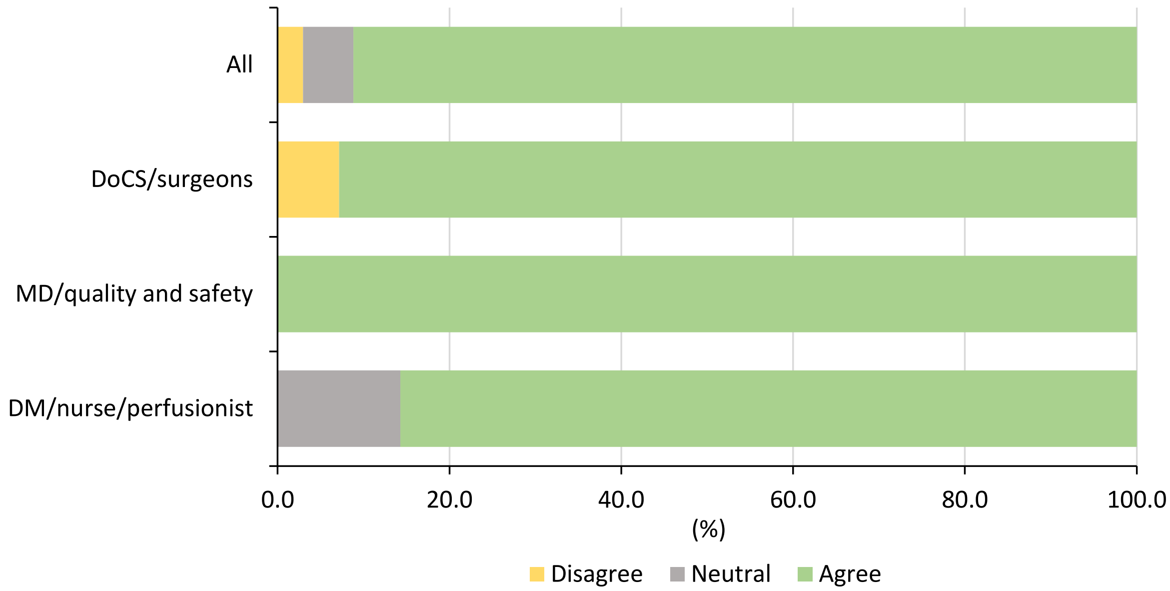


Figure 66. Results of key topics from the pilot study questionnaire

Statement: The CUSUM charts in the report are easy to understand.



Statement: Receiving feedback on the smaller procedure groups (isolated AVR and AVR and CABG) is useful for my unit.

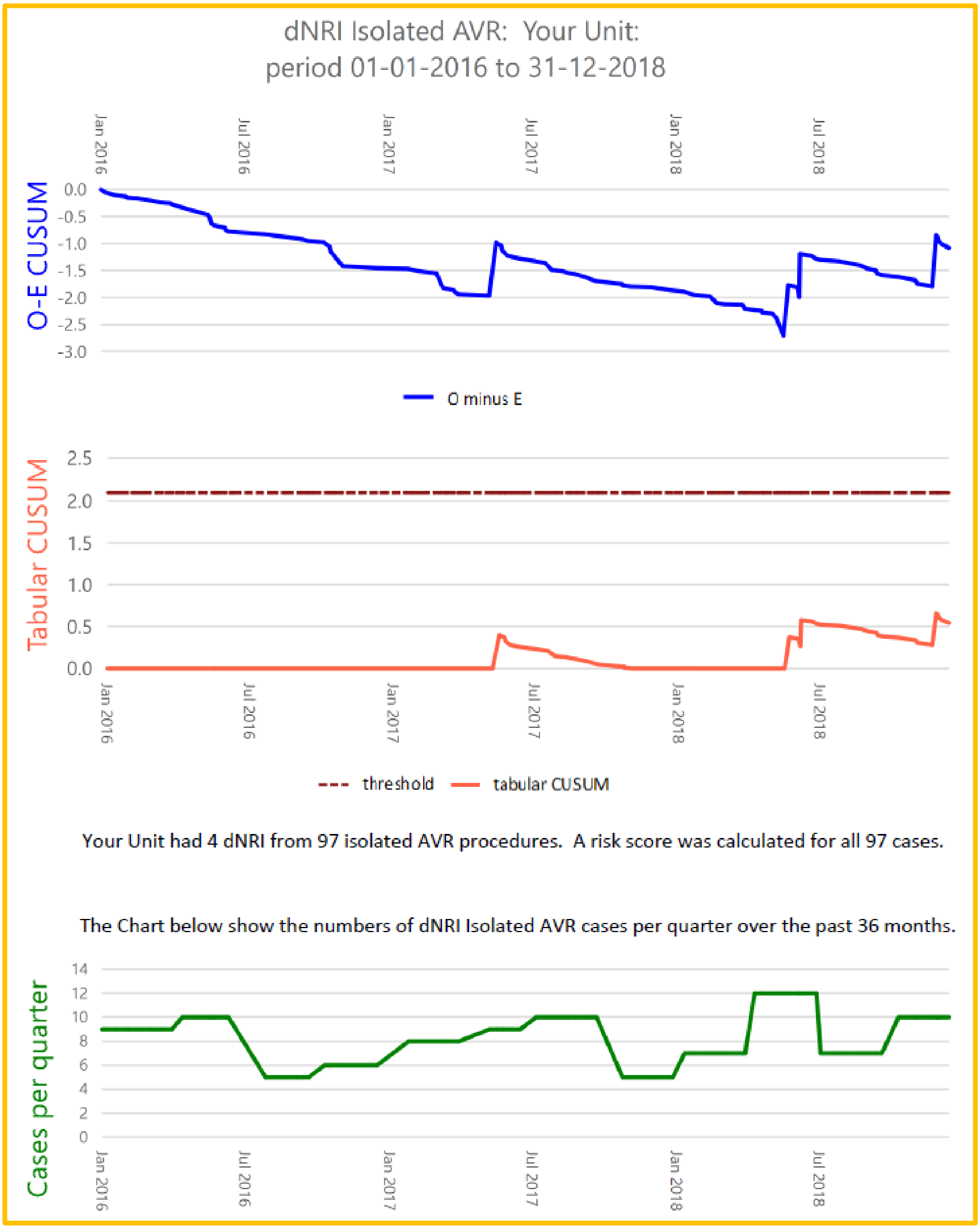


Implementation and review by the Steering Committee

Due to the number of participating sites and associated CUSUM charts, it was necessary to develop an efficient and reliable method of generating the Site CUSUM Chart Reports. The DMAC used Microsoft reporting services and the Microsoft SQL Server to automate report production.

