ANZSCTS Cardiac Surgery Database Program

Annual Report

2022

Second Edition

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Acronyms

ANZSCTS	Australian and New Zealand Society for Cardiac and Thoracic Surgeons
AusSCORE	Australian System for Cardiac Operative Risk Evaluation
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
CQR	Clinical quality registry
CUSUM	Cumulated sum
CVD	Cardiovascular disease
dNRI	Derived new renal insufficiency
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
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
SCV	Special cause variation
SVG	Saphenous vein graft
TAR	Total arterial revascularisation

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 Ashley Fletcher 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, and particularly for the consistent submission of data for all cases throughout the pandemic.

Photograph by Mark Lucas 2018 ©

Foreword

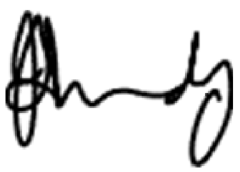
This is the 16th Annual Report of the ANZSCTS Cardiac Surgery Database Program. There are currently 61 units both public and private across Australia and New Zealand submitting data to the registry. This report includes data from 56 units including 31 private units and 16,692 cases from 2022 and again underpins the importance of data in ensuring quality outcomes in cardiac surgery.

Data presented in this report provide unit comparisons for surgery performed in the 2022 calendar year. Thirty-day follow-up dictates that surgical outcomes are collected to the end of January 2023. Information is also presented as pooled (four or five year) and annual (five years) data.

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

The Program has an important quality assurance function. Therefore, unit outcomes are compared against a set of performance indicators. The Steering Committee has a quarterly clinical quality meeting in which statistical analysis of outcomes is presented to identify variance 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 of outlying status in accordance with the ANZSCTS Database's *Special Cause Variation Management Policy*. The quality assurance process has been highlighted in detail in this year's theme (Section 6; pg. 69).

Overall, in the five-year period, although there is variation in practice, most participating cardiac surgical units had satisfactory outcomes for key performance indicators (mortality and complications). The Society's purpose is to ensure that high standards are maintained in all units performing cardiac surgery in Australia and New Zealand and where necessary, assist units to achieve that standard.



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 2022 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 highlighting the quality assurance program. The report is presented as follows:

- Section 1: Brief Overview of COVID-19 Pandemic Activity
- Section 2: Isolated Coronary Artery Bypass Graft (CABG) Surgery
- Section 3: Isolated Valve Surgery
- Section 4: Combined Valve and CABG Surgery
- Section 5: Other Cardiac Surgery
- Section 6: Quality Assurance in Cardiac Surgery
- Section 7: Concluding Remarks

Key performance indicators

The Database collects and analyses data for a range of clinically relevant surgical outcomes for the purpose of monitoring the performance of the following KPIs across cardiac surgical units:

- 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. 80). Information about the ANZSCORE risk-adjustment models can be found in Appendix B (pg. 82). 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

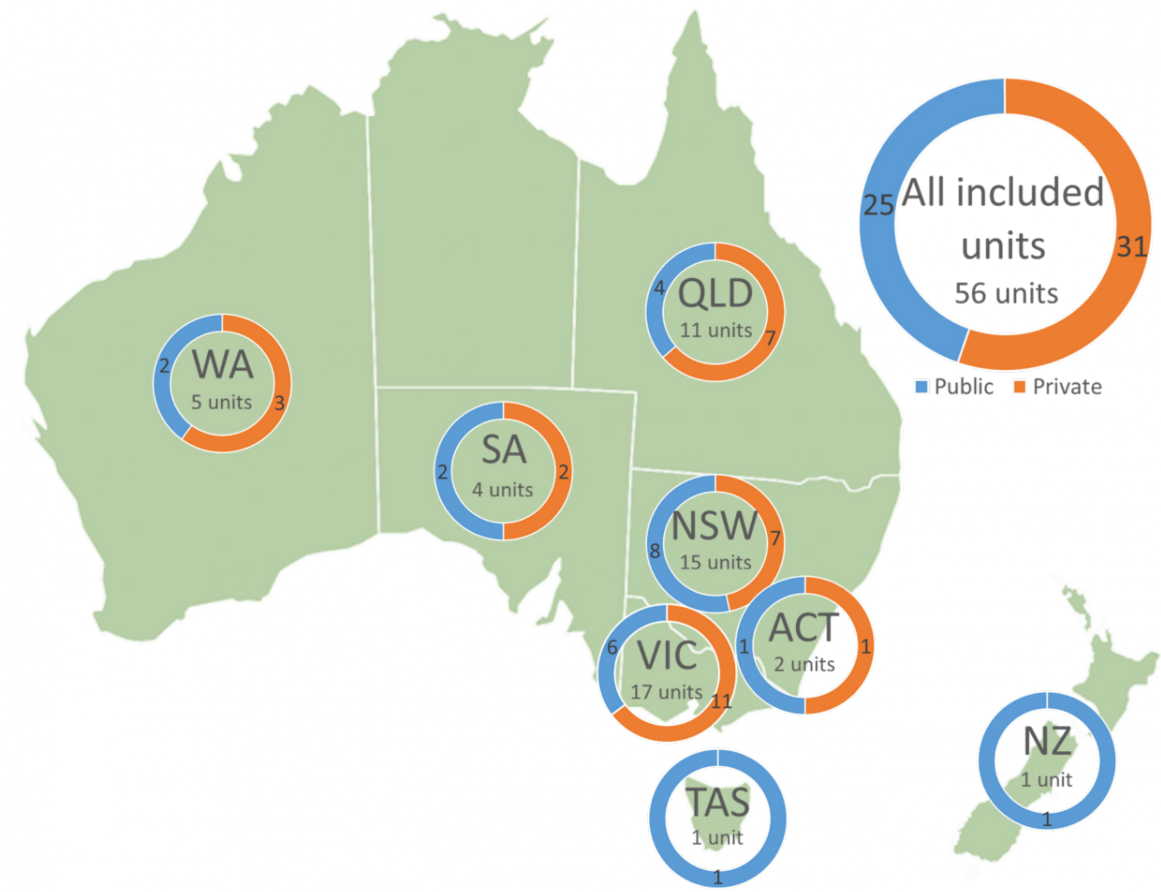
Of the cases submitted in 2022, 98.8% were flagged as complete. Incomplete cases miss one or more variables for a variety of reasons. The tables presented in this report include all available data. Accordingly, there are small variations in the total number of cases in each table due to the differing amount of missing data for each variable.

Where the number of cases in the current year is low (Sections 3 and 4), data is pooled with the preceding four years. Details of data preparation and key variable definitions are presented in Appendix C (pg. 84).

Contributing hospitals

Data from 56 cardiac surgery units are presented in this report, including 31 from 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) in 2022 are included in the report. A list of hospitals included in the report and the proportion of cases each hospital contributed to the report can be found in Appendix D (pg. 86).

Figure 1. Participating hospitals featured in the 2022 Annual Report, by state and country



Overview of procedures

In 2022, 16,692 cardiac surgical procedures were performed at the 56 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, 2022

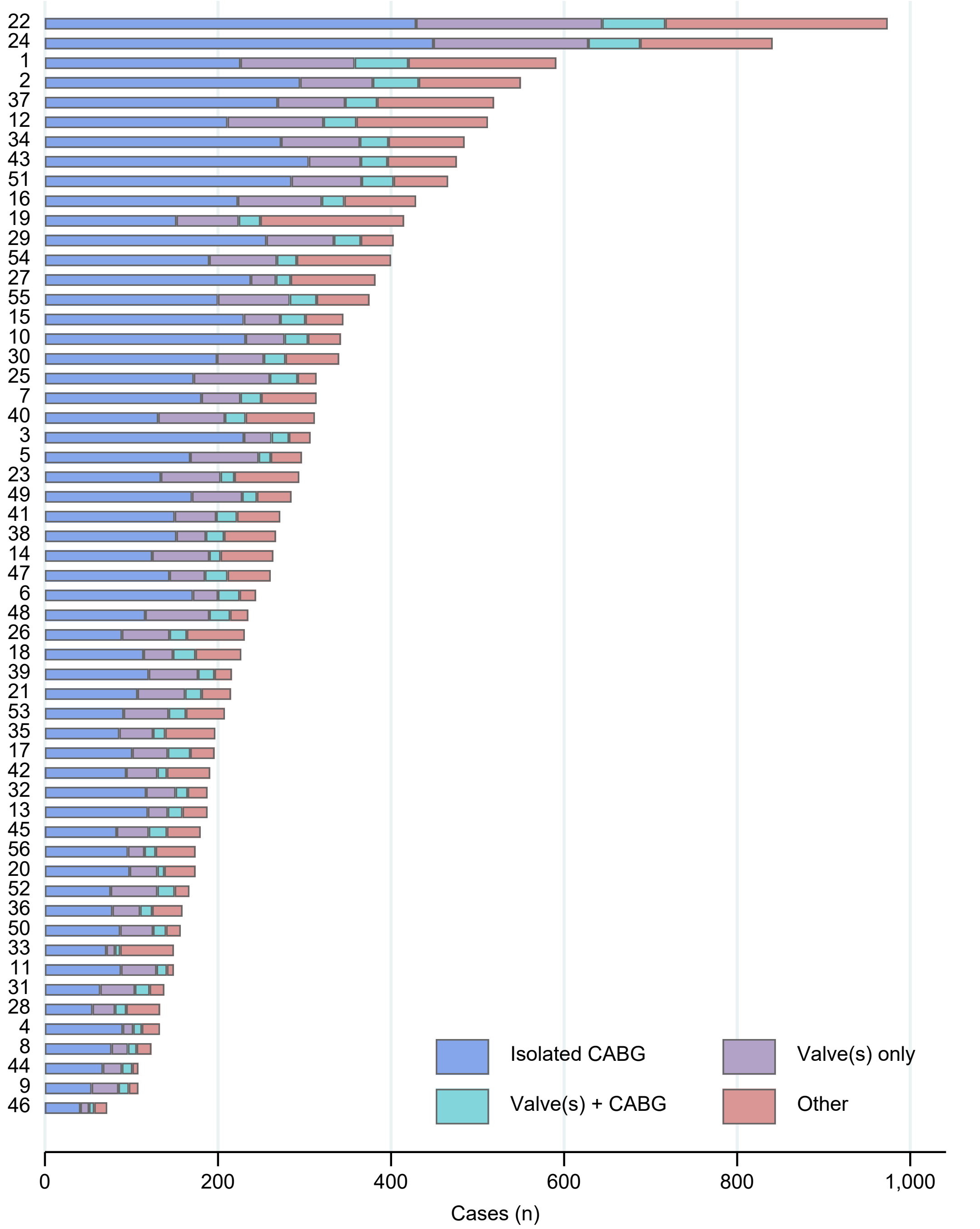
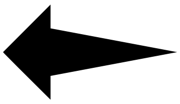


Table 1. Cardiac surgery procedure groups by year

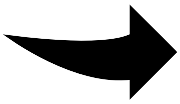
	2018	2019	2020	2021	2022	Total
Hospitals (n)	38	40	47	52	56	56
Total cases (n)	13,917	15,099	15,078	16,111	16,692	76,897
Isolated CABG (%)	50.1	50.9	51.4	51.8	53.1	51.5
Valve(s) only (%)	22.0	20.3	20.9	20.2	19.2	20.4
Valve(s) + CABG (%)	8.9	8.6	8.4	8.4	7.9	8.4
Other (%)	19.0	20.1	19.4	19.7	19.8	19.6

1. Brief overview of COVID-19 pandemic activity in 2022

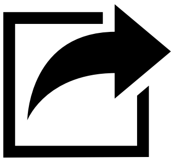
In 2022, the ANZSCTS Database continued to collect data on peri-operative patient COVID-19 diagnoses and the redirection of cases from public hospitals to private hospitals due to restrictions on surgery and changing resource allocation. A relatively small number of pre- and post-operative COVID-19 diagnoses were recorded, and close to 4% of total cases were redirected from public hospitals to private hospitals for surgery.



Pre-operative confirmed diagnosis of COVID-19 — 228 cases

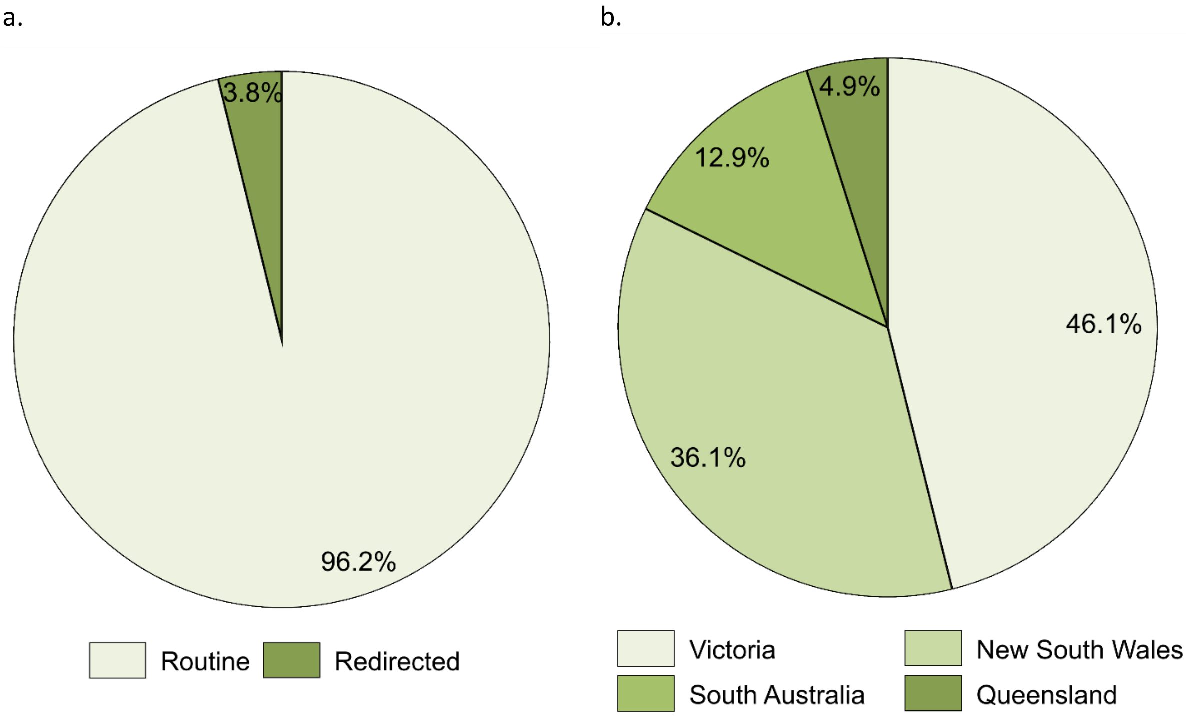


New post-operative confirmed diagnosis of COVID-19 — 142 cases



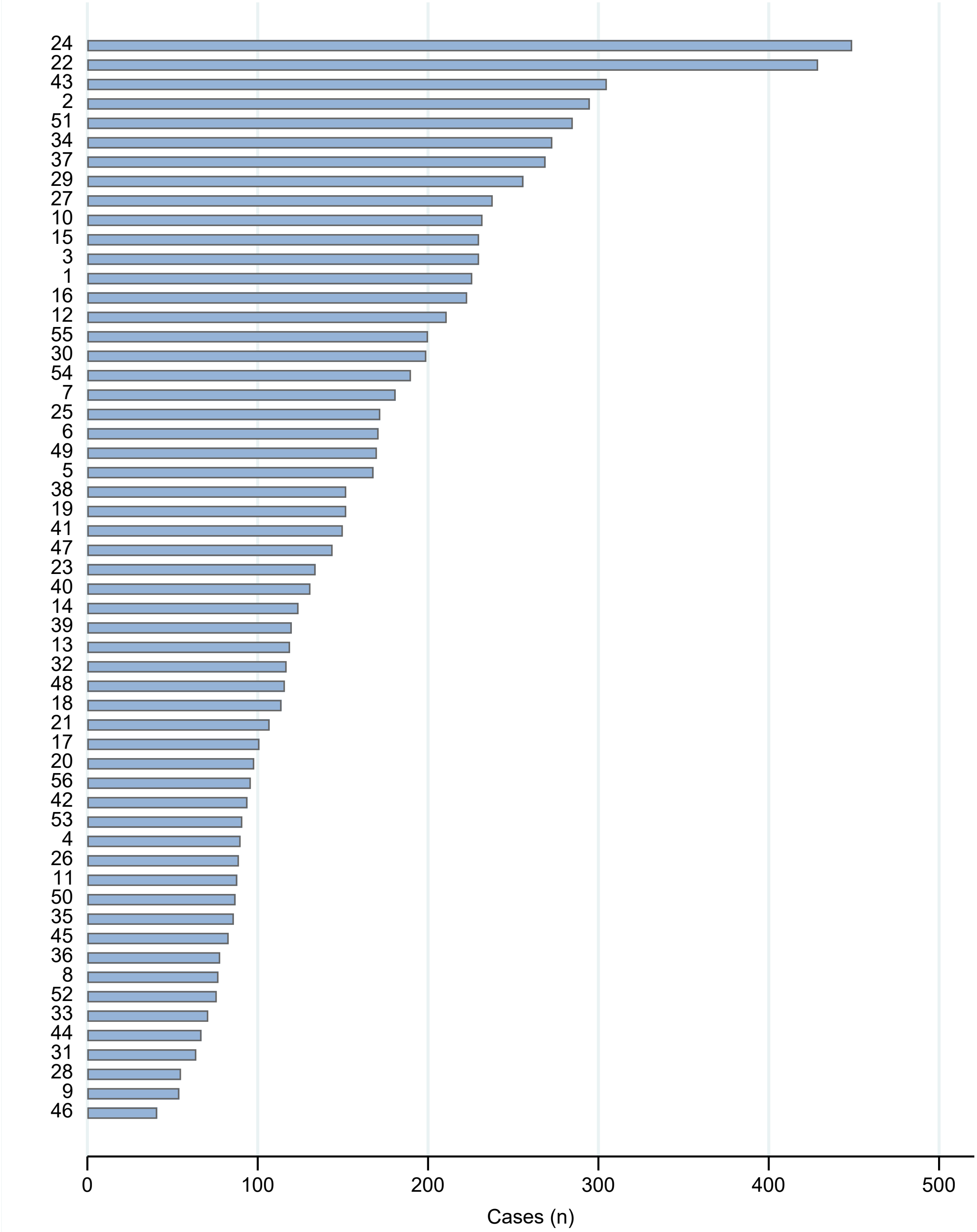
New post-discharge confirmed diagnosis of COVID-19 (within 30 days) — 173 cases

Figure 3. Cases redirected due to pandemic related restrictions overall (a) and by state (b), 2022



2. Isolated CABG Surgery

Figure 4. Isolated CABG cases by unit, 2022



Summary of isolated CABG surgery activity

Isolated CABG surgery accounted for 53.1% of cases submitted to the ANZSCTS Database in 2022 (Table 1). Case volume varied between units, with 19 performing less than 100 cases and 15 performing more than 200 (Figure 4).

Choice of conduits

There was large variation between units with the type of conduits used, particularly with radial arteries vs saphenous vein (Figure 13). Bilateral internal thoracic artery (BITA) grafts were associated with the most anastomoses (mean of 2.3), followed by saphenous vein graft (SVG) (mean of 1.8;

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 (TAR) generally decreased with increasing age, from 31.1% in 18-50-years old to 19.2% in patients 80 years and older (Table 10). Patients having off-pump surgery more commonly had TAR compared to on-pump surgery (41.8 vs 24.0%) and the proportion of cases involving TAR varied substantially between units (Table 10 and Figure 14).

Complications with risk factors

Consistent with expectations, complications varied for patients with key pre-operative risk factors. In particular, patients with markers of pre-operative renal dysfunction or diabetes tended to have higher incidences of permanent stroke, DSWI, new cardiac arrythmias and RTT for bleeding (Table 11). Unsurprisingly, these patients also had a higher post-operative incidence of dNRI (Table 14). There were weak trends suggesting increasing incidence of permanent stroke, new cardiac arrythmia and post-operative dNRI with age; however, age did not appear to affect DSWI and RTT for bleeding, on average (Table 12 and Table 14).

Emergency and salvage surgery had approximately a 17-fold increase in mean OM, compared to elective surgery in 2022. Low ejection fraction (EF) and pre-operative creatinine >200 µmol/L were associated with markedly increased OM (Table 15).

KPIs

The majority of units performed comparably in 2022, and units with outcomes outside the 99.7% control limit on funnel plot analysis were engaged by the ANZSCTS Database Steering Committee, in line with the *Special Cause Variation Management Policy*.

The OM for isolated CABG patients was 1.1% in 2022 and 2018-2021 (Figure 15a and Figure 15b), which is consistent with in-hospital and 30-day mortality rates reported by registries in the United States, Sweden, Germany, and the United Kingdom, which ranged from 1.1 – 2.5% for recent years (1-4). The risk-adjusted OM calculated using the Database's ANZSCORE model was 1.0% in 2022 (Figure 15c). In 2022, the incidences of other KPIs were consistent with previous years, including dNRI (2.6%), risk-adjusted dNRI (2.6%), permanent stroke (0.8%), DSWI (1.1%) and RTT for bleeding (2.2%; Figure 16-19). For the interpretation of funnel plots see Appendix E (pg. 88).

Resource utilisation

Over half of patients (51.8%) 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 22 and Table 16). Approximately 76.2% 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 23 and Table 17).

Almost one third (31.3%) of patients were extubated within six hours and 67.3% 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 25). Just under half of patients (47.7%) were discharged from the ICU within 48 hours (Table 20). The mean length of ICU stay was lower in public hospitals (64.2 hours) compared to private hospitals (66.9 hours; Table 21). Approximately one third 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 26).

2.1 Patient characteristics

2.1.1 Clinical status

Figure 5. Clinical status of isolated CABG patients by unit, 2022

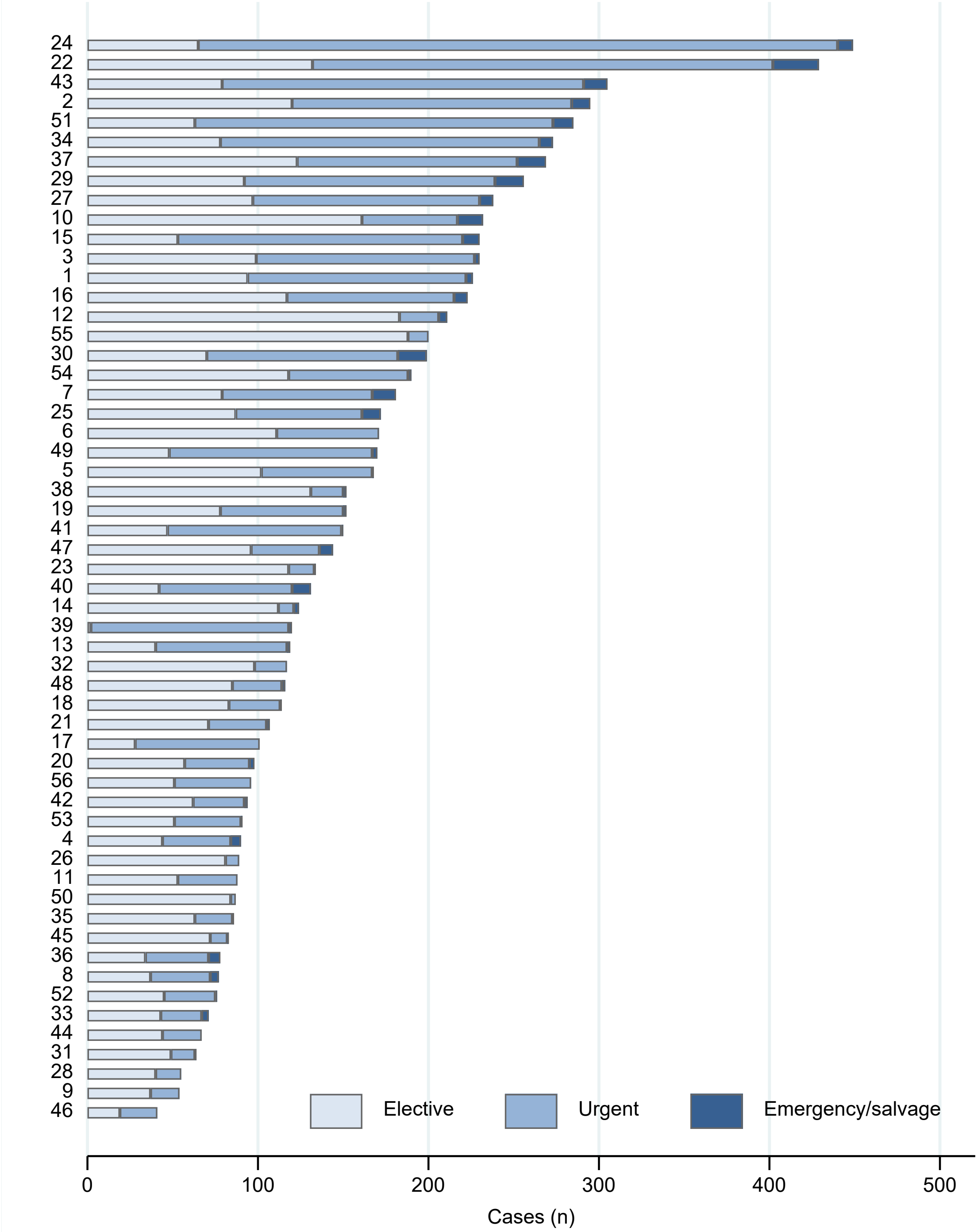


Table 2. Clinical status of isolated CABG patients by year

	2018	2019	2020	2021	2022	Total
Elective (%)	60.6	56.2	51.6	50.0	49.1	53.2
Urgent (%)	36.6	40.3	45.2	46.5	47.7	43.5
Emergency/salvage (%)	2.9	3.5	3.2	3.5	3.2	3.3

2.1.2 Sex and age

Figure 6. Sex of isolated CABG patients by unit, 2022

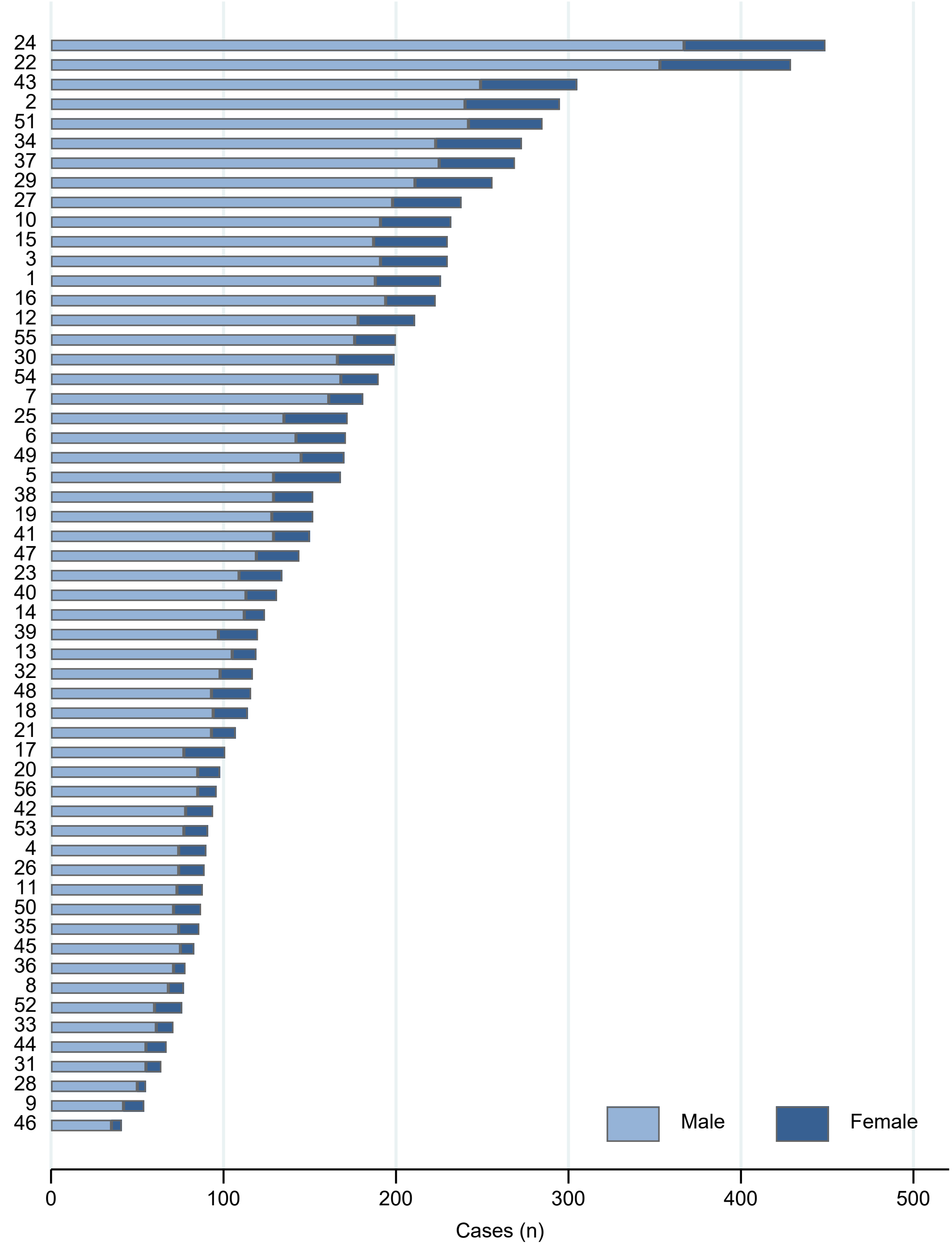
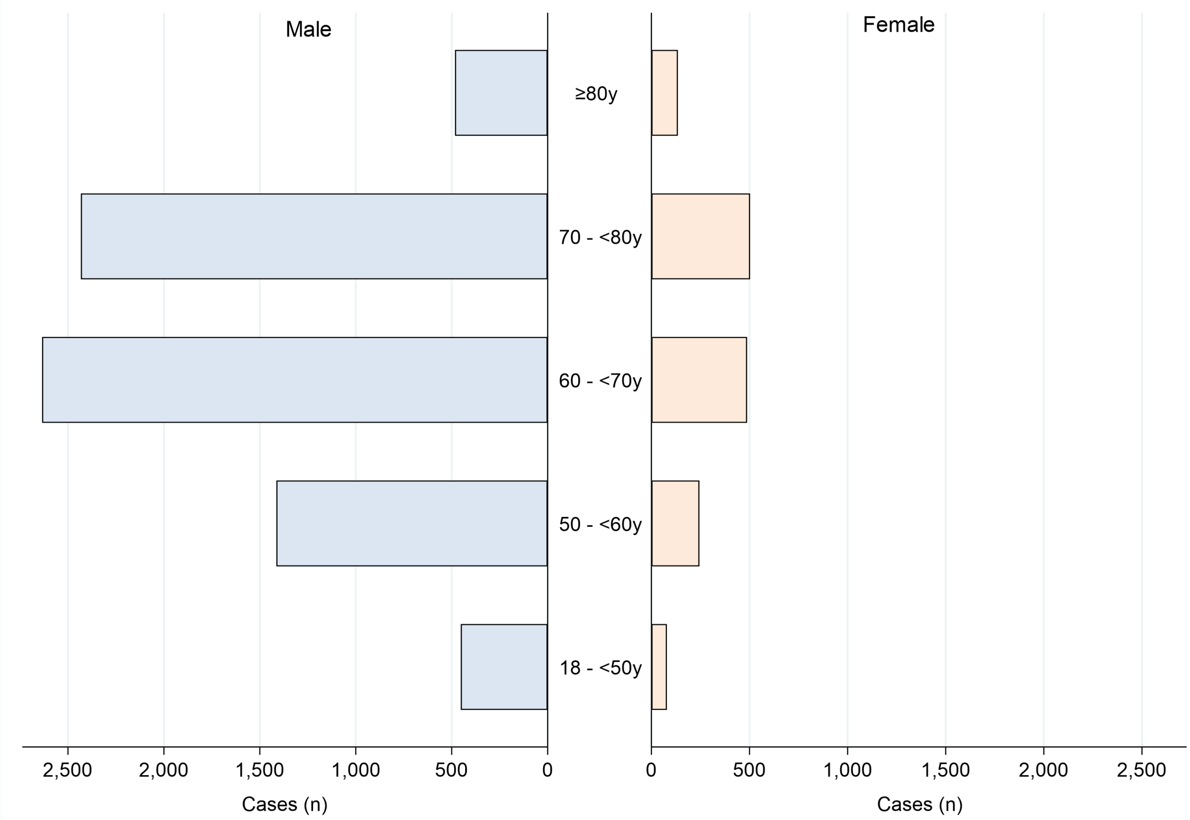


Table 3. Sex of isolated CABG patients by year

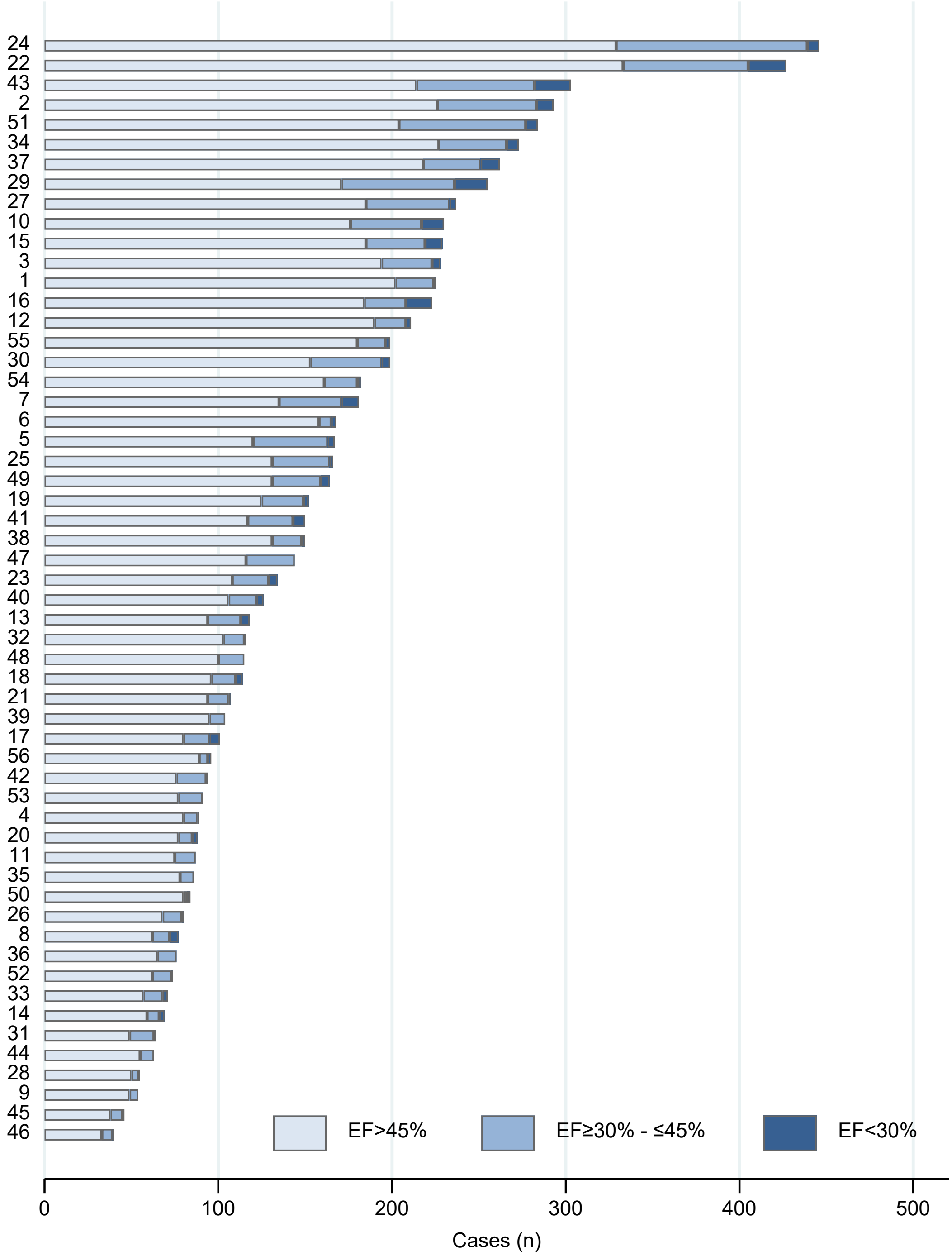
	2018	2019	2020	2021	2022	Total
Male (%)	82.0	82.3	82.8	83.4	83.6	82.9
Female (%)	18.0	17.7	17.2	16.6	16.4	17.1

Figure 7. Age of isolated CABG patients by sex, 2022



2.1.3 Left ventricular function

Figure 8. Pre-operative left ventricular function (LVF) of isolated CABG patients by unit, 2022



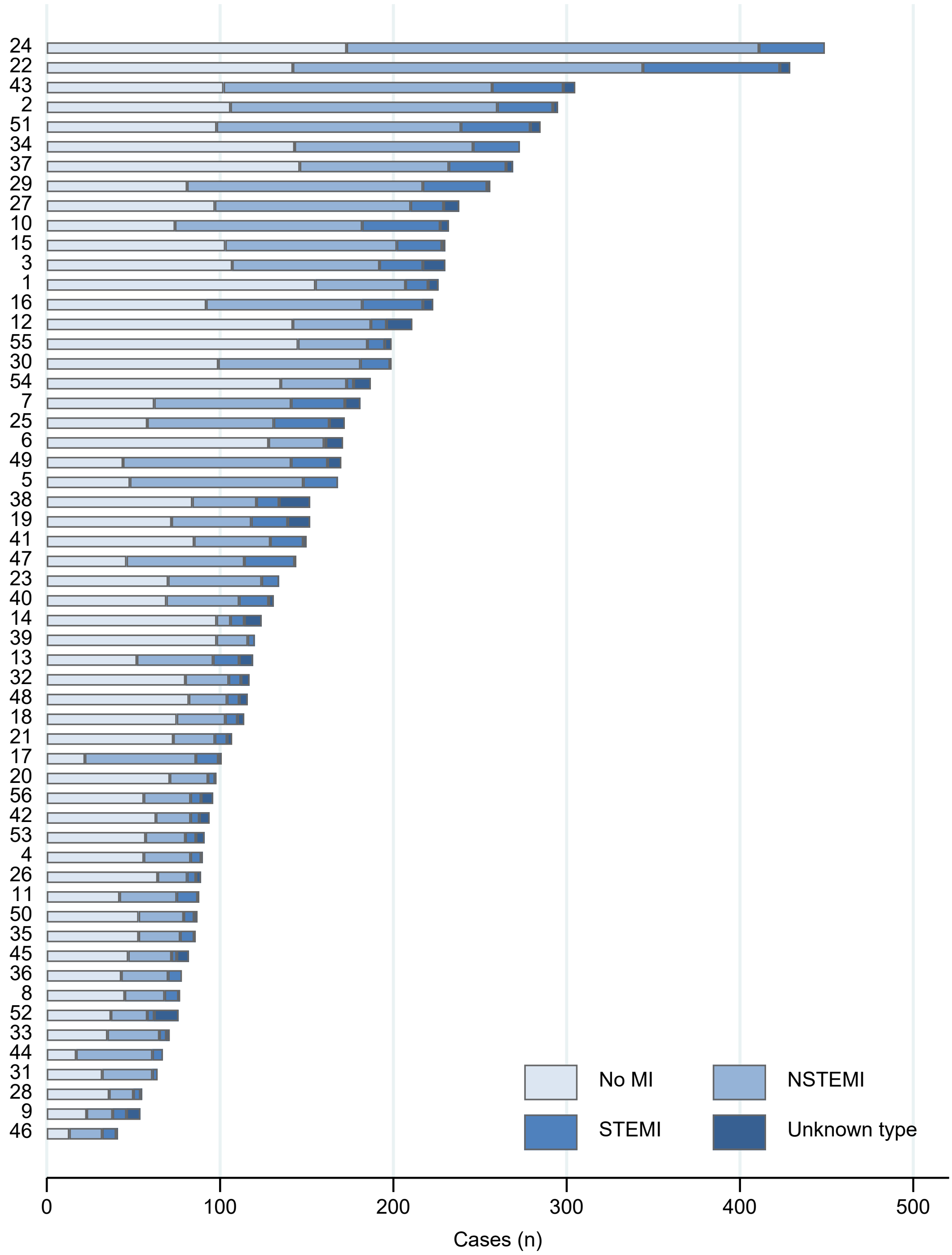
The ANZSCTS Database classifies an EF>45% as normal or mildly reduced, an EF≥30% - ≤45% as moderately reduced and an EF<30% as severely reduced LVF, respectively (Appendix C, pg. 84).

