ANNUAL PUBLIC REPORT 2021

VICTORIAN CARDIAC OUTCOMES REGISTRY

VCOR
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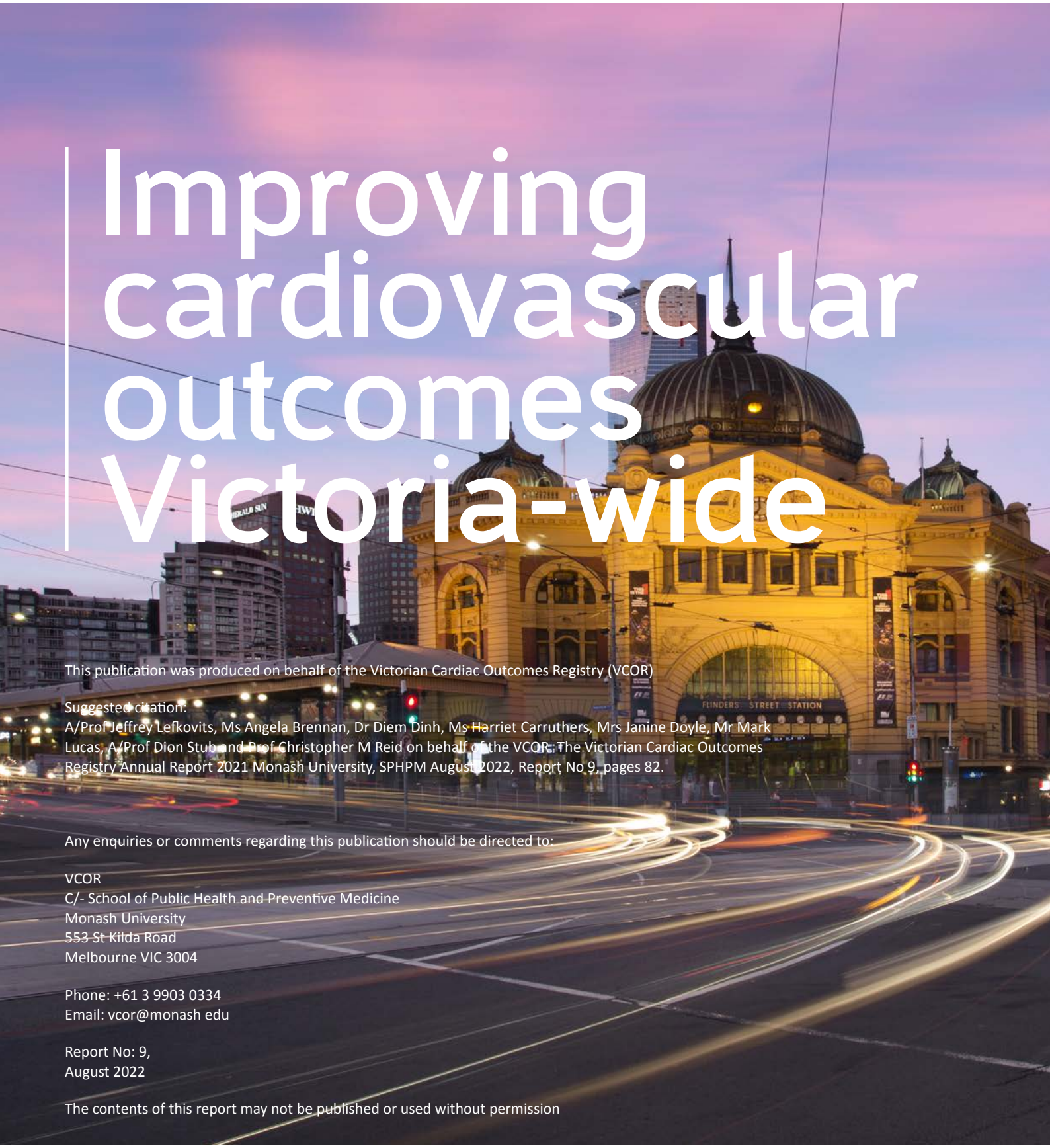

Improving cardiovascular outcomes Victoria-wide

This publication was produced on behalf of the Victorian Cardiac Outcomes Registry (VCOR)

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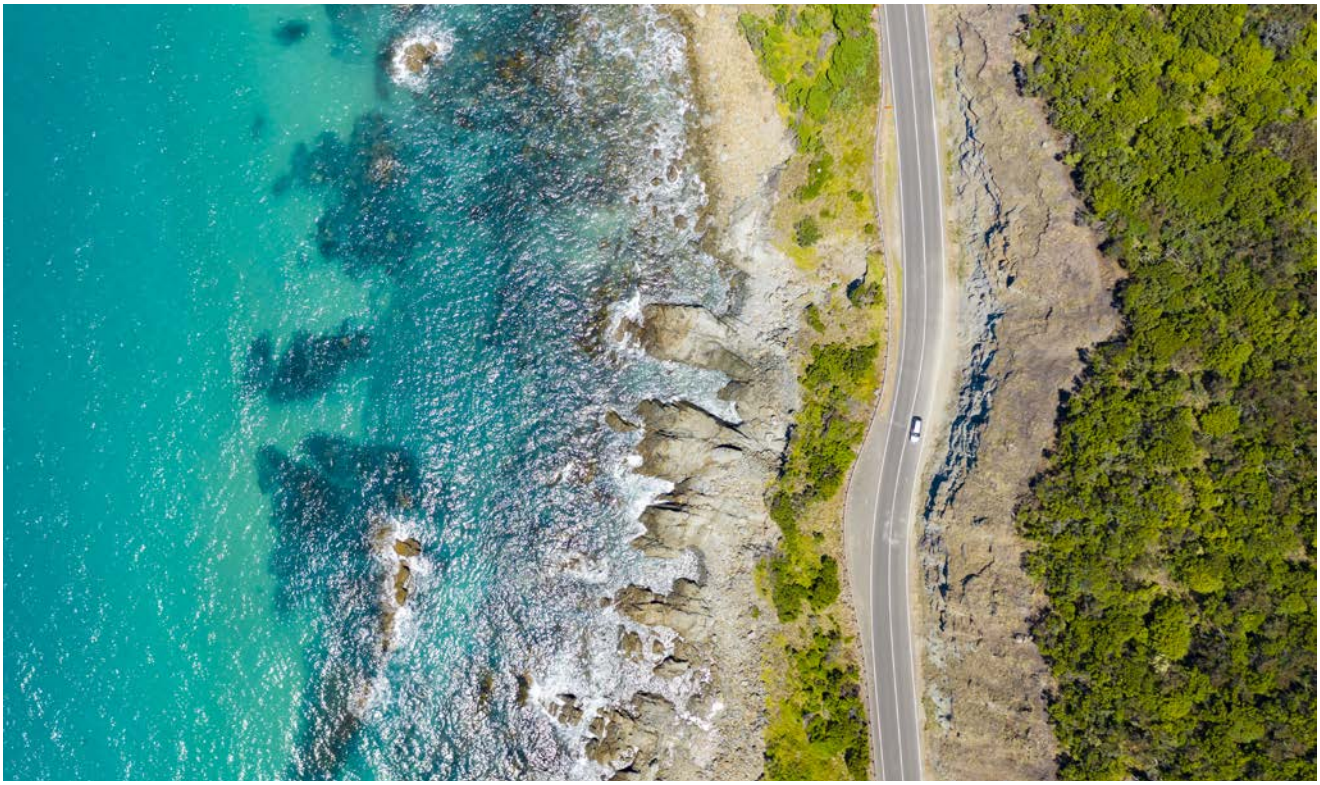

VCOR is funded by the Department of Health and Human Services (DHHS) Victoria with in-kind funding from Monash University. VCOR is operated by the Centre of Cardiovascular Research & Education in Therapeutics (CCRET) within the Department of Epidemiology and Preventive Medicine (DEPM), Monash University, in association with Safer Care Victoria and the DHHS.

We gratefully acknowledge contributions made by the VCOR Steering Committee, the VCOR Clinical Quality Committee, the VCOR Data Research and Publications Committee. We also acknowledge the VCOR Registry Custodian - Prof Christopher M Reid, the VCOR Clinical Director - A/Prof Jeff Lefkovits and the Co-Director of the Centre of Cardiovascular Research & Education in Therapeutics - A/Prof Dion Stub. We also acknowledge the VCOR Data and Project Management Committee staff at SPHPM (Ms Angela Brennan, Dr Diem Dinh, Ms Harriet Carruthers, Mrs Janine Doyle, Mr Mark Lucas and Mrs Jill Edmonds).

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VCOR would not be possible without the efforts of doctors, nurses, data managers and other relevant hospital staff who manage VCOR data related activities.

Lead clinical staff from the hospitals participating in the VCOR are also gratefully acknowledged.

Foreword

I am pleased to provide the foreword for the ninth Victorian Cardiac Outcomes Registry (VCOR) Annual Report 2021. VCOR is a clinical quality registry and a notable contributor to the medical research literature. In its tenth year this remarkable organization has cumulative state-wide data on over 90,000 patients who have undergone percutaneous coronary interventions. Neither this nor its other achievements could have been attained without the expertise and dedication of its staff and management, nor without the support of our State Government.

In the third year of the global corona virus pandemic, healthcare providers have faced new and continuing challenges that demand innovative solutions to support provision of first class health care. The current report confirms that those involved in the management of acute heart disease have managed to deliver volumes of work similar to those observed in the pre-pandemic era. More importantly, despite unprecedent system stress, the Victorian cardiac community has rallied to maintain high standards of care that are clearly demonstrated in the 2021 registry outcomes.

As it enters its tenth year, we must ask what is exceptional about VCOR? It is the first Australian clinical quality registry in percutaneous coronary intervention with universal jurisdictional participation. For a decade it has provided system assurance for patients, so that healthcare providers, consumers and regulators of cardiac care regularly access important information about timeliness of care, procedure choices, and importantly risk adjusted outcomes. Routine provision of information on safety outcomes and practice variation, assists hospitals and clinicians to engage in local quality improvement activities and facilitates benchmarking of individual hospital performance. Complete state-wide engagement by public and private providers is a testament to the value of this service.

In addition to delivering an outstanding quality registry, VCOR is part of a national network of similar organizations. Output from clinical registries has the potential to inform and assist Learning Health Networks which will benefit richly from the work of such groups. Although VCOR provides us with information regarding management of several conditions, participation in its implantable device registry is constrained by resources and at this time there is no comparable registry data on quality and safety relating to electrophysiological interventions for common rhythm disturbances. Clinicians involved in recent work to define optimal provision of cardiac procedures unanimously identified this as an important gap in our quality credentials and provided unqualified support for a similar registry to inform clinicians and consumers .

For the public and for healthcare consumers, this report provides confidence that the quality and consistency of cardiac procedural care is routinely reported to providers, supporting continuous service improvement. As the ninth VCOR report goes to press, all that is left is to commend the tireless work of this impressive organization and to express a sincere wish that the scope of its activities will be expanded for the benefit of more Victorians.

A/Prof Mark Horrigan

Cardiovascular Clinical Lead
Safer Care Victoria

Executive Summary

The all-encompassing public health issue that dominated the 2021 calendar year has been the continued COVID-19 pandemic. While it is challenging to accurately recall all the complexities of the progression of the COVID-19 pandemic throughout the year, it is fair to say that whereas 2020 was characterised by strong efforts to maintain "COVID zero", 2021 was the year of vaccine rollouts and for Victoria in particular, the year of multiple sequential lockdowns.

In the first year of the COVID-19 pandemic, the greatest impact was felt in the state of Victoria, where over 800 lives were lost in the second wave of infections from July to October 2020. In 2021, trends in case numbers across Victoria were mirrored in NSW with a peak in October, and a second acceleration 2 months later in December. Yet, by the end of 2021, nearly 5 million Victorians, representing 91.6% of the eligible population, had received 2 vaccine doses. We witnessed the introduction of COVID-19 digital certificates, a wholesale switch to telemedicine and longer-term effects on hospital workloads, workflows and healthcare workers. There were still many unknowns, including the impact on costs to the economy and community, uneven impost in certain sections of society including the aged and the disadvantaged, the longer-term mental health effects and how "living with COVID" was actually going to pan out. However, somewhat reassuringly, data from a Melbourne-based study suggested that people still presented in expected numbers with life-threatening conditions – including acute cardiac conditions - during Melbourne's lockdowns, and that switching to telemedicine did not cause widespread spill-over from primary care into hospital emergency departments [1].

We know that from a cardiac perspective COVID-19 infection has manifold effects. These range from an increased risk of serious disease among patients with pre-existing cardiovascular disease to acute cardiac manifestations of the infection - from asymptomatic rises in cardiac biomarkers to fully-fledged syndromes including acute myocarditis and Takotsubo cardiomyopathy. "Long COVID" too brings with it a longer-term risk of a broad range of cardiovascular disorders including arrhythmias, ischaemic heart disease, pericarditis, myocarditis, heart failure and thromboembolic disease.

This year's Annual Report includes a special section on the observed effects of the second year of the COVID-19 pandemic on the performance and outcome of percutaneous coronary intervention (PCI) across the state of Victoria. However, the main focus of the report has been to analyse and disseminate key information on the results of PCI in the state of Victoria, to benchmark the performance of hospitals undertaking this procedure and to identify unwanted variation in practice across the state. With so much health-related information now easily accessible and freely disseminated in mainstream media, it is more important than ever to ensure that the data being provided are accurate, appropriately contextualised based on risk adjustment, relevant to all stakeholders including the providers, consumers and regulators of that healthcare, and that the registry achieves its goal of improving the quality and safety of the care being delivered to all Victorians who are in need.

The Victorian Cardiac Outcomes Registry continues to provide comprehensive patient-level data on PCI, with complete engagement of all PCI centres in the state. Our Annual Report covers public and private sector healthcare delivery and benchmarks both sectors collectively. VCOR also maintains a second registry module on cardiac implantable electronic devices (CIEDs) - a device-based therapy primarily used in patients with weakened heart conditions (cardiomyopathy) to treat heart failure and life-threatening arrhythmias. In 2021, 13 hospitals contributed to this module with further expansion still limited by funding constraints. These sites are able to benefit directly from the quality assurance aspects of a clinical quality registry, with additional value to the general cardiology community and the public through the dissemination of the clinical information by this Annual Report.

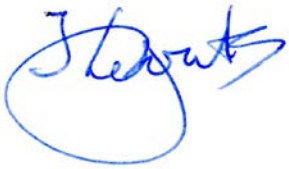
Executive Summary continued

We are also particularly proud about the increasing contribution the Victorian Cardiac Outcomes Registry is making in the areas of clinical research and epidemiology. In 2021, VCOR maintained strong links with researchers both within and outside our organisation, with 11 manuscripts published and a VCOR based PhD student completing his thesis. In addition, despite being unable to attend conferences in person, many abstracts were presented at scientific conferences both nationally and internationally.

This Annual Report would not have been possible without the full-hearted commitment and dedication of the Registry Management Team. It is a testament to their skill and professionalism that this Annual Report can be relied upon by all key stakeholders to deliver accurate and reliable information and guide healthcare professionals in providing the best possible standard of care to all Victorians. Similarly, I acknowledge the commitment and support that VCOR receives from Victoria's cardiac clinicians, participating hospitals' executives and the staff of those hospitals who provide the high-quality data this report relies on. VCOR would also like to express its gratitude to the Victorian Government for its vision and staunch support for the ongoing operation of a clinical quality registry in cardiology that aims to ensure that high-quality and safe healthcare is equitably delivered to all Victorians.

A summary of the key findings in this year's Annual Report is presented below. On behalf of the VCOR organisation I hope you find this year's report interesting and informative.

Yours sincerely,



A/Prof Jeffrey Lefkovits
VCOR Clinical Director

Key Findings

PCI Registry

- All 33 Victorian hospitals that perform PCI contributed to the registry in 2021, comprising 15 public and 18 private hospitals. A total of 12,478 completed procedures were collected on 11,053 patients. 56% of cases were managed in the public system.
- The majority of patients undergoing PCI were male (75%). The mean age was 67 years. Patients treated in private hospitals were six years older on average than public patients.
- A total of 19% of cases were performed outside normal working hours across both the public and private hospital sectors. Just over half of all ST-elevation myocardial infarction (STEMI) cases were out-of-hours and 83% of those were managed in the public sector.
- Just under half of the PCI cases in 2021 presented with an acute coronary syndrome (ACS), with the majority (75%) treated in public hospitals. ACS cases accounted for two-thirds of the public sector's caseload and one-third of the private sector's.
- For non-ACS PCI cases, the indication for the procedure was defined by 3 key clinical factors - the presence of ischaemic symptoms, functional ischaemia on stress testing and the presence of high-grade coronary stenosis. A total of 91% of cases had at least 2 of these key clinical factors. The proportion of cases with no or just 1 key clinical factor has been trending downwards over time (19% in 2017, 13% in 2018, 11% in 2019, 10% in 2020 and 9% in 2021).
- Particular lesion subsets including unprotected left main (2.3%), chronic total occlusion (3.6%) and in-stent restenosis (5.7%) cases were performed in similar numbers to previous years.
- The number of patients presenting with cardiogenic shock or out-of-hospital cardiac arrest was similar to previous years. High-volume public hospitals generally treated these high-acuity cases. Private hospitals treated only very small numbers of shock and cardiac arrest cases.
- Drug-eluting stents (DES) accounted for 99.9% of all stents implanted. There is now no gap between public and private hospital DES use.
- Utilisation of the radial artery for vascular access continues to increase year-on-year, accounting for 77% of all PCI cases in 2021. Rates still varied among hospitals, with public hospitals generally having higher radial vascular access (78%) compared with private hospitals (71%), although the gap between the two sectors is closing. There were lower rates in the elderly (63% >80 years vs 77% <80 years).
- In 2021, 20% of patients underwent PCI for STEMI, of whom 76% had primary PCI. Other categories of PCI for STEMI included rescue PCI (6.9%) and pharmaco-invasive PCI (3.8%). Patients with STEMI were younger, had fewer traditional cardiac risk factors such as diabetes and peripheral vascular disease, and had lower rates of previous revascularisation procedures.
- Primary PCI accounted for 15% of PCI caseload. The majority of primary PCI was undertaken in the public sector (87%). Radial access was used in 76% of cases. The median time taken from patient arrival at the hospital to the first balloon inflation (door-to-balloon time or DBT) was 61 minutes. The last two years' DBT results represent an increase compared to the previous two reporting periods and are likely due to the effect of the COVID-19 pandemic on medical service delivery in the acute hospital setting. Just over half the hospitals achieved a DBT ≤90 minutes in greater than 75% of primary PCI cases.
- For the first time, VCOR has been able to report in greater detail on the various time components that contribute to a patient's total ischaemic time. Measures of system delay in primary PCI are now trending towards measuring times from first medical contact (FMC) rather than from arrival at a hospital. The median FMC to reperfusion for the cohort was 106 minutes. Only 5 hospitals managed to meet the benchmark target of a median FMC to reperfusion ≤90 minutes. Another key process measure in STEMI treatment is the time from FMC to diagnostic ECG. In 2021, the overall median FMC to diagnostic ECG time was 6 minutes. Most hospitals met the recommended benchmark of 10 minutes.