There are no native functions to support CUSUM charts within Microsoft SQL Server, therefore custom procedures were created based on the work in Stata. The charts were modified to plot all sequential days along the x-axis, whereas the Stata function plots only the days where an operation was performed. This adjustment was made to improve the visualisation of outcomes over the time period and was further supported by the inclusion of an aligned plot showing the total cases per corresponding quarter. An example of the CUSUM charts produced in the automated reports is presented in Figure 67. The automated reports underwent multiple rounds of testing to validate the outputs against the data and charts produced in Stata.

Figure 67. Example CUSUM charts developed in an SQL server for the Site CUSUM Chart Report



The Site CUSUM Chart Reports are now generated annually for units that meet the minimum case requirement and include any periods of incomplete data submission within the 36-month period. The CUSUM charts will be routinely reviewed at the first Clinical Quality Meeting of each year; however, the SC may request to view progress for some or all units at six-month intervals.

These Site CUSUM Chart Reports are designed to complement the existing formal peer review process for isolated CABG outcomes and it must be noted that CUSUM charts and funnel plots cannot be directly compared as they are different in both their nature of development and the format of data presented. Funnel plots benchmark unit-level summary data whereas CUSUM charts monitor performance of an individual unit over time relative to defined limits. Both provide useful but distinct performance feedback information. CUSUM charts are an appropriate additional tool that can be used by the SC to continually review unit performance for these low volume procedures and can assist in the early identification of performance deviations, which require a distinct monitoring and escalation process. They are also now utilised to provide supplementary information for units showing special cause variation on funnel plots for isolated CABG surgery.

The SC reviews any AVR or combined AVR and CABG CUSUM charts with alert signals. The SC recognise that an alert does not always equate to a clinically significant result or special cause variation, and furthermore, low case numbers may be a limitation when interpreting the results. For this reason, the SC uses discretion when reviewing individual results and making recommendations for further action.

Dissemination of Site CUSUM Chart Reports and unit usability

The recipients of the Site CUSUM Chart Report are the same as those receiving the quarterly feedback for the isolated CABG reports. Recipients only receive reports for their unit and cannot compare performance with other units using the CUSUM charts at this time.

Units are able to utilise the individual report to monitor cumulative performance and identify if risk-adjusted outcomes are trending upward, which is indicative of sub-optimal outcomes. This highlights an opportunity to undertake appropriate review of the clinical data to understand potential causes for this increase. Conversely, any units that trend downwards or remain close to zero, thereby demonstrating that performance has been better than expected, may use this opportunity to reflect on whether any changes were implemented that have improved practice and whether this knowledge can be shared with other units to encourage similar outcomes. The DMAC and SC always welcome feedback on successful improvement activities for this purpose.

Acknowledgements

The DMAC would like to acknowledge and thank everyone who participated and contributed to the development and implementation of the CUSUM chart reporting in the ANZSCTS Database.

6. Concluding Remarks

At the end of 2023, the ANZSCTS Database contained data on 222,000 cardiac surgery cases from 58 public and private hospitals and this report provides insight as to the scope and value of the data held by the registry.

Since the last Annual Report, an additional two private Australian and two public New Zealand hospitals have started contributing data. The Database has always sought to capture the total cardiac surgery patient population and aims to achieve this by engaging the remaining small number of public (New Zealand) and private (Australia and New Zealand) cardiac surgery units.

The Database continues to expand its core activities to enhance the quality assurance program. As outlined in Section 5, the peer review and feedback activities were recently expanded to provide units with cumulative performance data for lower volume procedures. These CUSUM charts will soon also be available through the real-time data report module in the ANZSCTS Database web system to allow units and surgeons to self-monitor.

The review of the Data Definitions Manual was completed in 2023 and 2024 has been focused on internal and external development work to implement the changes in the web system and at hospitals with local databases. The new data definitions (version 5) will take effect for all cases with a date of procedure on or after the 1st of January 2025. The updated documents, guides and details will be circulated to all contributing hospitals towards the end of 2024.

As in previous years, the Research Program is supporting a large number of external researchers through access to the binational collated non-identifiable dataset, including linkage studies. Of note, researchers are seeking funding to operate the Australian arm of the international STICH 3 trial comparing CABG surgery and percutaneous coronary intervention through the Database, and to supplement data collection with patient reported outcomes.

The Database's Quality Assurance Program continues to successfully identify units showing special cause variation for any of the five KPIs and assist with the review of data and potential contributing factors. It is therefore not surprising that the mortality and morbidity incidences for the major procedure groups presented in this report are low and comparable to cardiac registries around the world. This suggests a high standard of care is provided to cardiac surgery patients in Australia and New Zealand.

Appendix A

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 operative mortality (OM)

- *Operative mortality*
  Includes all in-hospital mortality and any post discharge mortalities that occurred within 30 days of the procedure.
- *Risk-adjusted operative mortality (RA-OM)*
  Derived based on the ANZSCTS Database Program's risk model (Appendix B, pg. 79), and used to account for the degree of risk associated with the surgery and patient profile.

Return to Theatre (RTT) for bleeding

Did the patient return to theatre for bleeding/tamponade?

Derived new renal insufficiency (dNRI)^

- *This indicator is derived from reported renal data*
  a. Acute post-operative renal insufficiency is characterised by one of the following: 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
  b. A new post-operative requirement for dialysis/haemofiltration (when the patient did not require this pre-operatively).
- *Risk-adjusted derived new renal insufficiency (RA-dNRI)*
  The observed outcome is adjusted based on the ANZSCTS Database Program's risk model (Appendix B, pg. 79), and used to account for the degree of risk associated with the surgery and patient profile.

^Where this measure is reported patients on dialysis pre-operatively are excluded from analysis.