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

	2018	2019	2020	2021	2022	Total
EF>45% (%)	80.5	81.2	80.3	81.1	81.4	80.9
EF≥30% - ≤45% (%)	15.7	15.7	16.5	15.9	15.7	15.9
EF<30% (%)	3.8	3.1	3.2	3.0	2.9	3.2

2.1.4 Previous myocardial infarction

Figure 9. Previous MI in isolated CABG patients by unit, 2022



MI indicates myocardial infarction; NSTEMI, non-ST-elevation MI; STEMI, ST-elevation MI

Table 5. Previous MI in isolated CABG patients by year

	2018	2019	2020	2021	2022	Total
No MI (%)	49.0	48.4	47.6	50.5	48.8	48.9
NSTEMI (%)	37.1	38.0	39.2	36.0	37.7	37.6
STEMI (%)	10.0	10.0	10.0	10.5	10.4	10.2
Unknown type (%)	4.0	3.6	3.1	3.0	3.0	3.3

2.1.5 Timing of previous myocardial infarction

Figure 10. Timing of previous MI in isolated CABG patients by unit, 2022

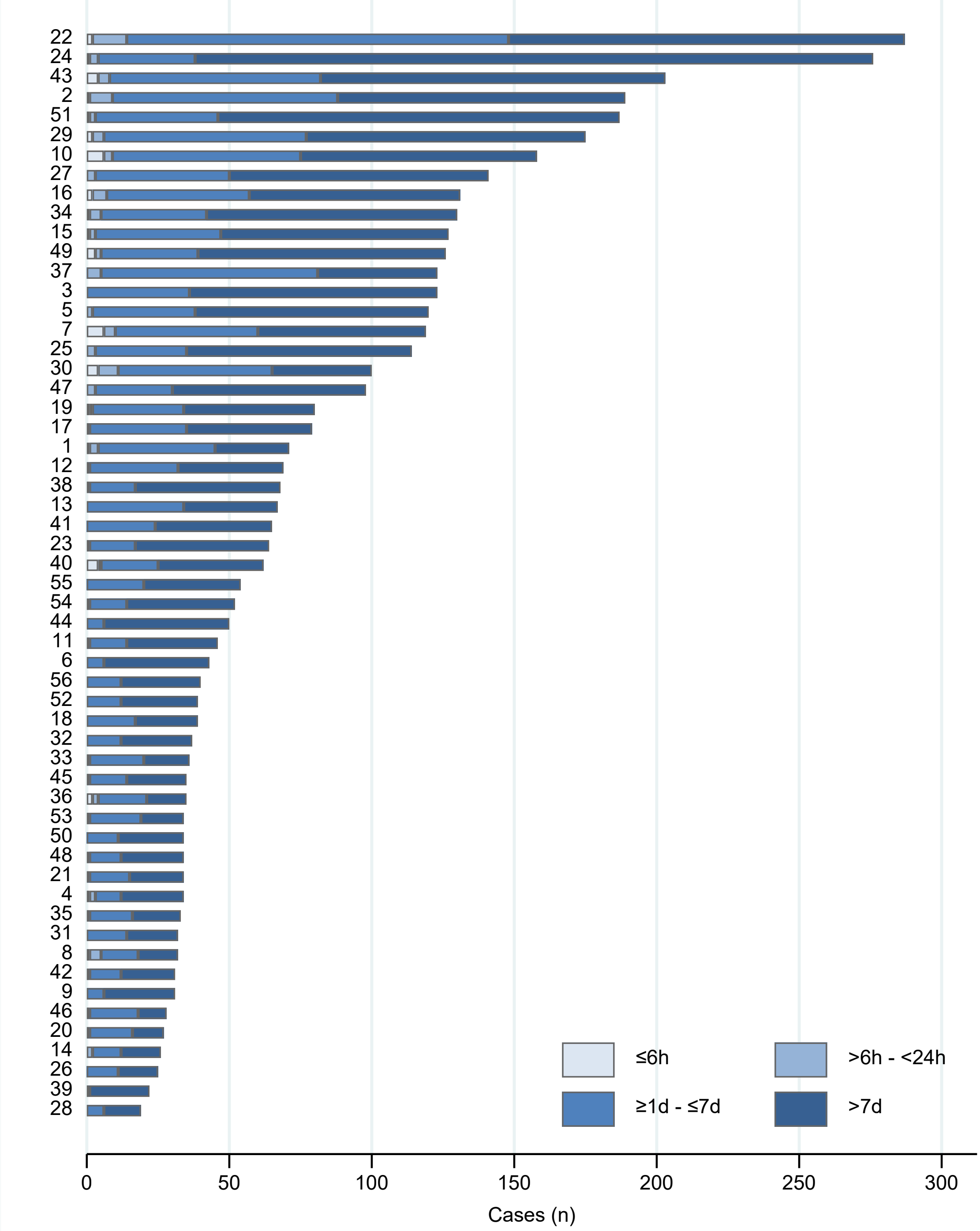


Table 6. Timing of previous MI in isolated CABG patients by year

	2018	2019	2020	2021	2022	Total
≤6hr (%)	1.2	1.6	1.5	1.5	1.1	1.4
>6hr - <24hr (%)	2.5	2.3	2.0	1.6	2.2	2.1
≥1d - ≤7d (%)	31.5	31.5	36.4	36.9	35.6	34.5
>7d (%)	64.7	64.7	60.1	60.0	61.1	62.0

2.2 Previous cardiac surgery

Figure 11. Initial vs redo surgery in isolated CABG patients by unit, 2022

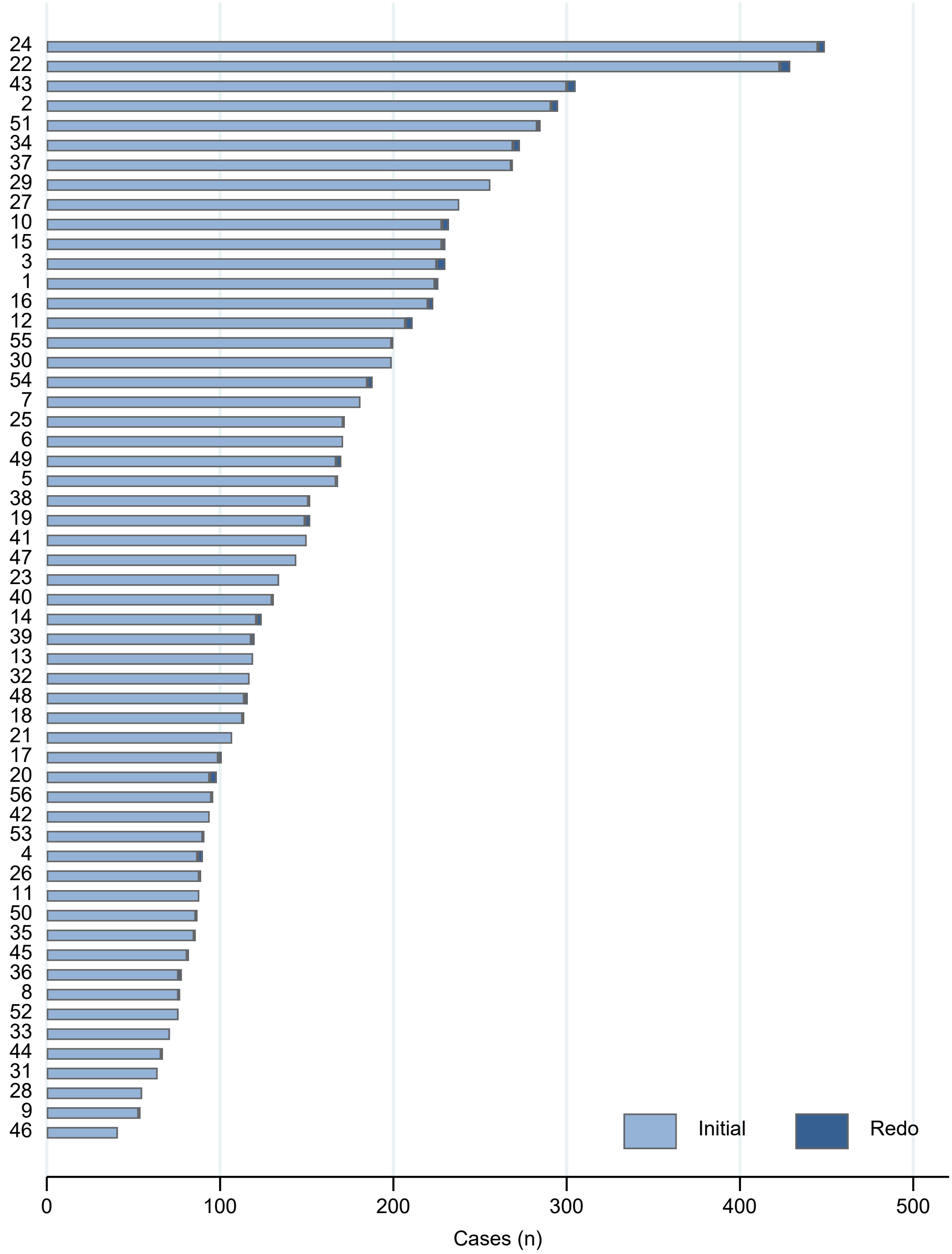


Table 7. Initial vs redo surgery in isolated CABG patients by year

	2018	2019	2020	2021	2022	Total
Initial (%)	98.8	98.8	98.9	98.9	99.0	98.9
Redo (%)	1.2	1.2	1.1	1.1	1.0	1.1

2.3 On-pump and off-pump coronary surgery

Figure 12. On-pump vs off-pump surgery in isolated CABG patients by unit, 2022

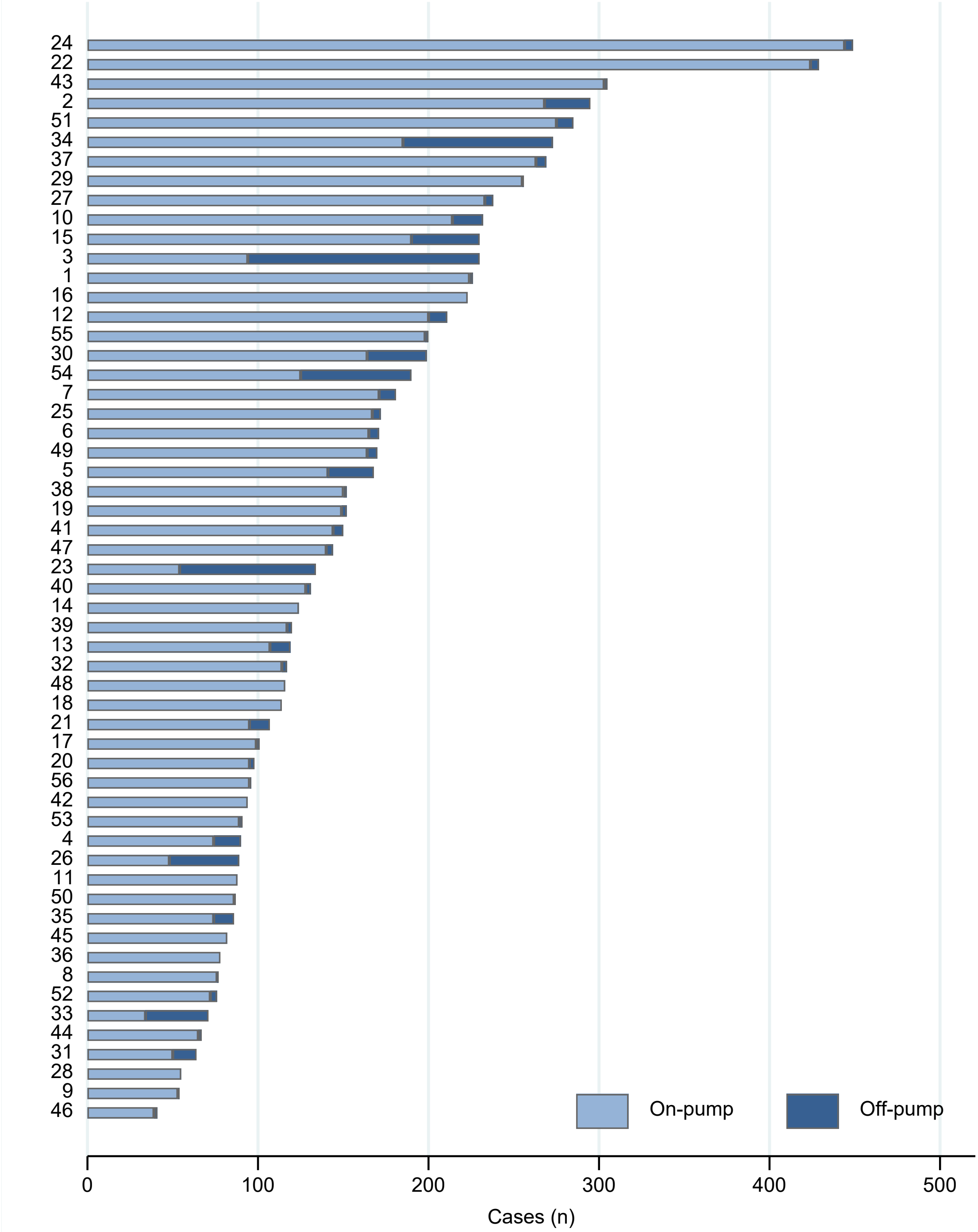


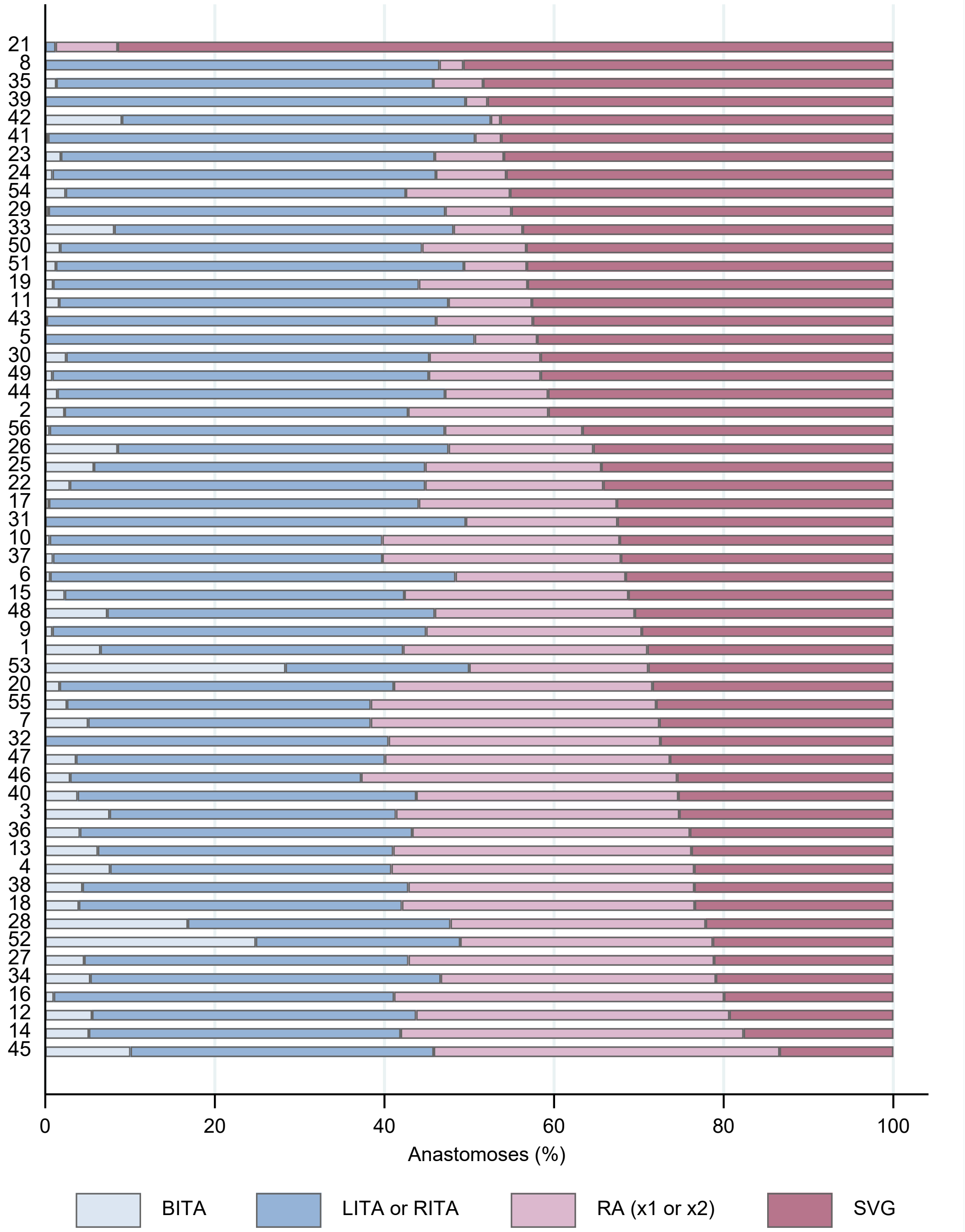
Table 8. On-pump vs off-pump surgery in isolated CABG patients by year

	2018	2019	2020	2021	2022	Total
On-pump (%)	92.5	93.3	94.2	94.1	91.2	93.0
Off-pump (%)	7.5	6.7	5.8	5.9	8.8	7.0

2.4 Conduit selection

2.4.1 Conduits used for anastomoses

Figure 13. Type of arterial and venous conduits harvested for isolated CABG surgery by unit, 2022



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

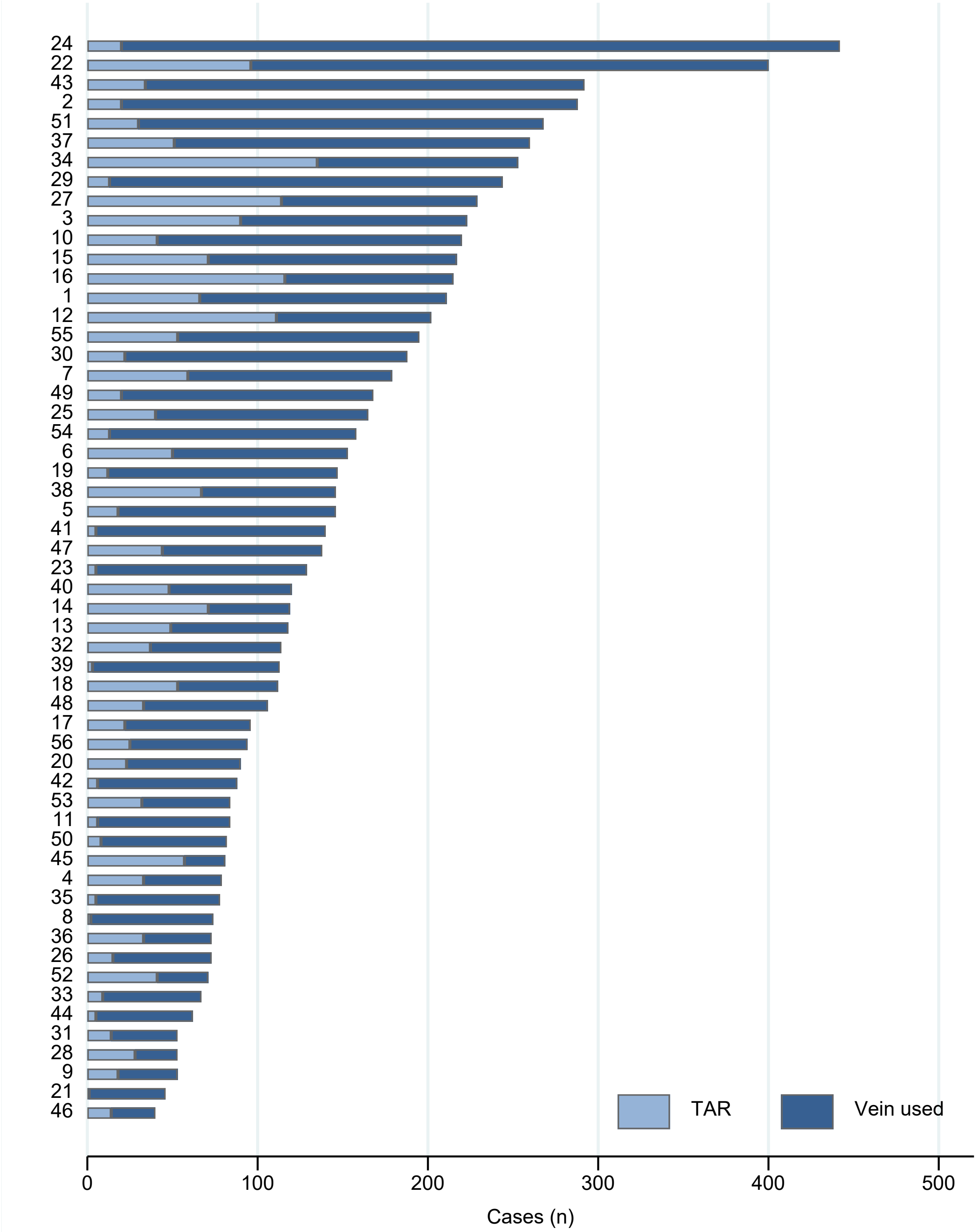
Table 9. Summary of the number of distal anastomoses based on conduit type used for isolated CABG surgery, 2022

	Mean	Median	IQR	Range
BITA	2.3	2	2 - 2	2 - 4
LITA or RITA	1.1	1	1 - 1	1 - 4
RA (x1 or x2)	1.4	1	1 - 2	1 - 6
SVG	1.8	2	1 - 2	1 - 9

Table 10. Grafts and multi-vessel disease in isolated CABG surgery by age and CPB, 2022

	Mean grafts (n)	Multi-vessel disease (%)	All arterial grafts (%)
Age			
18 - <50y	3.1	92.5	31.1
50 - <60y	3.0	94.7	30.3
60 - <70y	3.1	95.2	25.7
70 - <80y	3.0	95.3	22.1
≥80y	3.0	97.4	19.2
CPB			
On-pump	3.1	96.0	24.0
Off-pump	2.6	85.5	41.8

Figure 14. TAR vs vein used in isolated CABG surgery by unit, 2022



TAR indicates total arterial revascularisation. It should be noted that this analysis is based on any use of a vein for a case, and analysis only includes cases where the total number of distal anastomoses is equal to or greater than two.

2.5 Influence of co-morbidities on complications

2.5.1 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	>60mL /min/1.73m^2	≤60mL /min/1.73m^2
n	2022	7,859	1,001	8,663	199	7,358	1,500
	2018-2021	26,999	3,718	29,869	859	25,190	5,521
Permanent stroke (%)	2022	0.8	1.1	0.8	2.6	0.8	1.3
	2018-2021	0.9	1.6	1.0	2.2	0.9	1.8
DSWI (%)	2022	0.9	2.2	1.0	3.0	1.0	1.1
	2018-2021	0.8	2.5	1.0	2.7	1.0	1.2
New cardiac arrythmia (%)	2022	27.3	24.5	27.0	28.4	26.2	30.8
	2018-2021	26.6	25.2	26.4	29.5	25.6	30.5
RTT for bleeding (%)	2022	2.2	2.0	2.2	3.5	2.0	3.4
	2018-2021	2.4	2.6	2.3	5.5	2.1	3.4

2.5.2 Age

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

		Age				
		<50 y	**50-<60 y**	**60-<70**	**70-<80 y**	**≥80 y**
n	2022	532	1,659	3,123	2,936	618
	2018-2021	2,030	6,095	10,775	9,877	1,978
Permanent stroke (%)	2022	0.6	0.8	0.8	0.9	1.1
	2018-2021	0.6	0.7	0.9	1.3	1.4
DSWI (%)	2022	1.7	0.9	1.0	1.1	0.7
	2018-2021	0.9	1.1	0.9	1.1	0.8
New cardiac arrythmia (%)	2022	14.2	18.1	26.2	32.7	38.7
	2018-2021	11.4	18.0	26.1	32.8	38.2
RTT for bleeding (%)	2022	2.8	1.6	1.9	2.7	2.4
	2018-2021	2.0	2.1	2.4	2.5	2.9

2.5.3 Previous cardiac surgery or use of cardiopulmonary bypass

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

		Surgery		CPB	
		Initial	Redo	On-pump	Off-pump
n	2022	8,777	88	8,088	779
	2018-2021	30,392	350	28,764	1,984
Permanent stroke (%)	2022	0.8	2.3	0.9	0.4
	2018-2021	1.0	2.9	1.0	1.0
DSWI (%)	2022	1.1	1.1	1.1	0.4
	2018-2021	1.0	0.0	1.0	1.1
New cardiac arrythmia (%)	2022	27.0	25.3	27.6	20.8
	2018-2021	26.5	24.7	26.5	25.1
RTT for bleeding (%)	2022	2.2	5.7	2.3	1.4
	2018-2021	2.4	3.7	2.4	2.2

2.5.4 Influence of comorbidities on derived new renal insufficiency

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

	2022		2018 - 2021	
	n	dNRI (%)	n	dNRI (%)
Insulin dependent diabetes				
No	7,767	2.3	26,614	2.1
Yes	945	5.0	3,482	4.7
Pre-operative creatinine				
≤200 µmol/L	8,628	2.4	29,737	2.2
>200 µmol/L	85	25.9	393	15.0
Pre-operative eGFR				
>60mL/min/1.73m^2	7,330	1.7	25,102	1.7
≤60mL/min/1.73m^2	1,381	7.5	5,014	6.1
Age				
18 - <50y	512	2.5	1,957	2.0
50 - <60y	1,626	1.8	5,937	1.7
60 - <70y	3,073	2.1	10,568	2.2
70 - <80y	2,894	3.1	9,722	2.8
≥80y	608	5.6	1,946	3.9
Previous surgery				
Initial	8,627	2.6	29,783	2.4
Redo	86	5.8	338	4.1
CPB				
On-pump	7,955	2.7	28,193	2.4
Off-pump	758	2.5	1,930	2.0

2.6 Influence of patient characteristics on operative mortality

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

	2022		2018 - 2021	
	n	OM (%)	n	OM (%)
Clinical status				
Elective	4,292	0.4	16,574	0.6
Urgent	4,184	1.4	12,941	1.2
Emergency/salvage	284	7.0	999	6.7
Sex/age				
Male	7,327	0.9	25,212	0.9
18 - <50y	447	0.4	1,678	1.0
50 - <60y	1,398	0.1	5,155	0.5
60 - <70y	2,601	0.7	8,973	0.7
70 - <80y	2,402	1.3	7,910	1.3
≥80y	479	2.9	1,496	1.7
Female	1,433	2.1	5,302	1.8
18 - <50y	78	2.6	334	0.9
50 - <60y	242	2.1	898	1.3
60 - <70y	483	1.0	1,719	1.0
70 - <80y	496	2.2	1,886	2.4
≥80y	134	5.2	465	3.2
LVF				
EF>45%	6,979	0.7	24,341	0.7
EF≥30% - ≤45%	1,345	2.1	4,807	2.1
EF<30%	252	6.7	985	4.9
Previous MI				
No MI	4,259	0.5	14,912	0.7
NSTEMI	3,310	1.6	11,462	1.3
STEMI	920	2.1	3,092	2.1
Unknown type	267	1.1	1,036	0.6
Timing of previous MI				
≤6hr	50	10.0	220	10.0
>6hr - <24hr	99	5.1	324	6.2
≥1d - ≤7d	1,602	1.9	5,318	1.6
>7d	2,746	1.3	9,678	1.0
Previous surgery				
Initial	8,670	1.1	30,154	1.0
Redo	87	4.6	349	2.9
CPB				
On-pump	7,995	1.2	28,535	1.1
Off-pump	764	0.7	1,972	1.3
Dialysis				
No	8,634	1.0	29,968	1.0
Yes	121	7.4	541	7.2
Pre-operative creatinine				
≤200 µmol/L	8,557	1.0	29,631	0.9
>200 µmol/L	198	6.1	858	6.1

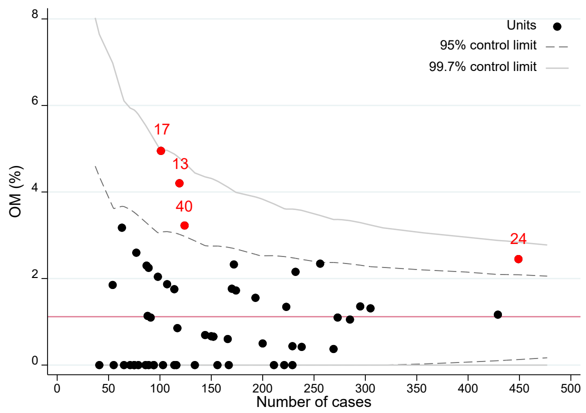
2.7 Unit outcomes – mortality, complications and resource utilisation

2.7.1 Operative mortality

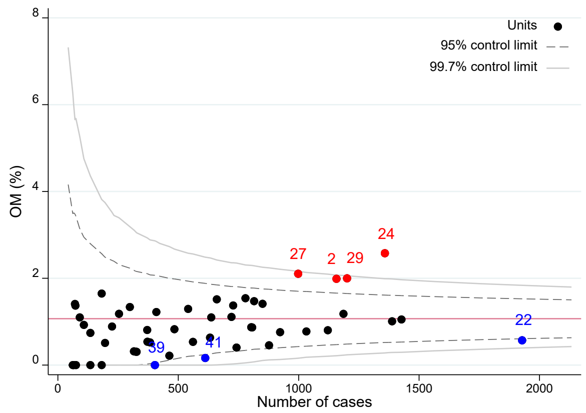
To enhance the visibility of the individual unit outcomes on the funnel plots, units with very low case numbers (<30 in the four-year pooled data) were excluded. A full summary of outcomes for all units is provided in Appendix F (pg. 89).