Key Findings continued

PCI Registry

- The unadjusted in-hospital mortality rate was 1.4%. Mortality was higher among patients presenting with STEMI (4.8%), and highest for patients with cardiogenic shock or out-of-hospital cardiac arrest (37.7%). Excluding these two high-risk groups, the unadjusted in-hospital mortality rate was 0.5%.
- The signature key performance indicator of risk adjusted 30-day mortality rate for the overall PCI cohort was 2.4%. There were no outlier hospitals.
- The median in-hospital major bleeding rate was 0.8% and of note was lower among radial access cases (0.5% radial vs 1.9% femoral). The 30-day unplanned cardiac readmission rate was 2.9%, with similar rates in the public and private sectors. Rates of other major adverse cardiac outcomes were low and similar to previous years. All hospitals were within control limits for each of these KPIs.

CIED Registry

- Thirteen health services across the state (9 public and 4 private hospitals) participated in the 2021 CIED module, with a total of 746 procedures performed on 721 patients.
- Three-quarters of patients were males and the mean age was 67 years. Overall, 56% were first implants and 37% of cases were generator replacements. Other procedure types were new lead (3%), removal of device without replacement and revision procedures (4%).
- ICD devices (ICD, CRT-D or S-ICD) represented 82% of first implants and 78% of generator replacements in this module.
- 44% of patients undergoing any ICD (ICD, CRT-D or S-ICD) had an ischaemic cause. Just over half of ICDs were implanted for primary prevention.
- For CRT-P devices, an ischaemic cause was reported in 28% of cases and 62% had an idiopathic cardiomyopathy.
- Among patients treated with CRT-D, 90% had a QRS width ≥120 milliseconds, 75% had severe left ventricular dysfunction and 89% NYHA Class II symptoms or greater. For CRT-P devices, 78% had a QRS width ≥120 milliseconds and there was more variability in the degree of left ventricular impairment.
- For ICD devices, 86% had either +++ or ++ strength indications for a defibrillator. In contrast, 62% of CRT-D and CRT-P cases had either +++ or ++ strength indications for CRT.
- In 2021, there were in total three in-hospital mortalities where two were cardiac related deaths. The unadjusted 30-day mortality rate was 0.5% with four deaths recorded within 30 days of hospital discharge. The overall 30-day unplanned cardiac readmission rate was 3.6% and the device related reoperation rate was 1.5%. The rate of 30-day device related infection was 1.2%. All hospitals were within control limits for each of these endpoints.

Introduction

The Victorian Cardiac Outcomes Registry (VCOR) has been in operation since 2013 and this is our ninth Annual Report. Now at a well-established and mature stage, VCOR continues to fulfil its purpose as a clinical quality registry, monitoring the quality and safety of cardiovascular care in Victoria. A key role of the registry - contained in this and other regular reports - is the benchmarking of hospitals' performance. We believe that this assessment of variation in practice and the timely feedback of these findings to hospitals and clinicians provides an important impetus to those stakeholders to actively engage in their own quality assurance activities. Additionally, the exposure of VCOR's activities and results through public reports such as this offers reassurance to consumers of cardiac healthcare and the general public, that the quality and safety of the treatment they receive is being actively monitored and tracked.

VCOR's success as an effective clinical quality registry is a direct result of the commitment of Victorian hospitals to the principles of quality assurance and continuous quality improvement. Proudly, VCOR enjoys the engagement of all PCI hospitals in Victoria – in both the public and private sectors. In the last 12 months, 1 additional hospital has commenced a PCI program and committed to contributing to VCOR from the outset of its new service. Currently, there are 33 hospitals in Victoria performing PCI.

The collection of clinical data related to PCI remains VCOR's primary activity. However, a second module involving the monitoring of cardiac implantable electronic devices (CIED) is also ongoing. This module was launched in 2018, with a total of 13 hospitals from both the public and private sectors currently contributing data. The number of participating sites has remained static over the last 12 months, with several hospitals still unable to join because of capacity constraints and limitations with their data collection resources. Nevertheless, the module has sufficient case volume to provide meaningful comparative data on performance, appropriateness, and acute outcomes.

Beyond its role of collecting data and reporting on performance and outcomes with PCI and CIED, VCOR continues to promote the place of quality assurance in routine clinical practice through a range of activities. We have forged links with several organisations including the recently established National Cardiac Registry (NCR) - an Australian Government-funded clinical quality registry relating to cardiovascular care. The NCR is structured as a federated system with each state and territory responsible for their own data collection and submission. VCOR also collaborates closely with Ambulance Victoria, with mutual data linkages and exchanges that enhance both organisations' analyses and reports. We are committed to clinical research and have reached out to researchers within and external to our organisation, resulting in a substantial body of research completed and many more projects underway or in advanced stages of planning. The registry also has key roles in assisting the State Government with its quality assurance responsibilities and as an advocate for the practice of high-quality evidence-based medical care.

Registry Governance and Structure

VCOR's governance structure and processes have been previously outlined in detail [2,3]. VCOR conforms to the Australian Health Ministers Advisory Councils Framework for Australian Clinical Quality Registries [4] including all relevant standards related to security and protection of data. VCOR also abides by the National Operating Principles for Clinical Quality Registries as set out by the Australian Commission on Safety and Quality in Health Care [5].

Steering Committee

The Steering Committee (SC) comprises representatives from all participating hospitals, a representative from Safer Care Victoria, a consumer representative, and representatives from the Department of Epidemiology and Preventive Medicine at Monash University. The SC is chaired by A/Prof Jeffrey Lefkovits. Steering Committee activities in 2021 included approving an update to the VCOR audit policy. SC meetings were held on four occasions in 2021 with excellent attendance across meetings.

Clinical Quality Committee

The Clinical Quality Committee (CQC) has responsibility for the oversight, analysis, interpretation, and release of hospital performance data. The CQC is central to VCOR's overall function as a clinical quality registry. For the PCI module the CQC undertakes quarterly and biannual review of hospital key performance indicators (KPIs) and other relevant data. Results and outcomes pertaining to the CIED module are also undertaken and presented to the CIED Expert Working Group. Relevant and meaningful reports are sent to participating hospitals and government. The CQC continues to assist hospitals with the management of any outliers including providing feedback and review as requested. This may include formal meetings with the Principal Investigator and other hospital executives. Clinical Quality Committee meetings were held on four occasions in 2021.

Data, Research and Publications Committee

The Data Research and Publications Committee (DRP) has an important and complementary role in VCOR. The DRP reviews and approves research requests, including for access to and analysis of group aggregate de-identified data. In total, the DRP has approved 73 requests and in 2021, an additional nine were approved. The various reports and research papers are outlined in the Publications and Presentations section of this report. All projects are considered collaborative and many approved projects from previous years remain ongoing, including the COVID-19 collaborative project. Data Research and Publications Committee meetings were held on four occasions in 2021.

Percutaneous Coronary Intervention (PCI)

Registry Module Activity

This report covers PCI activity in Victoria for the 2021 calendar year from January 1 to December 31. Comparisons of results and outcomes with preceding years are presented for various parameters. In 2021, all 33 hospitals that perform PCI in Victoria contributed data comprising 15 public and 18 private hospitals (Table 1).

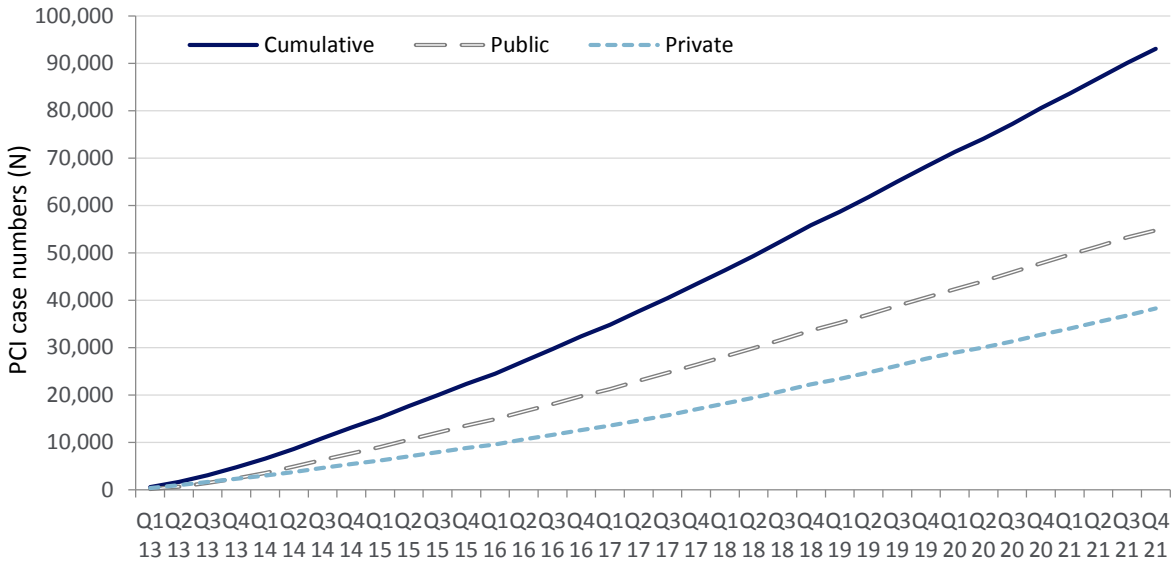
Table 1: Participating Victorian PCI hospitals

Victorian PCI hospitals	Hospital type	2013	2014	2015	2016	2017	2018	2019	2020	2021
Albury Hospital	Public	N/A	N/A	N/A	N/A	N/A	N/A	•	•	•
Alfred Hospital	Public	•	•	•	•	•	•	•	•	•
Austin Hospital	Public	•	•	•	•	•	•	•	•	•
Ballarat Base Hospital	Public	•	•	•	•	•	•	•	•	•
Bendigo Hospital	Public	•	•	•	•	•	•	•	•	•
Box Hill Hospital	Public	•	•	•	•	•	•	•	•	•
Cabrini Hospital Malvern	Private	•	•	•	•	•	•	•	•	•
Epworth Hospital Eastern	Private		•	•	•	•	•	•	•	•
Epworth Hospital Geelong	Private				•	•	•	•	•	•
Epworth Hospital Richmond	Private	•	•	•	•	•	•	•	•	•
Footscray Hospital	Public	•	•	•	•	•	•	•	•	•
Frankston Hospital	Public	•	•	•	•	•	•	•	•	•
Holmesglen Private Hospital	Private				N/A	•	•	•	•	•
Jessie McPherson Private Hospital	Private	•	•	•	•	•	•	•	•	•
Knox Private Hospital	Private	•	•	•	•	•	•	•	•	•
Latrobe Regional Hospital	Public	N/A	N/A	N/A	N/A	N/A	N/A	N/A	○	•
Melbourne Private Hospital	Private		•	•	•	•	•	•	•	•
Monash Heart	Public	•	•	•	•	•	•	•	•	•
Mulgrave Private Hospital	Private				•	•	•	•	•	•
The Northern Hospital	Public	•	•	•	•	•	•	•	•	•
Peninsula Private Hospital	Private				○	•	•	•	•	•
St John of God Hospital (Ballarat)	Private			○	○	•	•	•	•	•
St John of God Hospital (Bendigo)	Private			•	•	•	•	•	•	•
St John of God Hospital (Berwick)	Private	N/A	N/A	N/A	N/A	N/A	•	•	•	•
St John of God Hospital (Geelong)	Private			○	•	•	•	•	•	•
St Vincent's Hospital Melbourne	Public	•	•	•	•	•	•	•	•	•
St Vincent's Private Hospital	Private	•	•	•	•	•	•	•	•	•
St Vincent's Private Hospital (Werribee)	Private	N/A	N/A	N/A	N/A	N/A	•	•	•	•
The Royal Melbourne Hospital	Public	•	•	•	•	•	•	•	•	•
Sunshine Hospital	Public	N/A	N/A	•	•	•	•	•	•	•
The University Hospital, Geelong	Public	•	•	•	•	•	•	•	•	•
Warringal Private Hospital	Private				○	•	•	•	•	•
Western Private Hospital	Private	•	•	•	•	•	•	•	•	•

Table Legend: ● = contributing data; ○ = engaged but not yet contributing.

In 2021, 12,478 cases were entered into VCOR representing a slight increase from the previous year. As of December 31, 2021, a total of 93,052 PCI cases had been entered into the registry. The cumulative rate of recruitment since commencement by quarter and by hospital sector is shown in Figure 1. The lost-to-follow-up rate in 2021 was 0.4%, with an overall rate for the entire registry since its commencement of 1.1%. The number of requests from patients to opt-off from inclusion in the registry remains low – 0.14% in 2021 and 0.15% since registry commencement.

Figure 1: Cumulative case numbers by quarter: 2013 - 2021



In addition to its primary role of monitoring performance and outcomes of PCI in Victoria, VCOR continues to provide contracted registry services to Tasmania. The registry provides Tasmanian participating hospitals with data and reports on process and outcome measures and facilitates Tasmanian hospitals to benchmark their performance against peer hospitals in Victoria. In 2021, two Tasmanian public hospitals and one private hospital contributed data on their PCI cases and one public hospital was contributing data to the CIED module.

Data Quality

VCOR continues its commitment in ensuring accurate and reliable data with the purpose to provide comprehensive information regarding the quality and safety of cardiovascular care in Victoria. Ensuring data accuracy is a key operational activity of clinical quality registries [6].

Due to the ongoing COVID-19 pandemic in 2021, VCOR was unable to visit sites to conduct routine case ascertainment and data audits. Instead, VCOR continued to engage with health services to undertake a range of self-audits for the PCI and CIED modules (only case ascertainment audits are undertaken for the CIED module). The results were consistent with onsite conducted audits, with very low numbers of missing cases identified. The rate of missing PCI cases for 2021 was 0.5% while for CIED was 1.8%. VCOR intends to resume site-based auditing practices in the near future.

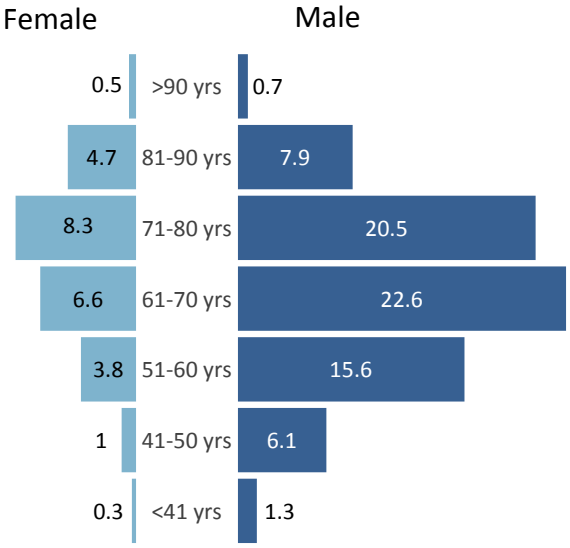
In addition, extensive additional data queries were developed to assist in data quality with support and completion of these queries by hospitals. VCOR specifically focused on data fields with a higher level of missing data than expected. The key variables queried were Indigenous status, cardiac rehabilitation referral as well as monitoring the missing data related to the 30-day follow-up.

VCOR continues to provide sites with detailed quarterly reports and sends regular data queries for review for the PCI module. In addition, the VCOR online system has many additional validation rules and mandatory fields to reduce inaccuracies. Regular newsletters, bulletins, training sessions and data manager meetings are also held with these aiding in ensuring the accuracy and reliability of the VCOR data.

Patient Characteristics

A total of 12,478 PCI procedures were performed on 11,053 patients with 1,425 patients undergoing more than one procedure. A total of 6,960 cases (56%) were performed in public hospitals. Overall, 75% of cases were performed on male patients, similar to the previous year. The median age for males was 67 years (IQR: 58, 75) and for females was 71 years (IQR: 62, 79). The peak frequency of PCI procedures occurred in the seventh decade for males and the eighth decade for females (Figure 2).

Figure 2: Age and sex distribution of patients undergoing PCI



Selected patient demographic characteristics over a six-year period are shown in Table 2. Only minor variations among the various demographic characteristics have been observed over time.