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

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

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 (RBC) 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 (NRBC) 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 B
ANZSCORE OM and dNRI models

Table B1. Variables that define risk in the ANZSCORE isolated CABG models

ANZSCORE (RA-OM, isolated CABG) model variables	ANZSCORE (RA-dNRI, isolated CABG) model variables
*Age^*	*Age^*
Timing of previous myocardial infarction	*Previous myocardial infarction*
Clinical status	*Clinical status*
*Estimated glomerular filtration rate^*	*Estimated glomerular filtration rate^*
NYHA class*	*NYHA* class*
Medicare	*Medicare*
Cerebrovascular disease	*Cerebrovascular disease*
Previous surgery	*Previous surgery with cardiopulmonary bypass*
Ejection fraction grade	*Ejection fraction grade*
Direct transfer from catheter lab/ICU to theatre	*Direct transfer from catheter lab/ICU to theatre*
Cardiogenic shock at the time of procedure	*Cardiogenic shock at the time of procedure*
IV nitrates at time of surgery	*IV nitrates at time of surgery*
Peripheral vascular disease	*Peripheral vascular disease*
Race	*Number of diseased vessels*
Pre-operative dialysis	*Body mass index^*
Resuscitation within one hour prior to operation	*Hypertension*
Lung disease	*Permanent pacemaker in situ*
Pre-operative arrhythmia	*History of diabetes*
Left main disease	*Congestive heart failure at the current admission*
Inotropes at time of surgery	*Sex*
	Previous catheterisation

*New York Heart Association
^data for continuous variables has an upper limit, any data that exceeds this upper limit for a case will not generate a risk score for that patient – the upper limits for age, eGFR and BMI are 130, 200mL/min/1.73m^2 and 60kg/m^2, respectively

Table B2. Variables that define risk in the ANZSCORE isolated AVR surgery models

ANZSCORE (RA-OM, isolated AVR surgery) model variables	ANZSCORE (RA-dNRI, isolated AVR surgery) model variables
*Age^*	*Sex*
*Estimated glomerular filtration rate^*	*Body mass index^*
Arrhythmia	*NYHA* class*
Ejection fraction grade	*Estimated glomerular filtration rate^*
Clinical status	*Arrhythmia*
Previous surgery	*Previous CABG*
Diabetes	*IV nitrates at time of surgery*
Respiratory disease	*Medicare*
Active endocarditis	*Infective endocarditis*
Shock	
Sex	
Anticoagulants at time of surgery	

*New York Heart Association
^data for continuous variables has an upper limit, any data that exceeds this upper limit for a case will not generate a risk score for that patient – the upper limits for age, eGFR and BMI are 130, 200mL/min/1.73m² and 60kg/m² respectively

Table B3. Variables that define risk in the ANZSCORE combined AVR and CABG models

ANZSCORE (RA-OM, combined AVR and CABG surgery) model variables	ANZSCORE (RA-dNRI, combined AVR and CABG surgery) model variables
*Age^*	*Sex*
*Estimated glomerular filtration rate^*	*Body mass index^*
Arrhythmia	*NYHA* class*
Ejection fraction grade	*Estimated glomerular filtration rate^*
Clinical status	*Arrhythmia*
Previous surgery	*Smoking*
Diabetes on med/Insulin	
Number of diseased vessels	
Active endocarditis	

*New York Heart Association
^data for continuous variables has an upper limit, any data that exceeds this upper limit for a case will not generate a risk score for that patient – the upper limits for age, eGFR and BMI are 130, 200mL/min/1.73m² and 60kg/m² respectively

Appendix C

Data preparation and key variable definitions

Data preparation and presentation

Data includes operative details and outcomes of cardiac surgery performed in 57 participating units in 2023, and from 2019-2022 (Section 1) or 2012-2023 (Sections 2 and 3) for pooled analyses.

Final data related to this report was received by the ANZSCTS Database Program Data Management and Analysis Centre in the Centre of Cardiovascular Research and Education in Therapeutics of the School of Public Health and Preventive Medicine, Monash University, on April 30th, 2024. 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 30th, 2024 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 Data Definitions Manual 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/salvage.*

- Ejection fraction (EF)

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 EF estimate.

This data is converted to a measure of left ventricular function (LVF) as follows:

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

- All-cause 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.