Figure 15. OM following isolated CABG surgery, by unit

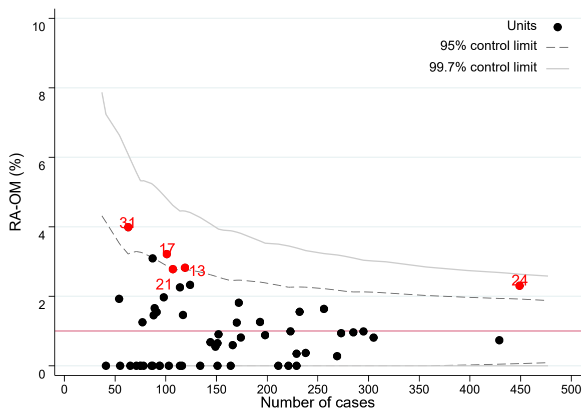
a. 2022 OM



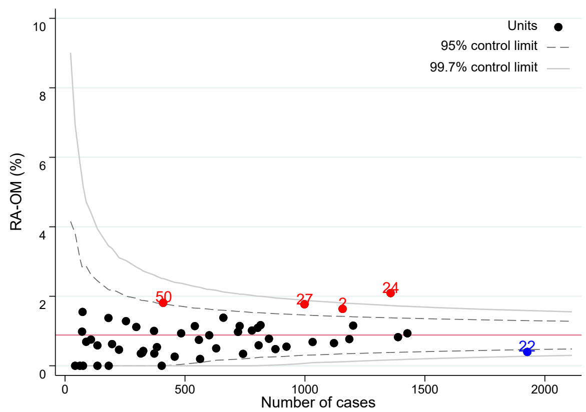
b. 2018 – 2021 OM



c. 2022 RA-OM



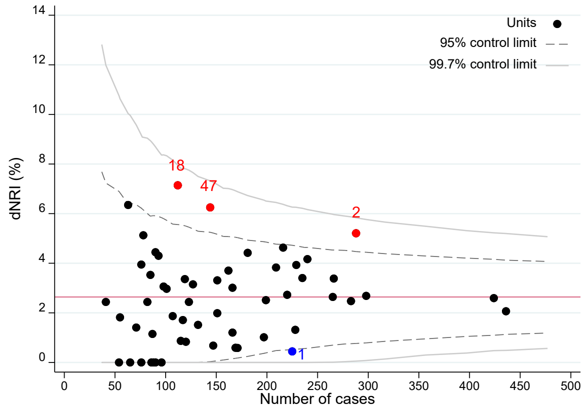
d. 2018 – 2021 RA-OM



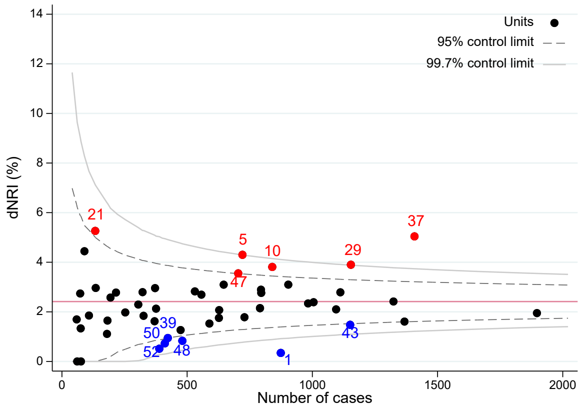
2.7.2 Complications

Figure 16. dNRI following isolated CABG surgery, by unit

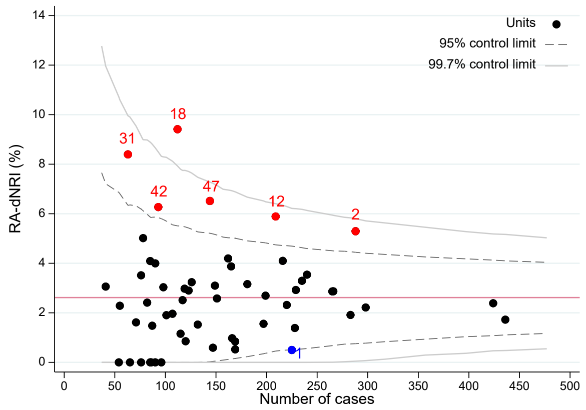
a. 2022 dNRI



b. 2018 – 2021 dNRI



c. 2022 RA-dNRI



d. 2018 – 2021 RA-dNRI

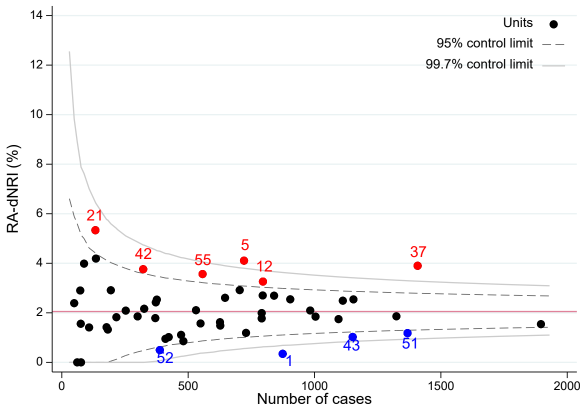
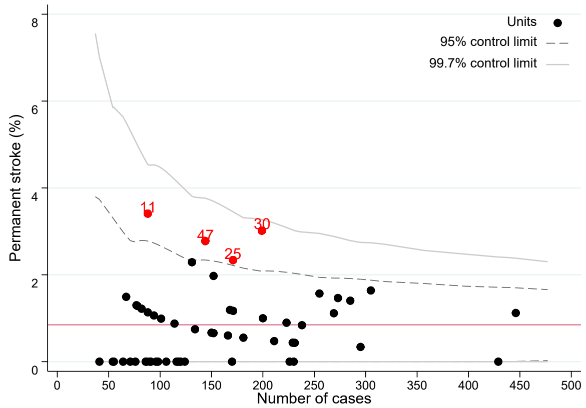


Figure 17. Permanent stroke following isolated CABG surgery, by unit

a. 2022 permanent stroke



b. 2018 – 2021 permanent stroke

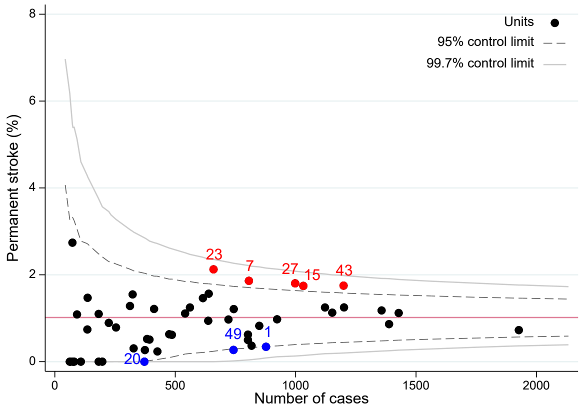
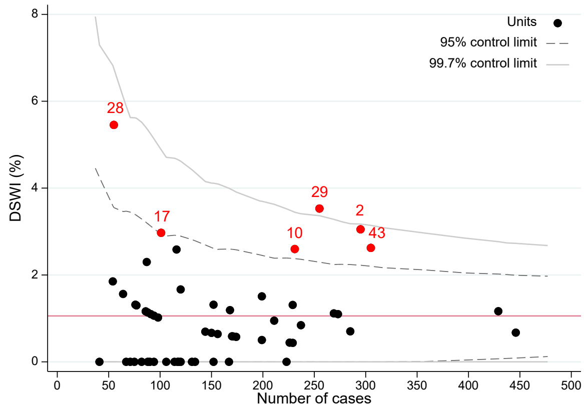


Figure 18. DSWI following isolated CABG surgery, by unit

a. 2022 DSWI



b. 2018 – 2021 DSWI

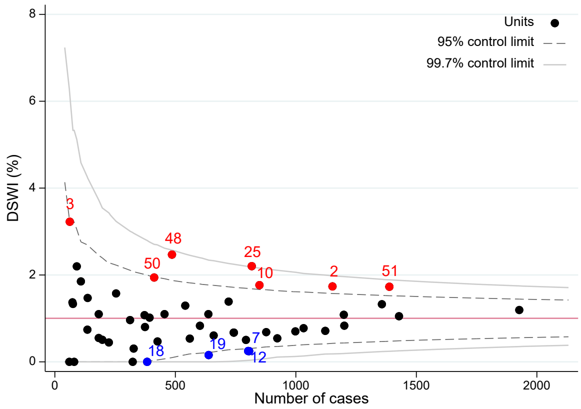
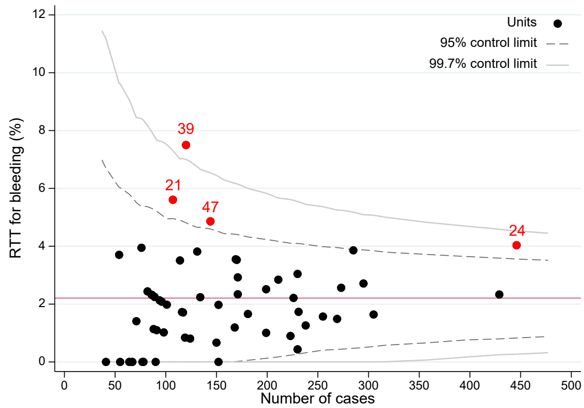


Figure 19. RTT for bleeding following isolated CABG surgery, by unit

a. 2022 RTT for bleeding



b. 2018 – 2021 RTT for bleeding

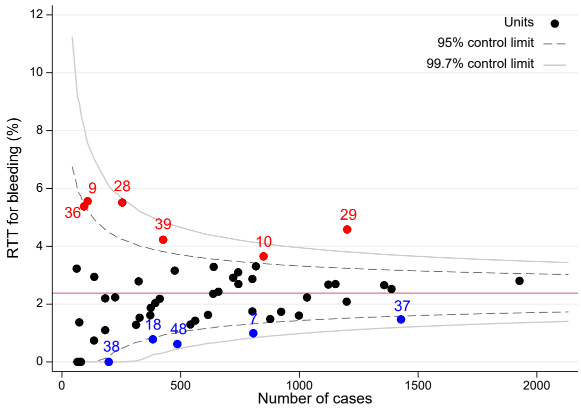
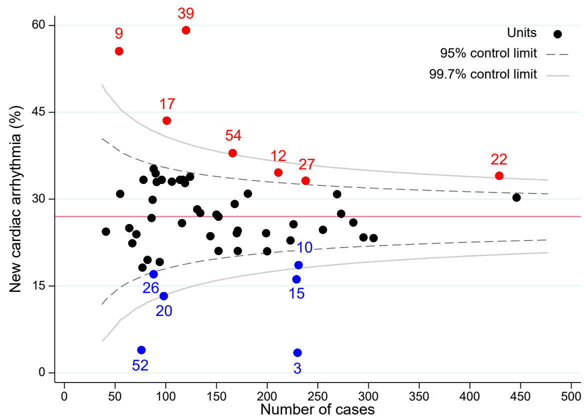


Figure 20. New cardiac arrhythmia following isolated CABG surgery, by unit

a. 2022 new cardiac arrhythmia



b. 2018 – 2021 new cardiac arrhythmia

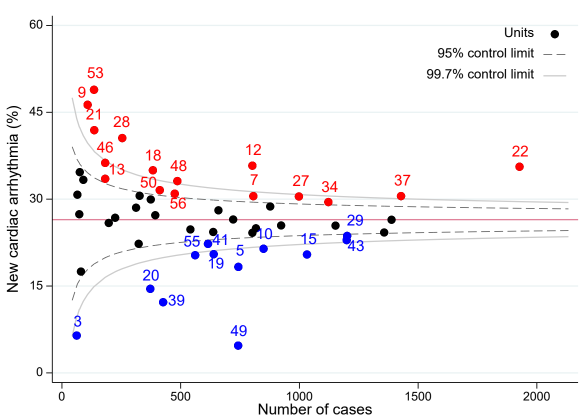
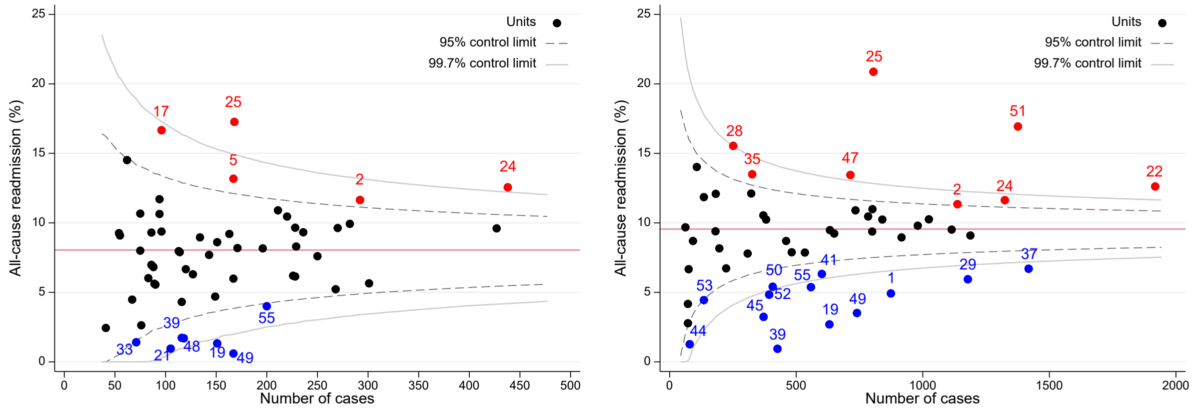


Figure 21. All-cause readmission following isolated CABG surgery, by unit

a. 2022 all-cause readmission b. 2018 – 2021 all-cause readmission



2.7.3 Resource utilisation

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

Figure 22. Distribution of pre-operative LOS for isolated CABG patients, 2022

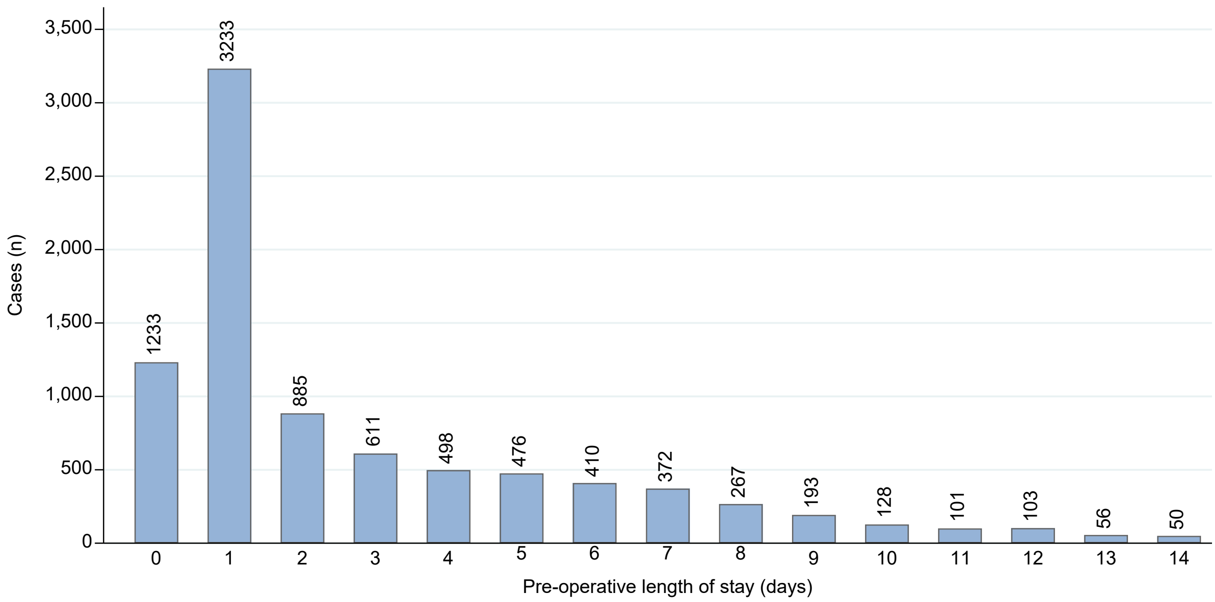


Table 16. Summary of pre-operative LOS for public and private isolated CABG patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	3.3	2	1 - 6
Private	2.3	1	1 - 3
Total	2.9	1	1 - 5

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

Figure 23. Distribution of post-operative LOS for isolated CABG patients, 2022

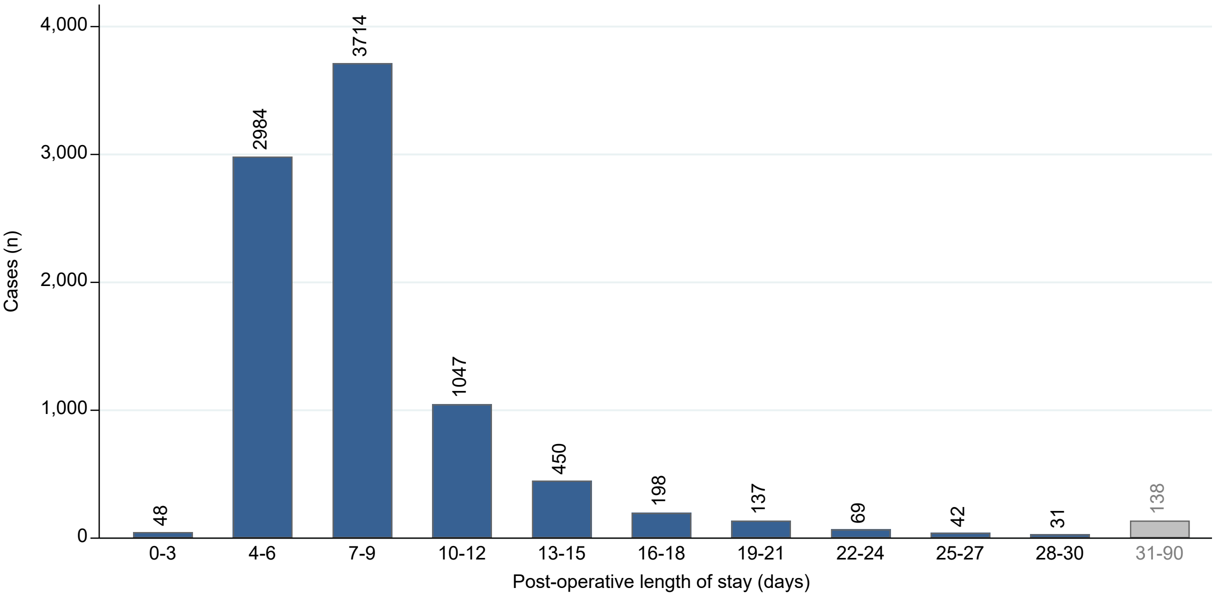


Table 17. Summary of post-operative LOS for public and private isolated CABG patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	9.0	7	6 - 9
Private	8.7	8	7 - 9
Total	8.9	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 24. Distribution of initial post-operative ventilation time for isolated CABG patients, 2022

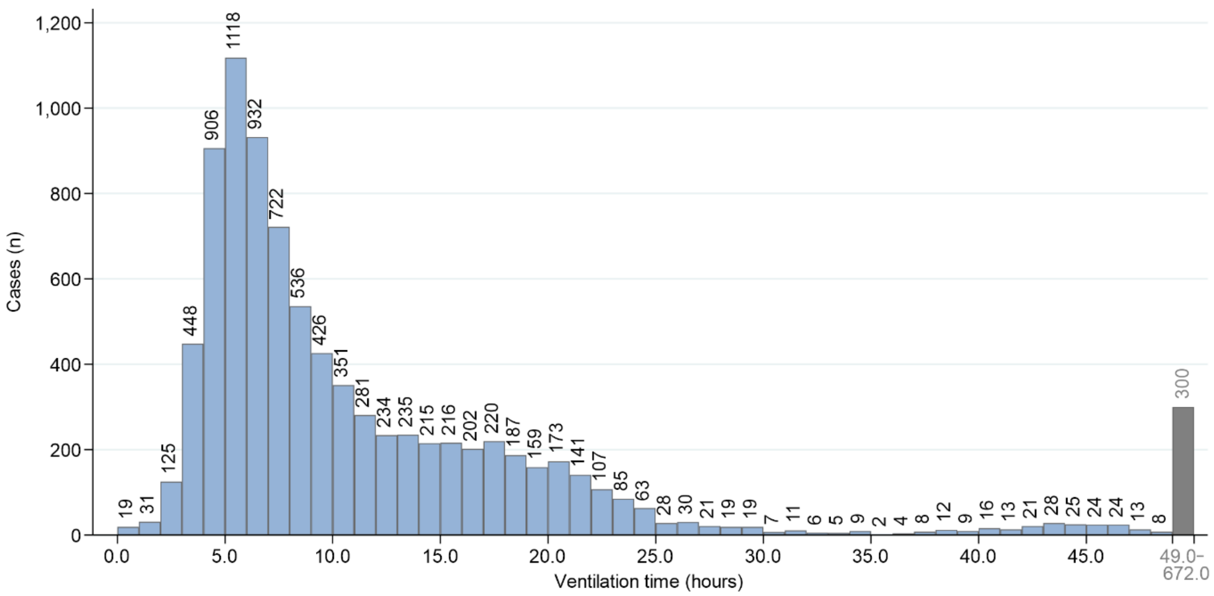


Table 18. Cumulative proportion of patients extubated by hour up to four weeks for isolated CABG surgery, 2022

	6h	12h	24h	48h	96h	192h	384h	672h
Cumulative patients (n)	2,749	5,914	8,074	8,486	8,667	8,750	8,786	8,794
Cumulative percentage (%)	31.3	67.3	91.8	96.5	98.6	99.5	99.9	100.0

Table 19. Summary of initial post-operative ventilation time for public and private isolated CABG patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	16.3	8.6	5.8 - 16.1
Private	11.8	7.3	5.3 - 13.6
Total	14.5	8.1	5.6 - 15.0

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

Figure 25. Distribution of ICU length of stay for isolated CABG patients, 2022

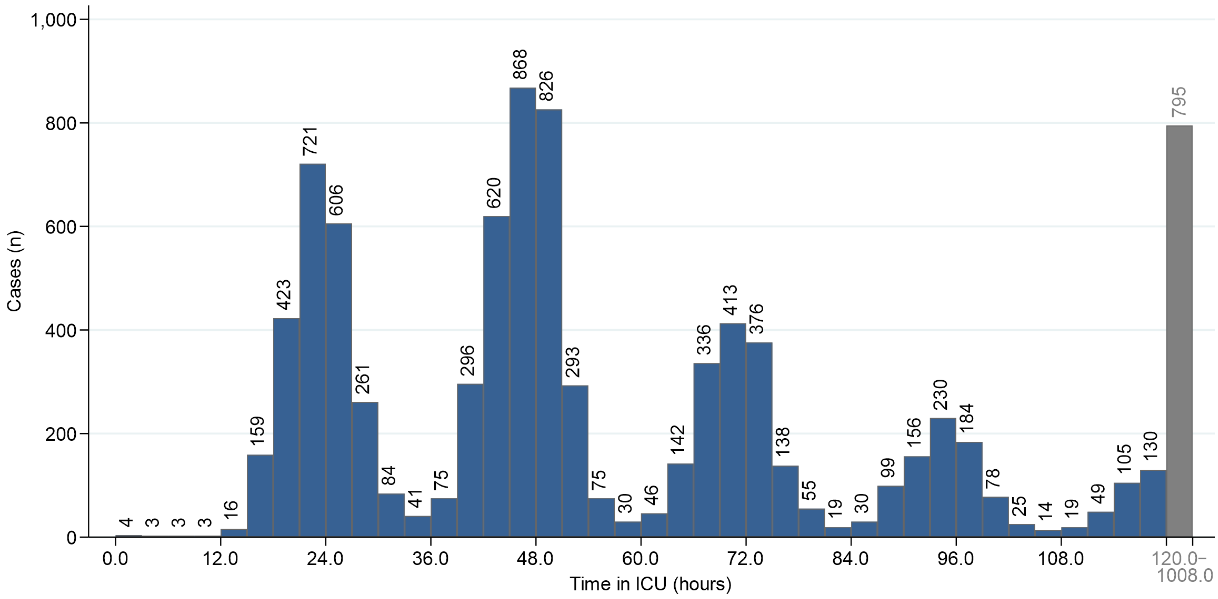


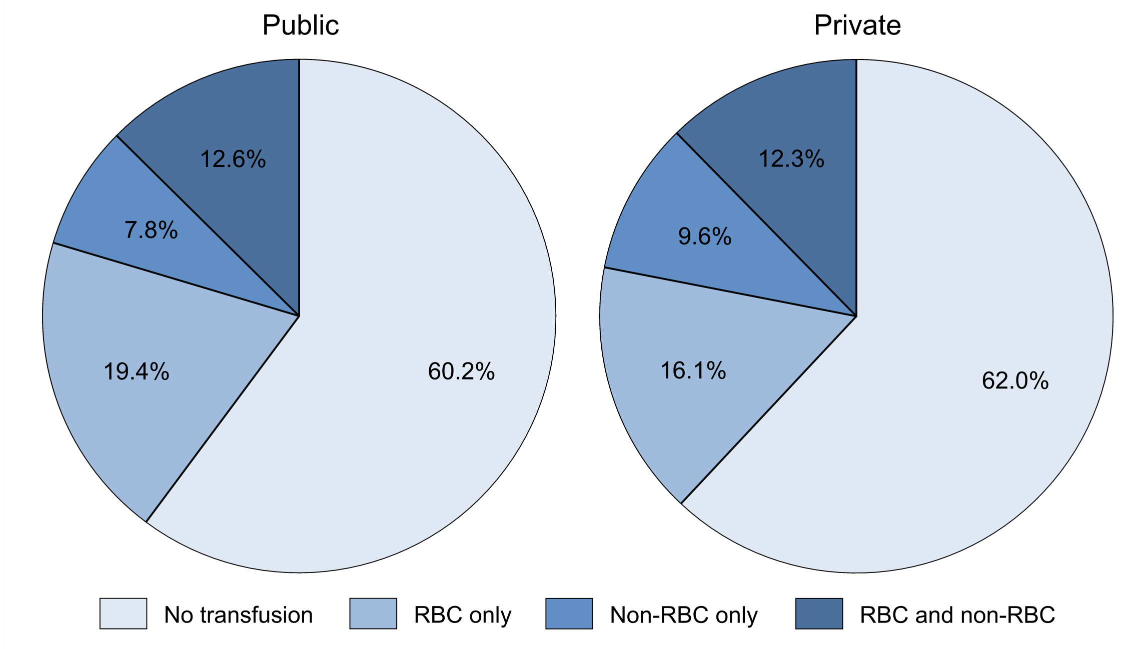
Table 20. Cumulative proportion of patients discharged from ICU by hour up to six weeks for isolated CABG surgery, 2022

	12h	24h	48h	72h	144h	288h	576h	1008h
Cumulative patients (n)	13	1,358	4,216	6,360	8,350	8,749	8,826	8,846
Cumulative percentage (%)	0.1	15.4	47.7	71.9	94.4	98.9	99.8	100.0

Table 21. Summary of ICU length of stay for public and private isolated CABG patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	64.2	46.7	24.7 - 74.2
Private	66.9	50.0	45.1 - 74.0
Total	65.3	48.8	30.4 - 74.2

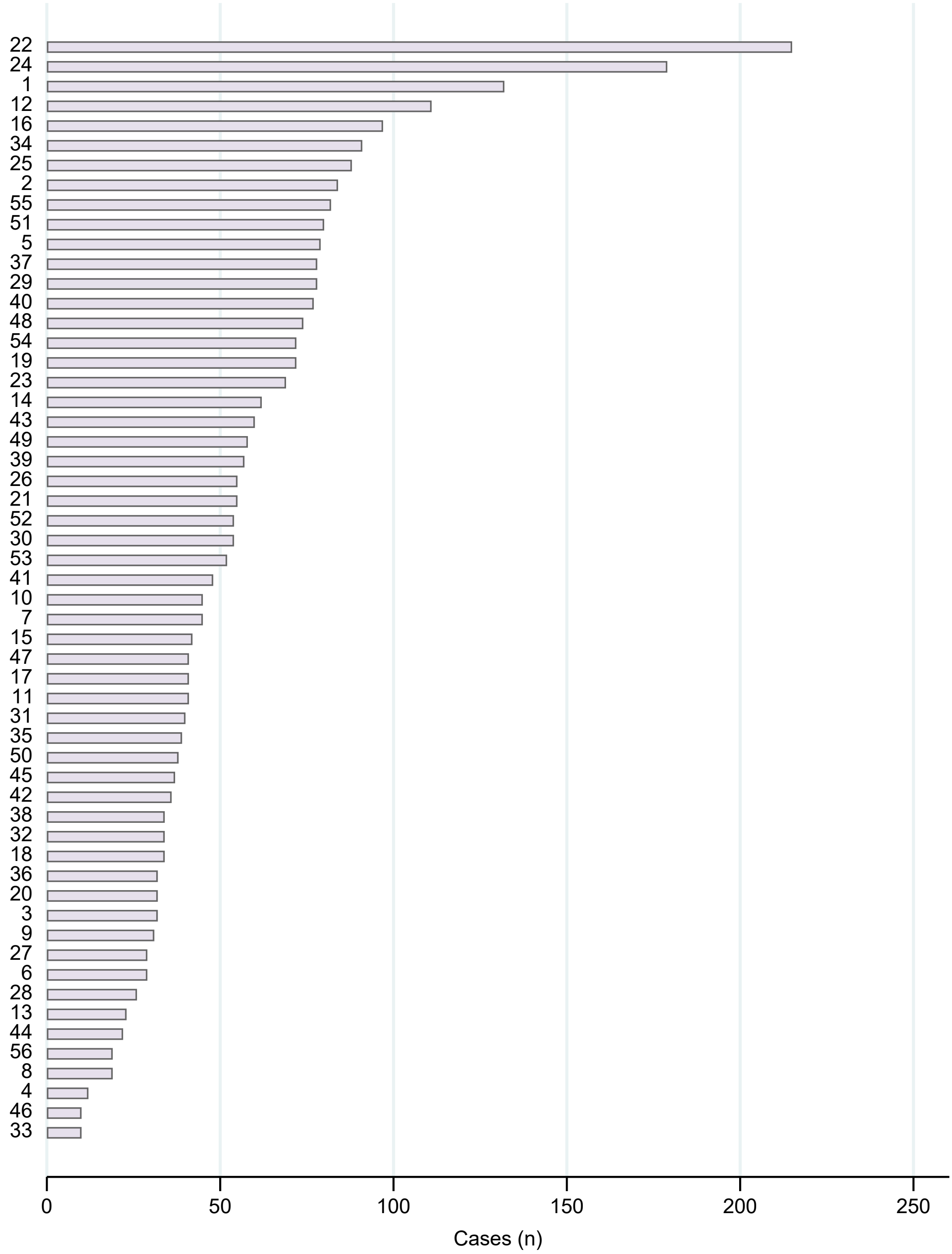
Figure 26. Blood product usage at public and private hospitals for isolated CABG patients, 2022



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

3. Isolated Valve Surgery

Figure 27. Isolated valve cases by unit, 2022



Summary of isolated valve surgery activity

Case volume and patient characteristics

There were 3,186 isolated valve procedures performed in 2022 and case volume varied largely between units. Over half of the participating units performed less than 50 procedures and only four units performed more than 100 (Figure 27).

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 2012 and 2022 were mitral valve replacement (MVR), MV repair and double valve procedures (Figure 32). In-hospital mortality and OM for all isolated valve patients were 1.9 and 2.1%, respectively, in 2022 (Table 25).

Single valve procedures: Valve choice and mortality

Bioprosthetic valves were used in 83.9% of AVR procedures in 2022, compared to 67.8% in MVR procedures. Homo- or allo-grafts were rarely used for AVR (<1% of cases) and were not used at all for MVR procedures (Figure 34).

For single valve surgery, emergency or salvage procedures were associated with a five- or eleven-fold increase in OM, compared to elective procedures, for MVR and AVR, respectively. There was no clear relationship between age or previous MI on OM; however, 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 less than 50 procedures in 2022 (Figure 35). 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 2018-22 (Figure 36a), which was comparable to in-hospital and 30-day mortality rates reported by international registries (range 0.8 – 2.9%) (1-3). The risk-adjusted OM calculated using the Database's ANZSCORE model was 0.8% for 2018-22 (Figure 36b). The incidences of the other key performance indicators were dNRI (2.9%), risk-adjusted dNRI (1.9%), permanent stroke (1.2%), DSWI (0.5%) and RTT for bleeding (3.9%; Figure 37 and Figure 38).

Resource utilisation

Most patients (72.8%) 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 39 and Table 28). The majority of patients (71.8%) were discharged less than ten days after their surgery, 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 (32.2%) were extubated within six hours and 92.0% within 24 hours of surgery (Figure 41 and Table 30). Mean ventilation time was higher in public hospitals, compared with private hospitals (17.7 vs. 11.7 hours, respectively; Table 31). ICU LOS showed a cyclical pattern with patients often discharged at 24-hour intervals (Cases with an ICU length of stay of more than six weeks (1,008 hours) were classified as clinical outliers and excluded from the analysis.

Figure 42). Half of patients were discharged from the ICU within 48 hours (50.0%; Table 32). The mean length of ICU stay was lower in public hospitals (61.1 hours) compared to private hospitals (71.1 hours; Table 33).

Blood product transfusions were given to approximately one third of patients, and there was similar use of RBC and non-RBC products at public and private hospitals (Figure 43).