Table 2: Comparison of selected patient characteristics: 2016 - 2021

Patient characteristics	2016 (N=10,035)	2017 (N=11,007)	2018 (N=12,463)	2019 (N=12,355)	2020 (N=12,349)	2021 (N=12,478)
Age- years (Mean ±SD)	66.0 (±12.0)	66.5 (±11.9)	66.7 (±11.7)	67.2 (±11.7)	66.9 (±11.9)	67.3 (+11.9)
	%	%	%	%	%	%
Sex - female	23.5	24.4	23.7	24.5	24.5	25.2
Diabetes	21.6	21.7	22.6	23.2	23.8	23.6
Peripheral Vascular Disease	3.4	3.4	3.4	3.6	3.4	3.4
Cerebrovascular Disease	3.3	3.9	3.4	3.8	3.5	3.0
Previous PCI	32.7	32.8	33.4	33.1	33.6	32.7
Previous CABG	7.6	7.3	7.2	6.8	5.9	6.0

Patient characteristics are compared by hospital sector in Table 3. Patients treated in the private sector were six years older on average than public hospital patients. The mean age of patients within each sector was largely unchanged from previous years. For the first time we have also reported on the proportions of patients with a history of hypertension and chronic lung disease. Private sector patients had a higher prevalence of hypertension (72.7% vs 60.9%), while the rate of chronic lung disease was similar across the sectors, with asthma predominating over chronic obstructive pulmonary disease. The prevalence of severe obesity (BMI ≥35kg/m^2) was greater among public sector patients and in women (16.6% women vs 10.4% men) - trends that have been apparent for a number of years. Research utilising data from VCOR has demonstrated that obesity is associated with poorer outcomes [7].

Table 3: Selected patient characteristics by hospital sector

Patient characteristics	Public (n=6,960)	Private (n=5,518)
Age- years (Mean ±SD)	64.5 (±12.2)	70.9 (±10.4)
	%	%
Sex - female	25.3	25.2
Diabetes	25.3	21.5
Peripheral Vascular Disease	2.8	4.1
Cerebrovascular Disease	3.3	2.7
Previous PCI	27.3	39.6
Previous CABG	4.6	7.8
Hypertension	60.9	72.7
Chronic Lung Disease	12.2	11.6
Body Mass Index (BMI) ≥35kg/m^2	13.4	10.1

Resource Utilisation

VCOR applies information relating to the timing of cases (in-hours vs out-of-hours) and delays in treatment of patients with ACS as markers that reflect the balance between the demands on health service resource utilisation and the efficiency of health services in dealing with those demands. Trends with these two process measures can assist hospitals in the appropriate allocation of resources and promote hospitals' overall efficiency and performance.

In-hours vs out-of-hours cases

A total of 2,397 cases (19.2% of total cases) were performed out-of-hours with the majority for STEMI (n=1,384, 58% of out-of-hours cases). NSTE-ACS cases accounted for 34% of the overall out-of-hours workload. A smaller proportion of the out-of-hours cases in 2021 were for non-ACS indications compared with the previous year (8% in 2021 vs 20.8% in 2020). The out-of-hours caseload burden was 21.2% in the public sector and 16.6% in the private sector - similar to the previous year.

Time delays to PCI for NSTE-ACS

Figure 3 presents time delays from hospital admission to PCI for NSTE-ACS cases. Australian practice guidelines recommend early coronary angiography and potential percutaneous revascularisation whenever practicable and hospital resources are utilised most efficiently if time delays to PCI for NSTE-ACS are as short as possible. Across the entire cohort, 47% of NSTE-ACS cases were treated in less than 24 hours - a 3% decrease compared with 2020. The proportion of NSTE-ACS cases where treatment was delayed >72 hours was similar to previous years.

Figure 3: Time delays from hospital admission to PCI for NSTE-ACS cases

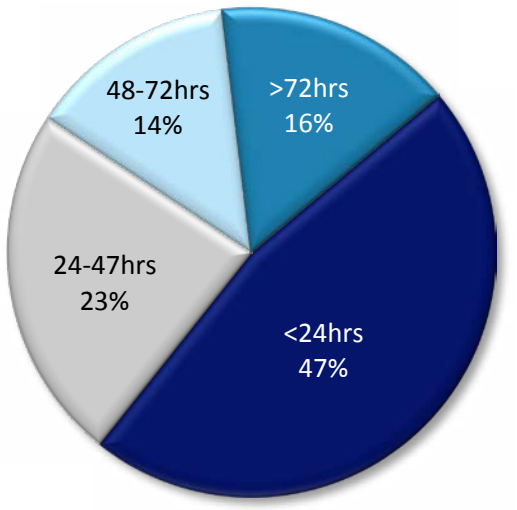
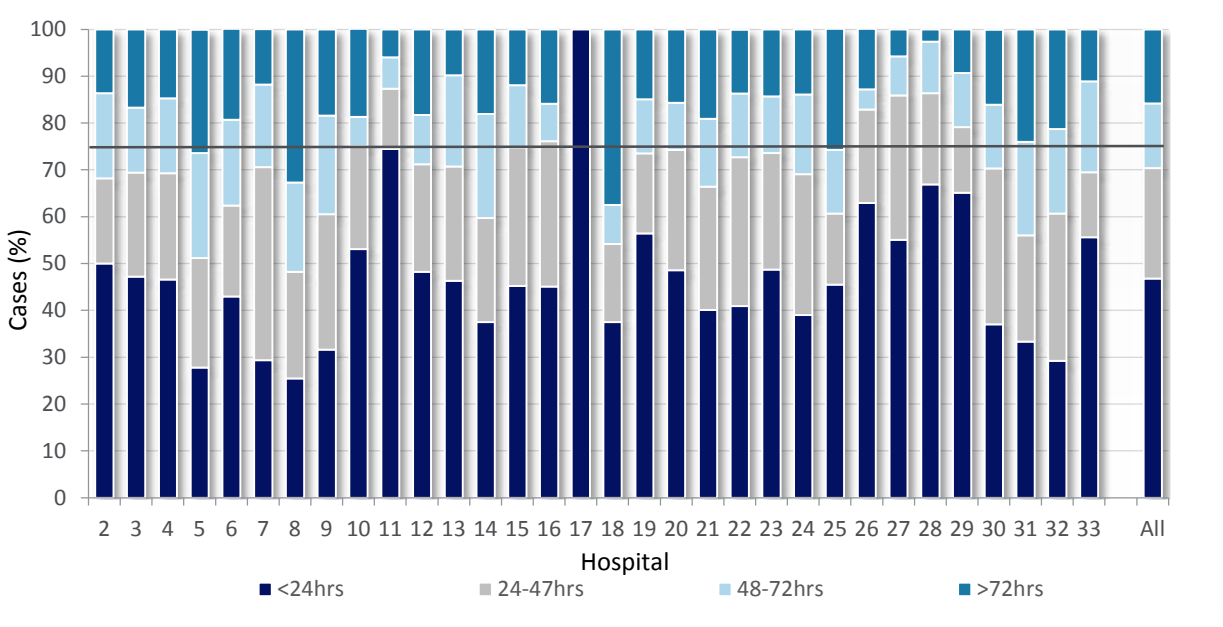


Figure 4 shows hospitals' performance in achieving timely PCI treatment of NSTE-ACS, benchmarked against a target of ≥75% of cases completed within 72 hours of hospital admission. Three hospitals did not meet this benchmark.

Figure 4: Time delays from hospital admission to PCI for NSTE-ACS cases by hospital



Site 1 had no NSTE-ACS cases. Site 17 had low NSTE-ACS cases n<5.

When NSTE-ACS time delays were examined by hospital sector, cases tended to be treated earlier in public hospitals – 86.2% within 72 hours in the public sector vs 80.3% in the private sector. Cases with delays (>72 hours) were more frequently seen among private sector patients (Table 4).

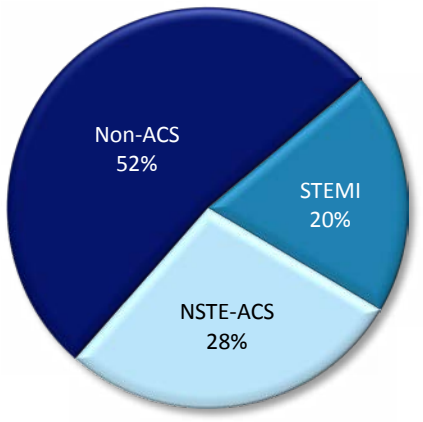
Table 4: Time delays from hospital admission to PCI for NSTE-ACS cases by hospital sector

	All sites (N=3,495)	Public (n=2,337)	Private (n=1,158)
	N (%)	N (%)	N (%)
<24hrs	1637 (46.8)	1160 (49.6)	477 (41.2)
24-47hrs	826 (23.6)	554 (23.7)	272 (23.5)
48-72hrs	481 (13.8)	300 (12.8)	181 (15.6)
>72hrs	551 (15.8)	323 (13.8)	228 (19.7)

Clinical Presentation

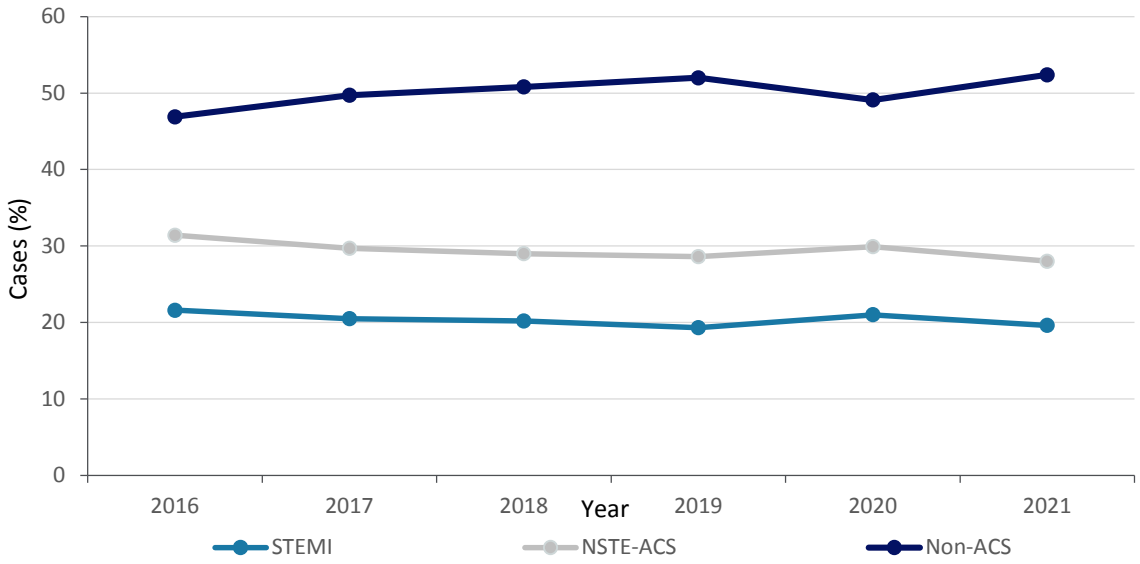
The proportions of cases of PCI for ACS and non-ACS were broadly similar, with non-ACS cases representing 52% of the total PCI volume (Figure 5). Trends for clinical presentations, as shown in Figure 6, have remained stable over time.

Figure 5: Procedures by clinical presentation



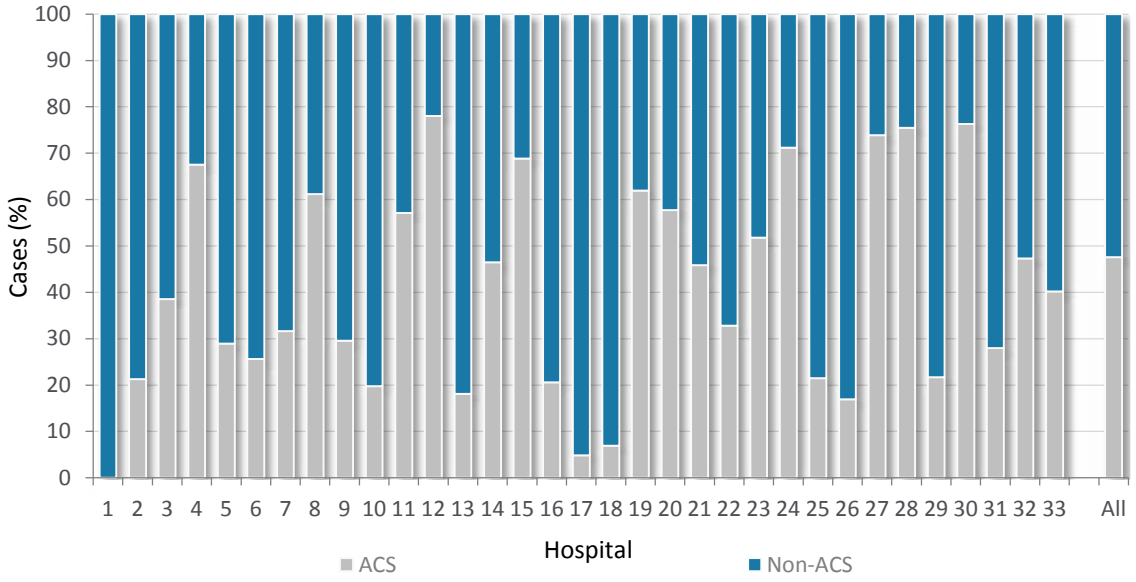
A small reduction in non-ACS cases observed in the previous year was likely due to the effect of cancellation of non-urgent cases due to the COVID-19 pandemic. The continuing effect of the pandemic is discussed in more detail later in this report.

Figure 6: Trends in procedural rates by clinical presentation: 2016 - 2021



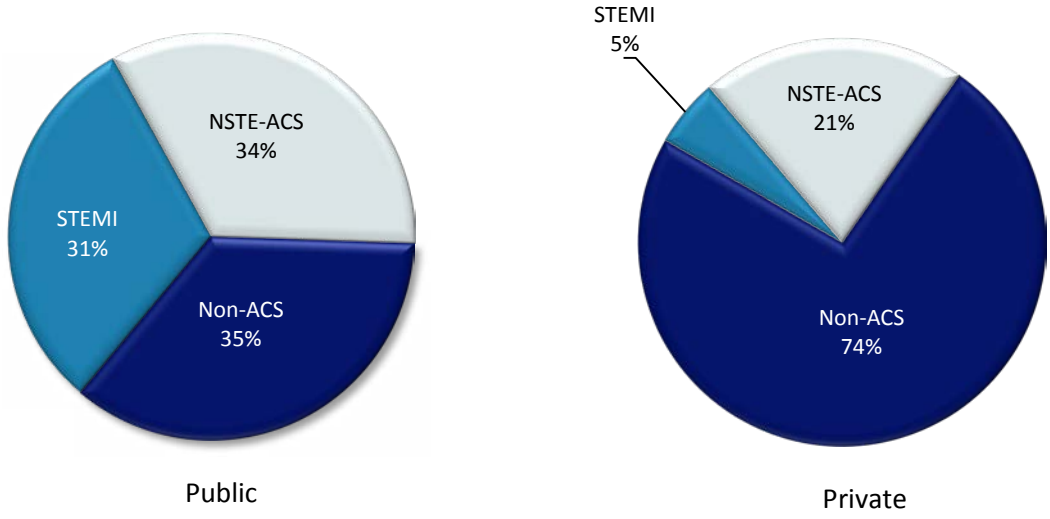
A comparison of case mix (ACS vs non-ACS) by hospital is shown in Figure 7. There was significant variation in the proportion of ACS cases across Victorian PCI hospitals. Some hospitals treated relatively few ACS cases including one that did not have any ACS cases. In contrast, in a number of hospitals, ACS accounted for a majority of their PCI workload, including 5 hospitals where ACS accounted for >70% of their cases.

Figure 7: ACS and non-ACS cases by hospital



As in previous years, the majority of public work was ACS-related, whereas private sector activity was mostly for non-ACS conditions (Figure 8).

Figure 8: Procedure by clinical presentation by hospital sector



Indications for PCI

Table 5 outlines the ACS-related indications for PCI among the patient cohort. In determining whether a procedure was undertaken for an appropriate indication, it is generally agreed that PCI for an acute coronary syndrome is clinically appropriate, and this is supported by Australian practice guidelines [8]. In 2021, 52.6% of patients had a PCI for an ACS-related, clinically appropriate indication. There was a small reduction in primary PCI cases compared with the previous year (1,856 in 2021 vs 1,934 in 2020). However, there was a small increase in the number of rescue PCI cases (169 in 2021 vs 116 in 2020), with the majority of these undertaken in the public sector (91% public vs 9% private).

Table 5: PCI indications by ACS category and hospital sector

PCI indications	All sites (N=6,557)	Public (n=4,782)	Private (n=1,775)
ACS Category	N (%)	N (%)	N (%)
Primary PCI*	1856 (28.3)	1616 (33.8)	240 (13.5)
STEMI PCI 12-24 hours after symptom onset	127 (1.9)	111 (2.3)	16 (0.9)
Pharmaco-invasive PCI	94 (1.4)	92 (1.9)	2 (0.1)
Rescue PCI	169 (2.6)	154 (3.2)	15 (0.8)
PCI For STEMI (1-7 Days no prior lysis)	136 (2.1)	118 (2.5)	18 (1.0)
PCI For STEMI (1-7 Days following lysis)	64 (1.0)	57 (1.2)	7 (0.4)
PCI for OHCA/shock (non-MI)	46 (0.7)	38 (0.8)	8 (0.5)
PCI for NSTE-ACS	4065 (62.0)	2596 (54.3)	1469 (82.8)
NSTE-ACS sub-category	N (%)	N (%)	N (%)
NSTEMI	2920 (44.6)	2089 (42.3)	831 (46.8)
UAP	574 (8.8)	247 (5.2)	327 (18.4)
Recent ACS 8-30 days ago	571 (8.7)	260 (5.4)	311 (17.5)

Primary PCI for STEMI presentations **including all inter-hospital transfer arrivals and patients with STEMI onset whilst a current in-patient.*

The number of PCIs performed for unstable angina has steadily declined over time, with the proportion of cases in 2021 (8.8%) being the lowest since VCOR commenced data collection. Yet, as in previous years, unstable angina case numbers were more than three times higher in the private sector.

A total of 5,919 cases were undertaken for non-ACS indications (Table 6). Almost three-quarters of these cases were for stable angina- an increase over the previous year (72 % in 2021 vs 66 % in 2020)- and observed across both hospital sectors. Cases undertaken in patients without symptoms, or an abnormal functional test are generally considered to have a relatively weak indication for PCI, with the proportion of cases with this indication continuing to decline over time.