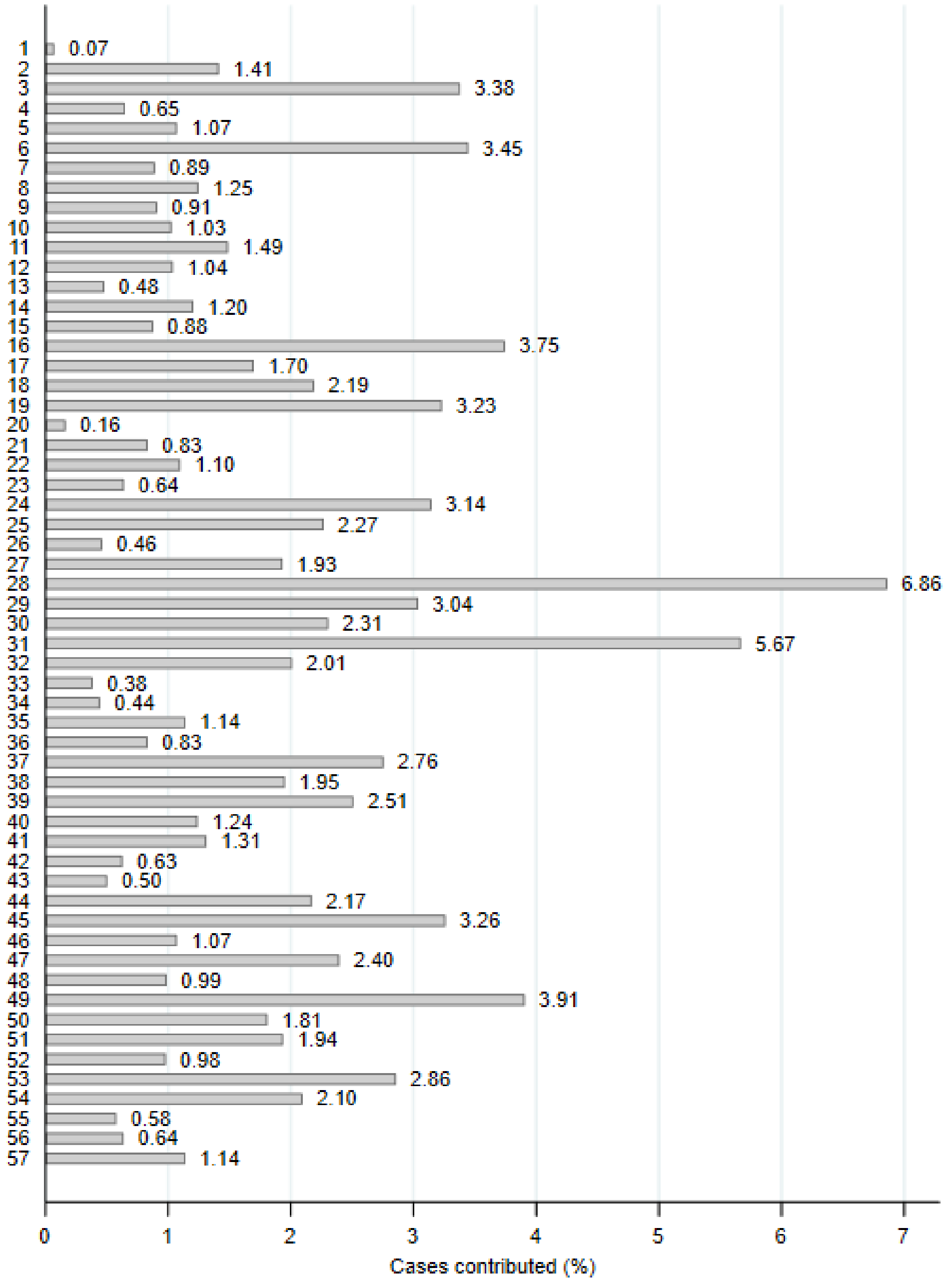
Appendix D

Units included in 2023 Annual Report

Table D. Summary of units included in the 2023 Annual Report

Contributing hospitals	Hospital type	Contributing hospitals	Hospital type
VICTORIA		**NEW SOUTH WALES**	
Alfred Hospital	Public	John Hunter Hospital	Public
Austin Hospital	Public	Lake Macquarie Private Hospital	Private
Cabrini Private Hospital	Private	Lingard Private Hospital	Private
Epworth Eastern	Private	Liverpool Hospital	Public
Epworth Richmond	Private	Newcastle Private Hospital	Private
Jessie McPherson Private Hospital	Private	North Shore Private Hospital	Private
Knox Hospital	Private	Norwest Private Hospital	Private
Melbourne Private Hospital	Private	Prince of Wales Hospital	Public
Monash Medical Centre	Public	Prince of Wales Private Hospital	Private
Mulgrave Private Hospital	Private	Royal North Shore Hospital	Public
Peninsula Private Hospital	Private	Royal Prince Alfred Hospital	Public
Royal Melbourne Hospital	Public	St George Hospital	Public
St John of God Geelong Hospital	Private	St George Private Hospital	Private
St Vincent's Hospital, Melbourne	Public	St Vincent's Hospital, Sydney	Public
St Vincent's Private Hospital, Melbourn	Private	Westmead Hospital	Public
University Hospital Geelong	Public	Westmead Private Hospital	Private
Warringal Private Hospital	Private	Wollongong Private Hopsital	Private
AUSTRALIAN CAPITAL TERRITORY		**SOUTH AUSTRALIA**	
Canberra Hospital	Public	Ashford Hospital	Private
National Capital Private Hospital	Private	Flinders Hospital	Public
QUEENSLAND		Flinders Private Hospital	Private
Gold Coast Private Hospital	Private	Royal Adelaide Hospital	Public
Gold Coast University Hospital	Public	**WESTERN AUSTRALIA**	
Greenslopes Private Hospital	Private	Fiona Stanley Hospital	Public
John Flynn Private Hospital	Private	Hollywood Private Hospital	Private
Mater Hospital	Private	Sir Charles Gairdner Hospital	Public
Prince Charles Hospital	Public	St John of God Hospital, Subiaco	Private
Princess Alexandra Hospital	Public	**TASMANIA**	
St Vincent's Private Hospital, Northside	Private	Royal Hobart Hospital	Public
Sunshine Coast University Private Hosp	Private	**NEW ZEALAND**	
The Wesley Hospital	Private	Auckland City Hospital	Public
Townsville Hospital	Public		

Figure D. Percentage of cases each hospital contributed to the 2023 Annual Report



Appendix E
Interpretation of funnel plots

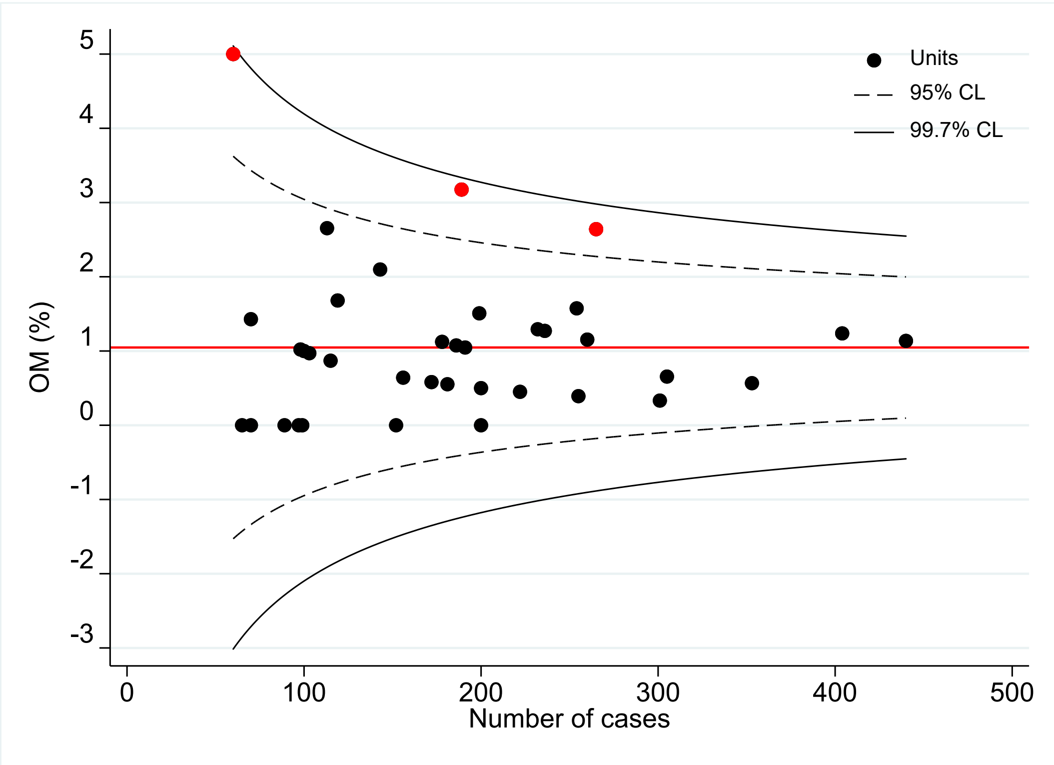
Funnel plots are an established benchmarking tool used to compare performance between healthcare providers. The plots include a single datapoint for each unit with the coordinates based on unit case number (x-axis) and aggregate outcome data (y-axis) for the specified time period.