3.1 Patient characteristics

3.1.1 Clinical status

Figure 28. Clinical status of isolated valve patients by unit, 2022

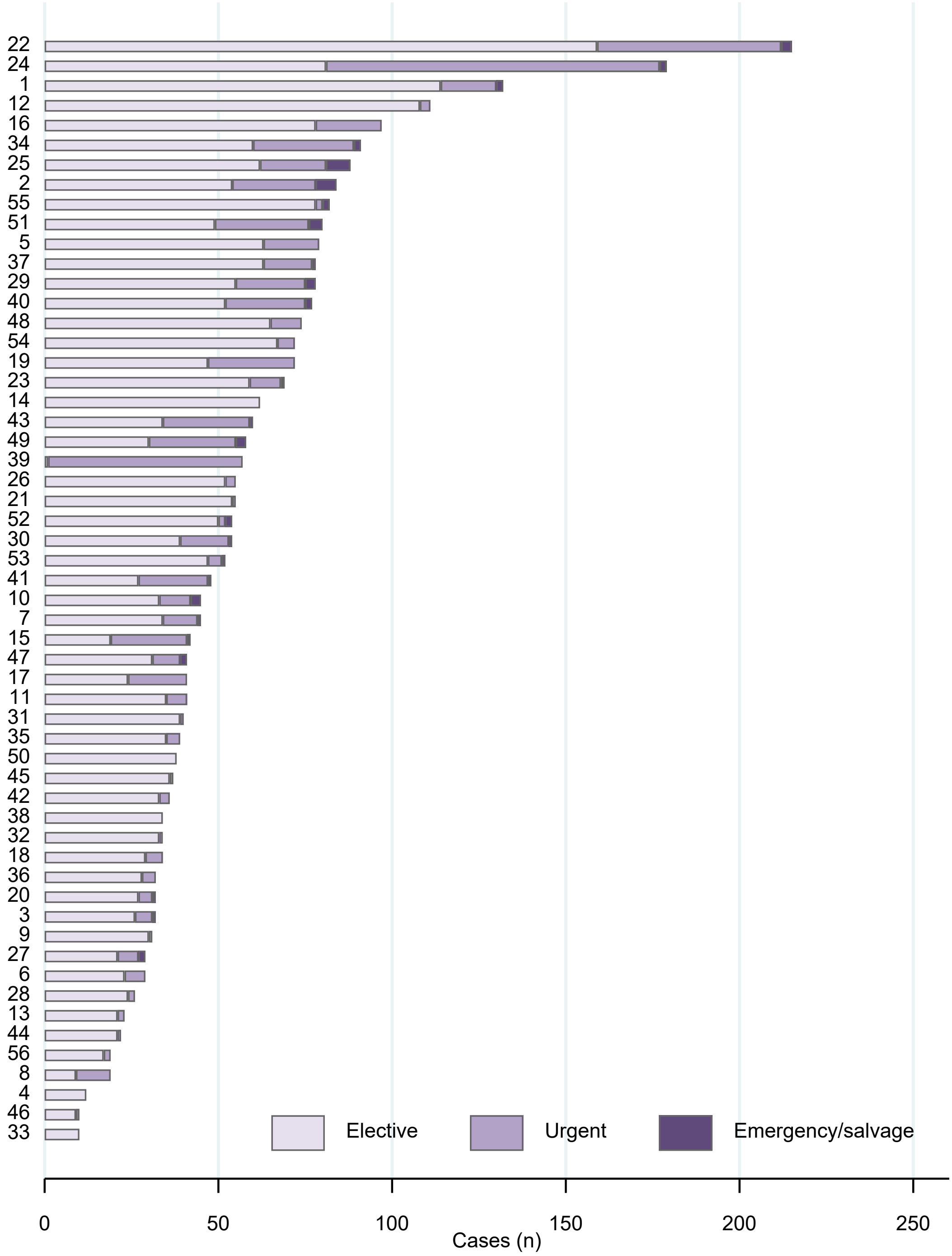


Table 22. Clinical status of isolated valve patients by year

	2018	2019	2020	2021	2022	Total
Elective (%)	85.2	82.0	78.5	78.2	76.6	80.0
Urgent (%)	13.3	16.1	19.7	19.7	21.7	18.1
Emergency/salvage (%)	1.5	2.0	1.8	2.1	1.7	1.8

3.1.2 Sex and age

Figure 29. Sex of isolated valve patients by unit, 2022

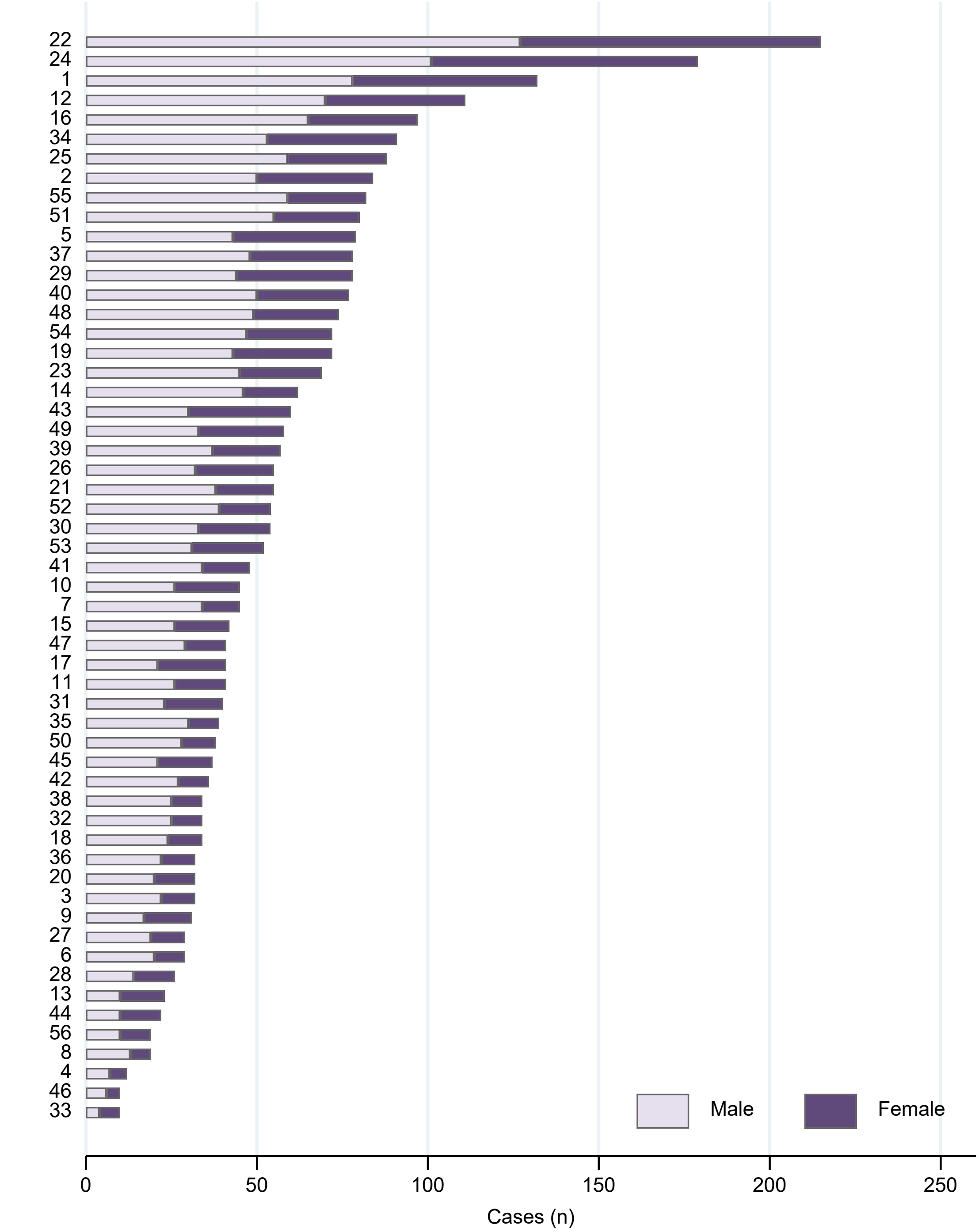
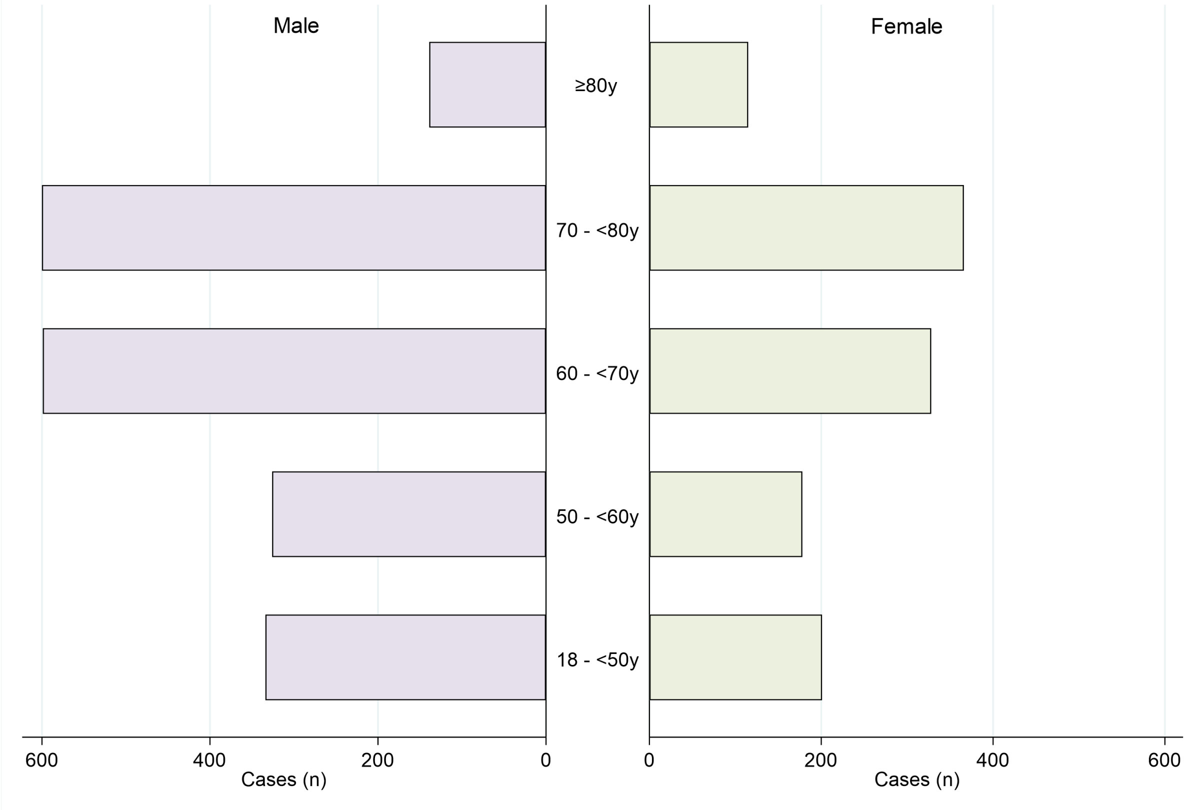


Table 23. Sex of isolated valve patients by year

	2018	2019	2020	2021	2022	Total
Male (%)	62.3	61.6	62.2	62.2	62.7	62.2
Female (%)	37.7	38.4	37.8	37.8	37.3	37.8

Figure 30. Age of isolated valve patients by sex, 2022



3.2 Previous cardiac surgery

Figure 31. Initial vs redo surgery in isolated valve patients by unit, 2022

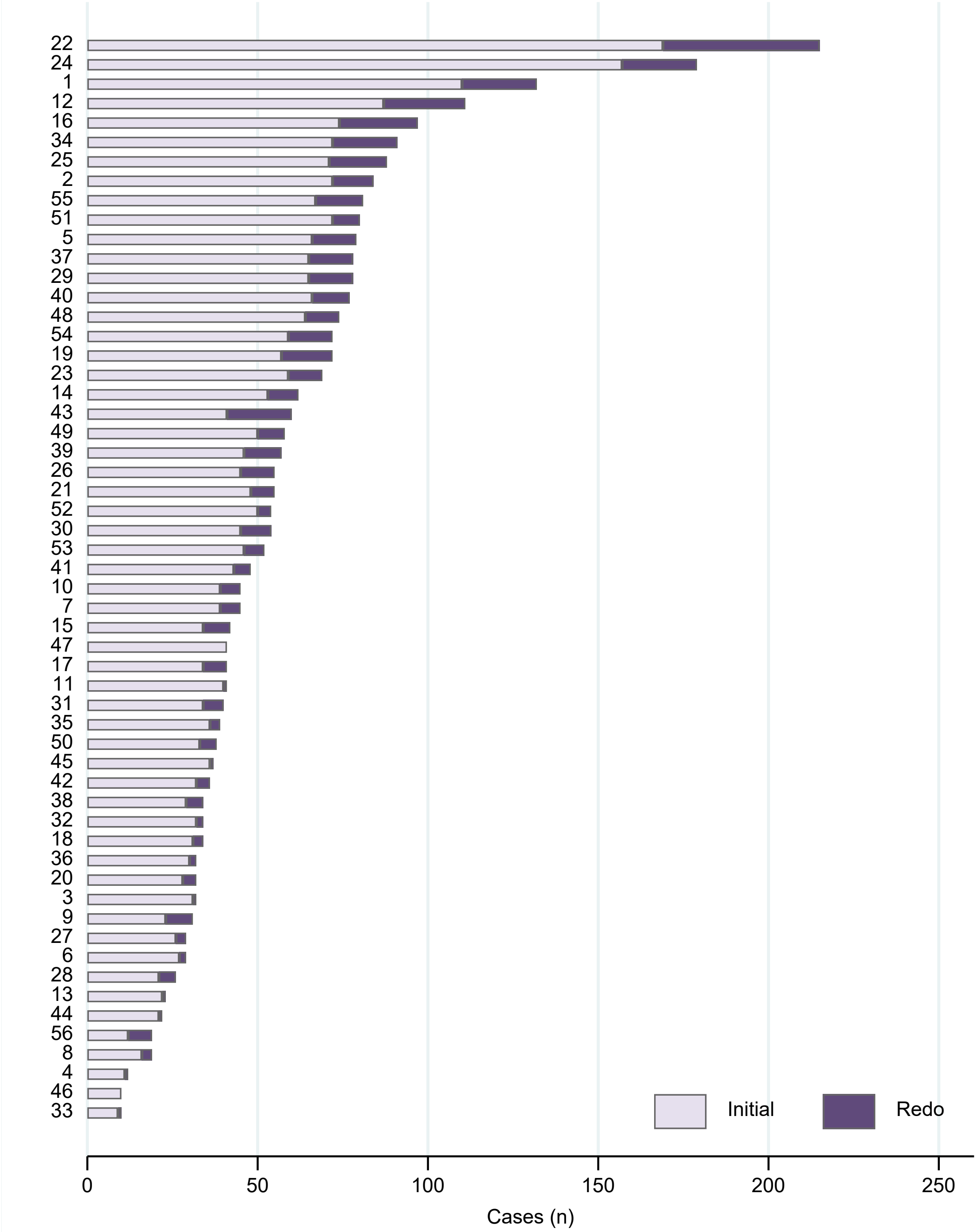
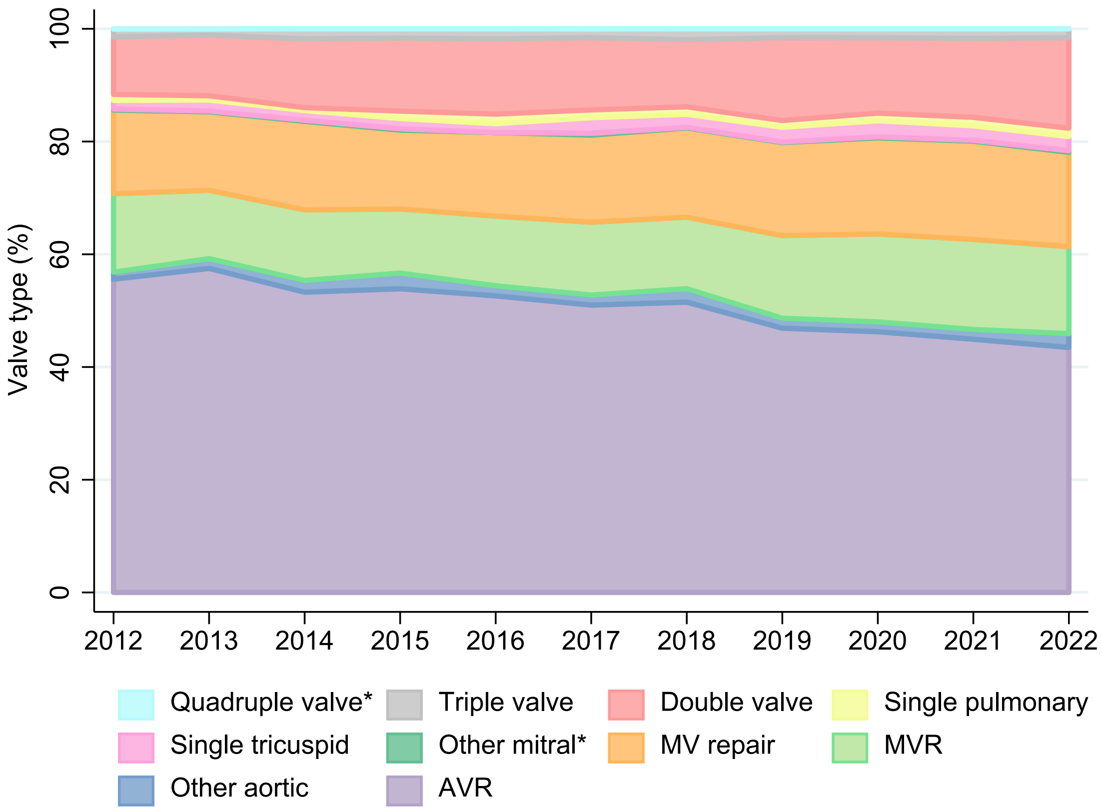


Table 24. Initial vs redo surgery in isolated valve patients by year

	2018	2019	2020	2021	2022	Total
Initial (%)	85.4	84.2	85.6	84.2	84.6	84.8
Redo (%)	14.6	15.8	14.4	15.8	15.4	15.2

3.3 Overview of all valve surgery

Figure 32. Isolated valve surgery by year, 2012 – 2022



* Not visible on figure as these categories represent a total of 54 out of 29,073 cases, combined, between 2012 and 2022

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, 2022

	Total cases		In-hospital mortality		Total OM	
Valve surgery type	n	%	n	%	n	%
Single aortic	1,439	45.8	19	1.3	21	1.5
AVR	1,367	43.5	18	1.3	19	1.4
Other aortic	72	2.3	1	1.4	2	2.8
Single mitral	1,026	32.6	14	1.4	17	1.7
MVR	487	15.5	13	2.7	15	3.1
MV repair	530	16.9	1	0.2	2	0.4
Other mitral	9	0.3	0	0.0	0	0.0
Single tricuspid	80	2.5	3	3.8	3	3.8
Single pulmonary	47	1.5	1	2.1	1	2.1
Aortic and mitral	215	6.8	10	4.7	11	5.1
Mitral and tricuspid	247	7.9	6	2.4	6	2.4
Aortic and tricuspid	18	0.6	2	11.1	2	11.1
Other double valve	24	0.8	3	12.5	3	12.5
Triple valve	49	1.6	2	4.1	2	4.1
Quadruple valve	0	-	0	-	0	-
Total valve surgery	3,145	100.0	60	1.9	66	2.1

3.4 Single valve surgery

Figure 33. Types of isolated single valve surgery performed by unit, 2022

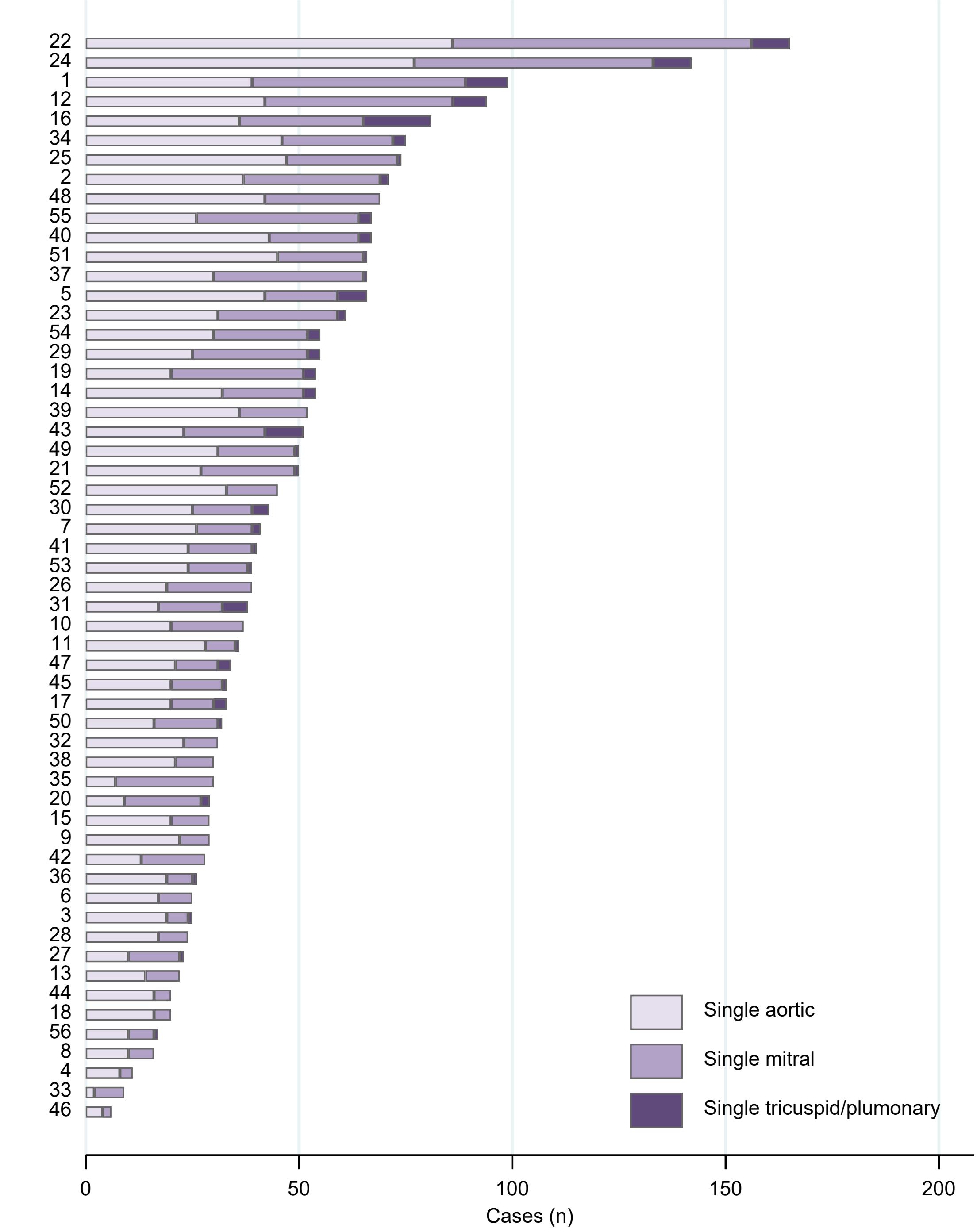
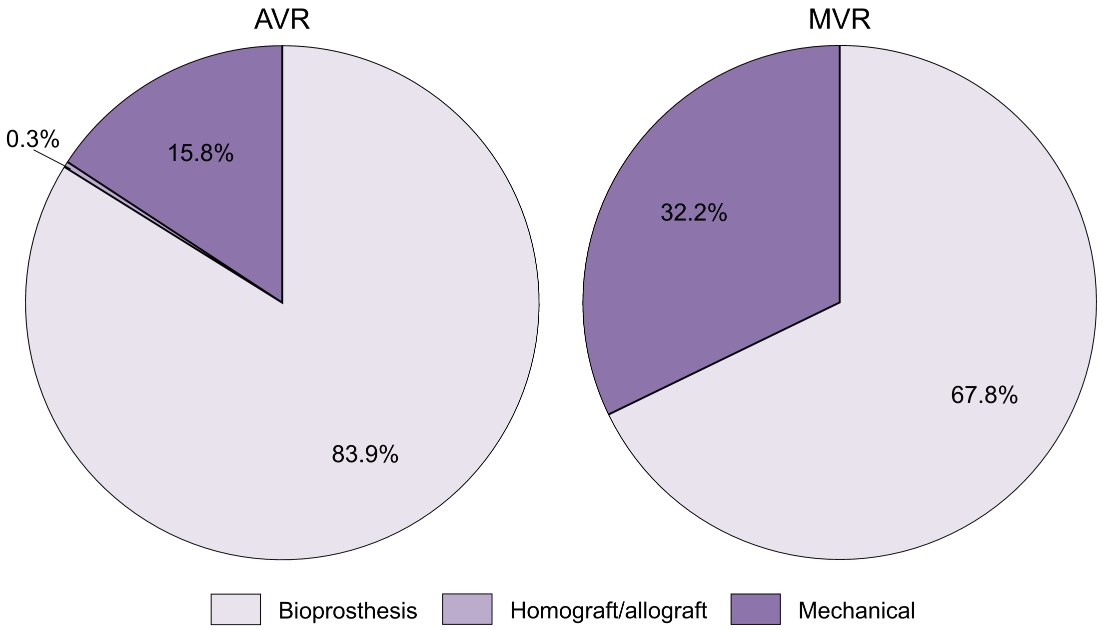


Table 26. Types of isolated single valve surgery performed by year

	2018	2019	2020	2021	2022	Total
Single aortic (%)	62.5	58.1	56.5	55.4	55.8	57.6
Single mitral (%)	33.2	37.3	38.6	39.8	39.4	37.7
Single tricuspid/pulmonary (%)	4.2	4.6	4.9	4.8	4.8	4.7

3.4.1 Prothesis types used

Figure 34. Prosthesis type used for single AVR or MVR surgery, 2022



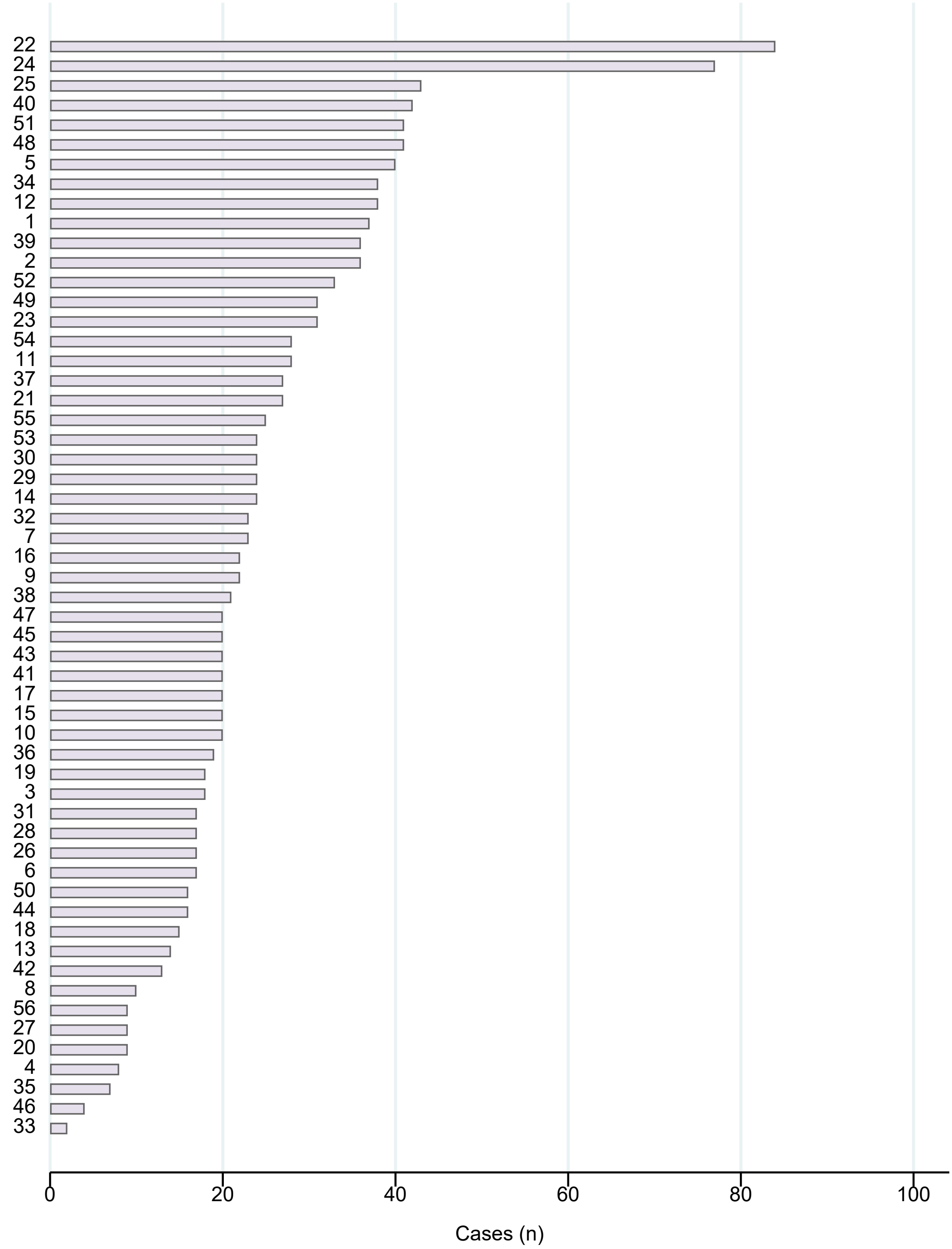
3.5 Influence of patient characteristics on operative mortality

Table 27. OM following the three most common isolated single valve surgeries, by patient demographics and risk factors, 2018 - 2022

	AVR		MVR		MV repair	
	n	OM (%)	n	OM (%)	n	OM (%)
Clinical status						
Elective	5,953	0.9	1,628	1.9	2,297	0.3
Urgent	1,198	2.5	578	4.0	288	1.0
Emergency/salvage	96	10.4	99	10.1	19	0.0
Sex/age						
Male	4,902	1.1	1,150	2.7	1,730	0.1
18 - <50y	500	0.6	201	2.0	360	0.0
50 - <60y	755	1.3	198	1.5	414	0.0
60 - <70y	1,539	0.6	277	4.0	503	0.0
70 - <80y	1,725	0.9	364	3.0	380	0.3
≥80y	383	4.2	110	1.8	73	1.4
Female	2,345	1.7	1,155	2.9	874	0.8
18 - <50y	177	2.8	260	1.5	155	0.0
50 - <60y	288	1.0	175	2.9	167	0.6
60 - <70y	709	1.3	244	2.0	250	0.8
70 - <80y	947	1.8	328	4.3	243	0.8
≥80y	224	2.2	148	3.4	59	3.4
LVF						
EF>45%	6,242	1.1	1,988	2.6	2,430	0.4
EF≥30% - ≤45%	690	2.0	242	2.9	126	0.0
EF<30%	202	4.0	32	9.4	6	0.0
Previous MI						
No MI	6,756	1.2	2,124	2.4	2,536	0.3
NSTEMI	319	2.5	96	3.1	34	2.9
STEMI	70	1.4	58	15.5	13	0.0
Unknown type	102	2.0	26	3.8	20	0.0
Previous surgery						
Initial	6,430	1.1	1,771	2.2	2,519	0.4
Redo	816	2.7	533	4.7	82	0.0
Dialysis						
No	7,153	1.2	2,258	2.6	2,594	0.3
Yes	94	9.6	46	13.0	9	0.0
Pre-operative creatinine						
≤200 µmol/L	7,069	1.2	2,213	2.6	2,587	0.3
>200 µmol/L	169	5.9	88	6.8	15	0.0

3.6 AVR

Figure 35. Isolated AVR surgery by unit, 2022



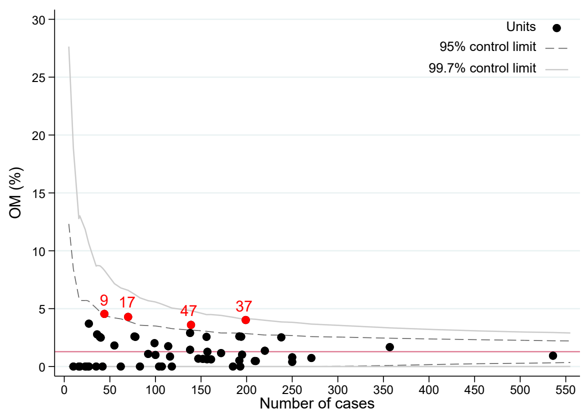
3.6.1 Unit outcomes – mortality, complications and resource utilisation

3.6.1.1 Operative mortality

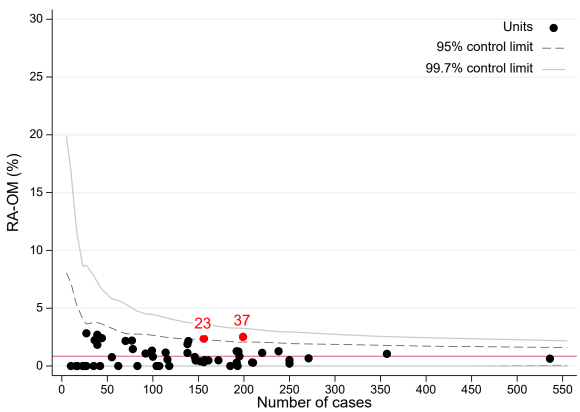
To enhance the visibility of the individual unit outcomes on the funnel plots, units with very low case numbers (<5 in the five-year pooled data) were excluded. A full summary of outcomes for all units is provided in Appendix F (pg. 89).

Figure 36. OM following isolated AVR surgery 2018 – 2022, by unit

a. OM



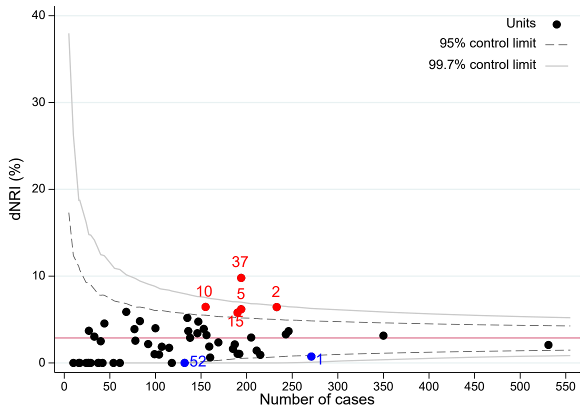
b. RA-OM



3.6.1.2 Complications

Figure 37. dNRI following isolated AVR surgery 2018 – 2022, by unit

a. dNRI



b. RA-dNRI

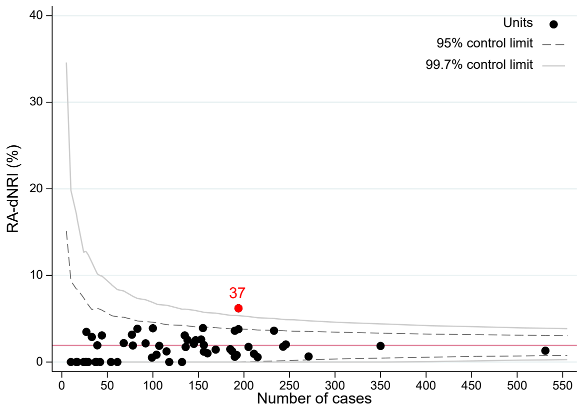
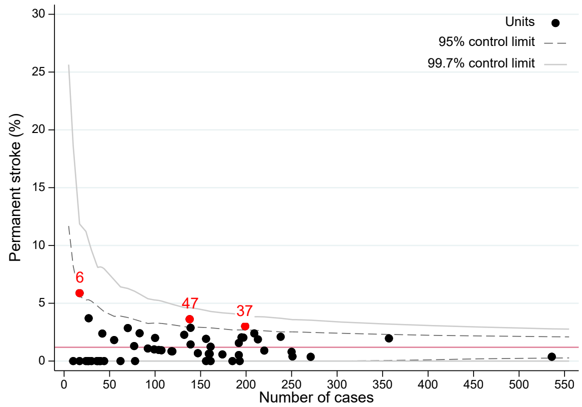
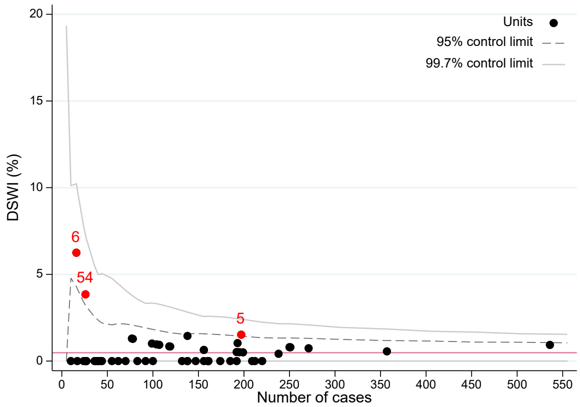


Figure 38. Complications following isolated AVR surgery 2018 – 2022, by unit

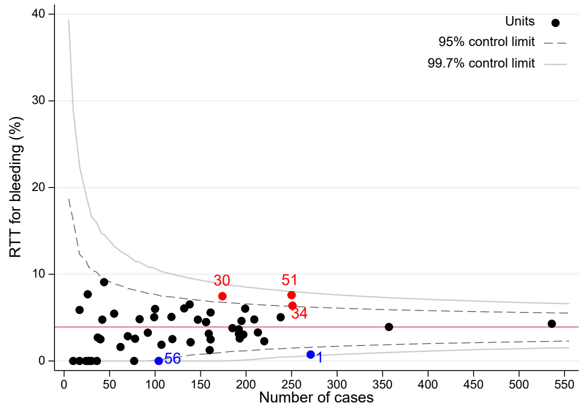
a. Permanent stroke



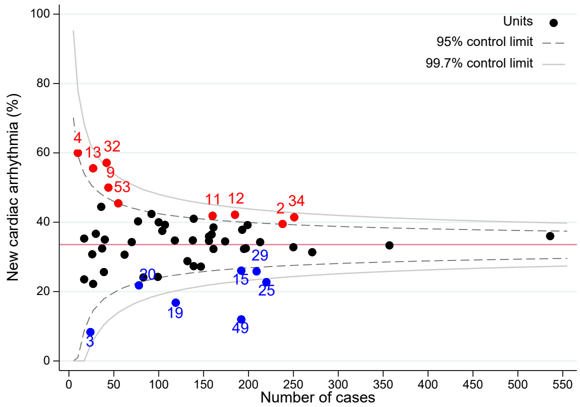
b. DSWI



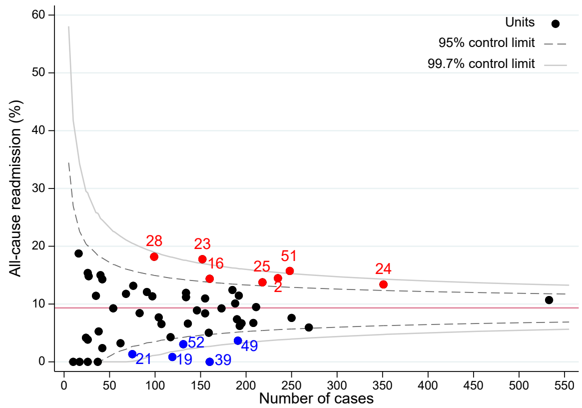
c. RTT for bleeding



d. New cardiac arrythmia



e. All-cause readmission



3.6.1.3 Resource utilisation

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

Figure 39. Distribution of pre-operative LOS for isolated AVR patients, 2022

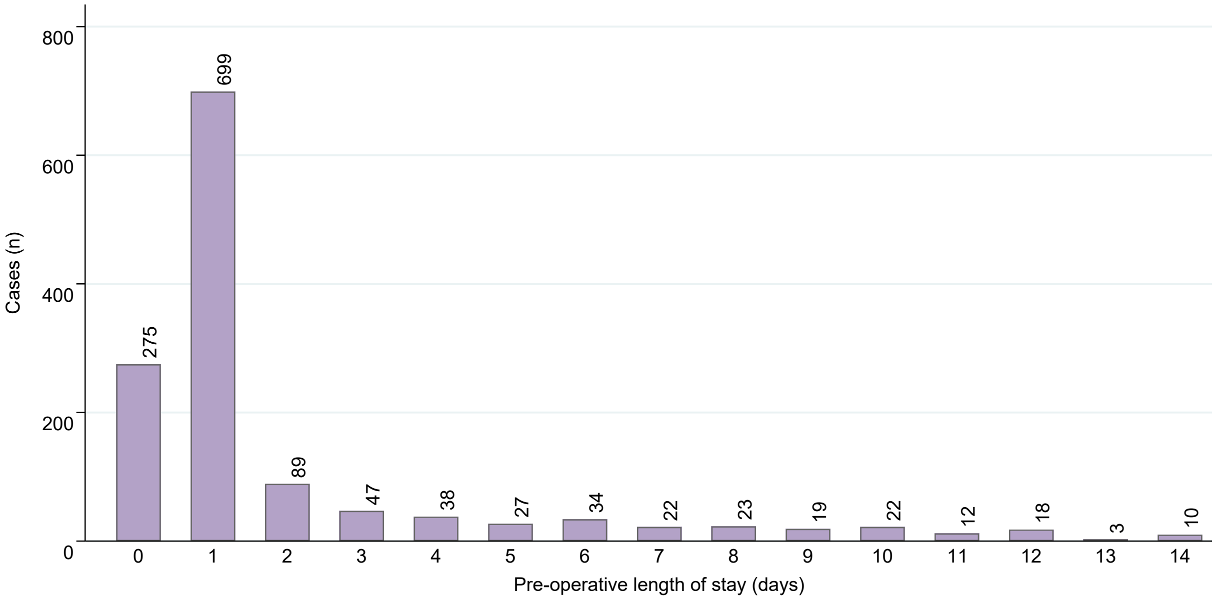


Table 28. Summary of pre-operative LOS for public and private isolated AVR patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	2.4	1	0 - 3
Private	1.7	1	1 - 1
Total	2.1	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 40. Distribution of post-operative LOS for isolated AVR patients, 2022