The indication of staged PCI refers to patients with multi-vessel disease undergoing a subsequent PCI after the initial PCI and is further categorised according to the indication of the original procedure. The proportion of staged PCIs after an original non-ACS indication have increased across both hospital sectors (Table 6).

Table 6: Non-ACS PCI indications

PCI indications	All sites (N=5,919)	Public (n=2,176)	Private (n=3,743)
	N (%)	N (%)	N (%)
Stable angina	4276 (72.2)	1522 (69.9)	2754 (73.6)
No symptoms and positive functional test	352 (5.9)	64 (2.9)	288 (7.7)
No symptoms and no functional test	259 (4.4)	113 (5.2)	146 (3.9)
Staged PCI after ACS (≤30 days after first procedure)	589 (10.0)	334 (15.3)	255 (6.8)
Staged PCI after ACS (>30 days after first procedure)	154 (2.6)	93 (4.3)	61 (1.6)
Staged PCI after original non-ACS indication	289 (4.9)	50 (2.3)	239 (4.0)

The assessment of clinical factors that determine the appropriateness of non-ACS PCI procedures is shown in Table 7. These clinical factors include the presence or absence of symptoms, the severity of the coronary lesion(s) and demonstration of functional ischaemia. In 2021, almost half of cases had all 3 clinical factors present - an increase compared to the previous year (49.6% in 2021 vs 42.8% in 2020). A total of 90.8% of patients had at least 2 key clinical factors and there was a continuing trend of gradual decline in the proportion of non-ACS PCI cases with one or no key clinical factor present (9.2% in 2021 vs 10.1% in 2020).

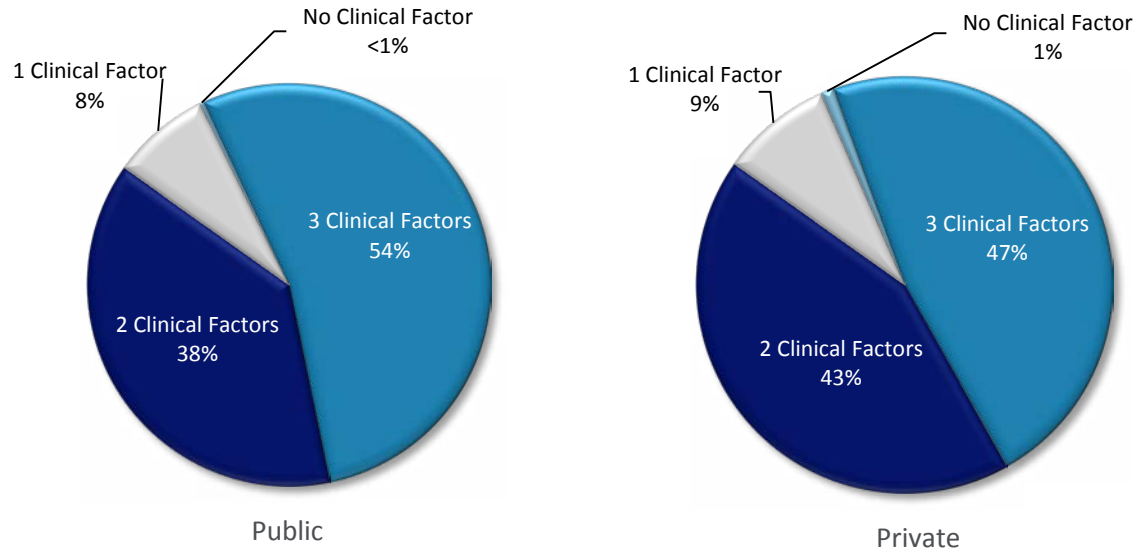
Table 7: Key clinical factors pertaining to non-ACS PCI indications

Symptoms	Positive functional test	High grade stenosis	Total
			N (%)
●	●	●	2423 (49.6)
○	●	●	315 (6.4)
●	●	○	245 (5.0)
●	○	●	1457 (29.8)
●	○	○	151 (3.1)
○	○	●	222 (4.5)
○	●	○	37 (0.8)
○	○	○	37 (0.8)
			4887 (100)

Table Legend: •= A clinical factor present; ○= clinical factor not present.

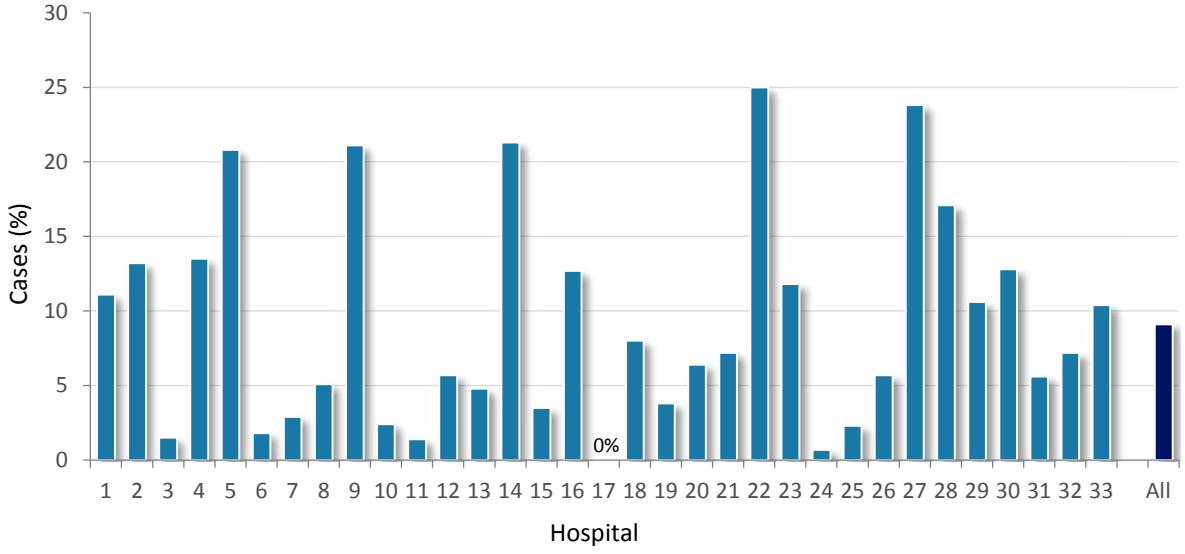
A comparison of the number of key clinical factors among non-ACS patients by hospital sector showed that the presence of all 3 clinical factors increased in both sectors compared to the previous year (54% in 2021 vs 45% in 2020 in the public sector and 47% in 2021 vs 42% in 2020 in the private sector). The rate of cases with 2 or 3 key clinical factors relating to appropriateness was 92% in the public sector and 90% in the private sector. The mean proportion of non-ACS PCI cases with just one or no key clinical factors dropped in the public sector (9% in 2021 vs 12% in 2020) whereas there was a small increase in the private sector (10% in 2021 vs 9% in 2020) (Figure 9).

Figure 9: Key clinical factors in non-ACS patients by hospital sector



We further examined the proportion of cases with just one or no key clinical factors by hospital (Figure 10). There was notable variation among hospitals (range 0% - 25%). For the 447 cases that had either no or just one key clinical factor, 307 (69%) were treated in the private sector.

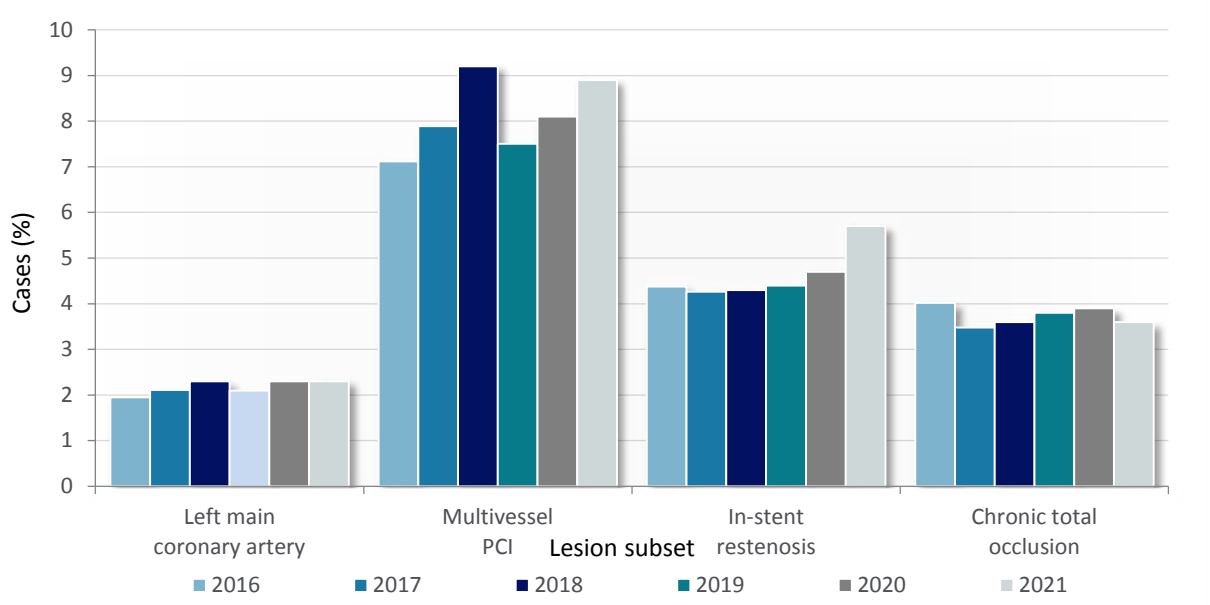
Figure 10: Proportion of non-ACS cases with 0 - 1 indicator for PCI by hospital



Lesion and Clinical Subsets

Trends in rates of PCI for selected lesion subsets over time are shown in Figure 11. There has been no substantial change in the number of left main coronary artery procedures over a 6 year period. Nor has there been any major increase in PCI cases for chronic total occlusion despite the availability of dedicated devices and techniques for this particular lesion subset. Cases undertaken for in-stent restenosis and multivessel PCI increased in 2021. Case numbers involving these lesion subsets were similar among public and private hospitals, apart from in-stent restenosis which has tended to be a more common lesion subset in the private sector than in public (4.7% public hospitals vs 6.9% private hospitals in 2021). Rates of PCI in bypass grafts remain similar to previous years (1.2% in 2021, 1.7% in 2020 and 1.4% in 2019).

Figure 11: Comparative trends in PCI for selected lesion subsets: 2016 - 2021



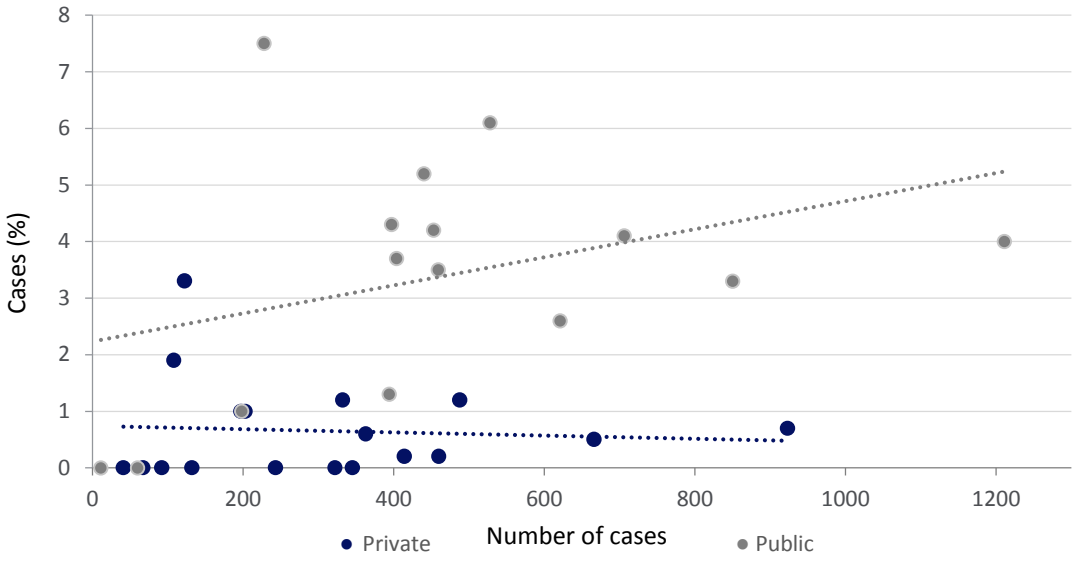
The proportions of cases treated for cardiogenic shock, intubated out of hospital cardiac arrest (OHCA) or cardiogenic shock and/or intubated OHCA have remained static over time (Table 8). Despite the number of patients with these life-threatening conditions being relatively small, these conditions are associated with higher rates of morbidity and mortality compared with the rest of the PCI cohort [9, 10].

Table 8: Rates of cardiogenic shock and intubated out of hospital cardiac arrest (OHCA): 2016 - 2021

Presentation type	2016 (N=10,035)	2017 (N=11,007)	2018 (N=12,463)	2019 (N=12,354)	2020 (N=12,347)	2021 (N=12,478)
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Cardiogenic shock	278 (2.8)	258 (2.3)	266 (2.1)	269 (2.2)	273 (2.2)	246 (2.0)
Intubated OHCA	126 (1.3)	142 (1.3)	137 (1.1)	151 (1.2)	129 (1.0)	138 (1.1)
Shock and/or intubated OHCA	309 (3.1)	310 (2.8)	329 (2.6)	320 (2.6)	326 (2.6)	300 (2.4)

The majority (89%) of the high-acuity cases of cardiogenic shock and/or intubated OHCA were managed in the public sector, comprising 3.8% of the public sector's workload compared to 0.6% in the private sector. Figure 12 plots individual hospitals' rates of cardiogenic shock and/or intubated OHCA as a proportion of their total volume.

Figure 12: Cardiogenic shock and/or intubated OHCA cases by hospital volume and hospital sector



In general, public hospitals with a higher volume of PCI cases tended to have a greater proportion of their workload taken up with these complex high-risk cases. However, the highest proportion of cardiogenic shock and or intubated OHCA cases in 2021 (7.5%) was in a public hospital with a moderate volume of PCI cases (<230).

Coronary Device Use

At least one stent was deployed in 93.5% of PCI cases in 2021. Virtually all stents were drug eluting stents (99.9%). The majority of patients (66%) received a single stent; one fifth (21%) received 2 stents; 5% received 3 stents and a very small proportion of patients received ≥4 stents. Stent implantation rates were similar in the public and private sectors. The average of the summed length of stents per case ranged between 16-37mm, with the median total stent length per case of 24mm, a slight increase compared to the previous year (summed range per case of 15-34mm with median total stent length of 23mm in 2020). Balloon angioplasty alone was undertaken in 4.4% of cases. Drug eluting balloons were utilised in 22.9% of cases with in-stent restenosis.

Adjunctive devices and drugs

Use of the more common adjunctive devices by hospital sector are presented in Table 9. Despite the rates of intravascular ultrasound (IVUS), pressure wire and optical coherence tomography (OCT) use gradually increasing over time across both hospital sectors, adjunctive devices were used in only small proportions of cases overall. The use of the pressure wire and rotational atherectomy were more common in the private sector where there is specific reimbursement for these devices, in contrast to other devices such as IVUS and OCT where there is no specific private sector funding. The majority of patients requiring extracorporeal membrane oxygenation (ECMO) were treated in the public sector. Coronary intravascular lithotripsy (IVL) was recently introduced into the market, and 47 cases of IVL were recorded in 2021. We predict that the use of this device will increase and we plan to monitor how its introduction into the catheterisation laboratory progresses over time.

Table 9: Adjunctive device use by hospital sector

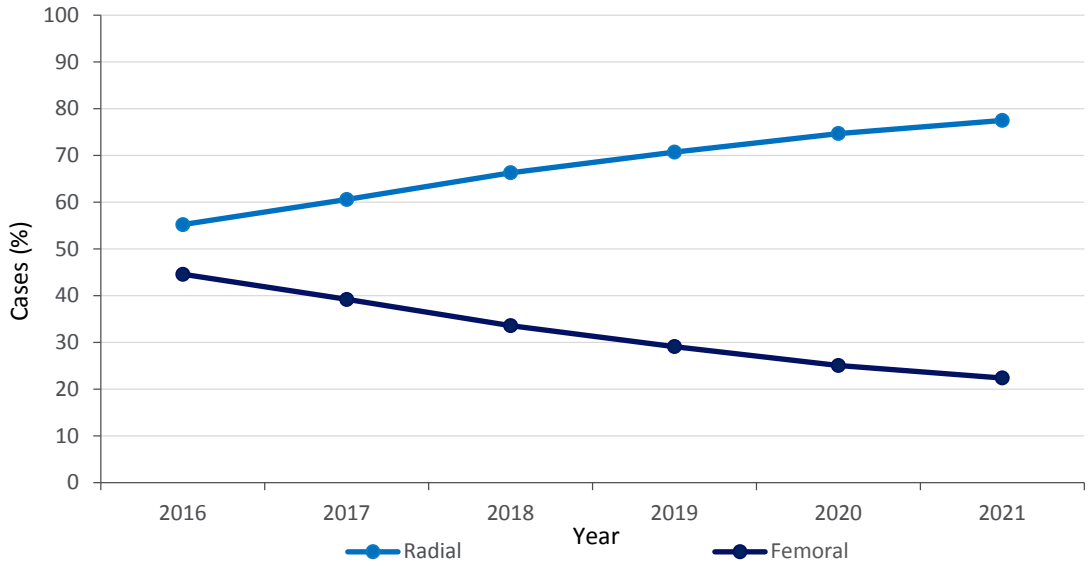
Adjunctive device type	All sites (N=12,478)	Public (n=6,960)	Private (n=5,518)
	N (%)	N (%)	N (%)
Intravascular ultrasound	378 (3.0)	226 (3.2)	152 (2.8)
Optical coherence tomography	238 (1.9)	157 (2.3)	81 (1.5)
Thrombus aspiration device	223 (1.8)	203 (2.9)	20 (0.4)
Rotational atherectomy	230 (1.8)	98 (1.4)	132 (2.4)
Pressure wire	710 (5.7)	233 (3.4)	477 (8.7)
IABP	28 (0.2)	22 (0.3)	6 (0.1)
ECMO	21 (0.2)	19 (0.3)	2 (0.1)

Intravascular ultrasound and OCT are particularly useful in the treatment of left main coronary lesions. The rate of adjunctive imaging with IVUS or OCT in left main coronary artery PCI was 46.2%. The use of glycoprotein (GP) IIb/IIIa receptor inhibitor use has remained constant (5.8% in 2021 vs 5.5% in 2020) and was primarily in STEMI patients (n=488).