The mean and standard deviation for all units, combined, are used to plot two sets of control limits (the ‘funnels’) which correspond to 95% (approximately two standard deviations) and 99.7% (approximately three standard deviations) from the mean. These cut-offs equate to the probability with which a unit performing at the expected level would be expected to fall within the control limits. Statistically, the selected limits impose a probability of false positive identification of an outlier of five or 0.3% for units outside the 95 or 99.7% control limits, respectively.

An advantage of funnel plots is that case number is factored into the control limits due to the reduced standard deviation for units with higher case volumes. This ensures that smaller volume units that are more susceptible to higher variation in outcomes are not evaluated using the lower thresholds associated with the larger volume units.

Figure E below illustrates operative mortality (OM) after isolated CABG in Australia in 2018. The solid red line represents the OM for all units, the two-dashed lines are the 95% control limits and the solid black lines are the 99.7% control limits. The funnel plot demonstrates how the control limits narrow as the number of cases increases. This representation illustrates 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 E. OM following isolated CABG by unit



Appendix F

Supplementary data - outcomes by unit

Table F1. Outcomes for isolated CABG surgery by unit, 2023

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	31	0.0	0.0	3.2	2.7	0.0	0.0	6.5
Unit 2	91	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 3	301	2.0	1.7	3.1	2.8	0.7	3.7^	3.3
Unit 4	181	0.0	0.0	3.4	3.5	0.6	0.0	2.2
Unit 5	130	1.5	1.0	4.7	3.1	0.0	3.1	2.3
Unit 6	314	0.3	0.3	1.3	1.0	0.6	0.6	2.9
Unit 7	220	0.9	0.8	2.8	2.2	0.5	0.0	1.4
Unit 8	47	0.0	0.0	4.3	4.2	2.1	0.0	0.0
Unit 9	71	0.0	0.0	1.4	1.8	0.0	0.0	1.4
Unit 10	59	1.7	3.1	5.1	6.5	0.0	1.7	1.7
Unit 11	125	0.0	0.0	2.4	2.7	0.8	0.8	2.4
Unit 12	130	0.8	1.1	2.3	2.2	1.5	0.0	3.1
Unit 13	66	0.0	0.0	1.5	1.6	0.0	0.0	1.5
Unit 14	74	1.4	2.4	0.0	0.0	0.0	0.0	4.1
Unit 15	48	2.1	1.8	2.1	2.0	0.0	0.0	6.3
Unit 16	266	0.4	0.4	0.8	0.7	0.8	0.8	1.9
Unit 17	152	0.0	0.0	0.7	0.6	0.7	0.0	2.0
Unit 18	208	1.9	1.1	2.0	1.6	0.5	1.0	1.9
Unit 19	331	0.9	0.5	0.9	0.7	2.4	1.5	3.0
Unit 20	42	0.0	0.0	0.0	0.0	2.4	0.0	2.4
Unit 21	125	0.0	0.0	3.7	3.9	0.9	0.0	2.6
Unit 22	92	1.1	1.5	8.7^	11.9^	0.0	1.1	2.2
Unit 23	177	1.7	2.6	1.1	1.3	0.6	1.1	0.6
Unit 24	274	1.1	0.6	3.1	1.8	1.1	1.8	2.6
Unit 25	266	2.3	1.8	4.9	4.3	0.0	0.4	1.1
Unit 26	85	1.2	1.5	1.2	1.4	2.4	0.0	2.4
Unit 27	145	0.0	0.0	0.7	1.1	0.7	0.0	0.0
Unit 28	407	1.5	1.0	1.3	1.1	0.2	0.5	1.7
Unit 29	203	0.5	0.8	4.0	5.7^	1.0	0.5	1.0
Unit 30	155	1.9	1.3	2.0	1.7	0.0	0.0	1.9
Unit 31	456	1.3	1.4	1.6	1.4	0.4	1.5	4.6
Unit 32	161	1.9	1.6	3.2	3.2	1.2	1.2	3.7
Unit 33	51	0.0	0.0	9.8	7.8	0.0	2.0	0.0
Unit 34	42	2.4	2.6	0.0	0.0	2.4	0.0	2.4
Unit 35	82	1.2	1.3	0.0	0.0	0.0	1.2	1.2
Unit 36	97	2.1	2.2	1.0	1.0	3.1	0.0	1.0
Unit 37	142	0.7	0.6	1.4	1.1	1.4	0.0	4.9
Unit 38	110	0.9	0.9	0.9	0.8	0.9	1.8	0.0
Unit 39	306	2.6	2.4	3.0	2.3	3.0^	2.6	0.3
Unit 40	82	0.0	0.0	1.2	1.3	0.0	0.0	2.4
Unit 41	125	0.0	0.0	2.4	3.2	0.0	0.0	0.8
Unit 42	66	1.5	1.4	0.0	0.0	0.0	0.0	3.0
Unit 43	81	0.0	0.0	1.3	1.4	0.0	0.0	1.2
Unit 44	193	0.5	0.3	0.5	0.4	0.0	0.5	2.6
Unit 45	372	1.1	0.8	0.6	0.5	0.3	0.8	2.2
Unit 46	61	1.6	1.6	5.0	4.4	0.0	1.6	1.6
Unit 47	255	1.6	1.3	4.4	3.4	3.5^	0.8	2.0
Unit 48	119	0.8	1.2	2.5	3.1	0.8	0.0	0.8
Unit 49	326	1.8	1.6	5.0	4.1	1.2	0.9	3.4
Unit 50	108	1.0	0.9	0.0	0.0	0.9	1.9	7.4
Unit 51	191	1.6	1.8	4.8	4.1	0.0	2.1	6.8^
Unit 52	111	0.9	0.7	2.8	2.4	0.9	2.7	2.7
Unit 53	239	1.7	1.3	4.3	3.4	1.3	0.4	2.1
Unit 54	198	1.0	1.0	4.7	4.5	1.0	1.5	2.0
Unit 55	76	0.0	0.0	1.3	1.7	1.3	0.0	1.3
Unit 56	103	0.0	0.0	0.0	0.0	0.0	0.0	2.9
Unit 57	95	0.0	0.0	1.1	1.0	0.0	0.0	2.1