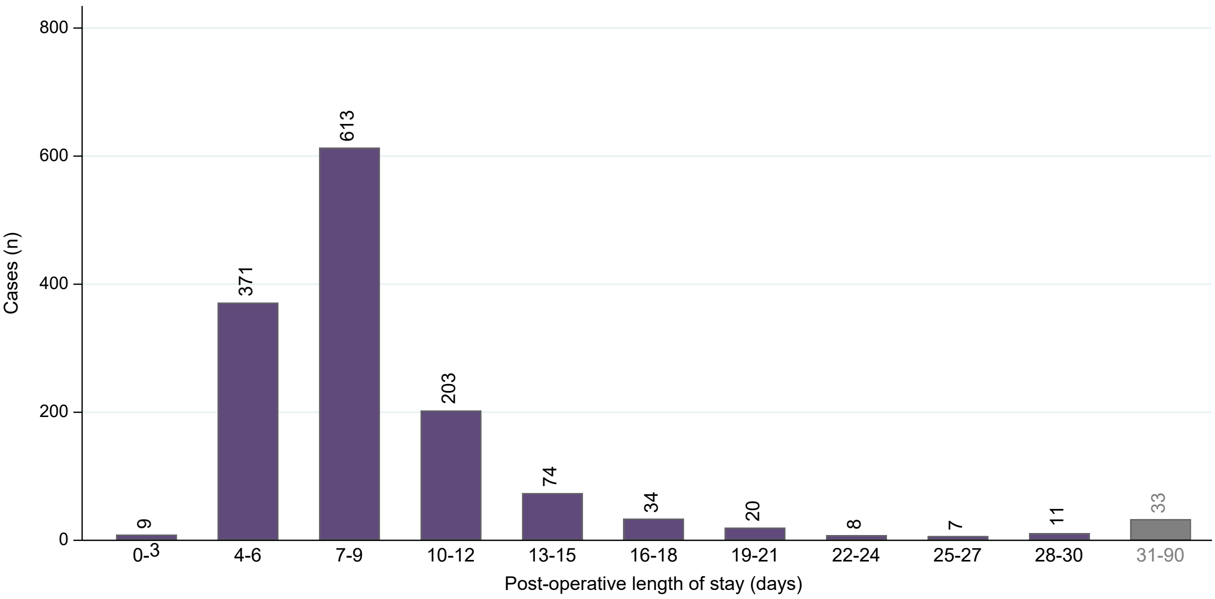


Table 29. Summary of post-operative LOS for public and private isolated AVR patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	9.7	7	6 - 10
Private	9.2	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 41. Distribution of initial post-operative ventilation time for isolated AVR patients, 2022

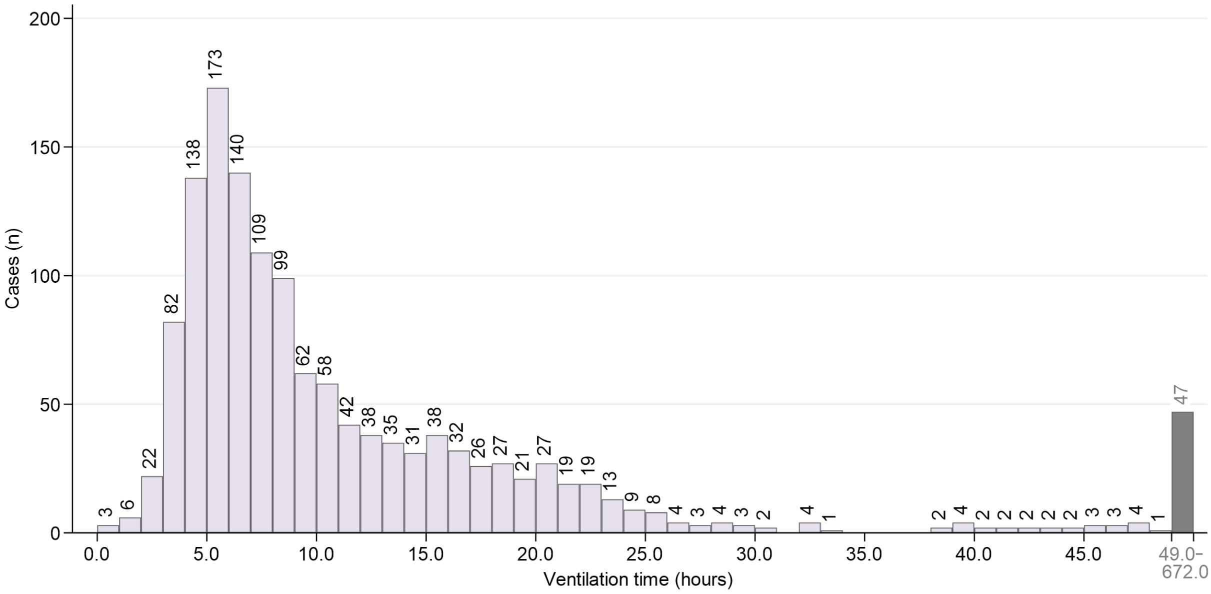


Table 30. Cumulative proportion of patients extubated by hour up to four weeks for isolated AVR surgery, 2022

	6h	12h	24h	48h	96h	192h	384h	672h
Cumulative patients (n)	442	939	1,262	1,324	1,353	1,367	1,368	1,372
Cumulative percentage (%)	32.2	68.4	92.0	96.5	98.6	99.6	99.7	100.0

Table 31. Summary of initial post-operative ventilation time for public and private isolated AVR patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	17.7	8.6	5.9 - 15.1
Private	11.7	7.2	5.1 - 13.3
Total	15.0	8.0	5.5 - 14.8

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

Figure 42. Distribution of ICU length of stay for isolated AVR patients, 2022

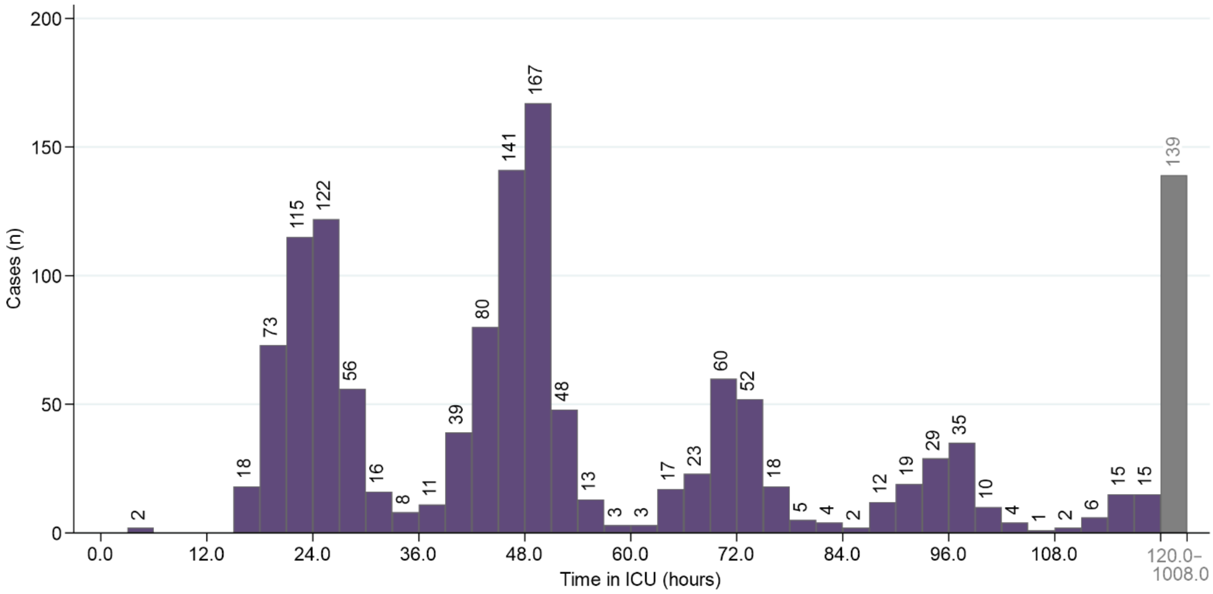


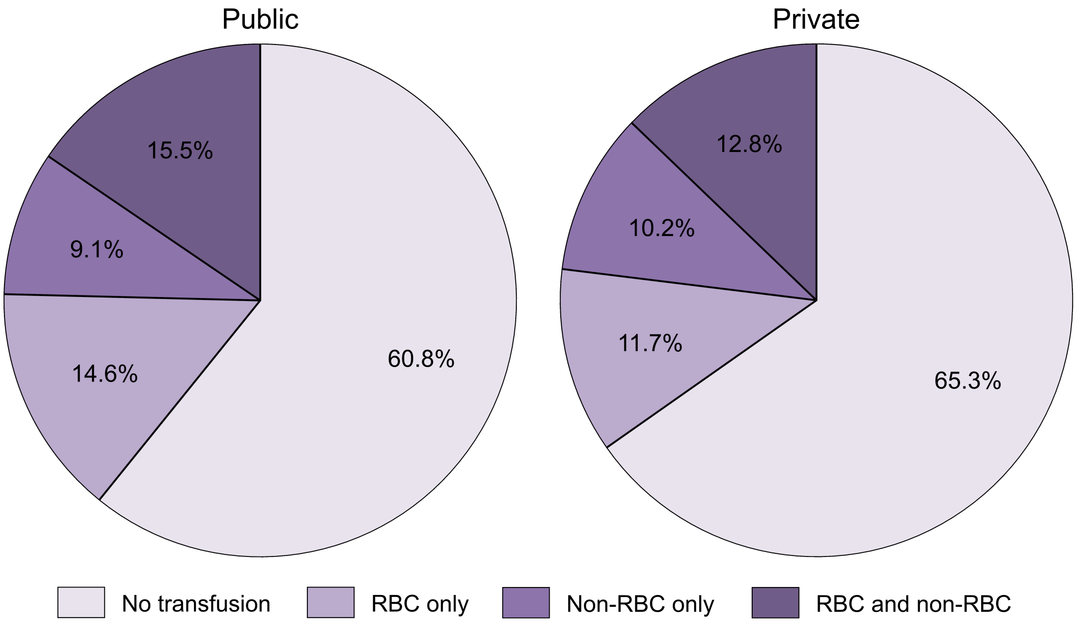
Table 32. Cumulative proportion of patients discharged from ICU by hour up to six weeks for isolated AVR surgery, 2022

	12h	24h	48h	72h	144h	288h	576h	1008h
Cumulative patients (n)	2	214	691	1,016	1,296	1,363	1,377	1,383
Cumulative percentage (%)	0.1	15.5	50.0	73.5	93.7	98.6	99.6	100.0

Table 33. Summary of ICU length of stay for public and private isolated AVR patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	61.1	41.7	24.0 - 70.0
Private	71.1	50.7	46.5 - 76.5
Total	65.5	48.1	27.5 - 72.7

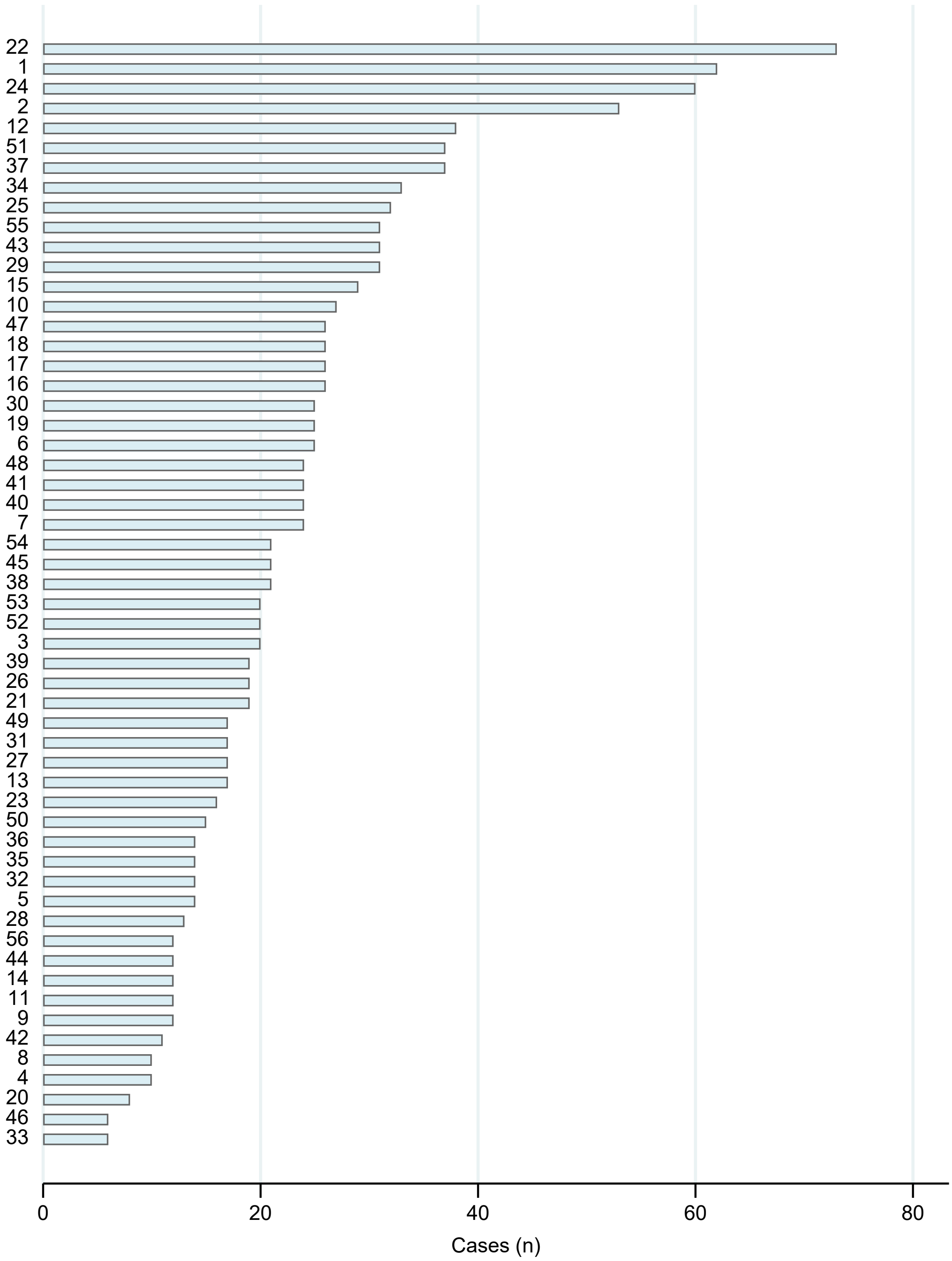
Figure 43. Blood product usage at public and private hospitals for isolated AVR patients, 2022



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

4. Combined Valve and CABG Surgery

Figure 44. Combined valve and CABG cases by unit, 2022



Summary of valve and CABG activity

All valve and CABG procedures: Type and mortality

The most common type of valve and CABG surgery in the last ten years has been AVR and CABG, despite a decrease from 68.7% of all valve and CABG procedures in 2012 to 63.3% in 2022. In 2022, the second and third most frequent procedures were MVR and CABG, followed by MV repair and CABG, which each accounted for approximately 25.2% of valve and CABG surgery cases (Figure 52). In-hospital mortality and OM for all valve and CABG patients were 3.6 and 4.2%, respectively, in 2022 (Table 40).

AVR with CABG: Case volume and outcomes

Despite AVR with CABG being the most common valve and CABG procedure, 86% of participating units had a case volume of 20 or less procedures in 2022 (Figure 55). Data for the last five years was pooled to provide sufficient case numbers for analysis of outcomes.

The majority of units performed comparably in 2022. The OM for AVR and CABG patients was 2.8% in 2018-22 (Figure 56a), which is lower than the OM reported by the STS for 2021 (4.4%) and in-hospital mortality reported by the registry of the German Society for Thoracic and Cardiovascular Surgery for 2022 (4.2%) (2, 3). The risk-adjusted OM calculated using the Database's ANZSCORE model was 2.5% for 2018-22 (Figure 56b) The incidences of the other key performance indicators were dNRI (5.0%), risk-adjusted dNRI (2.1%), permanent stroke (1.6%), DSWI (1.1%) and RTT for bleeding (5.1%; Figure 57 and Figure 58).

Resource utilisation

Most patients (64.4%) 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 59 and Table 47). The majority of patients (57.1%) were discharged less than ten days following their surgery, with a median post-operative LOS at public and private hospitals of nine days (Figure 60 and Table 48).

Approximately 8% of patients were ventilated for more than 48 hours and patients at public hospitals had a higher mean duration of ventilation (26.9 hours), compared to private hospitals (16.3 hours; Table 49 and Table 50). As was also seen with the other major procedure types, ICU LOS showed a cyclical pattern with patients often discharged at 24-hour intervals (Cases with an ICU length of stay of more than six weeks (1,008 hours) were classified as clinical outliers and excluded from the analysis.

Figure 62). Only 36.5% of patients were discharged in less than 48 hours and the mean ICU LOS was similar between public (87.6 hours) and private (85.1 hours) hospitals (Table 51 and Table 52).

There was slightly increased use of blood transfusions for AVR and CABG patients at public hospitals (63.0%), compared to private hospitals (57.9%), with the most common type of transfusion including both RBC and non-RBC products (Figure 63).

4.1 Patient characteristics

4.1.1 Clinical status

Figure 45. Clinical status of combined valve and CABG patients by unit, 2022

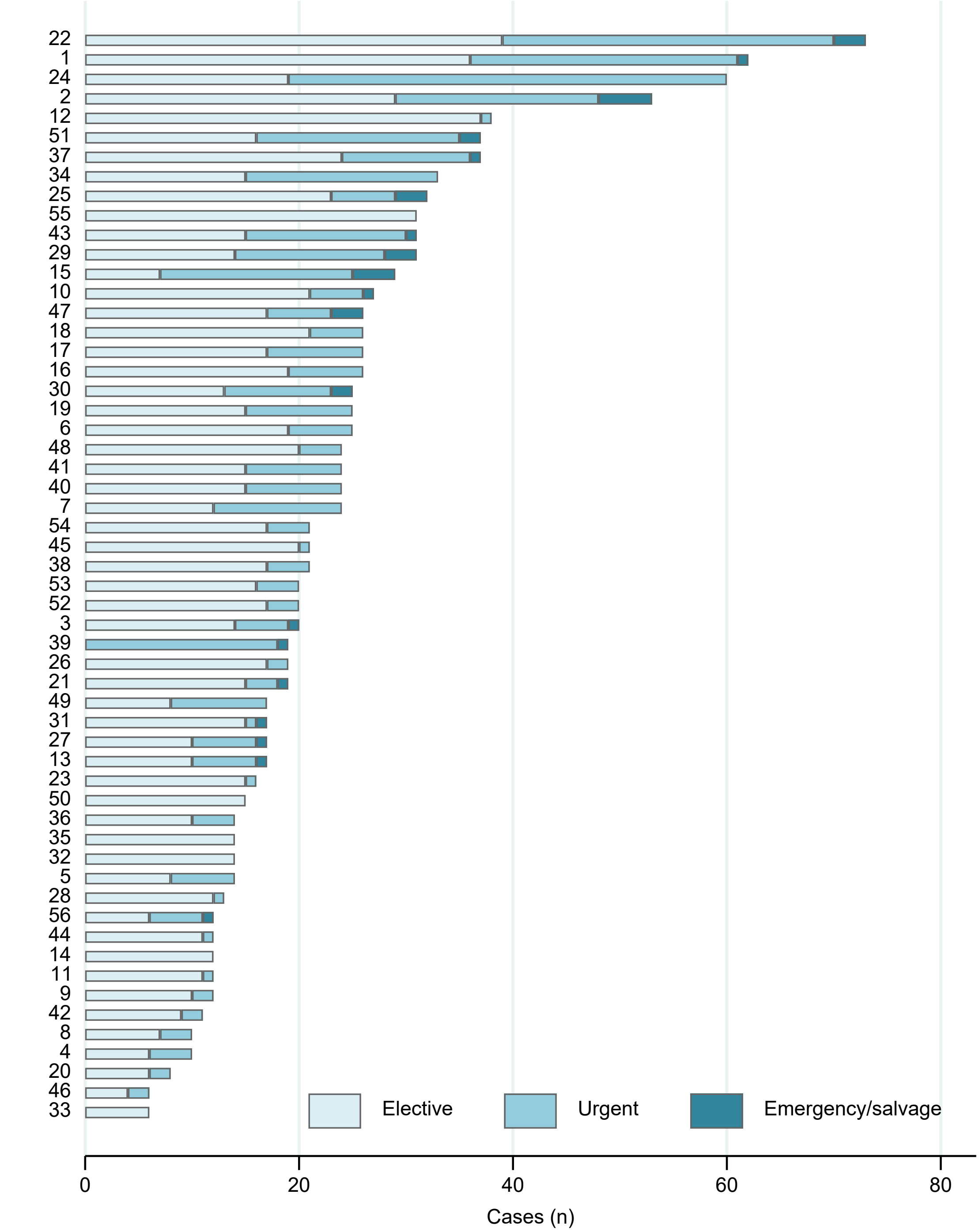


Table 34. Clinical status of combined valve and CABG patients by year

	2018	2019	2020	2021	2022	Total
Elective (%)	78.0	72.7	68.5	64.7	65.8	69.8
Urgent (%)	20.6	24.3	29.7	33.1	31.4	27.9
Emergency/salvage (%)	1.5	3.0	1.7	2.2	2.8	2.2

4.4.2 Sex and age

Figure 46. Sex of combined valve and CABG patients by unit, 2022

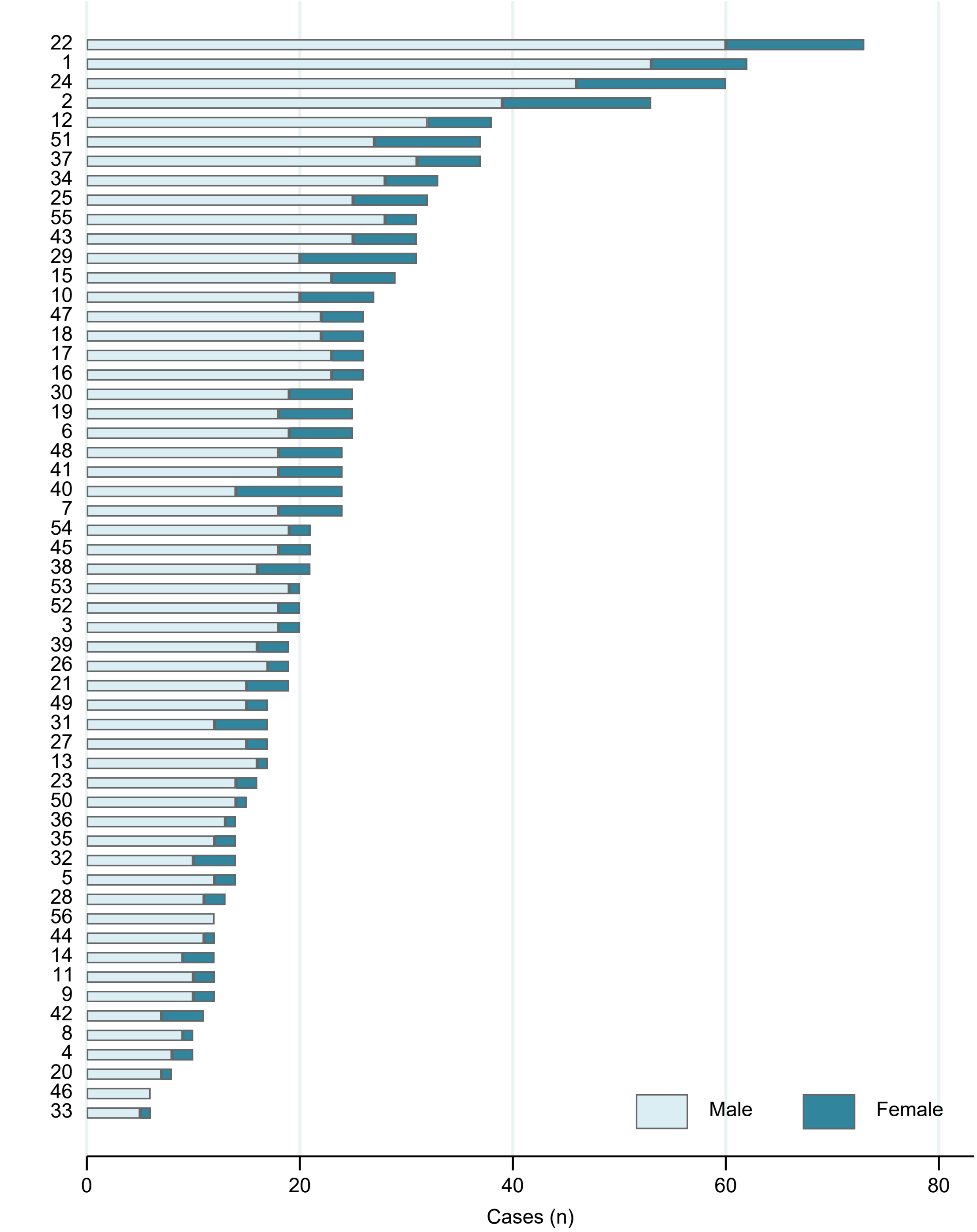
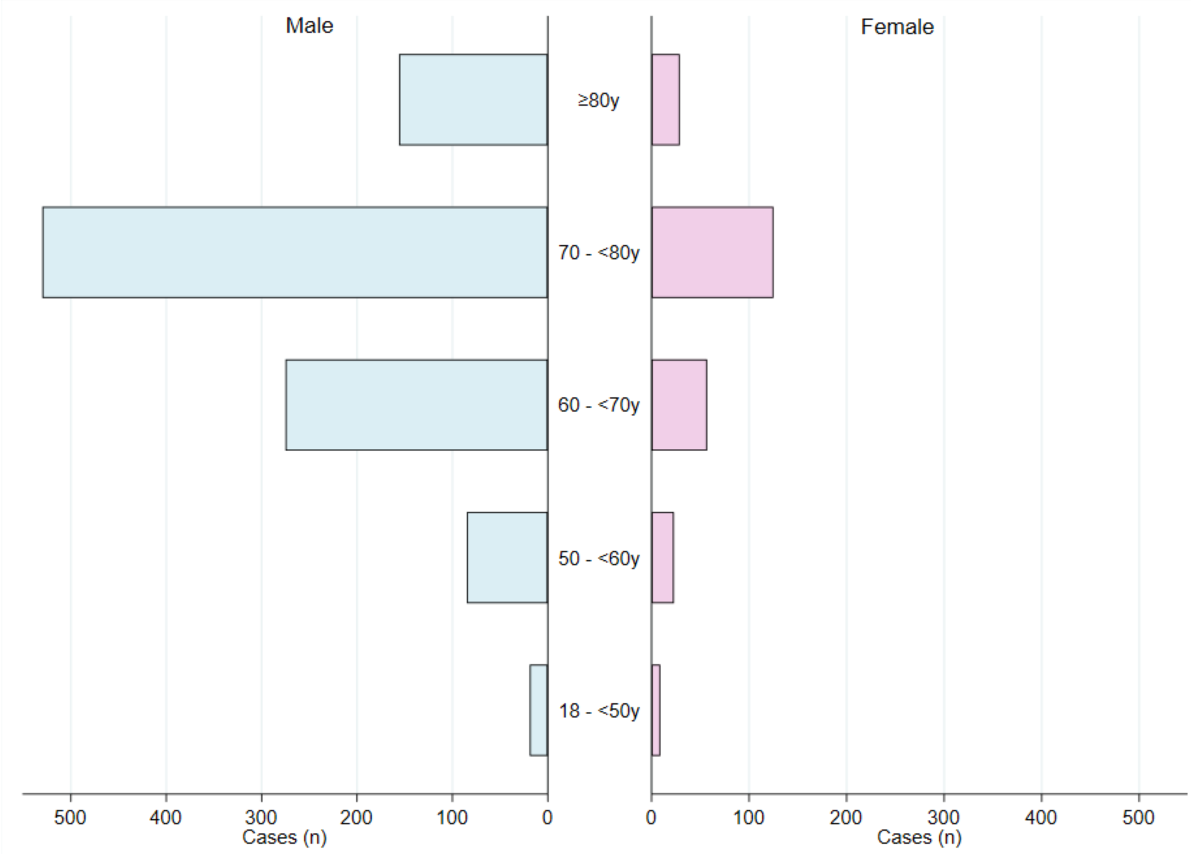


Table 35. Sex of combined valve and CABG patients by year

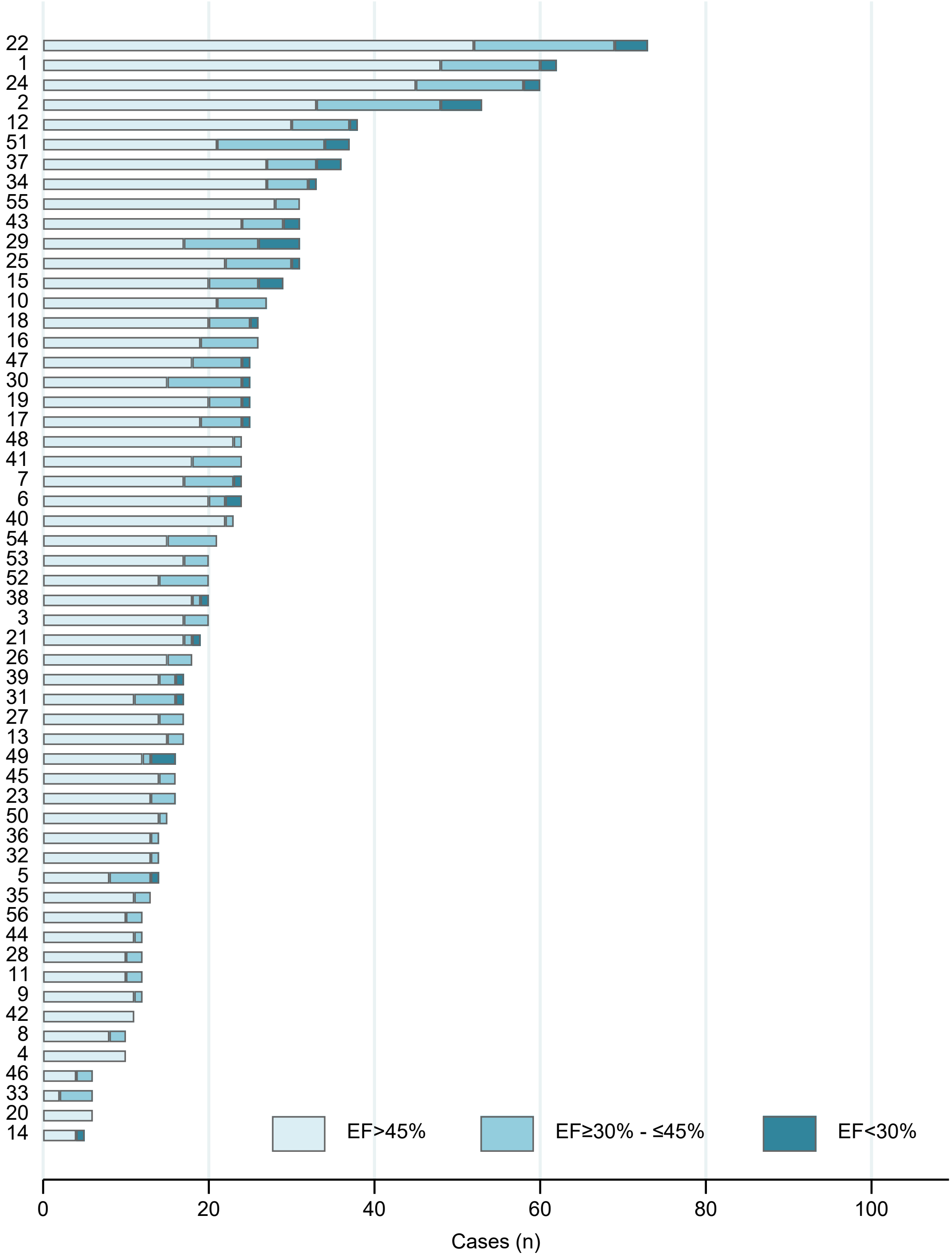
	2018	2019	2020	2021	2022	Total
Male (%)	79.8	81.5	80.6	80.4	81.4	80.8
Female (%)	20.2	18.5	19.4	19.6	18.6	19.2

Figure 47. Age of combined valve and CABG patients by sex, 2022



4.1.3 Left ventricular function

Figure 48. Pre-operative LVF of combined valve and CABG patients by unit, 2022



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. 84).