Arterial access

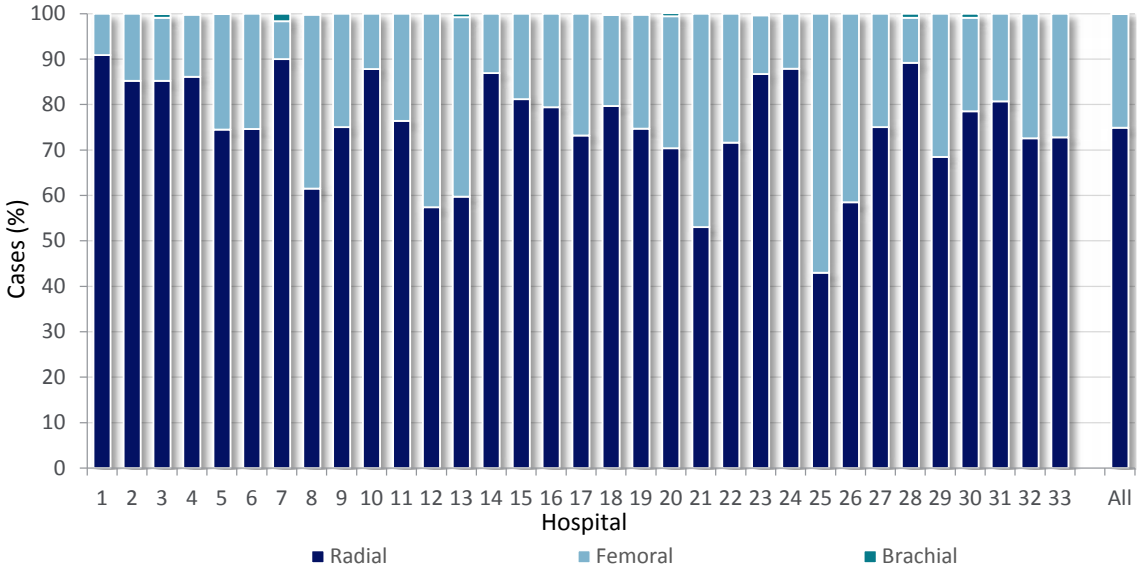
Radial artery vascular access continues its steady growth- a trend that has now been apparent for a number of years (Figure 13). The preference for radial access over femoral access is driven by a number of factors including patient comfort and safety. It is also clearly linked with lower rates of serious bleeding events [11] and has a mortality benefit in PCI for STEMI [12]. The rate of radial artery vascular access was 74.9%, representing a small increase over the previous year (Figure 13). Radial access was less common in octogenarians (62.7%) and women (69.8%).

Figure 13: Trends in arterial access: 2016 - 2021



Rates of arterial access by hospital is shown in Figure 14. Variation persisted among hospitals with radial access rates ranging from 43% to 91%. Radial access was used more frequently in the public sector (78.2% public vs 70.6% in private).

Figure 14: Arterial access route by hospital



PCI for STEMI

PCI is a highly effective reperfusion strategy for patients presenting with ST-elevation myocardial infarction (STEMI). Several subcategories of PCI exist for this condition, with the commonest being primary PCI - where PCI is performed as the primary reperfusion therapy for patients within the first 12 hours of symptom onset. In 2021, a total of 2,446 patients underwent PCI for STEMI of whom 1,856 (75.9%) had primary PCI.

Table 10 lists other categories of PCI for STEMI including rescue PCI - where PCI is undertaken in patients who have had a STEMI within the previous 24 hours, received thrombolysis as the initial reperfusion treatment but have ongoing signs of ischaemia or failed reperfusion. PCI can also be performed as part of a pharmaco-invasive strategy whereby patients who have had a STEMI and received thrombolysis undergo PCI routinely (rather than because of ongoing ischaemia) within the first 24 hours. Patients who undergo PCI beyond the 12-hour window for reperfusion and who did not receive any other form of reperfusion therapy are also considered in this section.

Table 10: Sub categories of patients undergoing PCI for STEMI

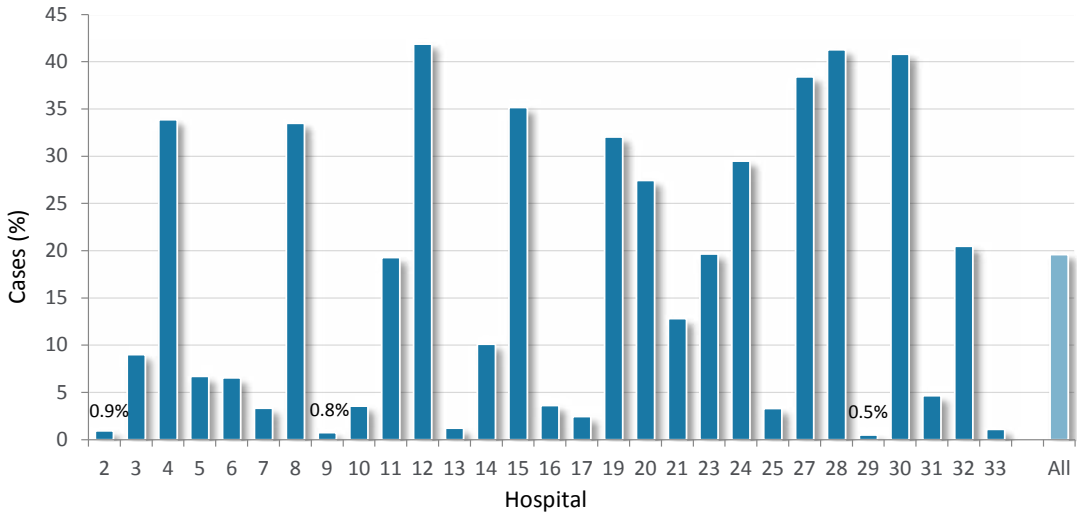
PCI for STEMI sub-categories	All sites (N=2,446)	Public (n=2,148)	Private (n=298)
	N (%)	N (%)	N (%)
Primary PCI* (<12 hrs, no thrombolysis)	1856 (75.9)	1616 (75.3)	240 (80.5)
PCI for STEMI 12-24 hours (no thrombolysis)	127 (5.2)	111 (5.2)	16 (5.4)
Pharmaco-invasive PCI (<24 hrs, previous thrombolysis, stable)	94 (3.8)	92 (4.3)	2 (0.7)
Rescue PCI (<24 hrs, previous thrombolysis, unstable)	169 (6.9)	154 (7.2)	15 (5.0)
PCI for STEMI 1-7 days following lysis	64 (2.6)	57 (2.7)	7 (2.3)
PCI for STEMI 1-7 days no prior lysis	136 (5.6)	118 (5.5)	18 (6.0)

**Includes inter-hospital transfers and in-patient STEMIs.*

In 2021, PCI for STEMI accounted for 20% (n=2,446) of the total PCI caseload in Victoria and was similar to previous years (n=2,592 in 2020 and n=2,338 in 2019).

The proportion of STEMI cases as a proportion of overall PCI caseload by hospital is shown in Figure 15. In 8 hospitals, the PCI workload for STEMI accounted for at least one-third of their total PCI activity. In contrast, another one-third of hospitals had very little STEMI-related PCI activity with just 0-5 STEMI cases over a 12-month period. Excluding hospitals that did not do any STEMI PCI, the range for STEMI PCI caseload by hospital was 0.5% to 42%.

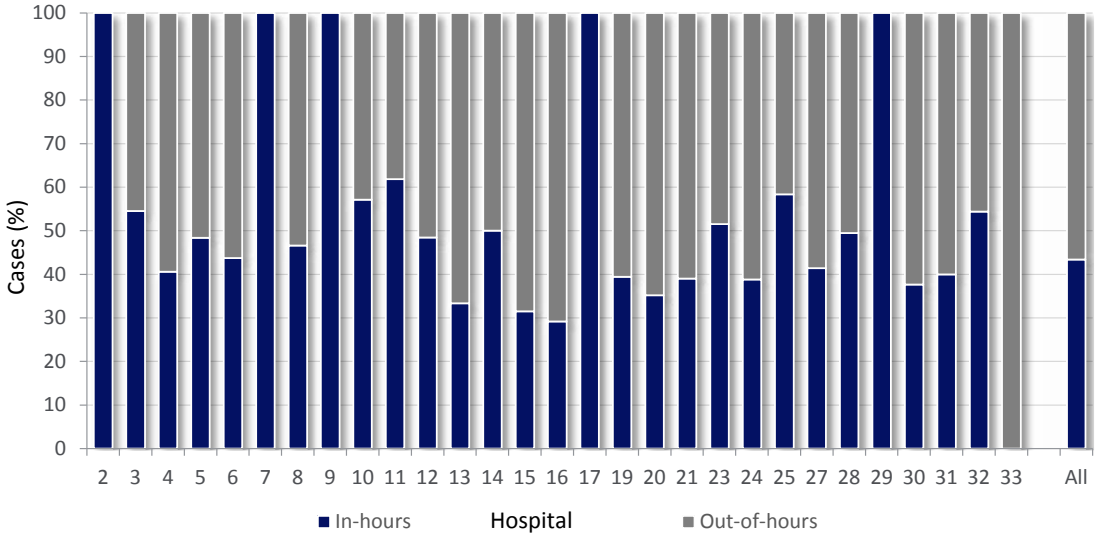
Figure 15: STEMI cases as a proportion of overall case numbers by hospital



Hospitals 1,18, 22 & 26 had NIL STEMI cases;
Hospitals 2, 7, 9, 13, 17, 29 & 33 had <5 STEMI cases.

The distribution of STEMI cases performed in-hours and out-of-hours by hospital is shown in Figure 16. Overall, 57% of PCI cases for STEMI were done out-of-hours. However, there was significant variation in out-of-hours case numbers by hospital (range 0% to 71%). Seven hospitals treated <5 cases of STEMI. Five hospitals (all of which had low case numbers) performed all their STEMI PCIs in-hours.

Figure 16: STEMI cases in-hours and out-of-hours by hospital



Hospitals 1, 18, 22 & 26 had no STEMI cases. Hospitals 2, 7, 9, 13, 17, 29 & 33 had <5 STEMI cases.
In-hours: 8.00am - 6.00pm (Mon-Fri excluding public holidays)
Out-of-hours: 6.00pm - 8.00am (Mon-Fri, public holidays and weekends)

Patients treated for STEMI tended to have different demographic profiles from the rest of the PCI cohort. They were younger overall (63+/-12.6% years vs 68+/-11.5 years), had fewer traditional cardiac risk factors such as diabetes (18.9% vs 24.8%), peripheral vascular disease (1.5% vs 3.8%) and had lower rates of previous revascularisation procedures - including previous PCI (14% vs 37.3%) and coronary artery bypass grafting (2.3% vs 6.9%). There were also differences in the demographic profiles among STEMI patients treated in the public and private sectors. Those in the private sector were older (63+/-12.7 years public vs 67+/-12 years private), had fewer previous strokes (2.2% public vs 1.7% private), more previous PCIs (13.4% public vs 18.8% private) and more previous coronary artery bypass grafting operations (2.1% public vs 3.7% private).

Primary PCI

In 2021, 1,856 patients underwent primary PCI. Of those, 1,565 patients presented to the treating hospital with acute STEMI either by ambulance or as self-presenters to an emergency department. The remaining 291 patients either developed a STEMI while already an in-patient or initially presented to an outside hospital and were transported to the treating hospital as an inter-hospital transfer. Further analysis on treatment delays, pre-hospital notification and other aspects relating to reperfusion therapy in the following sections excludes in-hospital and inter-hospital transfer STEMI patients because they are not influenced by time and other system delays in the same way as emergency presenters are.

Door-to-balloon times

The process measure of door-to-balloon time (DBT) is a frequently reported quality indicator for health services and is defined as the time delay from a patient's arrival to hospital to successful re-opening of their occluded infarct-related coronary artery. It is primarily applicable to cases that present to the hospital with a suspected myocardial infarction via the ambulance service or as self-presenters to the emergency department. Door-to-balloon time is not generally used as a quality indicator in cases where STEMI develops in a patient who is already an in-patient in the hospital or who is an inter-hospital transfer after initially presenting to an outside hospital.

Door-to-balloon time is utilised when benchmarking hospitals' performance in the acute management of patients with STEMI. Both Australian and international guidelines now recommend that the target maximum delay time should ideally be changed from the longstanding benchmark of ≤90 minutes to ≤60 minutes when the patient presents to a PCI capable hospital and that the delay should be measured from the time of first medical contact (FMC) rather than hospital arrival [8, 13]. VCOR currently still reports on outcomes benchmarked against a DBT ≤90 minutes to retain consistency with the majority of participant hospitals who still use this benchmark value for their own hospital quality assurance processes [14]. However, VCOR is working towards benchmarking performance against the DBT ≤60 minute target and from this year, reports the key time metric of time from FMC to balloon inflation.

Table 11: Door-to-balloon times for primary PCI cases: 2016 - 2021

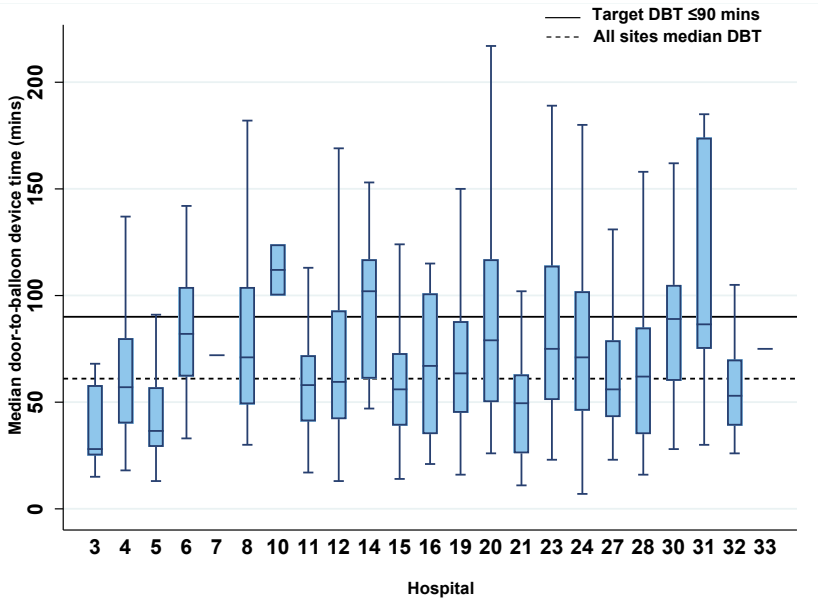
Door-to-balloon time	2016	2017	2018	2019	2020	2021
	(N=1,303)	(N=1,423)	(N=1,596)	(N=1,495)	(N=1,623)	(N=1,565)
Median – mins (IQR)	67 (47, 96)	63 (44, 89)	58 (39, 83)	58 (40, 84)	62 (43, 91)	61 (43, 92)
Proportion of cases ≤90mins (%)	71.9	77.3	80.5	80.8	74.7	74.4

Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.

In 2021, the second year of the COVID-19 pandemic, the median DBT was 61 minutes (IQR: 43, 92). Both this year's DBT result, and the previous year's outcomes reflect a reversal of a trend towards improving DBTs that was apparent from 2016-2019. We believe this is, at least in part, due to the effect of the COVID-19 pandemic on the initial assessment and acute management of suspected STEMI cases (Table 11). This is discussed in more detail in a later section of this report.

Two hospitals did not achieve a median DBT time of ≤90 minutes in this reporting period, similar to 2020 when 3 hospitals failed to reach this performance benchmark. For the 3 years prior to the COVID-19 pandemic (2017-2019), all hospitals achieved a median DBT time of ≤90 minutes. Despite the likely effects of the COVID-19 pandemic on hospital service delivery, 10 hospitals still managed to achieve a median DBT of ≤60 minutes (Figure 17).

Figure 17: Door-to-balloon times for primary PCI cases by hospital

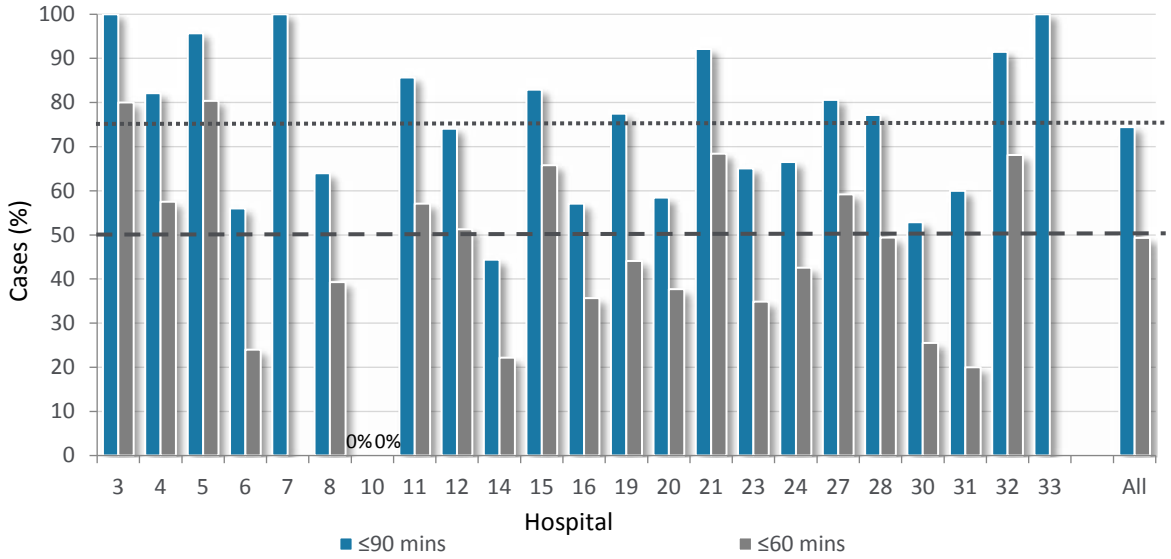


Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.