^ unit is above the upper 99.7% control limit on the corresponding funnel plot

v unit is below the lower 99.7% control limit on the corresponding funnel plot

Table F2. Outcomes for isolated CABG surgery by unit, 2019-2022

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 2	478	0.2	0.3	1.3	1.2	0.6	0.7	3.0
Unit 3	1193	2.0	1.7	3.6	3.4^	0.9	1.9	2.6
Unit 4	71	0.0	0.0	1.4	1.5	0.0	0.0	1.4
Unit 5	326	2.1	1.2	2.8	1.8	0.9	1.2	2.2
Unit 6	1320	1.1	1.0	1.9	1.5	1.0	1.4	2.7
Unit 7	292	0.0	0.0	1.0	1.0	0.0	1.0	3.1
Unit 8	392	0.8	0.9	1.8	1.9	0.5	0.8	2.3
Unit 9	226	0.4	0.6	1.8	2.5	0.4	0.9	0.9
Unit 10	380	1.3	2.0	0.3ᐯ	0.3	1.3	2.1	1.8
Unit 11	487	0.6	0.7	1.0	1.1	0.4	2.7^	0.8
Unit 12	256	1.2	1.2	4.0	4.0	0.8	0.8	3.9
Unit 13	164	0.0	0.0	1.2	1.6	0.6	0.6	1.2
Unit 14	447	0.5	0.6	0.7	0.7	0.2	0.4	5.1^
Unit 15	239	0.8	1.0	1.7	1.9	0.4	2.5	4.2
Unit 16	903	0.3	0.3	0.3ᐯ	0.3ᐯ	0.3	0.8	1.8
Unit 17	566	0.4	0.4	1.7	1.6	1.2	1.1	1.8
Unit 18	901	1.8	1.0	3.9	2.7	0.8	2.2^	2.9
Unit 19	1093	1.0	0.8	2.2	1.9	1.5	0.7	2.5
Unit 21	202	0.0	0.0	2.2	2.6	0.0	0.0	0.5
Unit 22	314	0.0	0.0	3.2	4.6	1.6	0.3	3.2
Unit 23	171	0.0	0.0	0.6	0.8	1.2	0.0	2.9
Unit 24	1193	1.9	1.2	3.9	2.8	1.4	1.4	3.8^
Unit 25	790	0.9	0.6	3.3	2.9	1.9	0.4	1.0
Unit 26	91	2.2	3.0	4.5	5.4	0.0	1.1	0.0
Unit 27	607	0.5	0.8	2.2	3.0	1.2	0.7	2.1
Unit 28	1918	0.6	0.4	2.2	1.8	0.6	1.0	2.5
Unit 29	783	0.5	0.7	3.1	3.9^	0.5	0.4	1.9
Unit 30	762	2.0	1.3	2.0	1.9	1.1	0.4	2.8
Unit 31	1807	2.5^	2.2^	2.3	1.8	1.2	1.2	3.0
Unit 32	683	1.0	0.9	2.1	1.9	1.8	1.3	2.0
Unit 33	163	1.9	1.6	3.7	3.4	1.2	0.6	0.6
Unit 34	162	1.2	1.1	1.2	0.9	0.0	1.9	4.9
Unit 35	505	1.2	0.9	3.0	2.4	1.2	1.6	0.8
Unit 36	301	1.7	1.2	2.3	1.9	0.0	0.7	1.7
Unit 37	646	0.8	0.7	2.4	1.9	1.2	0.2	3.3
Unit 38	605	0.7	0.7	3.2	2.8	2.0	0.5	2.8
Unit 39	982	1.8	1.6	2.8	2.6	1.5	0.5	1.2
Unit 40	315	0.0	0.0	2.6	3.1	0.0	0.6	1.3
Unit 41	397	0.3	0.3	3.6	4.2	0.8	0.0	1.5
Unit 42	172	0.6	0.4	4.8	4.4	1.2	1.2	2.9
Unit 43	147	0.7	0.6	0.0	0.0	0.7	0.0	0.0
Unit 44	803	1.7	1.4	1.5	1.3	0.6	1.9	2.4
Unit 45	1200	1.3	0.8	2.2	1.6	1.8	1.4	2.1
Unit 46	371	0.8	0.6	3.0	2.5	0.0	1.1	1.6
Unit 47	1024	0.6	0.5	2.0	1.6	1.2	0.7	1.9
Unit 48	349	0.6	0.7	2.3	2.7	0.3	0.9	0.0ᐯ
Unit 49	1293	0.9	0.7	3.8	3.0	1.1	1.0	1.5
Unit 50	721	0.6	0.5	1.8	1.3	0.1	0.8	3.1
Unit 51	643	1.2	1.1	4.3	3.7	1.6	1.1	3.0
Unit 52	330	1.6	1.5	1.9	1.8	2.1	1.2	1.2
Unit 53	891	1.0	0.7	3.1	2.6	1.1	0.2	2.0
Unit 54	736	1.3	1.2	4.7^	5.0^	0.8	0.8	2.3
Unit 55	192	0.5	0.8	1.6	2.0	0.0	0.5	1.0
Unit 56	89	0.0	0.0	0.0	0.0	1.1	0.0	2.2
Unit 57	381	0.3	0.3	0.5	0.5	0.5	1.1	2.6