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

	2018	2019	2020	2021	2022	Total
EF>45% (%)	80.4	79.6	79.6	80.4	77.1	79.4
EF≥30% - ≤45% (%)	15.3	16.3	16.1	15.3	19.0	16.4
EF<30% (%)	4.3	4.1	4.3	4.3	3.8	4.2

4.1.4 Previous myocardial infarction

Figure 49. Previous MI in combined valve and CABG patients by unit, 2022

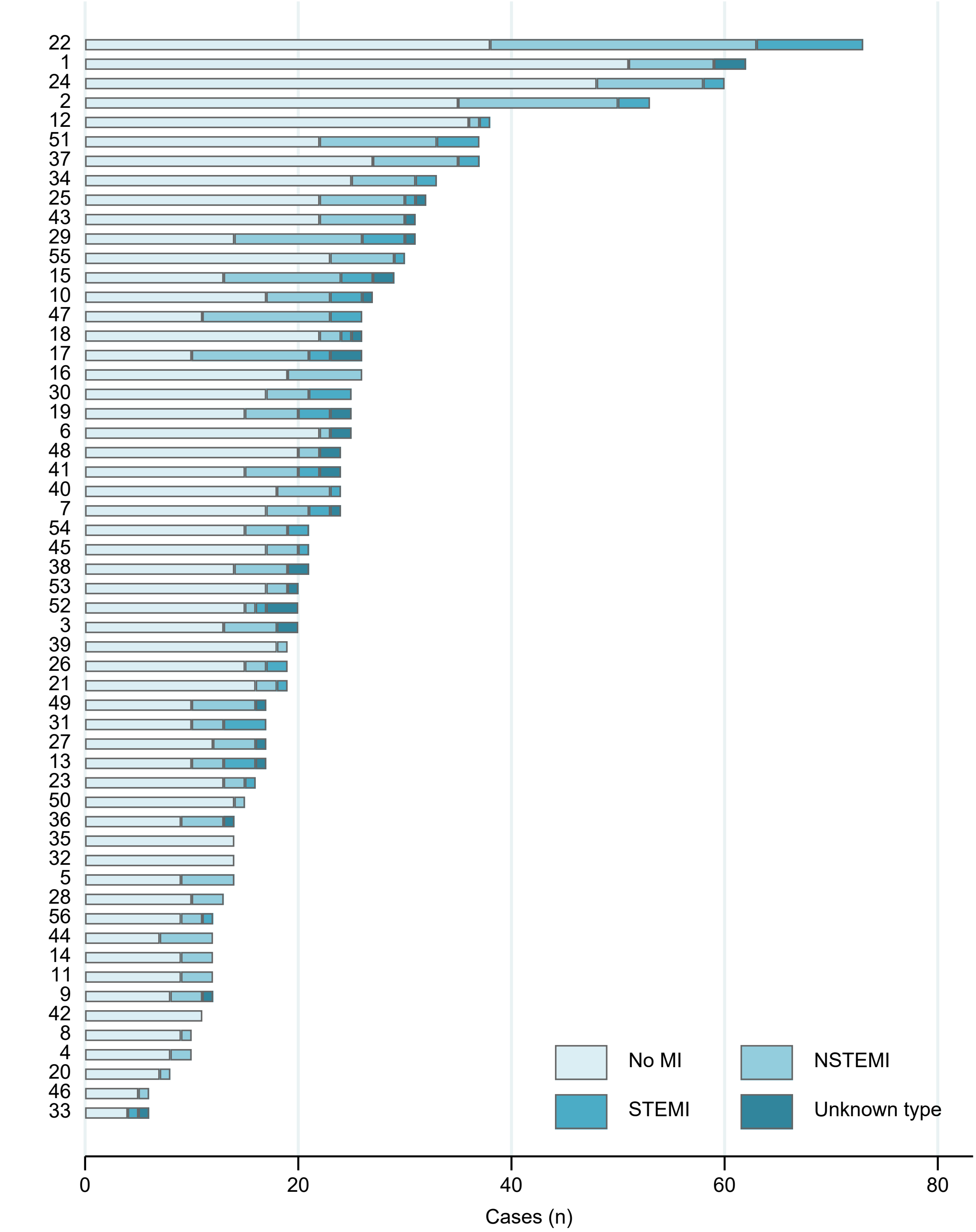


Table 37. Previous MI in combined valve and CABG patients by year

	2018	2019	2020	2021	2022	Total
No MI (%)	71.2	73.2	71.4	70.3	71.2	71.4
NSTEMI (%)	19.3	19.7	21.0	20.6	20.7	20.3
STEMI (%)	5.7	3.7	3.9	5.8	5.4	4.9
Unknown type (%)	3.9	3.4	3.7	3.3	2.8	3.4

4.1.5 Timing of previous myocardial infarction

Figure 50. Timing of previous MI in combined valve and CABG patients by unit, 2022

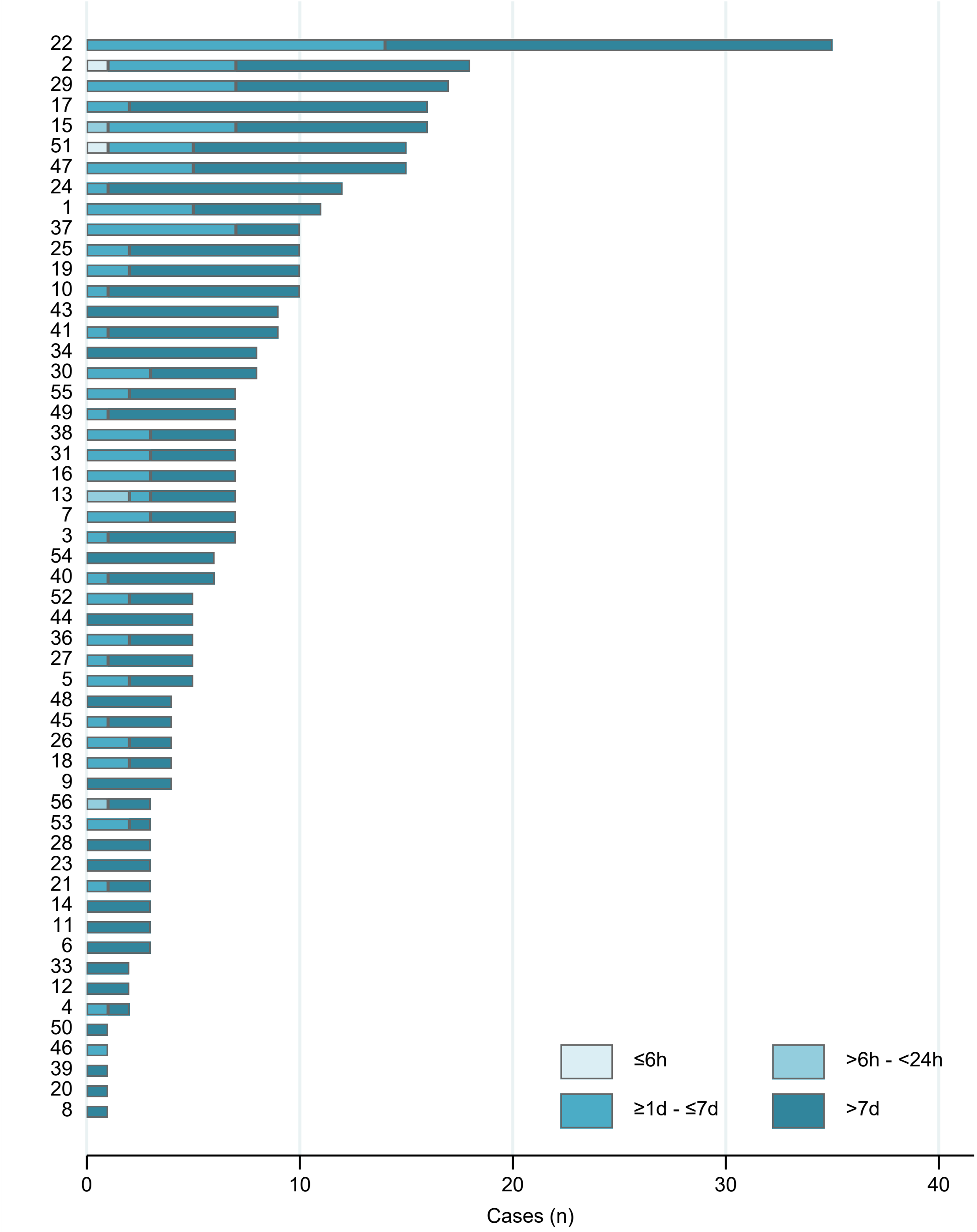


Table 38. Timing of previous MI in combined valve and CABG patients by year

	2018	2019	2020	2021	2022	Total
≤6hr (%)	0.8	1.7	0.6	1.3	0.5	1.0
>6hr - <24hr (%)	2.0	0.9	1.4	2.0	1.1	1.5
≥1d - ≤7d (%)	19.9	22.1	24.5	26.5	26.8	24.1
>7d (%)	77.3	75.3	73.5	70.2	71.6	73.5

4.2 Previous cardiac surgery

Figure 51. Initial vs redo surgery in combined valve and CABG patients by unit, 2022

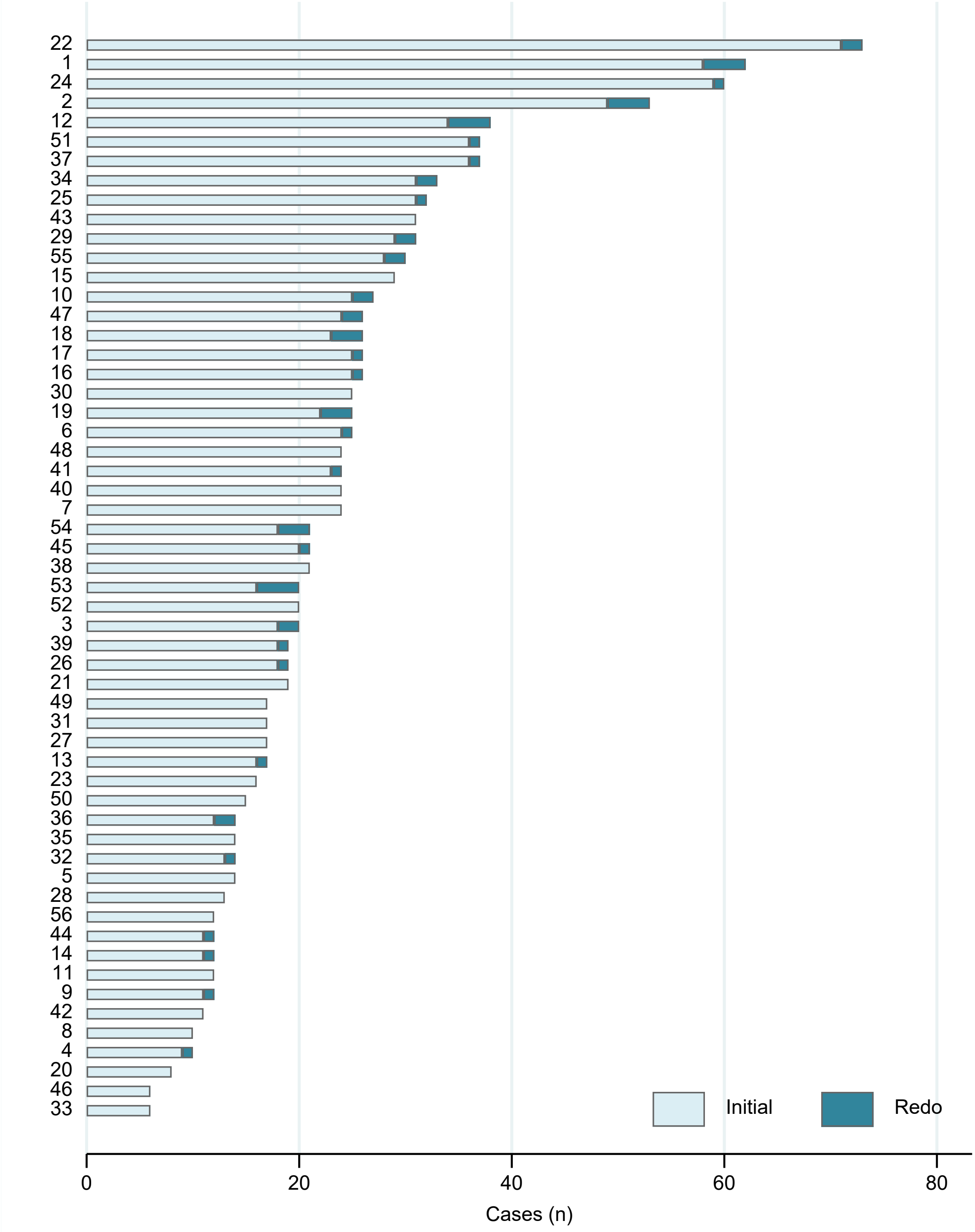
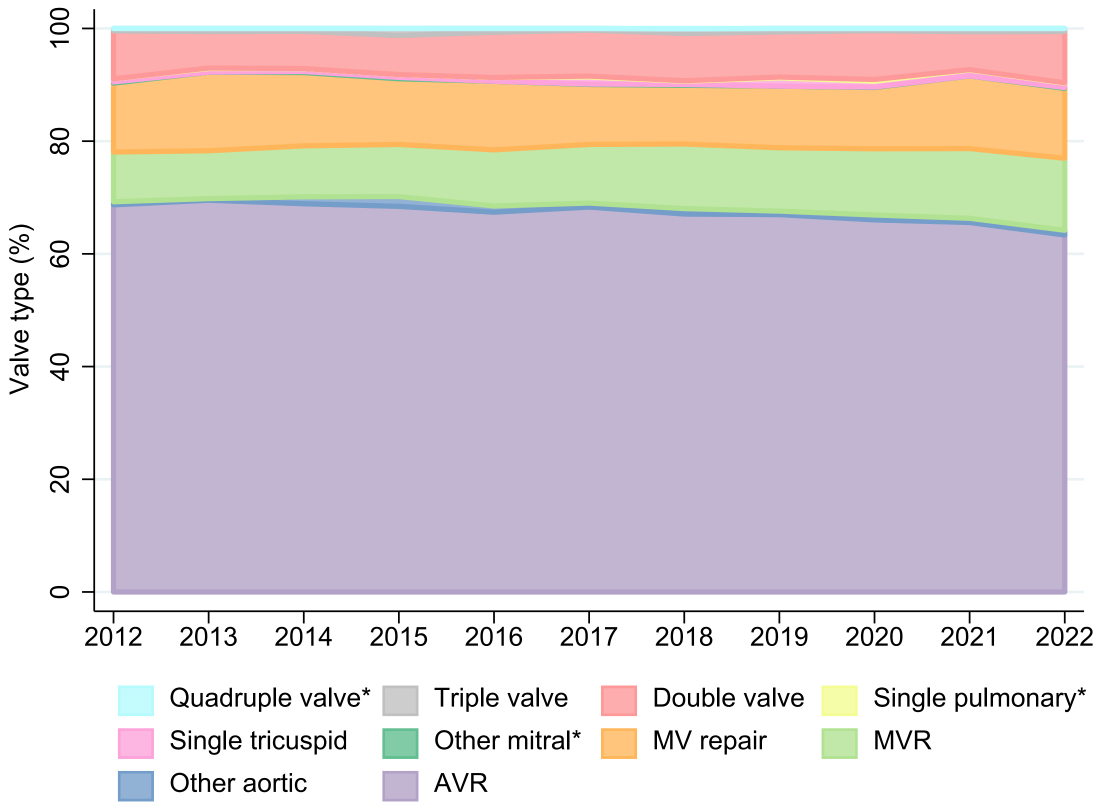


Table 39. Initial vs redo surgery in combined valve and CABG patients by year

	2018	2019	2020	2021	2022	Total
Initial (%)	95.0	95.5	94.5	95.6	95.6	95.2
Redo (%)	5.0	4.5	5.5	4.4	4.4	4.8

4.3 Overview of all valve combined with CABG surgery

Figure 52. Combined valve and CABG surgery by year, 2012 – 2022



*Not visible on figure as these categories represent a total of 26 out of 13,103 cases, combined, between 2012 and 2022

Table 40. In-hospital mortality and total OM in combined valve and CABG patients, 2022

	Total cases		In-hospital mortality		Total OM	
Valve surgery type	n	%	n	%	n	%
Single aortic	829	64.1	26	3.1	32	3.9
AVR	817	63.1	24	2.9	30	3.7
Other aortic	11	0.9	2	18.2	2	18.2
Single mitral	328	25.3	10	3.0	11	3.4
MVR	166	12.8	8	4.8	8	4.8
MV repair	160	12.4	2	1.3	3	1.9
Other mitral	2	0.2	0	0.0	0	0.0
Single tricuspid	10	0.8	2	20.0	2	20.0
Single pulmonary	1	0.1	0	0.0	0	0.0
Aortic and mitral	62	4.8	4	6.5	4	6.5
Mitral and tricuspid	50	3.9	4	8.0	4	8.0
Aortic and tricuspid	5	0.4	1	20.0	1	20.0
Other double valve	2	0.2	0	0.0	0	0.0
Triple valve	7	0.5	0	0.0	0	0.0
Quadruple valve	0	0.0	0	-	0	-
Total valve surgery	1,294	100.0	47	3.6	54	4.2

4.4 Combined single valve and CABG surgery

Figure 53. Types of combined single valve and CABG surgery performed by unit, 2022

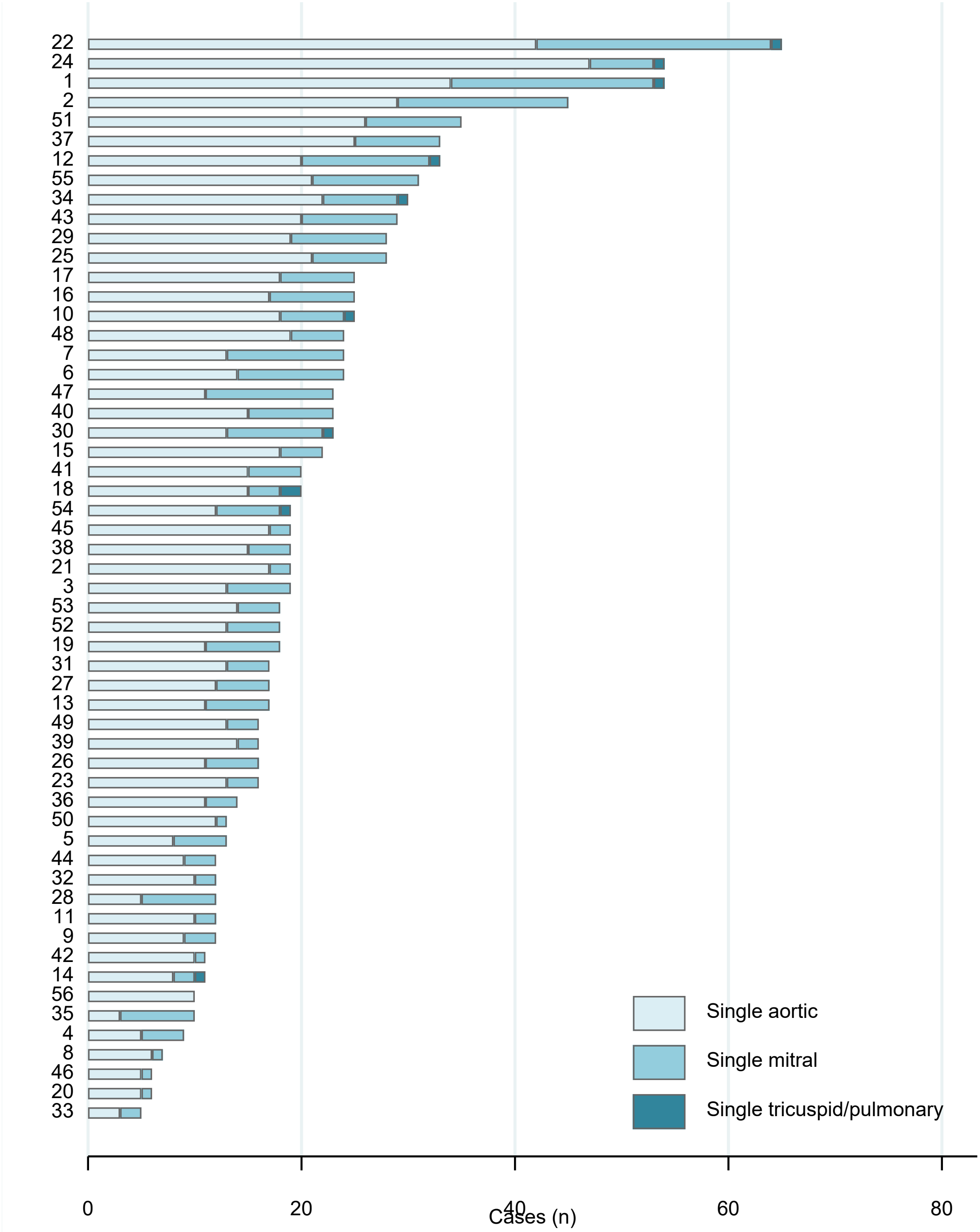
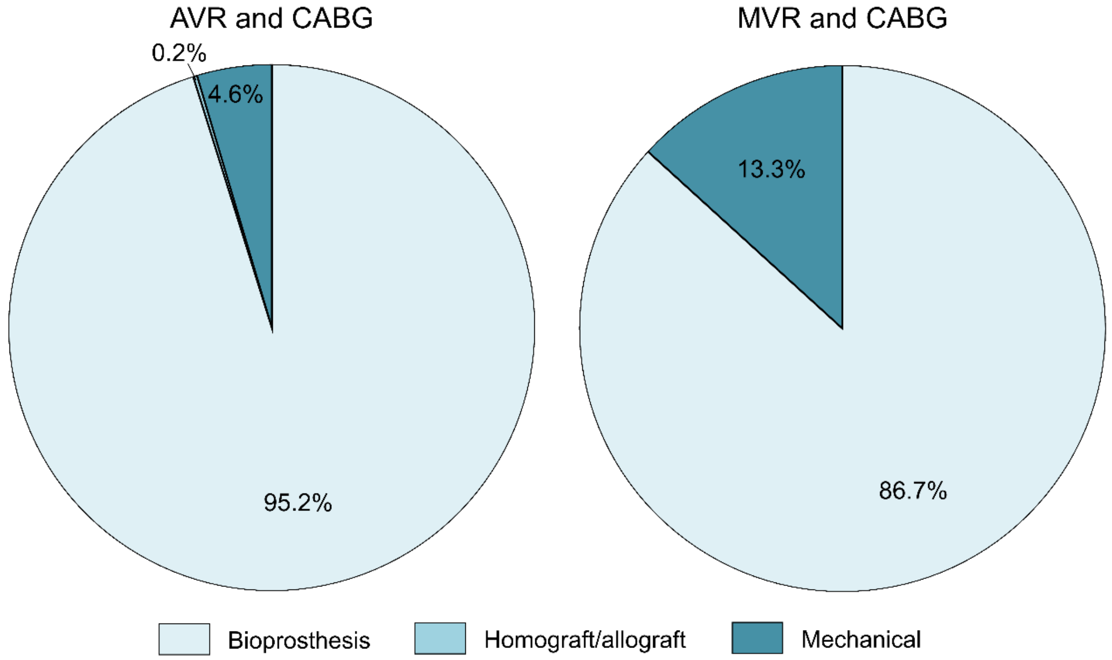


Table 41. Types of combined single valve and CABG surgery performed by year

	2018	2019	2020	2021	2022	Total
Single aortic (%)	75.0	74.0	73.6	71.5	71.1	73.0
Single mitral (%)	24.3	24.2	24.9	27.3	28.0	25.8
Single tricuspid/pulmonary (%)	0.7	1.8	1.5	1.2	0.9	1.2

4.4.1 Prothesis types used

Figure 54. Prosthesis type used for AVR or MVR, combined with CABG surgery, 2022



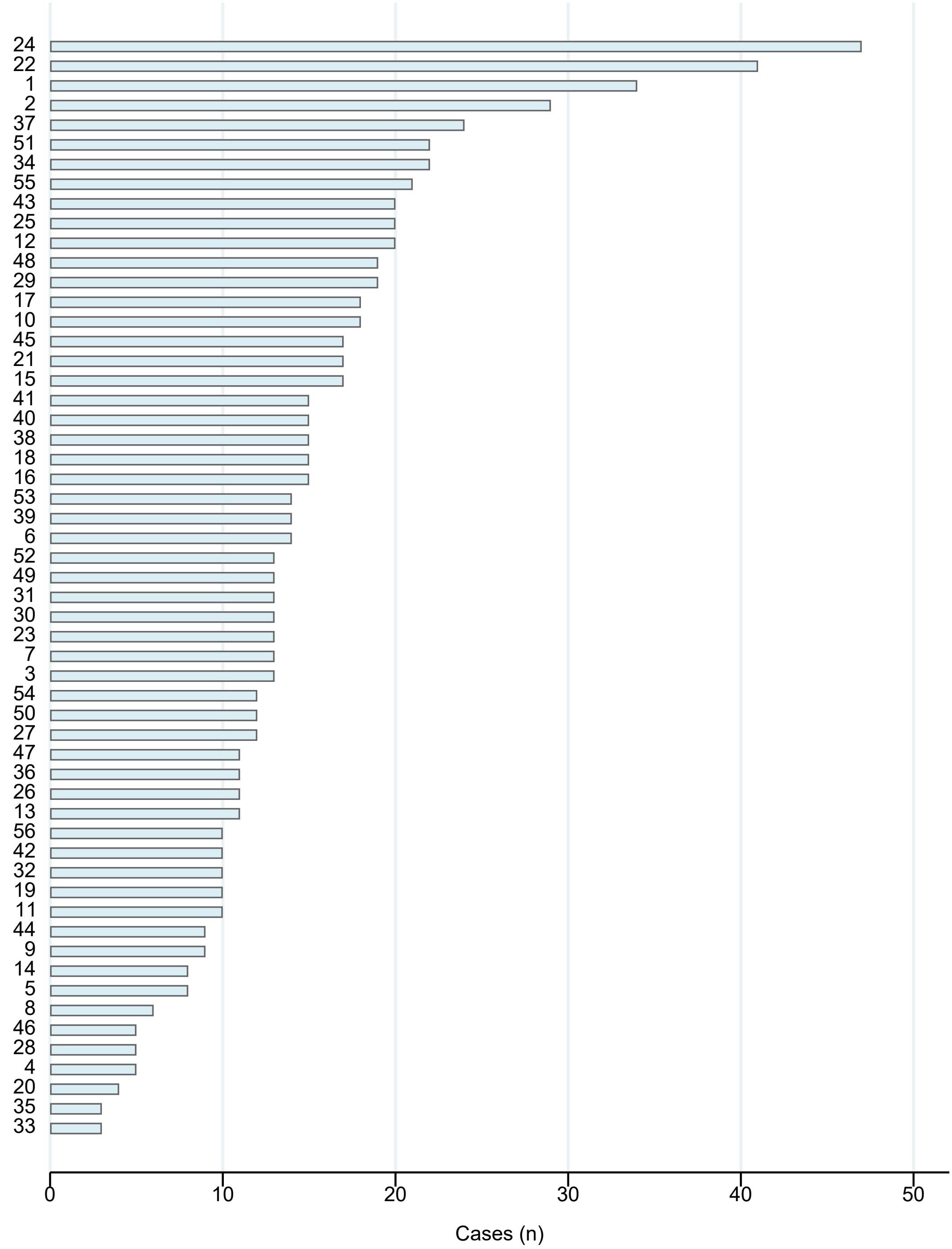
4.5 Influence of patient characteristics on operative mortality

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	3,035	2.0	448	2.0	493	1.6
Urgent	1,107	4.1	277	10.1	220	3.6
Emergency/salvage	66	18.2	37	27.0	20	10.0
Sex/age						
Male	3,488	2.4	546	6.0	608	1.8
18 - <50y	36	0.0	15	0.0	27	0.0
50 - <60y	227	2.6	62	3.2	85	4.7
60 - <70y	918	2.1	164	4.3	194	0.5
70 - <80y	1,790	2.3	232	8.6	242	2.5
≥80y	517	3.3	73	5.5	60	0.0
Female	720	4.7	216	6.5	125	5.6
18 - <50y	15	0.0	14	0.0	5	0.0
50 - <60y	39	2.6	25	0.0	17	5.9
60 - <70y	161	4.3	49	12.2	32	9.4
70 - <80y	367	4.4	90	6.7	54	5.6
≥80y	138	7.2	38	5.3	17	0.0
LVF						
EF>45%	3,464	2.3	534	3.9	519	1.7
EF≥30% - ≤45%	580	5.0	163	9.8	148	2.7
EF<30%	118	7.6	52	17.3	60	8.3
Previous MI						
No MI	3,115	1.8	478	2.9	473	1.7
NSTEMI	832	6.0	175	9.7	167	2.4
STEMI	134	5.2	82	17.1	64	7.8
Unknown type	125	2.4	27	7.4	29	3.4
Timing of previous MI						
≤6hr	8	25.0	7	42.9	2	0
>6hr - <24hr	13	0.0	5	40.0	5	0
≥1d - ≤7d	272	7.0	69	13.0	64	4.7
>7d	796	4.8	202	9.4	188	3.7
Previous surgery						
Initial	4,050	2.7	719	5.8	717	2.5
Redo	157	5.1	42	11.9	16	0.0
Dialysis						
No	4,133	2.6	737	6.1	727	2.3
Yes	72	12.5	25	8.0	6	16.7
Pre-operative creatinine						
≤200 µmol/L	4,095	2.6	709	5.1	713	2.0
>200 µmol/L	110	11.8	53	20.8	20	20.0

4.6 Combined AVR and CABG

Figure 55. Combined AVR and CABG surgery by unit, 2022



4.6.1 Influence of co-morbidities on complications

4.6.1.1 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	>60mL /min/1.73m^2	≤60mL /min/1.73m^2
n	2022	753	74	807	20	618	209
	2018-2021	3,111	300	3,320	91	2,550	861
Permanent stroke (%)	2022	0.7	0.0	0.6	0.0	0.3	1.4
	2018-2021	1.7	3.3	1.8	3.3	1.6	2.3
DSWI (%)	2022	1.1	2.7	1.1	5.0	1.0	1.9
	2018-2021	1.0	2.7	1.0	4.4	1.0	1.4
New cardiac arrythmia (%)	2022	41.2	37.8	40.7	50.0	40.7	41.3
	2018-2021	39.1	36.8	38.9	38.5	38.3	40.6
RTT for bleeding (%)	2022	5.1	8.1	5.0	20.0	5.5	4.8
	2018-2021	5.0	5.7	4.9	11.0	4.6	6.2

4.6.1.2 Age

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

		Age				
		18 - <50y	**50 - <60y**	**60 - <70y**	**70 - <80y**	**≥80y**
n	2022	11	59	198	443	117
	2018-2021	40	210	892	1,731	540
Permanent stroke (%)	2022	0.0	0.0	0.0	0.5	2.6
	2018-2021	0.0	1.0	1.7	1.8	2.6
DSWI (%)	2022	0.0	0.0	0.5	1.4	2.6
	2018-2021	2.5	1.0	1.3	0.9	1.3
New cardiac arrythmia (%)	2022	18.2	28.8	38.6	44.2	40.2
	2018-2021	20.0	30.1	36.2	40.0	44.5
RTT for bleeding (%)	2022	0.0	6.8	6.1	4.8	6.0
	2018-2021	7.5	4.3	5.4	4.9	4.8

4.6.1.3 Surgical history

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

		Initial	Redo
n	2022	796	31
	2018-2021	3,284	129
Permanent stroke (%)	2022	0.6	0.0
	2018-2021	1.8	1.6
DSWI (%)	2022	1.3	0.0
	2018-2021	1.1	0.8
New cardiac arrythmia (%)	2022	41.4	26.7
	2018-2021	38.9	37.2
RTT for bleeding (%)	2022	5.4	3.3
	2018-2021	5.0	4.7

4.6.1.4 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

	2022		**2018 - 2021**	
	n	dNRI (%)	n	dNRI (%)
Insulin dependent diabetes				
No	743	5.2	3,052	4.5
Yes	71	1.4	287	10.8
Pre-operative creatinine				
≤200 µmol/L	803	4.6	3,303	4.8
>200 µmol/L	11	27.3	38	23.7
Pre-operative eGFR				
>60mL/min/1.73m^2	615	3.4	2,540	3.3
≤60mL/min/1.73m^2	199	9.5	801	10.2
Age				
18 - <50y	11	0.0	35	2.9
50 - <60y	59	8.5	202	3.5
60 - <70y	193	2.6	869	5.9
70 - <80y	434	4.6	1,701	4.4
≥80y	117	8.5	534	6.2
Previous surgery				
Initial	784	4.7	3,216	4.9
Redo	30	10.0	125	7.2

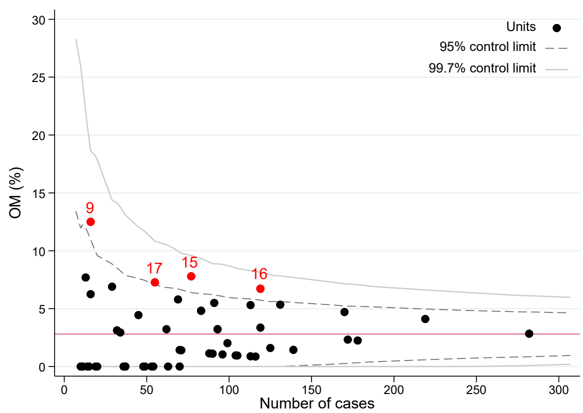
4.6.2 Unit outcomes – mortality, complications and resource utilisation

4.6.2.1 Operative mortality

To enhance the visibility of the individual unit outcomes on the funnel plots, units with very low case numbers (<5 in the five-year pooled data) were excluded. A full summary of outcomes for all units is provided in Appendix F (pg. 89).