An alternative way of assessing hospital performance in relation to DBT is to determine their compliance in achieving a DBT ≤90 minutes in at least 75% of their primary PCI cases – a performance benchmark recognised internationally [15]. In 2021, the average rate of compliance with a DBT≤90 minutes by hospital was 74.4% (Figure 18)- similar to 2020, and lower than in pre COVID-19 pandemic years. The range across hospitals was 44.4% to 100%, with just over half the hospitals (12 of 23 sites) successfully reaching or exceeding 75% compliance benchmark. For patients treated in the private sector, a DBT≤90 minutes was achieved in 83% of cases whereas in the public sector, the compliance was lower at 73%.

Hospitals' performance was also benchmarked by their compliance with a DBT ≤60 minutes (Figure 18). Only 2 hospitals managed to achieve a 75% compliance rate with the stricter ≤60 minute target, similar to results in 2019-2020. Currently, Victorian hospitals generally struggle to achieve the stricter DBT benchmark of ≤60 minutes in at least 75% of their cases and it may be more appropriate to consider measuring hospital compliance at >50% of cases when this stricter time point is used. When the >50% compliance benchmark was applied to the 2021 cohort, 9 out of 23 hospitals were compliant- showing that it is an achievable target.

Figure 18: Proportion of primary PCI cases with door-to-balloon time ≤90 minutes and ≤60 minutes by hospital



Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient. Hospitals 1,2,9,13,17,18,22,25,26 and 29 had no Primary PCI cases; Sites 3, 7, 10 & 33 had low Primary PCI cases N<5.

Pre-hospital notification (PHN)

Pre-hospital notification (PHN) of the pending arrival of a patient with STEMI by Ambulance Victoria to the receiving hospital allows those hospitals to activate the cardiac catheterisation laboratory team before the patient arrives. Pre-hospital notification facilitates direct transfer to the catheter laboratory, minimises delays in transfer and starting times and has been proven to shorten door-to-balloon times. All Victorian hospitals that perform primary PCI have PHN arrangements set up with Ambulance Victoria. In 2021, PHN was utilised in 69.8% of primary PCI cases. As has been seen with all previous VCOR reports, its use resulted in significant reductions in median DBT (Table 12).

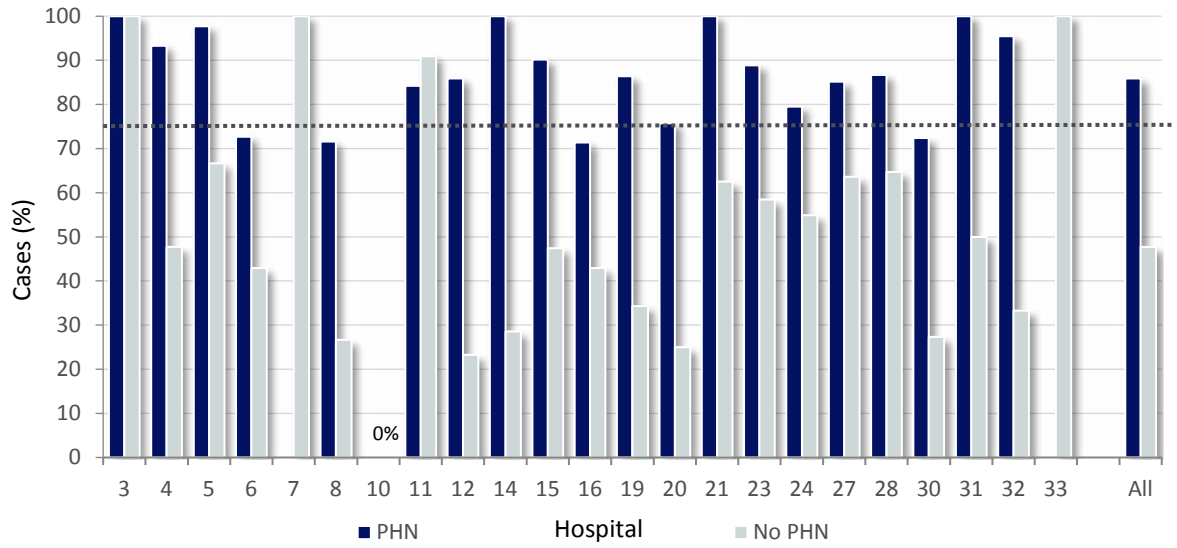
Table 12: Door-to-balloon times for primary PCI cases by pre-hospital notification status

Door-to-balloon time	Primary PCI*	Primary PCI* (PHN only†)	Primary PCI* (no-PHN†)
	(N=1,565)	(n=1,093)	(n=472)
Median – mins (IQR)	61 (43, 92)	54 (38, 74)	92 (66, 126)
Proportion of cases ≤90mins (%)	74.4	82.9	52.8

**Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.*
†Pre-hospital notification (PHN).

Figure 19 demonstrates the influence of PHN on compliance in achieving a DBT ≤90 minutes. The benefit of PHN was evident among all participating hospitals. However, despite the clear advantage of PHN on DBT, 4 hospitals still failed to achieve the compliance target of ≥75% cases with DBT≤90 minutes even with PHN.

Figure 19: Proportion of primary PCI cases with door-to-balloon time ≤90 minutes – pre-hospital notification vs no pre-hospital notification

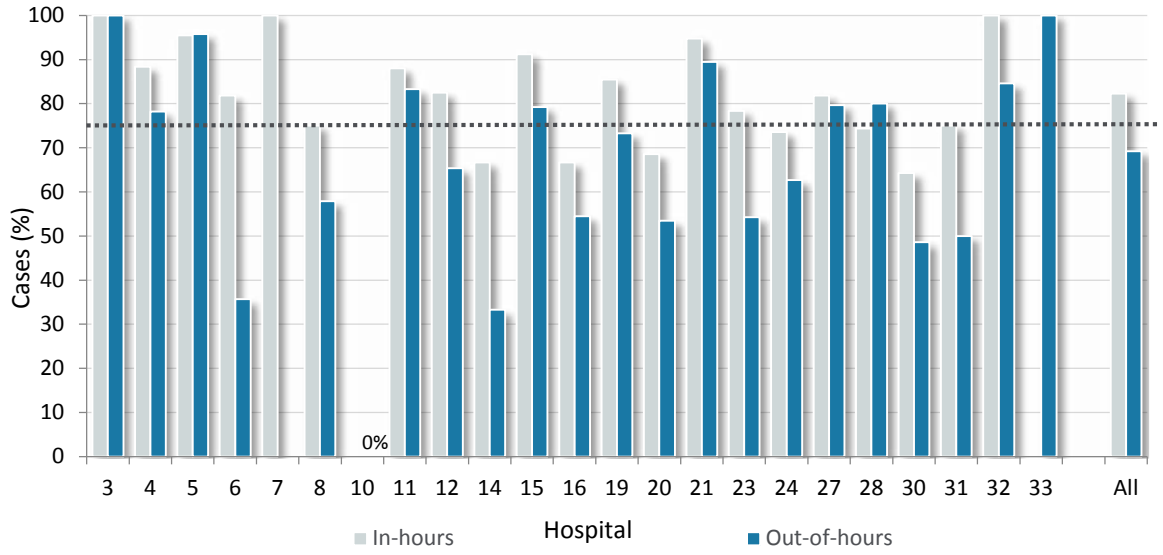


Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient. Hospitals 1,2,9,13,17,18, 22,25,26 and 29 had no Primary PCI cases; Sites 3, 7, 10 & 33 had low Primary PCI cases N<5. Site 7, 10 & 33 had no PHN cases.

In-hours versus out-of-hours presentation

There were 949 primary PCI cases (60.6%) treated out-of-hours with variation in the proportion of cases treated out-of-hours (49%-80%) among hospitals (Figure 20). In the majority of hospitals, DBT compliance rates were lower after-hours. Results in this and the previous reporting period (corresponding to the COVID-19 pandemic) demonstrated that the reduction in DBT compliance rates after-hours was even more marked than in pre COVID-19 years.

Figure 20: Proportion of primary PCI cases with door-to-balloon time ≤ 90 minutes – in-hours vs out-of-hours presentation

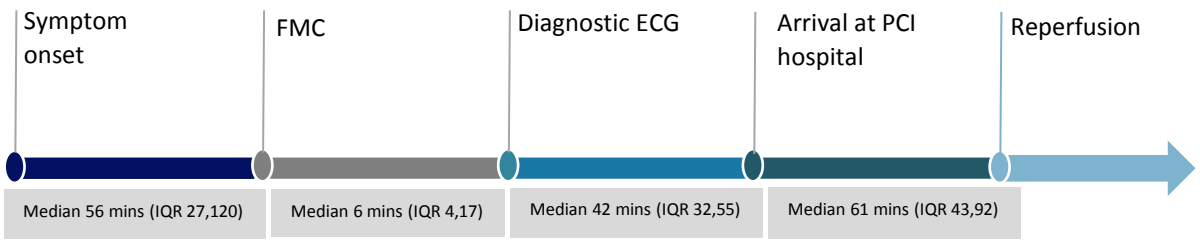


Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient. Sites 10 & 33 had NIL In-hours cases. Site 7 had NIL Out-of-hours cases. In-hours: 8.00am - 6.00pm (Mon-Fri excluding public holidays). Out-of-hours: 6.00pm - 8.00am (Mon-Fri, public holidays and weekends).

Times from symptom onset to first medical contact, diagnostic ECG and reperfusion

For the first time, VCOR has been able to provide greater detail of the various time components that make up the total ischaemic time from symptom onset to device use (reperfusion). The median time from symptom onset to first medical contact (ambulance service, emergency department or GP) was 56 minutes (IQR: 27, 120). This metric is patient-dependent and does not reflect the efficiency of the systems or networks responsible for STEMI treatment. The time from symptom onset was longer among private patients, but once these patients entered the system, remaining time delays were shorter than for public patients. These included shorter delays from first diagnostic ECG to hospital arrival and first medical contact (FMC) to reperfusion time (Table 13).

Figure 21: Median times from symptom onset to reperfusion



The metric of **system delay** consists of the time from FMC to diagnostic ECG, the time to transfer patients to a PCI-capable hospital after the diagnostic ECG and the time from hospital arrival to reperfusion (the door-to-balloon time). Australian practice guidelines and the ACS Clinical Care Standard [8,16] stipulate that the time from FMC to diagnostic ECG should be ≤10 minutes.

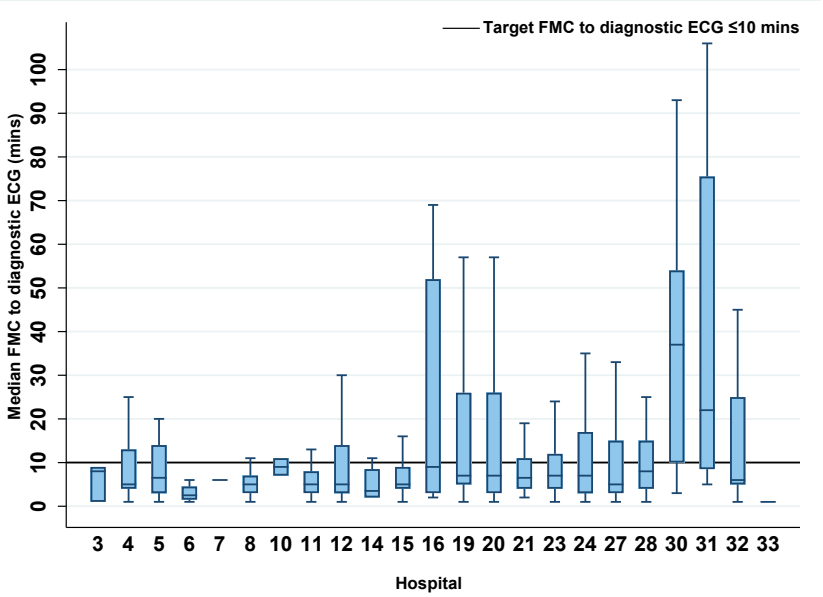
Table 13: Median times from symptom onset to reperfusion - public/private and PHN and no PHN

	All	Public	Private	PHN	No PHN
All Primary PCI*	(N=1,565)	(n=1,377)	(n=188)	(n=1,093)	(n=472)
Median Symptom onset to FMC- mins (IQR)	56 (27,120)	53 (26,120)	70 (32,135)	48 (24,110)	78 (37,150)
Median FMC to Diagnostic ECG- mins (IQR)	6 (4,17)	6 (4,17)	6 (4,14)	5 (3,13)	10 (4,28)
Median Diagnostic ECG to door- mins (IQR)	42 (32,55)	43 (33,55)	39 (29,53)	42 (32,55)	42 (29,56)
Median Diagnostic ECG to Balloon/Device time- mins (IQR)	96 (76,121)	97 (77,123)	83 (68,104)	97 (79,120)	90 (66,123)
Median FMC to Balloon/Device time - mins (IQR)	106 (85,139)	108 (87,141)	93 (78,121)	106 (87,132)	109 (79,156)

Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.

In 2021, the overall median FMC to diagnostic ECG time was 6 minutes (IQR: 4, 17) (Figure 21, Table 13). Two hospitals did not meet the recommended benchmark of 10 minutes (Figure 22). As with the door-to-balloon times in patients undergoing primary PCI, FMC to diagnostic ECG also improved when pre-hospital notification (PHN) of the arriving STEMI patient was received from the ambulance service. The median FMC to diagnostic ECG time with PHN was 5 minutes (IQR: 3, 13), 5 minutes shorter than without PHN (10 minutes, IQR: 4, 28).

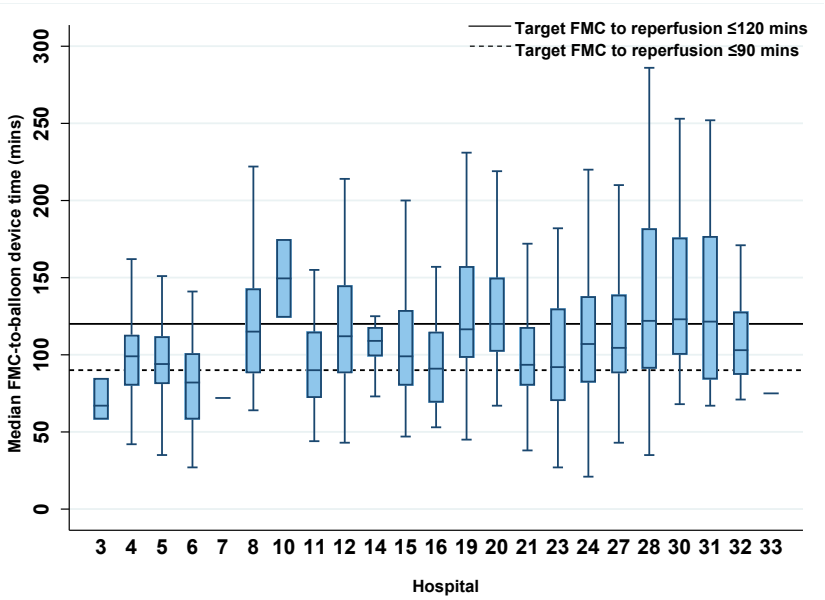
Figure 22: First medical contact to diagnostic ECG time for primary PCI cases by hospital



Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.

We further assessed time delays from FMC to reperfusion as an alternative and arguably more meaningful metric of system performance than DBT and as outlined in the Australian guidelines [8,13]. Internationally, these metrics are also utilised and reported on [17, 18]. VCOR explored the target of FMC to reperfusion ≤120 minutes and the newer stricter benchmark of FMC to reperfusion ≤90 minutes. The median FMC to reperfusion for the cohort was 106 minutes (IQR: 85, 139) (Table 13). Referencing this outcome to the older recommended benchmark of FMC to reperfusion ≤120 minutes [15], 19 out of 23 hospitals were compliant (Figure 23). In contrast, only 5 hospitals managed the more up-to-date and stricter benchmark of a median FMC to reperfusion time ≤90 minutes.

Figure 23: First medical contact to balloon time for primary PCI cases by hospital



Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.

The main components of this delay were the time taken from diagnostic ECG to arrival to hospital (median of 42 minutes) and a median DBT that was longer in 2021 than in previous years. As discussed later in this report, the COVID-19 pandemic was associated with longer DBTs and fewer hospitals achieving benchmark performance targets - likely related to additional inherent delays introduced in assessing patients' COVID-19 status, the use of PPE and extra requirements in transferring patients within the hospital. In turn, the results related to FMC to reperfusion time delays in this report suggest that Victorian primary PCI services struggled to achieve timely treatment when measured from time of first medical contact, partly related to COVID-19 related factors and partly due to delays in transporting patients quickly to hospital.

Hospital volumes and door-to-balloon time

In order to ensure adequate competency for the performance of STEMI PCI, The Cardiac Society of Australia and New Zealand (CSANZ) recommends hospitals should perform at least 36 primary PCI procedures per year among a total PCI volume >200 cases per year [19]. In 2021, 15 hospitals had case volumes compliant with CSANZ guidelines for primary PCI competency and 13 hospitals had volumes below the recommended standard. Table 14 compares DBT results for various subgroups of primary PCI by case volume and compliance with CSANZ primary PCI competency guidelines.