^ unit is above the upper 99.7% control limit on the corresponding funnel plot

ᐯ unit is below the lower 99.7% control limit on the corresponding funnel plot

Table F3. Outcomes for isolated AVR surgery by unit, 2019-2023

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	8	0.0	-	0.0	-	0.0	0.0	0.0
Unit 2	90	0.0	0.0	1.1	1.0	1.1	1.1	0.0
Unit 3	216	2.8	1.7	5.7	3.1	1.9	0.5	4.6
Unit 4	2	0.0	-	0.0	-	0.0	0.0	0.0
Unit 5	89	4.5	2.6	6.9	2.7	2.2	0.0	2.2
Unit 6	254	1.6	1.0	3.2	1.7	0.4	2.4^	6.7
Unit 7	45	0.0	0.0	0.0	0.0	0.0	0.0	2.2
Unit 8	104	1.0	0.7	0.0	0.0	1.0	0.0	5.8
Unit 9	69	1.4	0.6	1.5	1.2	1.4	1.4	5.8
Unit 10	90	1.1	1.1	2.2	1.9	0.0	0.0	1.1
Unit 11	176	0.0	0.0	2.3	1.9	0.0	1.1	2.8
Unit 12	99	2.0	1.6	3.0	2.3	1.0	1.0	1.0
Unit 13	29	0.0	0.0	3.7	2.8	0.0	0.0	0.0
Unit 14	152	0.7	0.4	0.7	0.8	0.0	0.0	5.3
Unit 15	77	1.3	0.8	5.3	5.0	1.3	0.0	6.5
Unit 16	265	1.1	1.1	1.1	1.0	0.4	0.8	1.1
Unit 17	138	0.7	0.4	3.9	2.4	0.0	0.0	4.3
Unit 18	150	0.7	0.5	4.1	2.7	1.3	0.7	4.0
Unit 19	229	0.0	0.0	4.4	2.3	0.0	1.3	6.1
Unit 20	18	0.0	0.0	0.0	0.0	0.0	0.0	5.6
Unit 21	41	0.0	0.0	0.0	0.0	0.0	0.0	2.4
Unit 22	67	0.0	0.0	6.0	4.7	1.5	0.0	6.0
Unit 23	41	0.0	0.0	2.5	1.7	2.4	5.0	4.9
Unit 24	204	1.5	0.9	4.5	2.4	2.5	0.0	5.4
Unit 25	121	1.7	0.9	5.1	2.3	2.5	0.0	2.5
Unit 26	54	0.0	0.0	1.9	1.8	1.9	0.0	0.0
Unit 27	126	2.4	1.8	4.8	3.7	2.4	0.0	2.4
Unit 28	525	0.6	0.4	2.5	1.5	0.2	0.8	4.0
Unit 29	168	0.6	0.6	3.0	2.8	0.6	0.0	3.0
Unit 30	225	0.0	0.0	1.8	1.2	1.3	0.4	4.9
Unit 31	425	1.6	1.1	3.1	1.7	2.4	0.5	4.0
Unit 32	152	1.3	0.7	2.7	1.6	0.7	0.0	5.9
Unit 33	13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 34	56	3.6	1.9	3.6	2.4	0.0	0.0	7.1
Unit 35	88	2.3	1.5	0.0	0.0	1.1	0.0	4.5
Unit 36	47	4.3	3.5	4.3	3.8	0.0	0.0	2.1
Unit 37	108	0.0	0.0	1.9	1.3	0.9	0.9	0.9
Unit 38	140	2.1	2.0	5.1	3.4	0.0	0.7	5.0
Unit 39	125	0.0	0.0	2.4	1.3	0.8	0.0	3.2
Unit 40	77	1.3	1.3	1.3	1.2	0.0	0.0	5.2
Unit 41	62	1.6	1.6	1.6	1.4	1.6	0.0	1.6
Unit 42	48	2.1	2.2	2.1	1.6	0.0	2.1	2.1
Unit 43	62	0.0	0.0	0.0	0.0	0.0	0.0	3.2
Unit 44	234	1.3	1.0	0.9	0.5	1.3	0.4	1.7
Unit 45	181	3.9	1.6	2.3	1.3	3.3	1.1	6.1
Unit 46	71	2.8	1.5	0.0	0.0	0.0	0.0	2.8
Unit 47	143	3.5	1.8	5.6	3.4	2.1	0.0	2.1
Unit 48	57	1.8	1.3	0.0	0.0	0.0	0.0	1.8
Unit 49	182	2.2	1.8	5.5	3.2	2.7	0.0	6.0
Unit 50	172	1.2	0.7	0.0	0.0	0.6	0.0	4.1
Unit 51	133	3.8	2.2	6.2	3.4	3.8	0.8	6.1
Unit 52	155	0.7	0.5	0.6	0.4	0.6	0.0	1.9
Unit 53	138	0.0	0.0	4.5	2.7	2.2	0.0	1.4
Unit 54	207	0.5	0.5	3.5	2.0	1.9	1.4	4.3
Unit 55	67	1.5	1.5	1.5	1.6	1.5	0.0	4.5
Unit 56	32	0.0	0.0	0.0	0.0	0.0	0.0	9.4
Unit 57	133	1.6	1.2	0.0	0.0	2.3	0.0	6.1