Figure 56. OM following combined AVR and CABG surgery 2018 – 2022, by unit

a. OM b. RA-OM



4.6.2.2 Complications

Figure 57. dNRI following combined AVR and CABG surgery 2018 – 2022, by unit

a. dNRI b. RA-dNRI

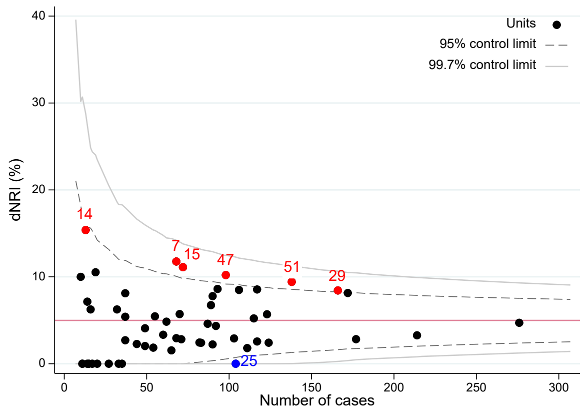
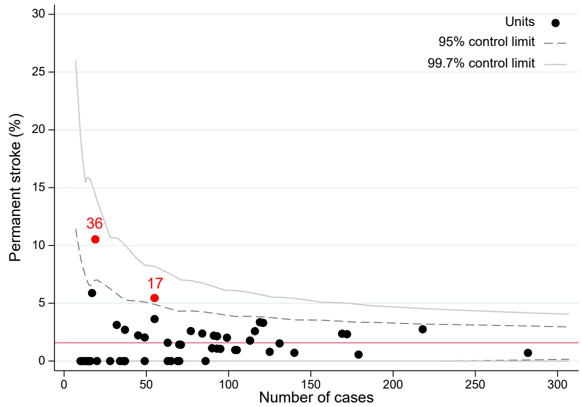
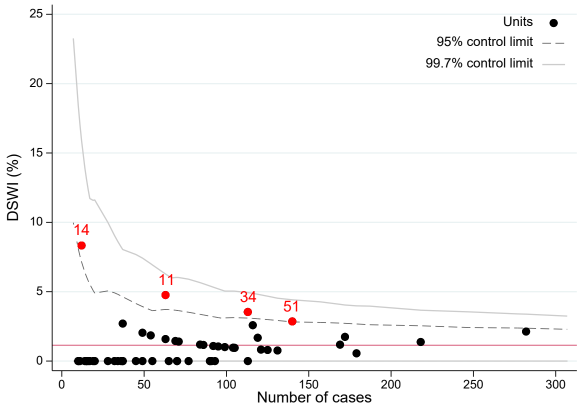


Figure 58. Complications following combined AVR and CABG surgery 2018 – 2022, by unit

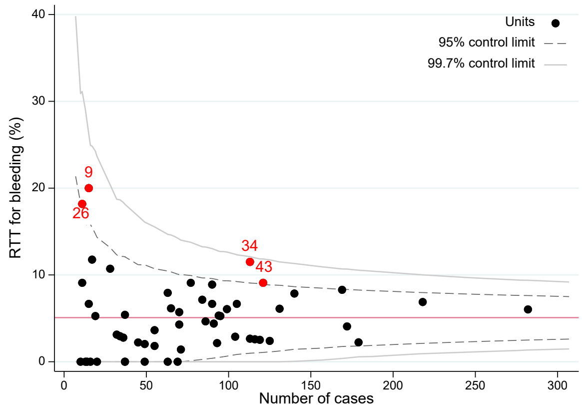
a. Permanent stroke



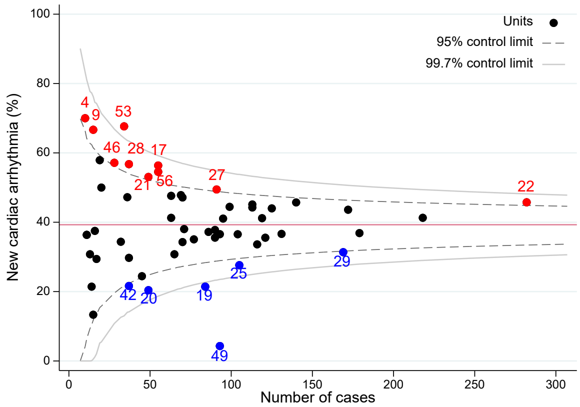
b. DSWI



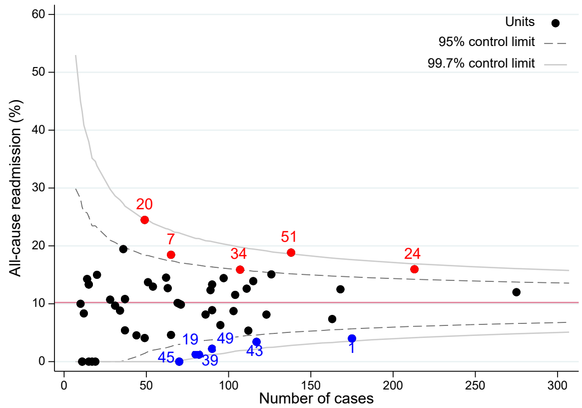
c. RTT for bleeding



d. New cardiac arrythmia



e. All-cause readmission



4.6.2.3 Resource utilisation

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

Figure 59. Distribution of pre-operative LOS for combined AVR and CABG patients, 2022

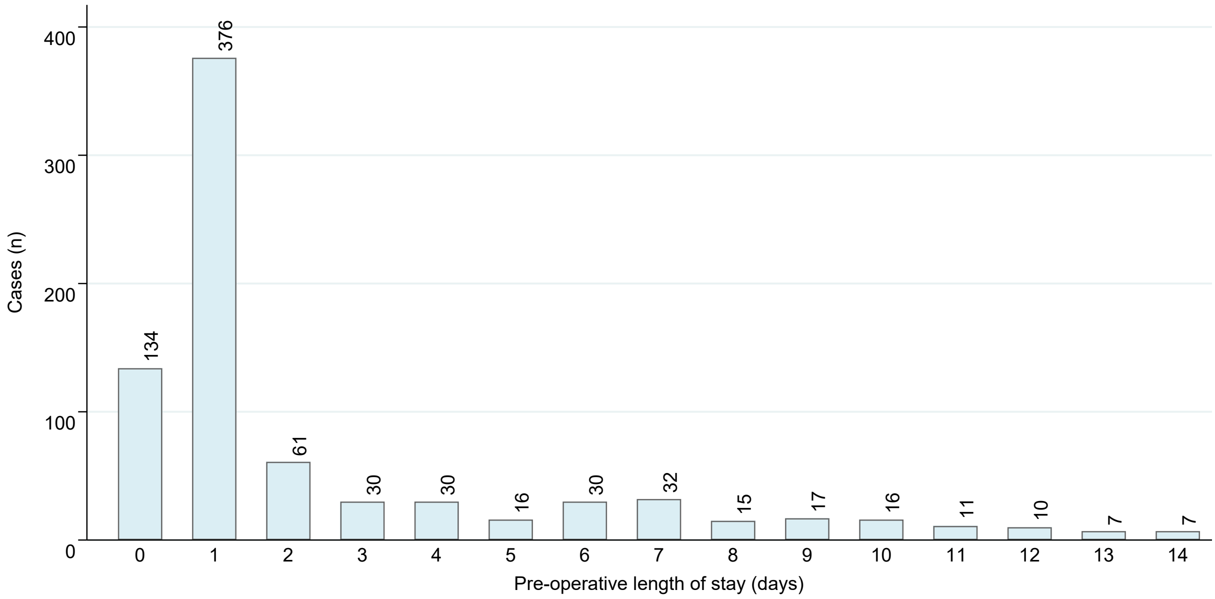


Table 47. Summary of pre-operative LOS for public and private combined AVR and CABG patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	3.0	1	1 - 5
Private	2.1	1	1 - 2
Total	2.6	1	1 - 3

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

Figure 60. Distribution of post-operative LOS for combined AVR and CABG patients, 2022

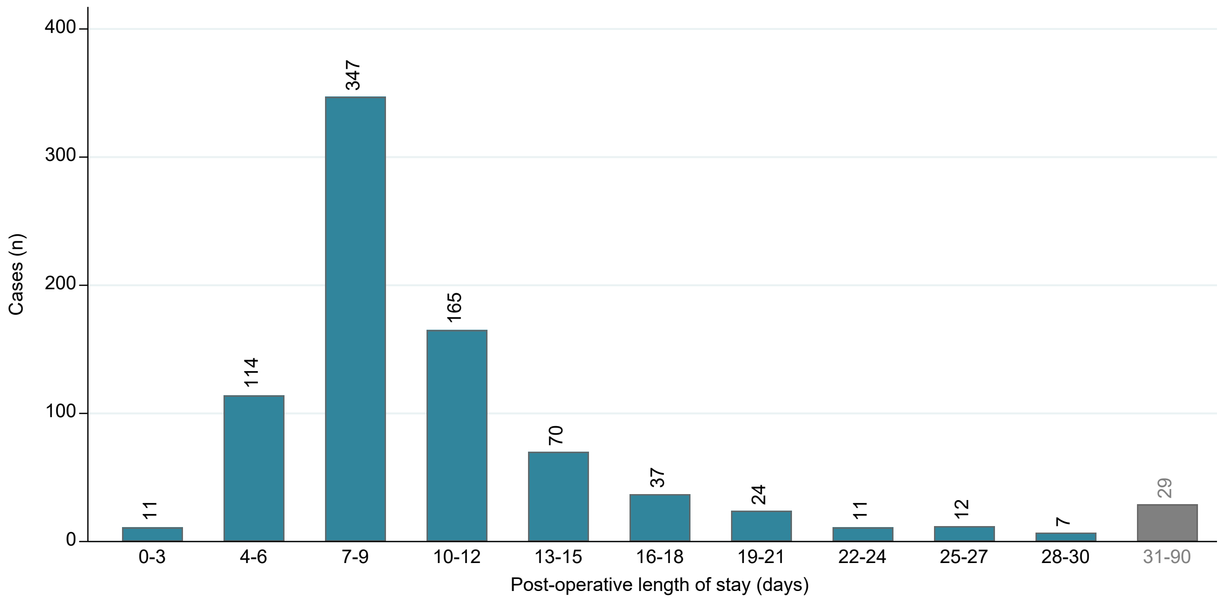


Table 48. Summary of post-operative LOS for public and private combined AVR and CABG patients, 2022

	Mean (d)	Median (d)	IQR (d)
Public	11.4	9	7 - 13
Private	10.8	9	7 - 11
Total	11.1	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 61. Distribution of initial post-operative ventilation time for combined AVR and CABG patients, 2022

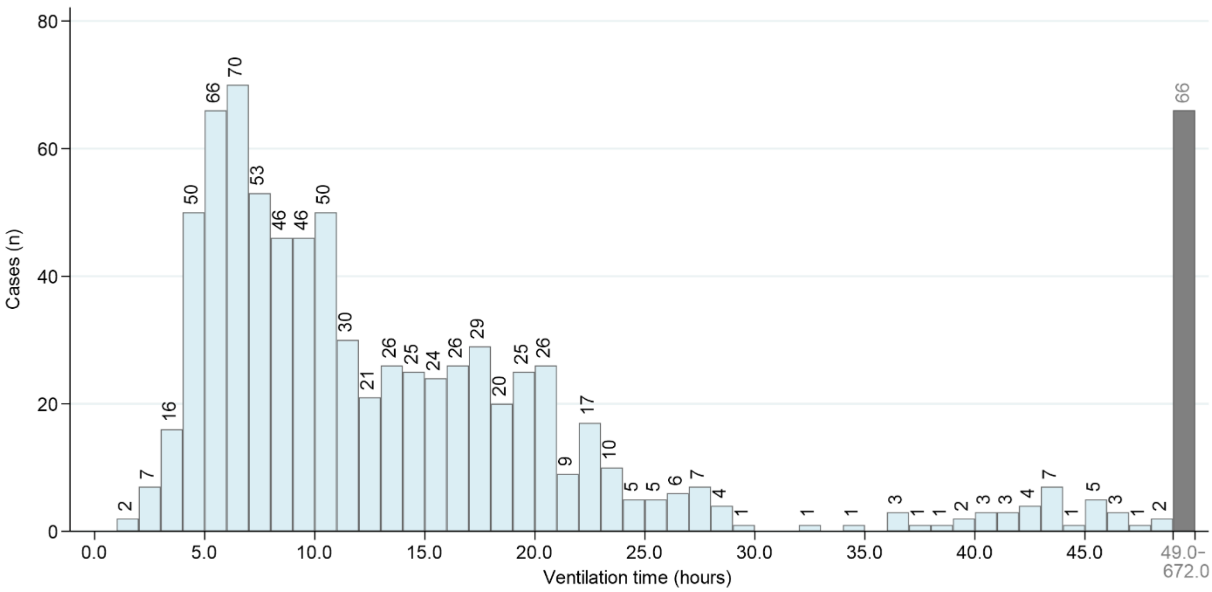


Table 49. Cumulative proportion of patients extubated by hour up to four weeks for combined AVR and CABG surgery, 2022

	6h	12h	24h	48h	96h	192h	384h	672h
Cumulative patients (n)	145	436	694	758	795	815	824	826
Cumulative percentage (%)	17.6	52.8	84.0	91.8	96.2	98.7	99.8	100.0

Table 50. Summary of initial post-operative ventilation time for public and private combined AVR and CABG patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	26.9	13.3	8.3 - 20.5
Private	16.3	9.2	6.3 - 17.1
Total	22.0	11.2	6.9 - 19.5

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

Figure 62. Distribution of ICU length of stay for combined AVR and CABG patients, 2022

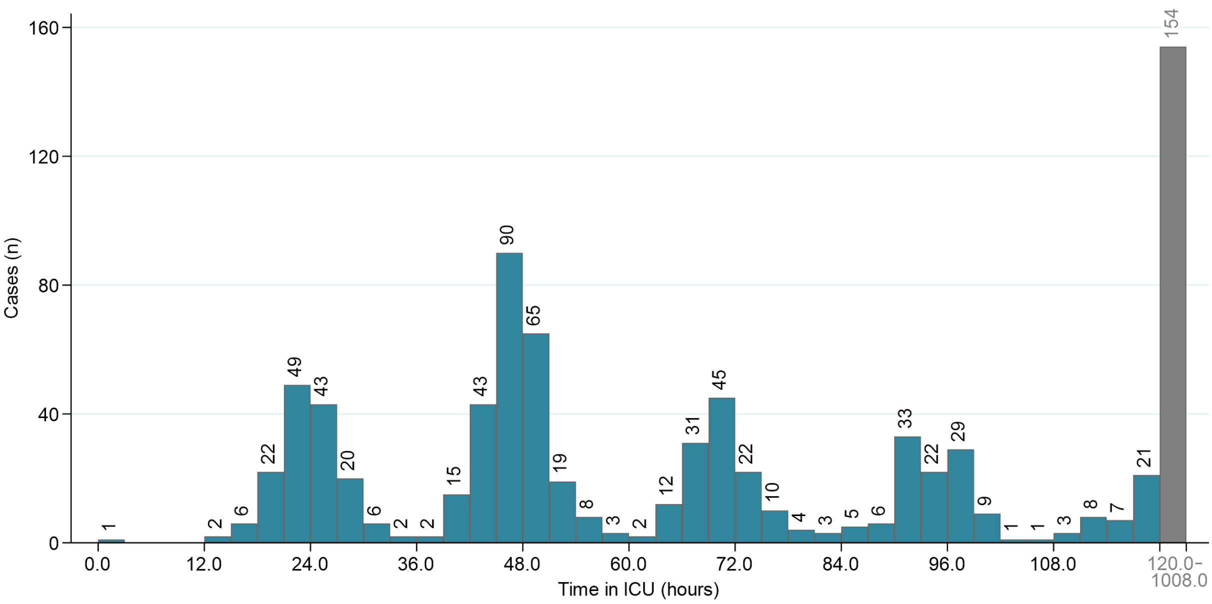


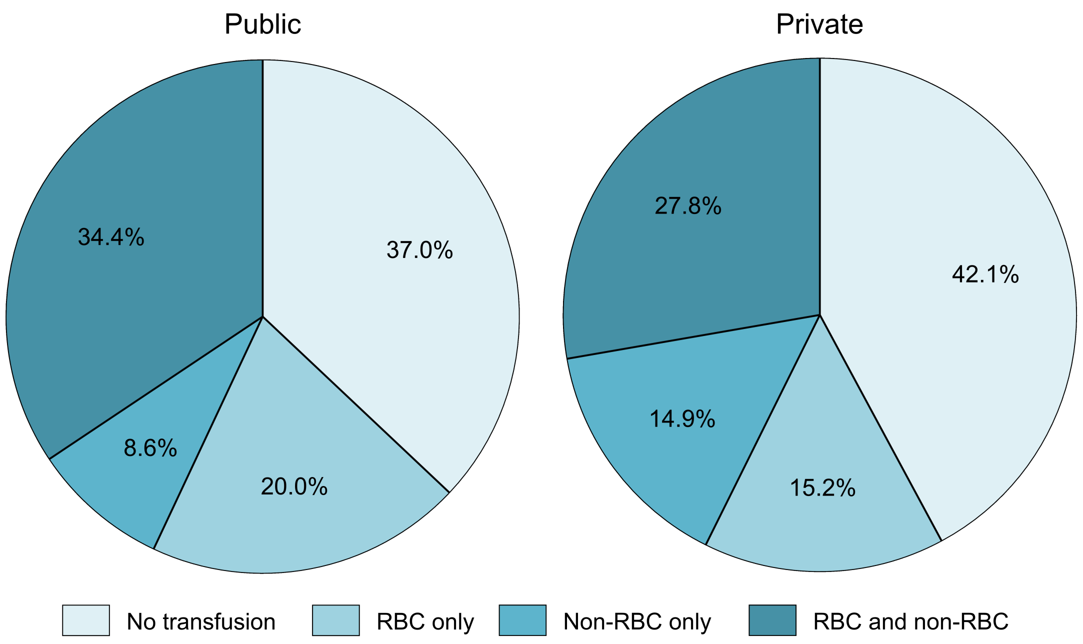
Table 51. Cumulative proportion of patients discharged from ICU by hour up to six weeks for combined AVR and CABG surgery, 2022

	12h	24h	48h	72h	144h	288h	576h	1008h
Cumulative patients (n)	1	81	301	486	726	804	818	824
Cumulative percentage (%)	0.1	9.8	36.5	59.0	88.1	97.6	99.3	100.0

Table 52. Summary of ICU length of stay for public and private combined AVR and CABG patients, 2022

	Mean (h)	Median (h)	IQR (h)
Public	87.6	67.4	29.0 - 112.4
Private	85.1	56.2	46.1 - 95.5
Total	86.5	66.1	44.8 - 98.2

Figure 63. Blood product usage at public and private hospitals for combined AVR and CABG patients, 2022



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

5. 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 aortic surgery, 2022

Surgery Type (not mutually exclusive)	n
Aortic replacement	1,366
Ascending only	993
Ascending + arch	266
Arch only	53
Descending	16
Thoraco-abdominal	3
Arch + descending	6
Descending + thoraco-abdominal	7
Ascending + arch + descending	15
Arch + descending + thoraco-abdominal	0
Other	7
Aortic repair	326
Endarterectomy	21
Patch repair	171
Endarterectomy + patch repair	3
Indication for aortic procedure	
Aneurysm	977
Dissection	371
Traumatic transection (<2 weeks)	5
Calcification	107
Other	228

Table 54: Case numbers for other uncommon cardiac surgery, 2022

Surgery Type (not mutually exclusive)	n
LV aneurysm	26
Acquired ventricular septal defect	35
Atrial septal defect	211
Other congenital	150
Cardiac trauma	4
LV outflow tract myectomy	169
LV rupture repair	11
Pericardiectomy	29
Pulmonary thrombo-endarterectomy	26
LV reconstruction	12
Pulmonary embolectomy	11
Cardiac tumour	127
Permanent LV epicardial lead	33
Left atrial appendage closure	721
Atrial arrhythmia surgery	518
Carotid endarterectomy	11
Other	386

LV indicates left ventricular

Table 55: Case numbers and OM for transplants, 2022

Surgery type (performed in isolation)	n	OM (%)
Cardiac transplant	99	4.0
Cardiopulmonary transplant	34	17.6

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	2022	326	59
	2018-2021	1,163	236
Pulmonary autograft aortic root replacement (Ross)	2022	29	0
	2018-2021	151	5
Aortic root reconstruction with valve sparing (David)	2022	46	2
	2018-2021	259	22
Total other valve surgery	2022	401	61
	2018-2021	1,573	263

6. Quality Assurance in Cardiac Surgery

Overview

The ANZSCTS Database is a clinical quality registry (CQR) that routinely and systematically collects and analyses epidemiologically sound data related to adult cardiac surgical procedures. In line with the Australian Commission on Safety and Quality in Health Care's Framework for Australian Clinical Quality Registries (2014) (5), which specifies that CQR data must be used to evaluate quality of care, the ANZSCTS Database has delivered a quality assurance program since 2001 to benchmark unit performance and achieve the best outcomes for patients.

The Database captures the pre-admission, in-hospital and 30-day post-discharge phases of care in both the public and private sectors. Evolution of the dataset, statistical methods, performance standards, and changes in the mix of units and cases, has necessitated a dynamic approach to the quality assurance activities. In particular, analytical methods and the threshold for identifying a deviation in unit performance have been subject to iterative improvements to form the current ANZSCTS Database Special Cause Variation Management Policy (SCV Policy), which underpins the quality assurance program.

The following section provides a brief summary of the core components of the peer review activities, examples of the feedback to units, and two case studies where early detection of a performance deviation resulted in quality improvement activities at regional and metro hospitals.

Steering Committee (SC)

The ANZSCTS Database SC chaired by A/Prof Julie Mundy, is composed of cardiac surgeon representatives from every Australian state and territory as well as New Zealand, along with a perfusionist, government representatives, Data Manager representatives, registry experts, and the Data Custodian. The SC meets quarterly to review reports and assess variations from expected standards of care at participating units and considers any serious clinical events that may be revealed by registry data. When report findings require action, the SCV Policy is used to drive quality improvement and this process is directed and overseen by the SC.

Methodology

Data is peer reviewed by the SC quarterly using reports that are prepared within three months of the end of the quarter. This allows for prompt feedback to units. The reports are based on the most common procedure type, isolated CABG surgery, and units are benchmarked on funnel plots for two time periods (six and 24 months). The choice of procedure type and time periods is largely influenced by case volume and statistical power, balanced with the need to review contemporaneous outcomes. Small changes in event numbers can lead to large changes in the overall incidence for units with low case volumes. For this reason, the Database uses a minimum threshold of 100 cases for reliable interpretation of unit results.

The SC has identified five key performance indicators for quarterly monitoring, which have excellent data completeness (>99%):

- Operative mortality (in-hospital + 30-day; unadjusted and risk-adjusted)
- Permanent stroke
- Deep sternal wound infection
- Derived new renal insufficiency (unadjusted and risk-adjusted)
- Return to theatre for bleeding

Risk-adjustment

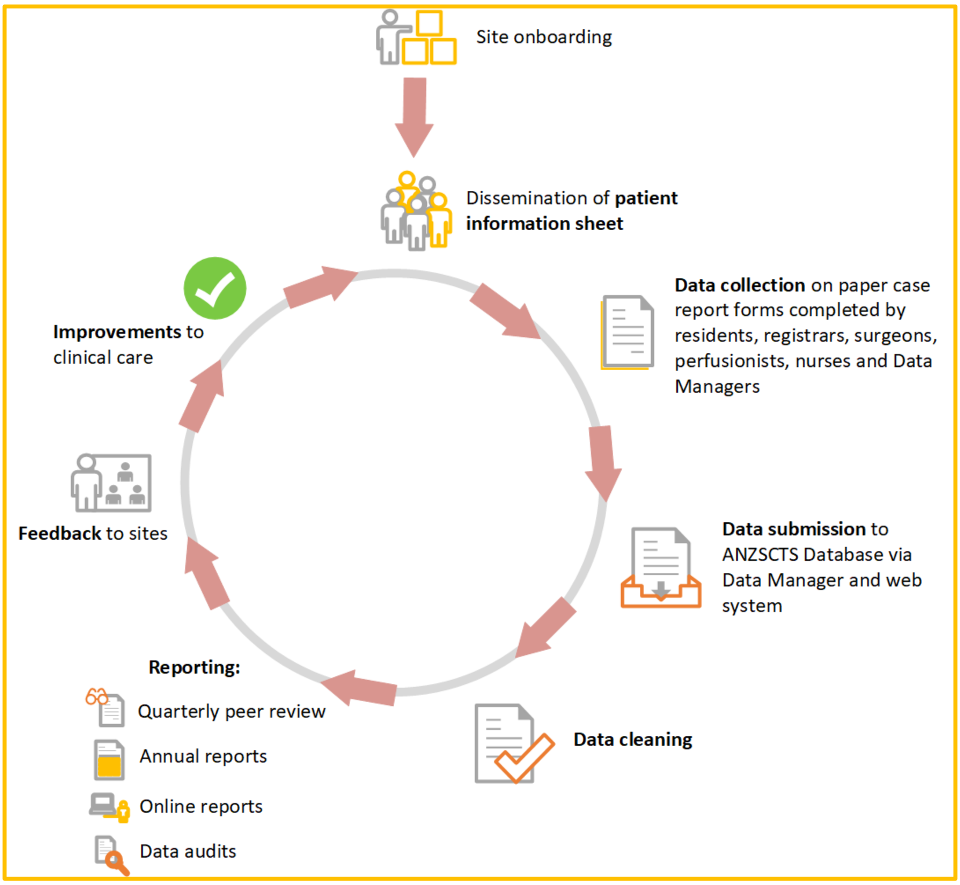
When comparing unit performance, it is critical that patient outcome data is appropriately risk-adjusted to account for differences in pre-operative patient factors. Such differences cause variance in outcomes that is often outside of the control of clinicians or units. Following risk adjustment, variation between the observed and expected outcomes can more reasonably be attributed to the quality of care provided by an individual unit and ensures units are not disadvantaged for taking on high-risk patients.

The Database currently uses the ANZSCORE risk-adjustment models for operative mortality and dNRI, which were developed by the Database in 2021 using data from a large number of cases collected between 2001 and 2019, inclusive. Validation of the models has shown they are a good fit for Australian and New Zealand data. The ANZSCORE models supersede the All Procedures model used previously for peer review, and the AusSCORE I and II models for isolated CABG (6-8).

Routine feedback

Feedback to units is a critical component of the CQR data collection, analysis, reporting and quality improvement cycle (Figure 64). After the quarterly reports have been peer reviewed, each unit is sent a de-identified copy along with a letter summarising their results. Feedback is shared with the Directors of the Cardiac Surgery units at public hospitals and with the Medical Directors at private hospitals.

Figure 64. The clinical quality registry cycle of using data for quality improvement



Management of variation

Units with results above the 99.7% control limits on funnel plot analyses are said to be showing special cause variation. This activates the SCV Policy, which is designed to engage and support the unit to reduce variation and improve patient outcomes. Units above the 99.7% control limit for the first time are noted as 'potential' (statistical) outliers and sent a Data Quality and Case Mix report (examples shown on pages 72-74) to assist the hospital with reviewing their cases and practice. If no non-clinical source of variation is identified, the unit is considered a confirmed outlier.

The SC reviews updated data and correspondence from the unit at subsequent quarterly Clinical Quality Meetings to determine what further actions, if any, are required. The process is designed to be collegiate and collaborative, focus on opportunities for quality improvement and the SCV Policy incorporates discretion from the Committee to account for the 'real world' clinical environment.

If a unit has a prolonged period of special cause variation and requires greater assistance, the SC can activate the external Peer Review and Quality Assurance Committee. This Committee includes senior members of the ANZSCTS Executive and the Royal Australasian College of Surgeons, and a member of the Australia and New Zealand Cardiac and Thoracic Surgery Research Institution.

All communications with hospitals are confidential. Further, the Database is a registered Quality Assurance Activity, declared under Part VC, Section 124X of the Health Insurance Act 1973 (9). Therefore, information known solely as the result of the Database's activity or documents created solely for the purposes of the activity are protected by The Commonwealth Qualified Privilege Scheme.

6.1 Data Quality and Case Mix Report

The Data Quality and Case Mix Report is provided to units identified as 'potential' outliers to provide supplementary information that can be used to check the data accuracy and quality or other factors not related to performance that may account for the deviation in outcomes. Below are examples of the type of information units receive in this report.

Figure 65. Excerpt of Data Quality and Case Mix report – summary data

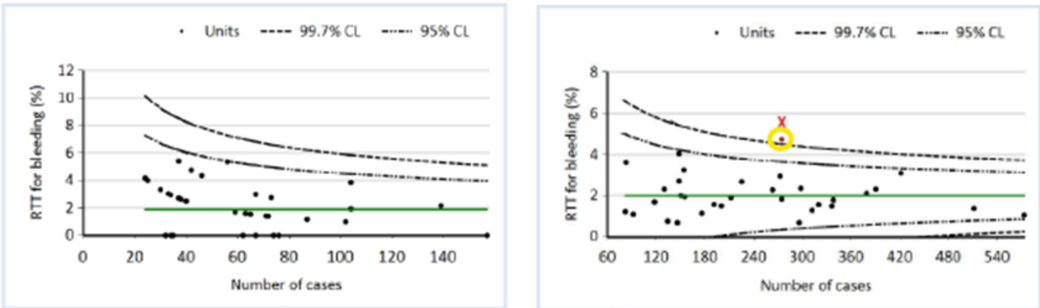
Section A: Summary of Peer Review Findings and Relevant Cases

At the most recent peer review for Q1 2020, The Mock Hospital was identified as a potential outlier for RTT for bleeding in the 24-month time period. Copies of the funnel plots for RTT for bleeding in both the 6- and 24-month time periods routinely reviewed are provided below and The Mock Hospital is represented as unit X, and circled in yellow. Refer to Appendix B for information about the interpretation of funnel plots.

Figure 2: Funnel plots for RTT for bleeding in the Q1 2020 review

6 months
Q4 2019 to Q1 2020

24 months
Q2 2018 to Q1 2020



The specific results from the funnel plots presented in Figure 2 are summarised in Table 1.

Table 1: Summary of incidence of RTT for bleeding at The Mock Hospital compared to all other units for Q2 2018 – Q1 2020

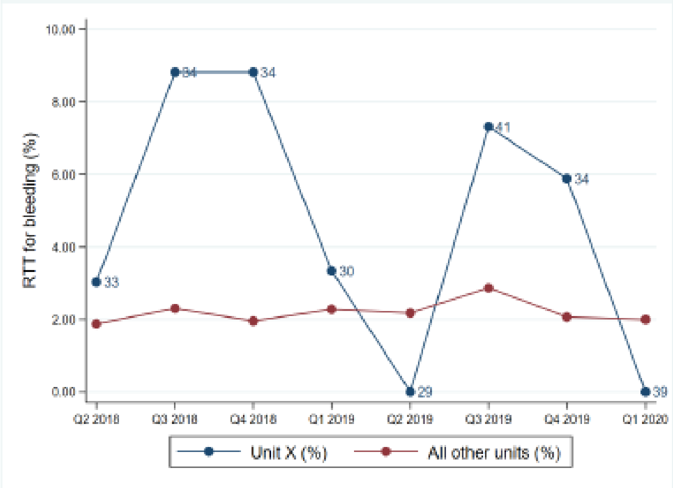
Hospital/group	Incidence (%)	Events (n)	Total cases (n)
The Mock Hospital	4.74	13	274
Binational cohort	1.99	155	7801

Additional line graphs are included to provide the unit with a quarter by quarter breakdown of the incidence rate for the KPI of interest. Data is also shown for all procedures, combined, to help identify whether the issue is systemic.

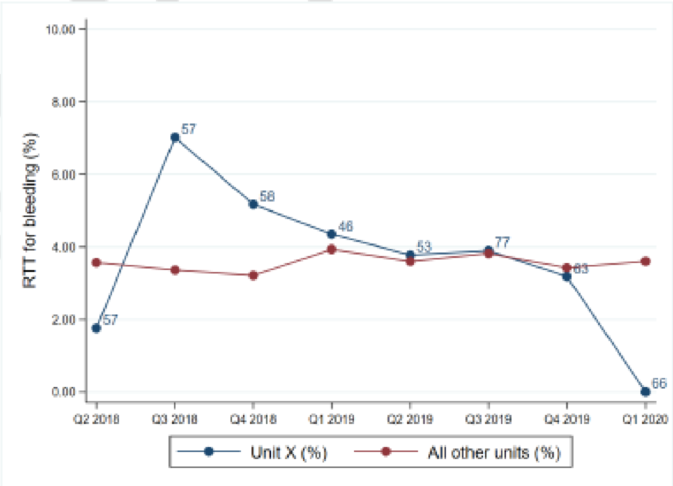
Figure 66. Excerpt of Data Quality and Case Mix report – supplementary data

Figure 3: Line chart showing incidence of RTT for bleeding at The Mock Hospital in iCABG (A) and all procedures, combined (B) from Q2 2018 – Q1 2020, inclusive

(A) iCABG



(B) All procedures



Units are also provided with summaries of their caseload completeness, data completeness (Figure 67), and data cleanliness.

Figure 67. Excerpt of Data Quality and Case Mix report – caseload completeness

Table 3: Unit case completeness and confirmations for The Mock Hospital

Q1 2020 cases	Avg caseload (Q1 2019 – Q4 2019)	Q1 2020 cases as % of avg caseload	DMAC comment
39	33.5	116.42	Case numbers confirmed as correct by unit Data Manager

Tables containing relevant risk factors specific to the KPI of interest are provided to assess case mix. The first table compares the incidence of a unit's risk factors compared to all other units included in the quarterly review, with statistical testing of the difference. The second table compares the incidence of risk factors with and without the KPI of interest for both the unit and all other units included in the quarterly review.

Figure 68. Excerpt of Data Quality and Case Mix report – assessing unit case mix

Section E: Summary of Unit Case Mix

Tables 5 and 6 show the incidence of key risk factors for [KPI] that are collected by the ANZSCTS Database, compared to all other units and split into cohorts with and without an event, respectively.

Table 5: Incidence of relevant risk factors collected by the Database for RTT for bleeding, Q2 2018 – Q1 2020

	Your unit	All other units	Significance
Continuous data (median)			
Age (years)	66.71	67.28	0.39
Body Surface Area (m²)	1.98	1.96	0.10
Body Mass Index (kg/m²)	28.72	28.40	0.63
Pre-operative haemoglobin (g/L)	142.50	140.00	<0.01
Perfusion time (minutes)			
ICC loss within 4hrs post-surgery			
Categorical data (%)			
Male			
Female			
Insulin dependent diabetes			
Pre-operative creatinine ≥ 200 μr			
eGFR ≤ 40mL/min per 1.73m²			
Pre-operative dialysis			
Renal transplant			
Pre-operative aspirin (within 2 da			
Pre-operative antiplatelets (withi			
Anticoagulants at time of surgery			
Previous cardiothoracic surgery			
Surgery status (emergency or sal			
iCABG perfomed with other cardi			
Tranexamic acid use			
Derived new renal insufficiency			

Table 6: Significant risk factors *with* and *without* RTT for bleeding between The Mock Hospital and all other units

	With RTT for bleeding		Without RTT for bleeding	
	Your unit	All other units	Your unit	All other units
Continuous data (median)				
Age (years)	70.97	68.50	66.49	67.25
Body Surface Area (m²)	1.94	1.93	1.98	1.96
Body Mass Index (kg/m²)	26.73	27.77	28.73	28.41
Pre-operative haemoglobin (g/L)	138.00	138.00	143.00	140.00
Perfusion time (minutes)	120.50	83.00	100.00	85.00
ICC loss within 4hrs post-surgery (ml)	800.00	505.00	197.50	180.00
Categorical data (%)				
Male	100.00	85.94	86.21	82.56
Female	0.00	14.06	13.79	17.44
Insulin dependent diabetes	15.38	10.94	14.18	12.35
Pre-operative creatinine ≥ 200 μmol/L	7.69	3.13	1.92	3.12
eGFR ≤ 40mL/min per 1.73m²	15.38	6.77	4.98	5.80
Pre-operative dialysis	7.69	1.04	1.92	1.72
Renal transplant	0.00	0.00	0.00	0.35
Pre-operative aspirin (within 2 days)	92.31	78.65	75.48	74.93
Pre-operative antiplatelets (within 2 days)	15.38	1.04	10.34	1.29
Anticoagulants at time of surgery	23.08	30.73	17.24	24.91
Previous cardiothoracic surgery	0.00	2.08	1.92	1.30
Surgery status (emergency or salvage)	15.38	3.13	8.43	2.49
iCABG perfomed with other cardiac surgery	7.69	6.77	5.75	4.70
Tranexamic acid use	100.00	90.10	99.23	88.04
Derived new renal insufficiency	8.33	11.05	3.91	2.43

6.2 Self-monitoring

The ANZSCTS Database web system includes a reporting module that allows users to download a range of reports using real time data, and which can be customised by procedure of interest and time period. A unit's Data Manager and Director (at public hospitals) have the ability to access reports that contain information similar to the quarterly report, which facilitates internal quality assurance processes. Similarly, surgeons have the ability to run reports comparing their outcomes to all other surgeons. Examples of what is included in the Surgeon Report are presented below.

Figure 69. Excerpts from a customisable web-system surgeon report

Total Isolated CABG Procedures 01-Jan-2019 - 31-Dec-2019

	Cases in database	% Baseline cases complete	% Follow-ups complete	Number of complete Isolated CABG procedures
Surgeon XYZ	46	100.0	100.0	46
All other surgeons	3860	99.9	99.9	3852

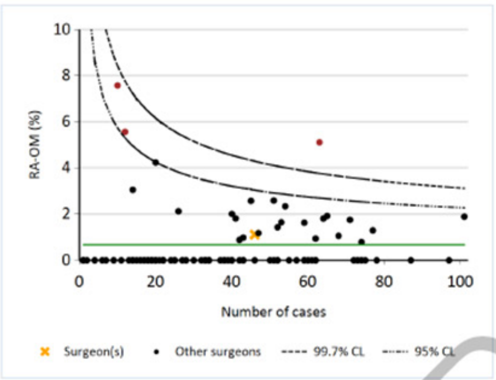
Risk factors for Isolated CABG Procedures 01-Jan-2019 - 31-Dec-2019

	Surgeon XYZ	All other surgeons
Total number of Procedures	46	3860
Risk Factors (%)		
Cerebrovascular disease		
Current Smoker		
Diabetes		
Hypertension		
Peripheral Vascular Disease		
Cardiac History (%)		
Congestive Heart Failure		
Myocardial Infarction		
MI <8 days before surgery		
Previous Cardiac Intervention		
Previous CABG		
Previous PTCA^/Stent		
Previous Valve Repair/Replac		
Admission (%)		
Elective admission on day of surg		

^Percutaneous transluminal coronar

Risk-adjusted operative mortality (RA-OM)*

01-Jan-2019 - 31-Dec-2019

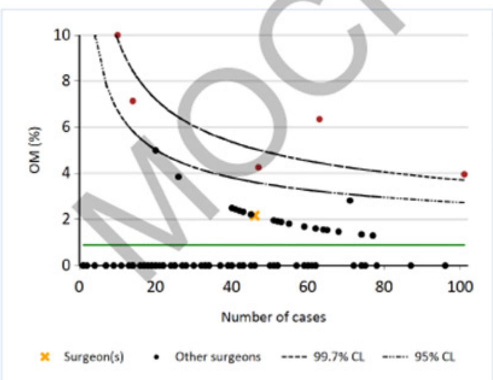


Surgeon	Case (n)	RA-OM (%)
Surgeon XYZ	46	1.11
All units (binational average)	3878	0.67

*calculated using the 2021 ANZSCORE for operative (in-hospital and 30-day) mortality for isolated CABG, refer to Appendix A for more information

Operative mortality (OM)

01-Jan-2019 - 31-Dec-2019



Surgeon	Case (n)	OM (%)
Surgeon XYZ	46	2.17
All units (binational average)	3898	0.90

6.3 Case studies

6.3.1 Deep sternal wound infection at a metropolitan hospital

Identification

During the routine analysis, a hospital was identified as having an incidence of DSWI that was four times higher than the incidence for the binational cohort in the preceding 24-month period. The unit was above the 99.7% control limit on funnel plot analysis and noted as a potential outlier. The SC followed its SCV Policy, the first step of which is to provide the unit with an opportunity to verify the findings and review supplementary information provided in a *Data Quality and Case Mix Report.*

Unit review

The unit completed a self-audit and detailed review of the cases involving DSWI including the types of infection involved, results of pre-and post-surgery swab tests, and the treatment provided which commonly involved returning to theatre for washout and intravenous antibiotics. They confirmed the data was accurate and that the majority of cases had pre-operative swabs that tested positive for methicillin-sensitive Staphylococcus aureus. They also confirmed that the patients with DSWI had extended lengths of stay in the ICU and hospital.