For all primary PCI cases (n=1,565, excluding in-hospital and inter-hospital transfer STEMI cases), the median DBT and proportion of cases achieving a DBT ≤90 minutes was better among higher volume hospitals that were compliant with competency guidelines. The difference between the high and low volume groups narrowed with pre-hospital notification. Conversely, the superiority of DBT results among high-volume centres was particularly marked in out-of-hours cases where the median DBT among lower-volume hospitals was 93 minutes - 24 minutes longer than higher-volume hospitals. These findings support the utility of providing competency recommendations to hospitals to guide them in their efforts with continuous quality improvement. All hospitals - especially low-volume centres - that wish to perform primary PCI, must ensure that once a STEMI is diagnosed, they have appropriate and well-designed processes that facilitate prompt activation of the catheterisation laboratory and maintain experienced nursing and technical catheterisation staff with the necessary training and skill sets.

Table 14: Door-to-balloon time outcomes by hospital case volumes

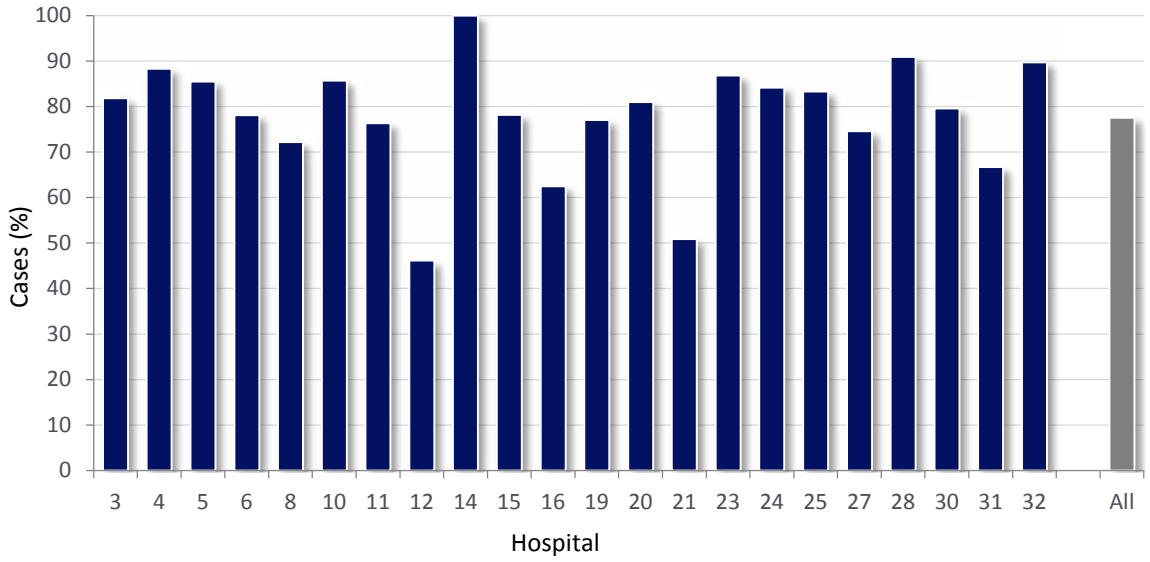
	All sites	Sites with 36+ Primary PCI Site Volume 200+	Sites with <36 Primary PCI Site Volume <200
All Primary PCI*	(N=1,565)	(n=1,498)	(n=67)
Number of sites	28	15	13
Median DBT- mins (IQR)	61 (43,92)	60 (42,90)	77 (58,107)
Proportion of cases within 90mins (%)	74	75	58
PHN only	(N=1,093)	(n=1,069)	(n=24)
Median DBT- mins (IQR)	54 (38,74)	54 (38,74)	53 (31,80)
Proportion of cases within 90mins (%)	86	86	79
No PHN	(N=472)	(n=429)	(n=43)
Median DBT- mins (IQR)	93 (66,127)	87 (59,121)	92 (70,119)
Proportion of cases within 90mins (%)	48	48	47
Out-of-hours	(N=949)	(n=905)	(n=44)
Median DBT- mins (IQR)	70 (50,100)	69 (50,99)	93 (64,115)
Proportion of cases within 90mins (%)	69	70	48
In-hours	(N=616)	(n=593)	(n=23)
Median DBT- mins (IQR)	51 (35,73)	50 (36,73)	60 (33,77)
Proportion of cases within 90mins (%)	82	83	78

**Primary PCI for STEMI presentations excluding all inter-hospital transfers and patients with STEMI onset whilst a current in-patient.*

Radial access

There is a strong evidence base supporting radial vascular access among patients presenting with acute STEMI [11]. Over the last several years, radial artery access in this patient group has increased. However, the radial access rate plateaued in 2021 (77.5% in 2021 vs 78.8% in 2020). Radial access rates among hospitals varied from 46%-100% (Figure 24), with the proportion of hospitals using radial access in ≥75% of their acute STEMI cases dropped slightly compared with the previous year (73% in 2021 vs 76% in 2020).

Figure 24: Radial access rates in acute STEMI by hospital



Sites 1, 18, 22 & 26 had no acute STEMI cases. Sites 2, 7, 9, 13, 17, 29 & 33 had <5 acute STEMI cases.

Other Categories of PCI for STEMI

Apart from those STEMI patients who underwent primary PCI, there were an additional 610 STEMI patients that had PCI that was not a primary PCI for acute reperfusion within 12 hours. A total of 169 patients underwent rescue PCI. Anterior STEMI accounted for 44% with cardiogenic shock and/or intubated OHCA being present in 8.9% of cases. GP IIb/IIIa inhibitor therapy was used in 11% of cases, an increase from the previous report (8.6% in 2020). The majority (91%) of rescue PCI were performed in the public sector. Eighty-seven patients were treated early within 6 hours, a further 57 were treated between 6-12 hours, and 20 patients underwent rescue PCI between 12-24 hours (treatment time data missing for the remaining 5 cases). This contrasts with the previous year when no cases of rescue PCI occurred >12 hours.

Notably, the number of rescue PCI cases in 2021 was higher than in previous years (n=116 in 2020, n=116 in 2019 and n=101 in 2018). In contrast, fewer patients underwent PCI for STEMI as part of a pharmaco-invasive approach (n=94 in 2021, n=156 in 2020, n=141 in 2019, n=148 in 2018). Both rescue PCI and the pharmaco-invasive approach involve STEMI patients who received thrombolysis in the previous 24 hours. The difference is that in rescue PCI, patients are clinically unstable with ongoing ischaemia or failed reperfusion, whereas patients treated with a pharmaco-invasive approach are clinically stable after thrombolytic therapy. It is uncertain whether factors such as the COVID-19 pandemic influenced the trends in case numbers with these two categories of STEMI PCI, especially as the pandemic was also present in 2020 when rescue PCI numbers were as expected. This is a trend that will be flagged for further monitoring.

Among the pharmaco-invasively treated patients, 43% (n=40) had their PCI within 12 hours and of those 7.4% (n=7) had their PCI within the first 4 hours. The most commonly treated infarct-related artery was the LAD (44%). There was a larger proportion of patients that received adjunctive GP IIb/IIIa receptor inhibitors in this reporting period (8.5% in 2021 vs 1.9% in 2020).

For STEMI patients who presented to non-PCI hospitals and did not receive reperfusion therapy (PCI or thrombolysis) within the first 12 hours, possible explanations for the lack of reperfusion therapy include late presentation, initial confusion or ambiguity about the diagnosis or contra-indications to thrombolytic therapy. Of the 263 patients in this category, 48% (n=127) underwent PCI within 24 hours, an increase over the previous report (35% in 2020). A further 136 STEMI patients had PCI 1-7 days after symptom onset, with a mean delay of 31+/-25 hrs. Among this group, almost one third (n=78) of patients were inter-hospital transfers, 19 patients had cardiogenic shock and/or intubated OHCA and a balloon pump was used in 2 cases. The majority (87%) of these cases were in public hospitals. In addition, 64 patients underwent PCI 1-7 days following thrombolysis. The most commonly treated infarct related artery was RCA (53%), and GP IIb/IIIa receptor inhibitor therapy was used in 4.7% of cases.

COVID-19 Pandemic in 2021

For the majority of the period covered by this report, health services in the state of Victoria were significantly impacted by restrictions and limitations related to the COVID-19 pandemic [20]. During the 4 lockdown periods from 12 February to 16 February 2021, 27 May to 10 June 2021, 16 July to 27 July 2021 and the much longer period from 5 August 2021 to 21 October 2021, access to cardiac services were curtailed with reductions in the number of elective admissions and procedures (up to 80%), as well as in-patient and outpatient diagnostic studies and outpatient consultations.

The mandatory use of personal protective equipment (PPE) continued throughout 2021, with its inherent impact on patient access and treatment times - particularly in the emergency department, catheterisation laboratories and cardiac wards. Data from one large Melbourne teaching hospital found a four-fold increase in symptom-to-door-time in patients with ACS requiring percutaneous revascularization during the COVID-19 period (16). All these effects, plus the under-utilisation of hospital resources, have the potential to influence hospital performance and outcomes.

Effects on case numbers

There was no appreciable effect on overall PCI case numbers during the second year of the COVID-19 pandemic in 2021- a finding mirrored in 2020, the first year of the pandemic. In 2021, there was a total of 12,478 PCI cases in Victoria - similar to 2020 (n=12,349) and 2019 (n=12,355). The proportion of cases presenting with an ACS was 48%, similar to non COVID-19 years. The number of primary PCI cases presenting to the emergency department with STEMI fell in 2021 compared with the previous year, but was similar to non COVID-19 years (n=1565 in 2021, n=1623 in 2020 and n=1495 in 2019).

From around early October 2021, arrangements were established to transfer public sector patients to the private sector in order to free up resources in public hospitals to cope with the COVID-19 surge. This included cardiac patients. In a number of centres, elective and emergency PCI cases on public patients were performed in the private sector. This surge of cases in the private sector may have counterbalanced a trend earlier in 2021 when private hospitals were discouraged to do elective cases with all but the more urgent ones being deferred. By the end of 2021, there were 5,518 PCI cases performed in private hospitals, a greater number than either the first pandemic year (2020, n=5,109) or pre-pandemic (2019, n=5,287). The majority of this increase in case numbers in the private sector were for elective non-ACS cases (Table 15).

Table 15: PCI case numbers - before and during COVID-19 pandemic

	Pre-COVID year 2019 (N=12,355)	COVID year 2020 (N=12,349)	COVID year 2021 (N=12,478)
	N (%)	N (%)	N (%)
Public	7066 (57.2)	7240 (58.6)	6690 (55.8)
Private	5287 (42.8)	5109 (41.4)	5518 (44.2)
STEMI Cases	2390 (19.3)	2592 (21.0)	2445 (19.6)
Public	2080 (87.0)	2338 (90.2)	2147 (87.8)
Private	310 (13.0)	254 (9.8)	298 (12.2)
NSTE-ACS Cases	3537 (28.6)	3659 (29.9)	3495 (28.0)
Public	2406 (68.0)	2526 (68.4)	2337 (66.9)
Private	1131 (32.0)	1169 (31.6)	1158 (33.1)
Non-ACS Cases	6426 (52.0)	6062 (49.1)	6538 (52.4)
Public	2580 (40.1)	2376 (39.2)	2476 (37.8)
Private	3846 (59.9)	3686 (60.8)	4062 (62.2)

There were no obvious changes to the proportions of patients from non-metropolitan locations or with low socio-economic status during the first or second COVID-19 pandemic years. The proportion of patients treated for an ACS indication remained similar, although the median DBT increased in both the COVID-19 years compared with previous years. Outcomes were similar across all three time periods (Table 16).

Table 16: Characteristics of patients undergoing PCI - before and during COVID-19 pandemic

	Pre COVID year 2019 (N=12,355)	COVID year 2020 (N=12,349)	COVID year 2021 (N=12,478)
Demographics/presentation	%	%	%
ACS indication	48.0	51.0	47.6
Public hospital treatment	56.4	58.6	55.8
Low SES	23.0	23.0	22.5
Non-metro hospital treatment	28.0	27.0	27.0
Median DBT (mins)	58.0	62.0	61.0
Achieved DBT ≤90mins	80.8	74.7	74.4
Median SBT (mins)	171.0	181.0	180.0
Median SDT (mins)	110.0	115.0	110.0
Outcomes	%	%	%
Procedural success	92.0	93.0	92.6
In-hospital mortality	1.7	1.4	1.4
30-day MACE	4.0	3.0	3.2
30-day stroke	0.4	0.4	0.4

Active COVID-19 cases

In 2020, the first year of the COVID-19 pandemic, VCOR attempted to track the number of probable or definite COVID-19 cases treated with PCI. Unfortunately, we encountered difficulties with the definitions used for the additional COVID-19 related data fields chosen, and the completeness of the data collection by a number of sites. Additional data collection was undertaken by direct follow-up with data managers at each site and as result, by VCOR's best estimate, none or possibly very few patients with known active COVID-19 infection received a PCI in Victoria during the 2020 calendar year.

In 2021, a similar system was utilised, although refinements were made to field definitions to avoid confusion and ambiguity. A total of 31 patients were identified as active or probable COVID-19 cases, with 10 PCI cases of confirmed COVID-19 positive patients. The demographic profile of the patients presenting with COVID-19 were similar to the rest of the PCI cohort. The 10 COVID-19 patients were treated across 8 public hospitals and all presented with an ACS. There were 6 STEMI PCI cases, 5 of which were primary PCI cases and 4 PCIs for NSTE-ACS. Five COVID-19 patients were admitted to ICU and the overall median length of stay was 10 days.

Effects on treatment of acute STEMI

For the 2021 year, the time taken from the onset of symptoms of acute STEMI to hospital arrival was actually similar to the previous COVID-19 pandemic year and also to the non COVID-19 period. This contrasts with the results from a large Melbourne teaching hospital that showed delays in ACS presentations in the first year of the pandemic [21]. However, it is possible that STEMI presentations in particular - as higher acuity, more time-critical conditions - weren't as adversely affected as less acute NSTE-ACS presentations. The key performance indicator of median door-to-balloon time was a few minutes more in the COVID-19 pandemic years, with similar results observed in 2020 and 2021. There was also a corresponding decrease in the proportion of cases that were treated within the 90-minute treatment target. Two hospitals did not achieve a median DBT≤90 minutes, while just over half the hospitals achieved a DBT≤90 minutes in greater than 75% of primary PCI cases, representing a significant decline compared with the non COVID-19 period the previous year (52% in 2021, 43% in 2020 and 62% in 2019). Longer delays with door-to-balloon time during the COVID-19 pandemic were to be expected, given that additional time was needed for patient assessment and infection control - particularly in a high exposure risk environment like the catheterisation laboratory.

Effects on procedural and clinical outcomes

Despite differences in case mix and treatment times for STEMI, procedural and clinical outcomes of PCI in 2021 broadly matched both the previous COVID-19 pandemic year and earlier non COVID-19 years. The numbers of complex procedures and high-risk cases were similar. Procedural complications such as the need for emergency CABG surgery were comparable to non-COVID years - in contrast to 2020, the first year of the pandemic - when they were particularly low.

Focusing on in-hospital and 30-day outcomes, procedure success rates were similar for the two COVID-19 pandemic years and for the pre-pandemic year of 2019. In-hospital mortality rates - including those for the major clinical subgroups of STEMI, NSTE-ACS, cardiogenic shock and/or intubated OHCA and non-ACS - were lower in the pandemic years of 2021 and 2020, as were 30-day rates of major adverse cardiac events. Thirty-day risk adjusted mortality rates were similar for COVID-19 pandemic and non COVID-19 years. For acute STEMI cases, the longer times to presentation and longer delays with door-to-balloon time did not have any discernible effect in 30-day mortality for STEMI compared with previous years.

Interestingly, despite a concerted effort by hospitals to reduce length of stay as much as possible to free up hospital resources to cope with the increase in resource demands with COVID-19, the median lengths of stay for STEMI, NSTE-ACS and non-ACS cases did not differ to previous years. As in earlier reports, length of stay tended to be shorter in the private hospital setting. There was however, a 13% increase in the number of same day discharges in 2021 compared with the previous year.

Finally, patient-reported measures of quality of life showed that rates of anxiety and depression at follow-up were present in similar proportions during COVID-19 pandemic years and non COVID-19 years, even when analysed by age group (<50 years, 50-75 years and >75 years).

Outcomes

Lesion and procedure success rates

The successful treatment of a coronary lesion is defined as a residual stenosis of ≤10% following stent placement and <50% following balloon angioplasty alone. In 2021, the mean lesion success rate was similar to the previous year (95.4% in 2021 vs 95.3 %in 2020) with a range among hospitals of 92.7% - 100%. Procedural success rate is defined as the successful treatment of all lesions and the absence of any major in-hospital complications. The overall procedural success rate was 92.6%, ranging from 86.8% to 100% across hospitals.

A comparison of selected clinical and lesion features associated with procedural success and failure is shown in Table 17. Unsuccessful procedures were more commonly associated with particular comorbidities including reduced renal function, moderate and severe left ventricular impairment, cardiogenic shock and/or intubated OHCA and chronic total occlusion (CTO) lesions. They were also more commonly linked with out-of-hours cases and patients treated in the public sector.