^ unit is above the upper 99.7% control limit on the corresponding funnel plot

v unit is below the lower 99.7% control limit on the corresponding funnel plot

Table F4. Outcomes for combined AVR and CABG surgery by unit, 2019-2023

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	3	0.0	-	33.3	-	0.0	0.0	0.0
Unit 2	48	0.0	0.0	2.1	0.8	4.2	2.2	4.2
Unit 3	138	3.6	2.6	3.7	1.7	1.4	0.0	5.1
Unit 4	3	0.0	-	0.0	-	0.0	0.0	0.0
Unit 5	69	7.2	4.7	5.9	2.3	4.3	0.0	2.9
Unit 6	130	2.3	1.9	10.2	3.5	1.5	3.1	7.7
Unit 7	27	0.0	0.0	3.7	1.6	0.0	0.0	3.7
Unit 8	62	0.0	0.0	3.3	1.4	0.0	0.0	4.8
Unit 9	41	2.4	3.0	0.0	0.0	0.0	0.0	2.4
Unit 10	61	1.6	2.0	3.3	0.9	1.6	0.0	0.0
Unit 11	106	0.9	1.0	1.0	0.5	0.9	0.0	2.8
Unit 12	65	0.0	0.0	3.1	0.8	1.5	3.1	4.6
Unit 13	21	4.8	6.5	0.0	0.0	0.0	0.0	14.3
Unit 14	76	4.2	5.7	2.7	1.6	0.0	0.0	7.9
Unit 15	36	0.0	0.0	2.8	1.6	2.8	0.0	0.0
Unit 16	175	1.7	1.4	1.2	0.5	0.6	0.0	1.7
Unit 17	88	0.0	0.0	4.8	1.7	1.1	0.0	3.4
Unit 18	123	0.8	0.8	4.9	2.3	1.6	2.4	2.4
Unit 19	115	5.3	3.6	8.2	3.7	2.6	3.5	10.4
Unit 20	8	0.0	-	0.0	-	12.5	0.0	12.5
Unit 21	27	0.0	0.0	11.1	6.2	0.0	3.7	0.0
Unit 22	31	0.0	0.0	12.9	5.0	0.0	0.0	0.0
Unit 23	26	0.0	0.0	3.8	1.7	0.0	0.0	0.0
Unit 24	151	4.7	2.5	8.2	3.4	2.7	0.7	6.7
Unit 25	69	5.8	3.6	11.8	5.1	0.0	1.4	0.0
Unit 26	26	3.8	3.4	3.8	1.5	0.0	0.0	0.0
Unit 27	91	2.2	2.5	4.4	2.0	1.1	1.1	4.4
Unit 28	257	2.7	2.2	4.7	2.1	0.8	1.9	4.7
Unit 29	111	0.9	1.1	0.9	0.5	0.0	0.9	1.8
Unit 30	90	3.4	3.0	5.6	2.5	2.2	1.1	6.7
Unit 31	263	4.2	3.5	4.3	2.2	2.7	1.9	7.3
Unit 32	79	0.0	0.0	2.6	1.2	0.0	0.0	8.9
Unit 33	18	0.0	0.0	5.6	2.6	5.6	0.0	0.0
Unit 34	25	8.0	6.8	4.3	1.7	0.0	0.0	12.5
Unit 35	35	5.7	4.9	2.9	1.5	0.0	0.0	2.9
Unit 36	44	2.3	1.3	7.0	2.7	4.5	0.0	2.3
Unit 37	82	3.7	2.5	3.7	1.8	2.4	1.2	6.1
Unit 38	59	0.0	0.0	5.5	2.3	0.0	1.7	10.2
Unit 39	80	5.1	4.6	10.1	4.6	2.5	0.0	2.5
Unit 40	29	0.0	0.0	0.0	0.0	3.4	0.0	3.4
Unit 41	66	1.5	1.2	1.5	0.8	1.5	0.0	3.0
Unit 42	23	0.0	0.0	13.0	5.7	13.0^	0.0	8.7
Unit 43	30	3.8	3.5	0.0	0.0	3.3	0.0	10.0
Unit 44	107	0.0	0.0	0.9	0.4	0.9	1.9	5.6
Unit 45	114	3.5	2.3	3.6	1.5	3.5	0.0	7.9
Unit 46	41	0.0	0.0	0.0	0.0	0.0	0.0	2.4
Unit 47	70	7.1	4.1	13.6	6.0	4.3	0.0	8.6
Unit 48	50	0.0	0.0	4.0	2.5	0.0	2.0	4.0
Unit 49	167	3.0	2.4	10.2	4.3	3.0	1.8	2.4
Unit 50	93	3.2	3.1	4.3	1.9	1.1	0.0	4.3
Unit 51	101	2.0	1.7	7.0	2.8	1.0	1.0	5.0
Unit 52	63	3.2	2.6	3.2	1.2	1.6	3.2	1.6
Unit 53	122	5.7	4.9	5.8	2.5	3.3	0.8	3.3
Unit 54	94	1.1	1.2	8.7	3.4	2.1	0.0	7.4
Unit 55	26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 56	21	0.0	0.0	0.0	0.0	0.0	4.8	23.8^
Unit 57	65	0.0	0.0	3.1	1.3	0.0	0.0	6.2

^ unit is above the upper 99.7% control limit on the corresponding funnel plot

v unit is below the lower 99.7% control limit on the corresponding funnel plot

References

1. Kim KM, Arghami A, Habib R, Daneshmand MA, Parsons N, Elhalabi Z, et al. The Society of Thoracic Surgeons Adult Cardiac Surgery Database: 2022 Update on Outcomes and Research. Ann Thorac Surg. 2023;115(3):566-74.
2. SWEDEHEART Annual Report 2023. 2024.
3. Beckmann A, Meyer R, Eberhardt J, Gummert J, Falk V. German Heart Surgery Report 2023: The Annual Updated Registry of the German Society for Thoracic and Cardiovascular Surgery. The Thoracic and Cardiovascular Surgeon. 2024;72(05):329-45.
4. Programme NCA. National Adult Cardiac Surgery Audit (NACSA) 2024 Summary Report (2020/21 - 2022/23 data). 2024.
5. StataCorp. 2021. *Stata: Release 17*. Statistical Software. College Station, TX: StataCorp LLC.
6. McSharry B. TABCUSUM: Stata module to graph observed minus expected CUSUM vertically aligned with tabular CUSUM. 2018.
7. Siregar S, Roes KCB, van Straten AHM, Bots ML, van der Graaf Y, van Herwerden LA, et al. Statistical Methods to Monitor Risk Factors in a Clinical Database. Circulation: Cardiovascular Quality and Outcomes. 2013;6(1):110-8.

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