In response to the feedback from the ANZSCTS Database, the unit worked with a lead infectious disease physician from their Infection Control Committee to implement new mitigation strategies in the form of decolonisation products. The unit began using a wash lotion in combination with a nasal gel for five days prior to surgery, which were known to reduce the risk of Staphylococcus infection.

SC decision and follow-up

The results of the changes were, and continue to be, monitored by both the hospital and its governance committees, and the Database through its quarterly review and communications. Six months following the original notification, the unit was within control limits for the most recent six-month period and inside the 99.7% control limit for the 24-month period.

6.3.2 RTT for bleeding at a regional hospital

Identification

Under a previous version of the SCV Policy and during routine analysis, a unit was identified as above the 99.7% control limit for RTT for bleeding with an incidence rate approximately double that of the national cohort. The data analysed was across a 36-month period. The Chair of the SC wrote to the unit to notify them of the finding and provided a list of cases for review and requested confirmation data was entered correctly.

Unit review and Database support

The initial reply from the unit confirmed that there had been some errors in the data supplied to the Database. The errors were corrected; however, the unit remained above the 99.7% control limit for RTT for bleeding. During subsequent SC meetings, the data suggested that the unit was having an ongoing issue and additional information regarding case mix was supplied to the unit and an internal review of practice was recommended.

A formal investigation was conducted which revealed underlying problems with aspects of surgical technique as well as not enough supervision for junior staff. A plan aimed at remedying the problem took a multidisciplinary approach between surgeons, anaesthetists and the ICU to help secure haemostasis and increase supervision of junior staff during surgery, particularly closings. The surgical team also discussed the types of surgical clips used for branch occlusion and changes were made to the type of clips being used. The specific clinical indications for using silk ligatures and clips were discussed and agreed on. A progress report, including relevant indicators were also made a regular item on the unit's quality committee agenda.

SC decision and follow-up

The unit returned to within control limits within nine months of the formal investigation; however, did have fluctuating outcomes over the following few months. The Committee acknowledges that even once an issue has improved, it can take some time for the long-term data to consistently reflect this. Due to the initial improvement in outcomes the unit ceased reporting to the hospital quality committee. However, after returning to having a result above the 99.7% control limit, every adverse event was discussed at monthly surgeon meetings and reviewed tri-annually as part of their audit process. The unit has since remained within control limits. The results of the changes were, and continue to be, monitored by the Database through its quarterly review and communications.

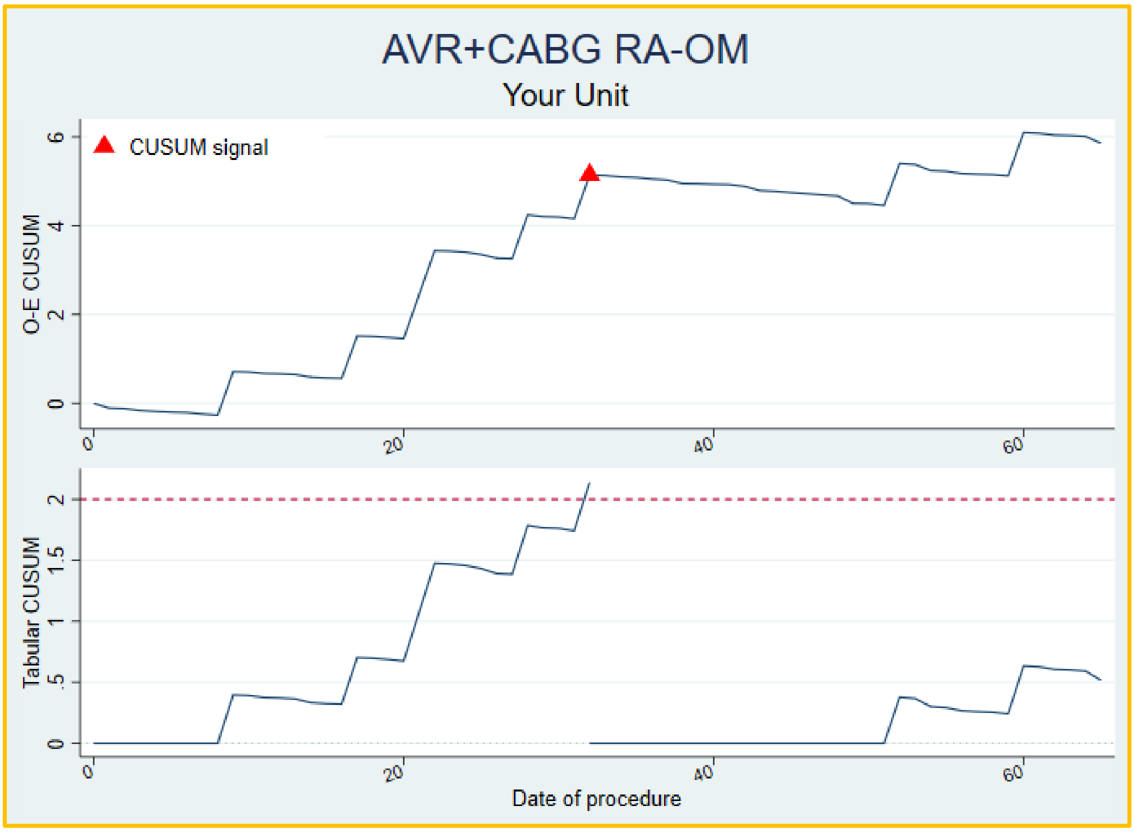
Future Directions

Isolated CABG surgery accounts for approximately half of the cases in the Database and the remainder of the cases cover an extensive number of low volume procedures. These low volume procedures are challenging to evaluate, but the Database will be expanding the peer review in 2024 to include AVR and AVR with CABG using cumulated sum (CUSUM) charts.

CUSUM charts can be used to plot the outcomes for sequential cases over time for an individual unit and therefore can be used to identify deviations in performance over time. An example of an ANZSCTS Database CUSUM chart is shown in Figure 70. They utilise the difference between observed and expected outcomes for each case and are therefore limited to KPIs with risk-adjustment models. The CUSUM chart thresholds have been set using a combination of clinical input and simulations and when they are breached will signal an alert for special cause variation. This process differs to the unit benchmarking process currently used for isolated CABG, and will involve a different reporting frequency, timeframe, and peer review process.

The SC would also like to include a 'whole of practice' measure in the Database reporting. At present, the clinical leadership are investigating which procedures and pathologies can be grouped or are of particular importance to assist with the development of a new 'All Procedures' risk model. Once the new model has been developed, a variety of new data presentations will be introduced into the annual reports.

Figure 70. CUSUM chart for risk-adjusted operative mortality for AVR with CABG



Note: The above CUSUM is based on sample data only

7. Concluding Remarks

This Annual Report is a summary of activity for 56 cardiac surgery units over the most recent five-year period and demonstrates the magnitude and value of the data held by the registry.

The Database Program continues to review and refine its dataset and reporting to broaden the types of analyses that can be performed. To this end, a multidisciplinary Working Group was established in 2022 to review the dataset and definitions, which has continued throughout 2023. The Working Group has decided on a number of additions, deletions and modifications that will bring the dataset better in line with changing practice and focus on key risk factors and outcomes. Further, in 2022 the Database conducted a pilot study exploring the use of cumulated sum chart reports for lower volume procedures (AVR, and AVR and CABG), which received favourable feedback. New unit reports will be incorporated into the peer review from March 2024.

The Database continues to recruit additional private hospitals in Australia, with the intention of achieving 100% population coverage. Ongoing work with the public hospitals in New Zealand is promising, and the Database looks forward to their future contributions to the Program. The Research Program is supporting a large number of external researchers through access to the binational collated non-identifiable dataset, including two linkages with the ICU registry (ANZICS) and dialysis and transplant registry (ANZDATA).

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 their 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. 82), 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. 82), 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 (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 (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/1.73m^2 and 60kg/m^2 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 (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/1.73m^2 and 60kg/m^2 respectively

Appendix C
Data preparation and key variable definitions

Data preparation and presentation

Data includes operative details and outcomes of cardiac surgery performed in 56 participating units in 2022, and from 2018-2021 (Sections 2 and 5) or 2012-2022 (Sections 3 and 4) 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 (CCRET) of the School of Public Health and Preventive Medicine, Monash University, on May 15th, 2023. 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 May 15th, 2023 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.

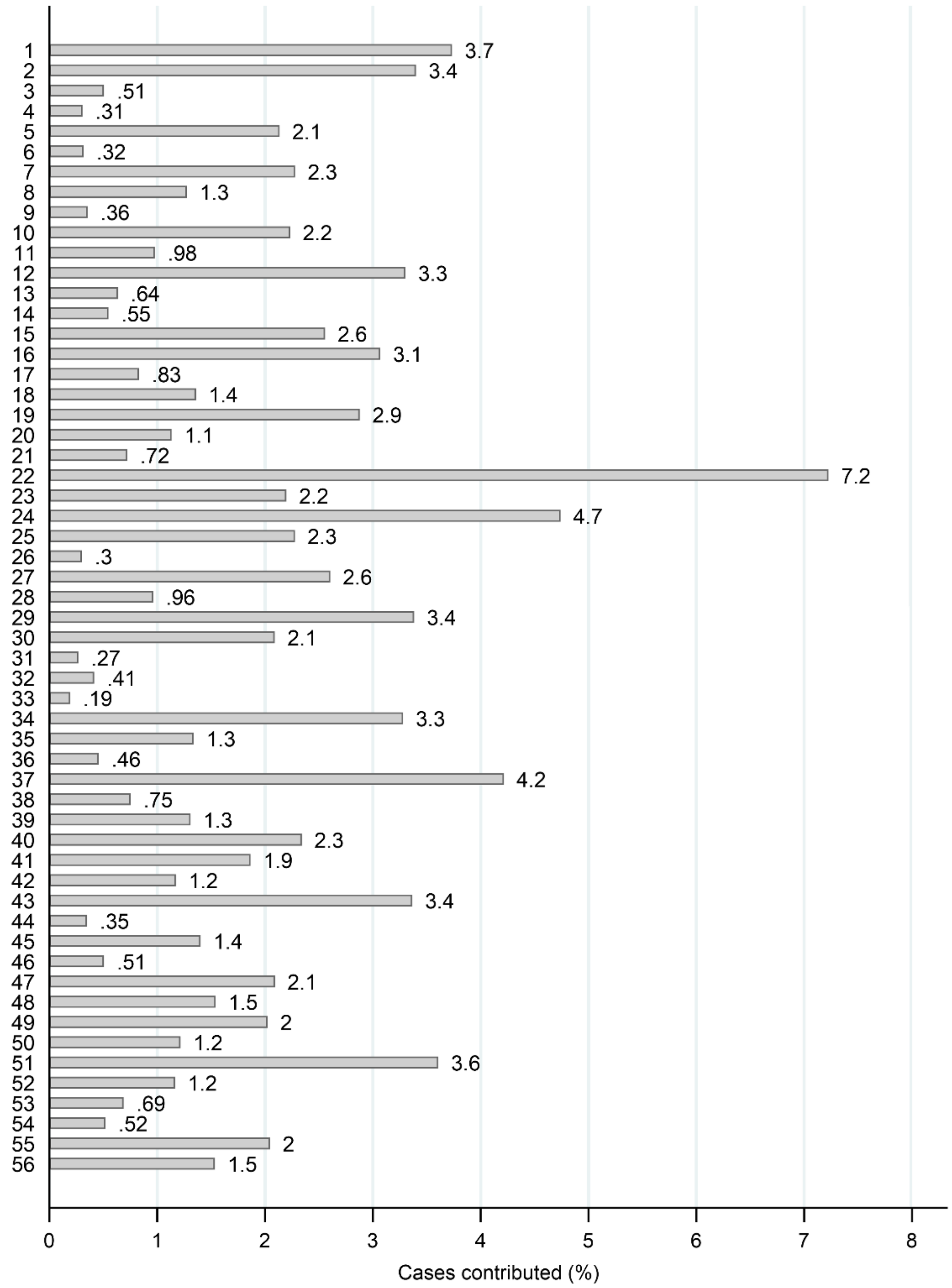
Appendix D

Units included in 2022 Annual Report

Table D. Summary of units included in the 2022 Annual Report

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

Figure D. Percentage each hospital contributed to the 2022 Annual Report



Appendix E

Interpretation of funnel plots

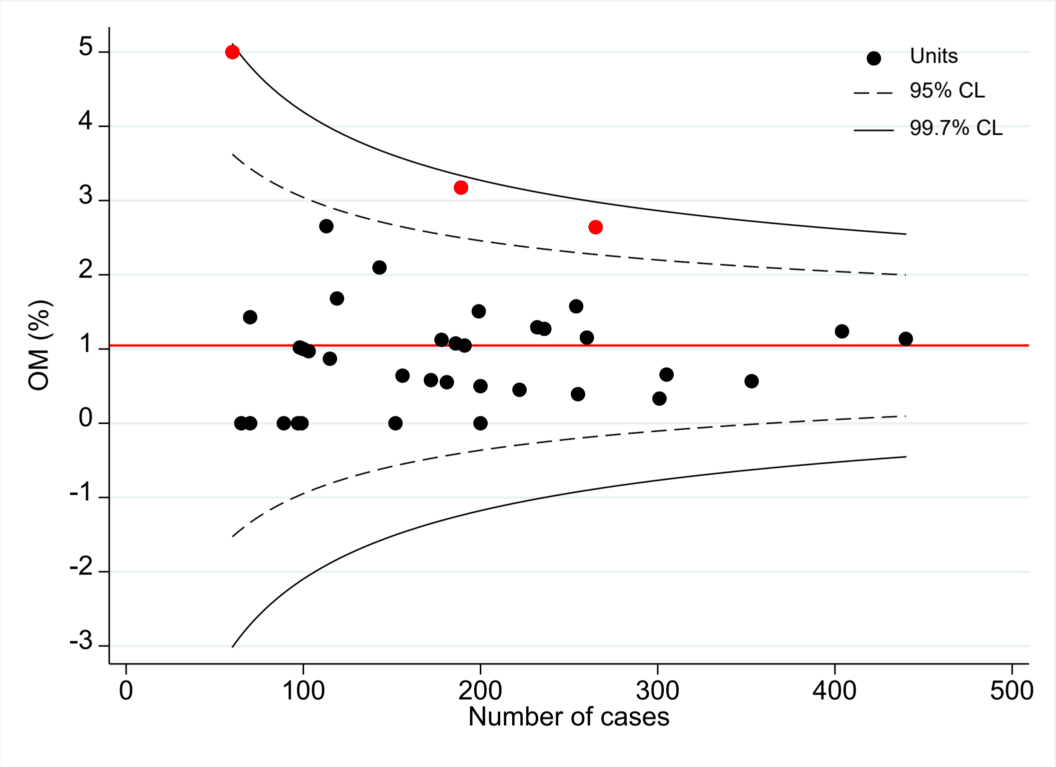
Funnel plots are an established benchmarking tool used to compare performance between healthcare providers. The plots include a single datapoint for each unit with the coordinates based on unit case number (x-axis) and aggregate outcome data (y-axis) for the specified time period.

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 70 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.

<u>Figure E. OM following isolated CABG by unit</u>



Appendix F

Supplementary data - outcomes by unit

Table F1. Outcomes by unit in isolated CABG by unit, 2022

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	226	0.0	0.0	0.4	0.5	0.0	0.4	2.2
Unit 2	295	1.4	1.0	5.2	5.3	0.3	3.1	2.7
Unit 3	230	0.0	0.0	1.3	1.4	0.0	0.4	3.0
Unit 4	90	2.2	1.7	4.4	4.0	0.0	0.0	0.0
Unit 5	168	0.6	0.6	3.7	4.2	1.2	1.2	1.2
Unit 6	171	0.0	0.0	0.6	0.8	1.2	0.0	2.9
Unit 7	181	1.7	0.8	4.4	3.2	0.6	0.6	1.7
Unit 8	77	2.6	1.3	3.9	3.5	1.3	1.3	0.0
Unit 9	54	1.9	1.9	0.0	0.0	0.0	1.9	3.7
Unit 10	232	2.2	1.6	3.9	2.9	0.4	2.6	1.7
Unit 11	88	1.1	1.5	1.1	1.5	3.4	1.1	1.1
Unit 12	211	0.0	0.0	3.8	5.9	0.5	0.9	2.8
Unit 13	119	4.2	2.8	3.4	3.0	0.0	0.0	0.8
Unit 14	124	0.0	0.0	2.4	2.9	0.0	0.0	0.8
Unit 15	230	0.4	0.3	2.7	2.3	0.4	1.3	0.4
Unit 16	223	1.3	1.0	4.6	4.1	0.9	0.0	0.9
Unit 17	101	5.0	3.2	3.0	1.9	1.0	3.0	2.0
Unit 18	114	0.0	0.0	7.1	9.4^	0.9	0.0	3.5
Unit 19	152	0.7	0.7	3.3	3.1	2.0	0.0	2.0
Unit 20	98	2.0	2.0	3.1	3.0	0.0	1.0	1.0
Unit 21	107	1.9	2.8	1.9	2.0	0.0	0.0	5.6
Unit 22	429	1.2	0.7	2.6	2.4	0.0	1.2	2.3
Unit 23	134	0.0	0.0	1.5	1.5	0.7	0.0	2.2
Unit 24	449	2.4	2.3	2.1	1.7	1.1	0.7	4.0
Unit 25	172	2.3	1.8	0.6	0.5	2.3	0.6	2.3
Unit 26	89	0.0	0.0	0.0	0.0	1.1	0.0	2.2
Unit 27	238	0.4	0.4	3.4	3.3	0.8	0.8	1.3
Unit 28	55	0.0	0.0	1.8	2.3	0.0	5.5	0.0
Unit 29	256	2.3	1.6	4.2	3.5	1.6	3.5^	1.6
Unit 30	199	1.6	1.3	2.5	2.7	3.0	1.5	1.0
Unit 31	64	3.2	4.0	6.3	8.4	0.0	1.6	0.0
Unit 32	117	0.9	1.5	1.7	2.5	0.0	0.0	1.7
Unit 33	71	0.0	0.0	1.4	1.6	0.0	0.0	1.4
Unit 34	273	1.1	0.9	2.6	2.9	1.5	1.1	2.6
Unit 35	86	0.0	0.0	3.5	4.1	0.0	1.2	2.3
Unit 36	78	0.0	0.0	5.1	5.0	1.3	0.0	0.0
Unit 37	269	0.4	0.3	3.4	2.9	1.1	1.1	1.5
Unit 38	152	0.7	0.9	2.0	2.6	0.7	1.3	0.0
Unit 39	120	1.8	2.3	0.8	0.9	0.0	1.7	7.5^
Unit 40	131	3.2	2.3	3.1	3.2	2.3	0.0	3.8
Unit 41	150	0.7	0.5	0.7	0.6	0.7	0.7	0.7
Unit 42	94	0.0	0.0	4.3	6.3	1.1	1.1	2.1
Unit 43	305	1.3	0.8	2.7	2.2	1.6	2.6	1.6
Unit 44	67	0.0	0.0	0.0	0.0	1.5	0.0	0.0
Unit 45	83	0.0	0.0	2.4	2.4	1.2	0.0	2.4
Unit 46	41	0.0	0.0	2.4	3.1	0.0	0.0	0.0
Unit 47	144	0.7	0.7	6.3	6.5	2.8	0.7	4.9
Unit 48	116	0.0	0.0	0.9	1.2	0.0	2.6	1.7
Unit 49	170	1.8	1.2	1.2	1.0	0.0	0.6	3.5
Unit 50	87	2.3	3.1	0.0	0.0	0.0	2.3	2.3
Unit 51	285	1.1	1.0	2.5	1.9	1.4	0.7	3.9
Unit 52	76	0.0	0.0	0.0	0.0	0.0	1.3	3.9
Unit 53	91	1.1	1.5	0.0	0.0	0.0	1.1	1.1
Unit 54	190	0.0	0.0	3.0	3.9	0.6	0.6	3.6
Unit 55	200	0.5	0.9	1.0	1.6	1.0	0.5	2.5
Unit 56	96	0.0	0.0	0.0	0.0	0.0	0.0	2.1

^ unit is above the upper 99.7% control limit on funnel plot for the associated KPI

ᵛ unit is below the lower 99.7% control limit on funnel plot for the associated KPI

Table F2. Outcomes by unit in isolated CABG by unit, 2018 – 2021

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	877	0.5	0.5	0.3ᵛ	0.3ᵛ	0.3	0.7	1.5
Unit 2	1158	2.0	1.6	2.8	2.5	1.1	1.7	2.7
Unit 3	62	0.0	0.0	0.0	0.0	0.0	3.2	3.2
Unit 4	73	1.4	1.5	2.7	2.9	2.7	1.4	1.4
Unit 5	743	1.4	1.1	4.3^	4.1^	1.2	0.7	2.7
Unit 7	808	0.9	0.6	2.9	2.7	1.9	0.2	1.0
Unit 8	541	1.3	1.1	2.8	2.1	1.1	1.3	1.3
Unit 9	108	0.9	0.8	1.9	1.4	0.0	1.9	5.6
Unit 10	850	1.4	0.8	3.8	2.7	0.8	1.8	3.7
Unit 11	312	1.3	1.1	2.3	1.9	1.3	1.0	1.3
Unit 12	804	0.9	1.1	2.8	3.3	0.5	0.2	1.7
Unit 13	182	0.0	0.0	1.6	1.3	0.0	1.1	2.2
Unit 14	78	0.0	0.0	1.7	2.4	0.0	0.0	0.0
Unit 15	1032	0.8	0.7	2.4	1.8	1.7	0.8	2.2
Unit 16	923	0.8	0.6	3.1	2.5	1.0	0.5	1.7
Unit 17	225	0.9	0.5	2.8	1.8	0.9	0.4	2.2
Unit 18	383	0.5	0.5	2.1	2.5	0.5	0.0	0.8
Unit 19	639	1.1	0.9	2.1	1.6	1.6	0.2	3.3
Unit 20	372	0.5	0.4	3.0	2.4	0.0	1.1	1.6
Unit 21	136	0.7	0.6	5.3	5.3	1.5	1.5	2.9
Unit 22	1929	0.6	0.4	2.0	1.5	0.7	1.2	2.8
Unit 23	660	1.5	1.4	3.1	2.6	2.1	0.6	2.4
Unit 24	1358	2.6^	2.1^	2.4	1.9	1.2	1.3	2.7
Unit 25	817	1.5	1.2	2.1	1.8	0.4	2.2^	3.3
Unit 27	998	2.1	1.8	2.3	2.1	1.8	0.7	1.6
Unit 28	254	1.2	1.3	2.0	2.1	0.8	1.6	5.5
Unit 29	1202	2.0	1.2	3.9^	2.5	1.2	0.8	4.6^
Unit 30	637	0.6	0.5	1.8	1.5	0.9	1.1	2.4
Unit 31	27	0.0	-	0.0	-	0.0	0.0	0.0
Unit 32	75	0.0	0.0	1.3	1.6	0.0	1.3	0.0
Unit 34	1122	0.8	0.7	2.1	1.7	1.2	0.7	2.7
Unit 35	327	0.3	0.4	1.8	2.2	0.3	0.3	1.5
Unit 36	94	1.1	0.7	4.4	4.0	1.1	2.2	5.4
Unit 37	1428	1.1	0.9	5.0^	3.9^	1.1	1.1	1.5
Unit 38	197	0.5	0.6	2.6	2.9	0.0	0.5	0.0
Unit 39	426	0.0	0.0	0.9	1.0	0.2	0.5	4.2
Unit 40	803	1.5	1.0	2.1	2.0	0.6	0.5	2.9
Unit 41	616	0.2	0.2	1.5	1.6	1.5	0.8	1.6
Unit 42	323	0.3	0.4	2.8	3.8	1.5	0.0	2.8
Unit 43	1200	1.2	0.8	1.5	1.0	1.8	1.1	2.1
Unit 44	80	1.4	1.0	0.0	0.0	0.0	0.0	0.0
Unit 45	374	0.8	1.0	1.6	1.8	0.3	0.8	1.9
Unit 46	183	1.6	1.4	1.1	1.4	1.1	0.5	1.1
Unit 47	721	1.1	1.0	3.6	2.9	1.0	1.4	2.9
Unit 48	486	0.8	0.9	0.8	0.9	0.6	2.5	0.6
Unit 49	742	0.4	0.3	1.8	1.2	0.3	0.7	3.1
Unit 50	412	1.2	1.8	0.7	0.9	1.2	1.9	2.2
Unit 51	1388	1.0	0.8	1.6	1.2	0.9	1.7	2.5
Unit 52	394	0.3	0.4	0.5	0.5	0.5	1.0	2.0
Unit 53	135	0.0	0.0	3.0	4.2	0.7	0.7	0.7
Unit 55	562	0.5	0.7	2.7	3.6	1.2	0.5	1.4
Unit 56	479	0.2	0.3	1.3	1.1	0.6	1.1	3.2

^unit is above the upper 99.7% control limit on funnel plot for the associated KPI

ᵛunit is below the lower 99.7% control limit on funnel plot for the associated KPI

Table F3. Outcomes by unit in isolated AVR surgery by unit, 2018 – 2022

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	271	0.7	0.7	0.7	0.6	0.4	0.7	0.7
Unit 2	238	2.5	1.3	6.4	3.6	2.1	0.4	5.0
Unit 3	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 4	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 5	197	1.0	0.8	6.2	3.8	2.0	1.5	3.0
Unit 6	17	0.0	0.0	0.0	0.0	5.9	6.3	0.0
Unit 7	139	2.9	1.9	3.7	1.7	1.4	0.0	2.2
Unit 8	99	2.0	1.3	1.0	0.5	1.0	1.0	5.1
Unit 9	44	4.5	2.4	4.5	3.1	0.0	0.0	9.1
Unit 10	156	0.6	0.3	6.5	3.9	1.9	0.6	4.5
Unit 11	160	0.6	0.5	1.9	1.2	0.6	0.0	1.3
Unit 12	185	0.0	0.0	1.6	1.5	0.0	0.0	3.8
Unit 13	27	3.7	2.8	0.0	0.0	0.0	0.0	0.0
Unit 14	30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 15	192	2.6	1.3	5.8	3.6	1.6	0.5	3.1
Unit 16	161	0.6	0.5	3.2	2.0	1.2	0.0	2.5
Unit 17	70	4.3	2.2	5.9	2.2	2.9	0.0	2.9
Unit 18	62	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Unit 19	119	0.0	0.0	1.7	1.2	0.8	0.8	2.5
Unit 20	78	2.6	1.5	2.6	1.9	0.0	1.3	2.6
Unit 21	77	2.6	2.2	3.9	3.2	1.3	1.3	0.0
Unit 22	536	0.9	0.6	2.1	1.3	0.4	0.9	4.3
Unit 23	156	2.6	2.4	3.9	2.6	0.0	0.6	4.5
Unit 24	357	1.7	1.1	3.1	1.9	2.0	0.6	3.9
Unit 25	220	1.4	1.1	0.9	0.6	0.9	0.0	2.3
Unit 26	17	0.0	0.0	0.0	0.0	0.0	0.0	5.9
Unit 27	147	0.7	0.5	4.8	2.5	0.7	0.0	4.8
Unit 28	100	1.0	0.8	4.0	3.9	2.0	0.0	6.0
Unit 29	209	0.5	0.3	2.9	1.7	2.4	0.0	4.8
Unit 30	174	1.2	0.5	2.4	1.4	0.6	0.0	7.5
Unit 31	27	0.0	0.0	3.7	3.5	3.7	0.0	0.0
Unit 32	42	0.0	0.0	0.0	0.0	2.4	0.0	4.8
Unit 33	2	0.0	-	0.0	-	0.0	0.0	0.0
Unit 34	251	0.4	0.2	3.7	2.0	0.4	0.8	6.4
Unit 35	92	1.1	1.1	2.2	2.2	1.1	0.0	3.3
Unit 36	40	2.5	2.7	2.5	1.9	0.0	0.0	2.5
Unit 37	199	4.0	2.5	9.8^	6.2^	3.0	0.5	6.0
Unit 38	39	2.6	1.8	0.0	0.0	0.0	0.0	2.6
Unit 39	161	0.7	0.4	0.6	1.0	0.0	0.0	5.6
Unit 40	213	0.5	0.3	1.4	0.9	1.9	0.0	3.3
Unit 41	159	1.3	0.8	3.4	2.1	0.6	0.0	3.1
Unit 42	83	0.0	0.0	4.8	3.8	2.4	0.0	4.8
Unit 43	195	2.6	1.3	2.1	1.3	2.1	0.5	4.6
Unit 44	37	0.0	0.0	0.0	0.0	0.0	0.0	2.7
Unit 45	118	0.9	0.6	0.0	0.0	0.8	0.8	5.1
Unit 46	36	2.8	2.2	3.0	2.9	0.0	0.0	0.0
Unit 47	139	3.6	2.2	5.2	3.1	3.6	1.4	6.5
Unit 48	193	0.0	0.0	1.0	0.8	0.0	1.0	2.6
Unit 49	192	0.5	0.3	1.1	0.6	0.5	0.0	3.6
Unit 50	107	0.0	0.0	1.9	1.9	0.9	0.9	1.9
Unit 51	250	0.8	0.5	3.3	1.8	0.8	0.8	7.6
Unit 52	133	1.8	1.2	0.0	0.0	2.3	0.0	6.1
Unit 53	55	1.8	0.8	0.0	0.0	1.8	0.0	5.5
Unit 54	28	0.0	0.0	0.0	0.0	0.0	3.8	7.7
Unit 55	139	1.4	1.1	2.9	2.6	2.9	0.0	2.2
Unit 56	104	0.0	0.0	1.0	0.8	1.0	1.0	0.0

^unit is above the upper 99.7% control limit on funnel plot for the associated KPI
˅unit is below the lower 99.7% control limit on funnel plot for the associated KPI

Table F4. Outcomes by unit in combined AVR and CABG surgery by unit, 2018 – 2022

	n	OM (%)	RA-OM (%)	dNRI (%)	RA-dNRI (%)	Permanent Stroke (%)	DSWI (%)	RTT for bleeding (%)
Unit 1	179	2.2	2.0	2.8	1.3	0.6	0.6	2.2
Unit 2	131	5.3	3.9	5.7	2.4	1.5	0.8	6.1
Unit 3	15	0.0	0.0	0.0	0.0	0.0	0.0	6.7
Unit 4	10	0.0	0.0	10.0	4.2	0.0	0.0	0.0
Unit 5	90	1.1	1.4	6.7	2.7	1.1	0.0	6.7
Unit 6	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 7	69	5.8	4.8	11.8	5.2	0.0	1.4	0.0
Unit 8	45	4.4	4.3	2.3	1.0	2.2	0.0	2.2
Unit 9	16	12.5	10.7	7.1	2.8	0.0	0.0	20.0
Unit 10	116	0.9	0.9	5.2	2.5	2.6	2.6	2.6
Unit 11	63	3.2	2.6	4.8	1.7	1.6	4.8	0.0
Unit 12	125	1.6	2.2	2.4	1.4	0.8	0.8	2.4
Unit 13	32	3.1	1.7	6.3	2.2	3.1	0.0	3.1
Unit 14	13	0.0	0.0	15.4	8.8	0.0	8.3	0.0
Unit 15	77	7.8	5.0	11.1	4.7	2.6	0.0	9.1
Unit 16	119	6.7	6.2	8.5	3.6	3.4	1.7	2.5
Unit 17	55	7.3	4.9	5.5	2.0	5.5	0.0	1.8
Unit 18	70	1.4	1.2	5.7	3.0	1.4	0.0	4.3
Unit 19	84	4.8	3.1	2.4	1.1	2.4	1.2	7.1
Unit 20	49	0.0	0.0	2.0	0.8	0.0	0.0	0.0
Unit 21	49	0.0	0.0	4.1	1.0	2.0	2.0	2.0
Unit 22	282	2.8	2.5	4.7	2.0	0.7	2.1	6.0
Unit 23	63	0.0	0.0	3.3	1.4	0.0	1.6	7.9
Unit 24	219	4.1	3.8	3.3	1.6	2.8	1.4	6.9
Unit 25	105	1.0	0.9	0.0	0.0	1.0	1.0	6.7
Unit 26	11	0.0	0.0	0.0	0.0	0.0	0.0	18.2
Unit 27	91	5.5	5.7	7.8	3.8	2.2	0.0	4.4
Unit 28	37	0.0	0.0	2.7	1.7	2.7	0.0	0.0
Unit 29	170	4.7	3.1	8.4	3.5	2.4	1.2	8.3
Unit 30	90	1.1	0.9	4.6	1.9	1.1	0.0	8.9
Unit 31	16	6.3	5.6	6.3	2.8	0.0	0.0	0.0
Unit 32	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unit 33	3	0.0	-	0.0	-	0.0	0.0	0.0
Unit 34	113	5.3	3.8	8.5	3.8	1.8	3.5	11.5
Unit 35	36	0.0	0.0	0.0	0.0	0.0	0.0	2.8
Unit 36	19	0.0	0.0	10.5	4.4	10.5	0.0	5.3
Unit 37	172	2.3	1.9	8.1	3.0	2.3	1.7	4.1
Unit 38	37	0.0	0.0	5.4	3.3	0.0	2.7	5.4
Unit 39	86	4.8	7.9	2.4	1.4	0.0	1.2	4.7
Unit 40	94	3.2	3.1	8.6	3.9	2.2	1.1	5.3
Unit 41	96	1.0	0.0	2.2	0.7	1.1	1.1	5.3
Unit 42	37	0.0	0.0	8.1	3.4	0.0	0.0	0.0
Unit 43	121	3.4	2.7	2.6	1.0	3.3	0.8	9.1
Unit 44	17	7.7	8.3	0.0	0.0	5.9	0.0	11.8
Unit 45	70	0.0	0.0	2.9	1.1	0.0	0.0	5.7
Unit 46	29	6.9	10.5	0.0	0.0	0.0	0.0	10.7
Unit 47	99	2.0	1.8	10.2	4.1	2.0	1.0	6.1
Unit 48	113	0.9	0.9	1.8	0.8	1.8	0.0	2.7
Unit 49	93	3.2	3.8	4.3	2.0	1.1	0.0	2.2
Unit 50	71	1.4	1.9	2.8	0.9	1.4	1.4	1.4
Unit 51	140	1.4	1.2	9.4	3.4	0.7	2.9	7.9
Unit 52	65	0.0	0.0	1.5	0.7	0.0	0.0	6.2
Unit 53	34	2.9	3.8	0.0	0.0	0.0	0.0	2.9
Unit 54	12	0.0	0.0	0.0	0.0	0.0	0.0	9.1
Unit 55	104	1.0	1.2	2.9	1.3	1.0	1.0	2.9
Unit 56	55	0.0	0.0	1.9	0.6	3.6	1.9	3.6

^unit is above the upper 99.7% control limit on funnel plot for the associated KPI
˅unit is below the lower 99.7% control limit on funnel plot for the associated KPI

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