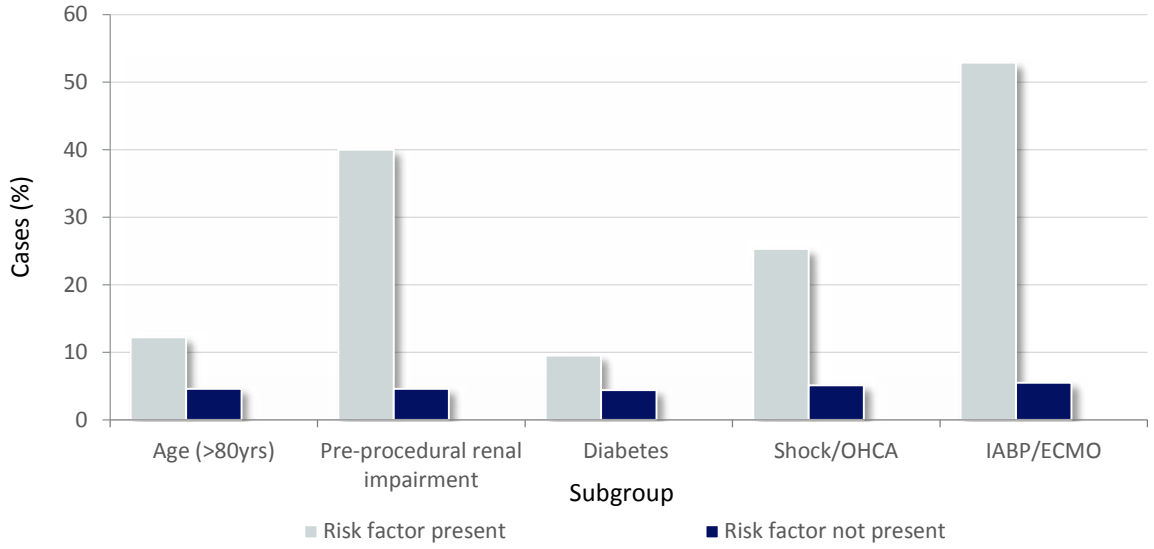
Table 17: Comparison of clinical and lesion features among successful and failed PCI cases

Clinical and lesion characteristics	Successful procedures (n=11,550)	Failed procedures (n=928)	All procedures (n=12,478)
Age- years (Mean ± SD)	67.1 (+11.8)	69.5 (±12.3)	67.3 (±11.9)
	N (%)	N (%)	N (%)
Sex- female	2890 (25.0)	259 (27.9)	3149(25.2)
Diabetes	2717 (23.5)	232 (25.0)	2949 (26.6)
Peripheral Vascular Disease	370 (3.2)	53 (5.7)	423 (3.4)
Cerebrovascular Disease	338 (2.9)	40 (4.3)	378 (3.0)
Previous PCI	3799 (32.9)	285 (30.7)	4084 (32.7)
Previous CABG	675 (5.8)	73 (7.9)	748 (6.0)
eGFR≤45/Renal replacement therapy	950 (8.2)	151 (16.3)	1101 (8.8)
Mildly impaired LVEF (45-49%)	1650 (16.1)	161 (19.3)	1881 (16.3)
Moderately impaired LVEF (35-44%)	1007 (9.8)	133 (15.9)	1140 (10.3)
Severely impaired LVEF (<35%)	445 (4.3)	120 (14.4)	565 (4.1)
Shock and/or intubated OHCA	152 (1.3)	148 (15.9)	300 (2.4)
Out-of-hours	2166 (18.8)	231 (24.9)	2397 (19.2)
Public hospital	6387 (55.3)	573 (61.7)	6960 (55.8)
Chronic total occlusion	276 (2.4)	171 (18.4)	447 (3.6)

New renal impairment

New renal impairment (NRI)- defined as serum creatinine rise >44 µmol/L or 25% above pre-procedural value within 5 days of a PCI procedure - occurs more commonly in high-risk sub-groups of patients, such as those with cardiogenic shock or requiring mechanical ventricular support [22]. Post PCI renal function results were available in approximately two-thirds of the patient cohort. The overall rate of NRI was 5.7%, comparable to international registry data [23]. However, Figure 25 demonstrates that particular clinical subgroups were associated with substantially increased rates of NRI. For the various clinical presentations, the rate of NRI post-PCI was highest in patients undergoing PCI for STEMI (8.7%), lower in NSTE-ACS (5.7%) and lowest in non-ACS patients (3.6%).

Figure 25: Rates of new renal impairment in selected high-risk subgroups

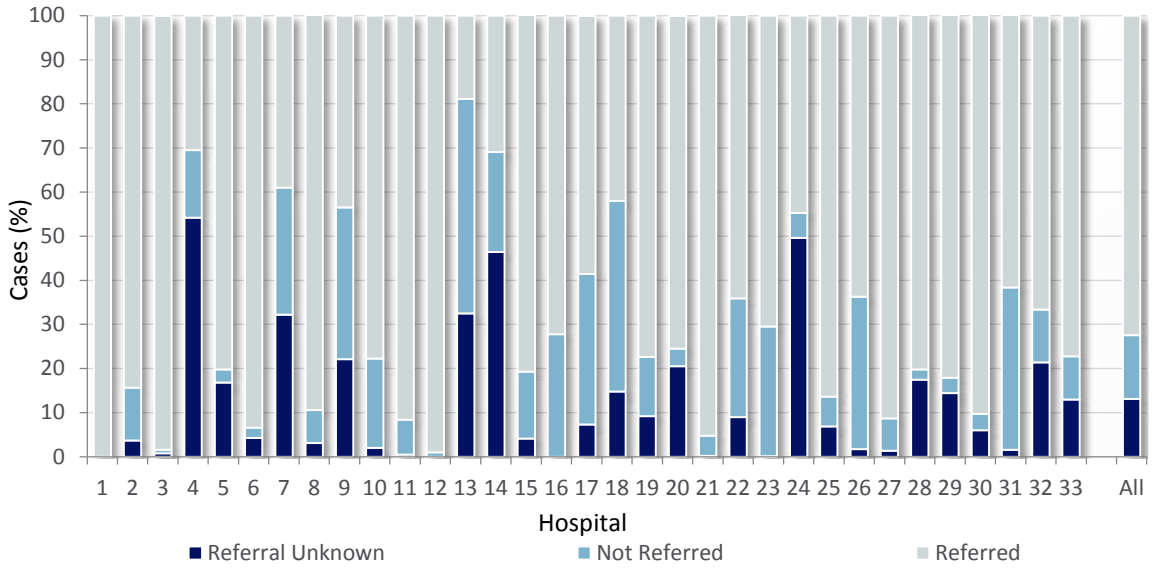


Data available for 7598 cases.

Referral to cardiac rehabilitation

In 2021, VCOR undertook a focused evaluation of cardiac rehabilitation referrals by hospital on the background that Australian practice guidelines strongly recommend patients undergoing PCI for any indication be referred to a cardiac rehabilitation/ secondary prevention program [13,24]. The review included feedback to hospitals regarding their referral rate (referred / not referred / referral unknown). A comparison among hospitals revealed a wide disparity in referral rates (Figure 26). The overall referral rate was 72.4%; 14.5% of patients were not referred and referral status was unknown in a further 13.1% of cases. Referral rates ranged from 19% to 100% across hospitals.

Figure 26: Referral to cardiac rehabilitation at discharge by hospital



Site 1 had low case numbers N<20.

Referrals to a cardiac rehabilitation/secondary prevention program were more common in patients presenting with acute coronary syndromes (Table 18). Compared to the previous two years, the rate of referral among the STEMI cohort declined (78.8% in 2021 vs 79.6% in 2020 vs 84.4% in 2019), with similar declines in the NSTE-ACS and non-ACS cohorts. Yet, the gap in referral rates between public and private sectors (lower in private) noted in previous years, had closed with similar referral rates in both hospital sectors (71.9% public vs 73% private).

Table 18: Rates of referral to cardiac rehabilitation by clinical presentation

Clinical presentation	Total	Rehabilitation referral rate
	N	N (%)
STEMI	2327	1834 (78.8)
NSTE-ACS	3463.0	2541 (73.4)
Non-ACS	6508	4528 (69.6)
All cases	12298	8903 (72.4)

Compliance with guideline-recommended medications at discharge

The use of optimal medical therapy should accompany all PCI procedures and includes dual antiplatelet therapy (DAPT) and statins [8]. Rates of DAPT and statin use were high and similar to previous years. However, a gap between public sector and private sector prescriptions of DAPT and statins was noted (Table 19) - possibly reflecting differences in demographic and clinical profiles between public and private sector patients.

Table 19: Rates of prescription of dual antiplatelet therapy and statins at discharge

Medications	All sites	Public	Private
	N (%)	N (%)	N (%)
Dual antiplatelet therapy*	11530 (94.0)	6476 (95.5)	5054 (92.1)
Statin	11268 (92.4)	6403 (95.3)	4865 (89.0)

** DAPT is aspirin plus another antiplatelet drug.*

Beta blockers and ACE inhibitors/angiotensin receptor blockers (ARB) are also guideline-recommended for patients presenting with acute coronary syndromes [25]. The rates of use of these medications by clinical presentation are shown in Table 20. As in previous reports, the lowest usage rates of these medications were in patients undergoing PCI for non-ACS conditions.

Table 20: Rates of prescription of selected medications at discharge by clinical presentation

Clinical presentation	DAPT	Statin	BB	ACE-I/ARB
	%	%	%	%
STEMI	95.3	96.4	85.2	81.5
NSTE-ACS	95.2	94.8	70.7	70.7
Non-ACS	92.9	89.8	53.8	62.3

The proportion of STEMI patients discharged on at least 4 of the 5 evidence-based medications (aspirin, second antiplatelet agent, statin, beta blocker and ACE inhibitor/ARB) was a little lower than in 2020 but better than in earlier years (90% in 2021, 93% in 2020, 69% in 2019 and 81% in 2018). Among the cohort of NSTE-ACS patients, the rate was similar to the previous year (84% in 2021 vs 86% in 2020).

Key Performance Indicators

VCOR reports on the following key performance indicators (KPIs)

- In-hospital mortality
- In-hospital major bleeding
- Length of stay
- In-hospital unplanned revascularisation
- Door-to-balloon device time for STEMI patients
- 30-day risk adjusted mortality [26]
- 30-day major adverse cardiac and cerebrovascular event (MACCE)

In-hospital mortality

The overall unadjusted in-hospital mortality rate for 2021 was 1.4%. In-hospital mortality rates for selected clinical subgroups are shown in Table 21, with higher death rates among patients with higher-acuity clinical presentations. Patients with cardiogenic shock and/or intubated OHCA had the highest rate of in-hospital mortality. When high-acuity cases were excluded from the analysis, the in-hospital mortality rate fell to 0.5%. Overall, in-hospital mortality rates have remained stable over a 6 year period.

Table 21: Trends in in-hospital mortality rates for selected clinical presentations: 2016 - 2021

Patient category	2016 (N=10,035)	2017 (N=11,007)	2018 (N=12,463)	2019 (N=12,355)	2020 (N=12,349)	2021 (N=12,478)
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
All PCI patients	193 (1.9)	204 (1.9)	174 (1.4)	212 (1.7)	184 (1.5)	180 (1.4)
STEMI	138 (6.4)	145 (6.4)	119 (4.7)	148 (6.2)	140 (5.4)	118 (4.8)
Shock and/or intubated OHCA	119 (38.5)	133 (42.9)	116 (35.3)	138 (43.1)	116 (35.6)	113 (37.7)
NSTE-ACS	29 (0.9)	34 (1.0)	29 (0.8)	27 (0.8)	19 (0.5)	32 (0.9)
Non-ACS	26 (0.6)	25 (0.5)	26 (0.4)	37 (0.6)	25 (0.4)	30 (0.5)

Given that for STEMI patients undergoing primary PCI, there was an association of poorer door-to-balloon time results in hospitals with lower case volumes, we examined the relationship between in-hospital mortality and other key performance measures and primary PCI case volume (Table 22). Contrary to expectation, rates of in-hospital and 30-day mortality were actually lower in the low-volume centres, as were 30-day MACCE rates. However, when high-acuity cases of cardiogenic shock and/or OHCA were excluded, 30-day MACCE was similar (3.7% higher-volume hospitals vs 3.3% lower-volume hospitals). Bleeding rates were similar, while the rate of unplanned revascularisation was higher in low-volume hospitals.

Most (96%) primary PCI cases were performed in higher-volume hospitals and the actual number of primary PCIs in low-volume centres was quite low. It is likely that these and other factors contribute to a potentially complex relationship between primary PCI volume and patient outcomes. We believe that further analysis of these relationships is warranted - including pooling of results over a number of years to observe longer-term trends - before firm conclusions can be drawn regarding the links between primary PCI volumes and patient outcomes.

Table 22: Outcomes for primary PCI by hospital volume

	All sites	Sites with ≥36 Primary PCI Site volume ≥200	Sites with <36 Primary PCI Site volume <200
	(N=1,564)	(n=1,497)	(n=67)
Median LOS- days	4.0	4.0	4.0
	%	%	%
In-hospital mortality	5.4	5.5	1.5
In-hospital mortality excl shock and/or intubated OHCA	1.1	1.1	0.0
In-hospital unplanned revascularisation	1.0	0.9	3.00
In-hospital major bleeding	1.2	1.1	1.5
30-day mortality	6.1	6.3	1.5
30-day mortality excl shock and/or intubated OHCA	1.4	1.4	0.0
30-day MACCE	8.4	8.6	4.5
30-day MACCE excl shock and/or intubated OHCA	3.7	3.7	3.3

In-hospital major bleeding

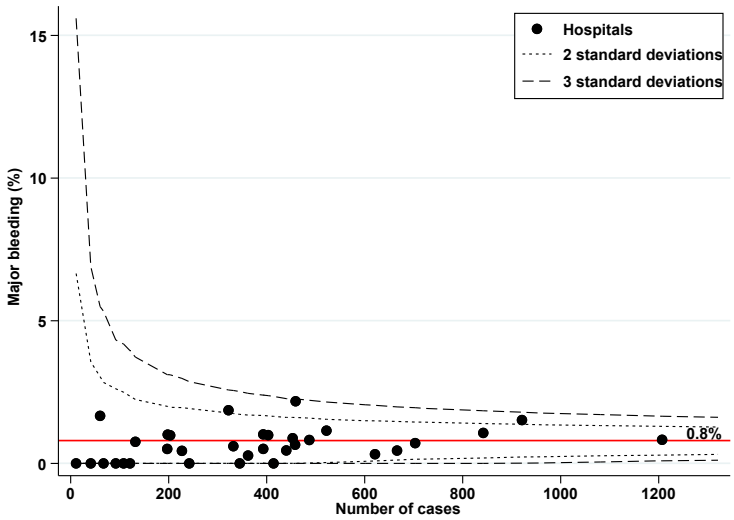
VCOR utilises the standardised bleeding definitions of the Bleeding Academic Research Consortium (BARC) [27], and specifically reports on major bleeding that comprises BARC Type 3 and Type 5 bleeding events. Major bleeding rates for selected patient subgroups are presented in Table 23. The overall major bleeding rate of 0.8% was low but slightly higher than the previous year (0.6% in 2020). Major bleeding rates for selected subgroups were also higher by small margins compared with 2020. Major bleeding was again more common in females (1.8%) and more than triple the rate in males (0.5%). The majority of major bleeding events occurred in patients who underwent PCI via femoral arterial access. Bleeding rates were particularly high among patients requiring ECMO or left ventricular assist devices (LVAD).

Table 23: In-hospital major bleeding rates for selected patient groups

Sub-group	N	Major bleeding rate
Clinical Presentation		N (%)
STEMI	2441	38 (1.6)
NSTE-ACS	3494	20 (0.6)
Non-ACS	6527	45 (0.7)
Sex		N (%)
Male	9320	48 (0.5)
Female	3142	55 (1.8)
Arterial Access Route		N (%)
Radial access	9331	43 (0.5)
Femoral access	3109	60 (1.9)
Brachial access	22	0 (0)
Total	12442	103 (0.8)

Major bleeding rates by hospital are presented in Figure 27. There were no outlier hospitals for major bleeding.

Figure 27: Rates of in-hospital major bleeding by hospital

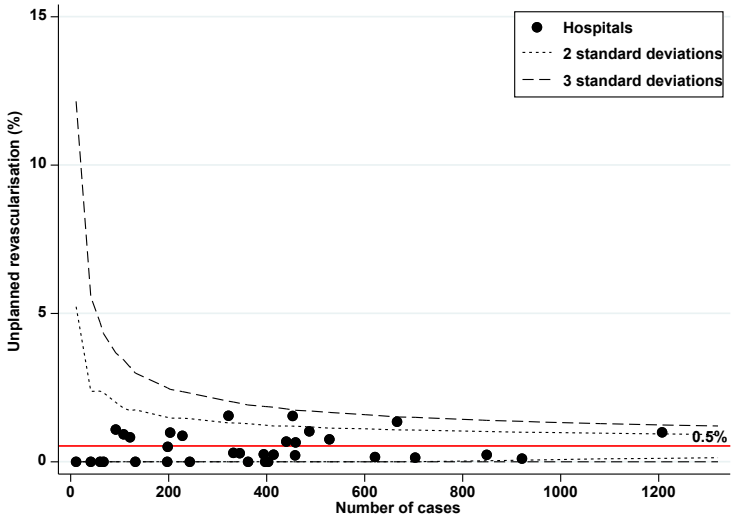


Excludes ECMO cases (n=20).

In-hospital unplanned revascularisation

A revascularisation procedure (PCI or CABG surgery) performed after the initial PCI is considered "unplanned" if it is unexpected and not pre-arranged. Unplanned revascularisation generally occurs in the setting of a post PCI complication such as stent thrombosis, coronary artery perforation or dissection and the rate of unplanned revascularisation reflects hospital performance and a measure of quality of care. The rate of in-hospital unplanned revascularisation was 0.5%, low and unchanged from the previous year.

Figure 28: Rates of in-hospital unplanned revascularisation by hospital



All participating hospitals had rates of unplanned revascularisation that were within control limits with no outlier hospitals identified (Figure 28).

A total of 34 cases required emergency or urgent cardiac bypass (CABG) surgery. This was higher than in the previous year but was consistent with earlier years (34 in 2021, 14 in 2020, 28 in 2019 and 40 in 2018). Table 24 presents selected clinical features and outcomes that were associated with emergency cardiac surgery following PCI. Just over 20% of cases requiring urgent CABG were performed in hospitals without onsite cardiac surgery capability, thus involving inter-hospital transfer of these patients. Mortality and major bleeding rates were higher among the emergency CABG surgery patients compared to the overall cohort.

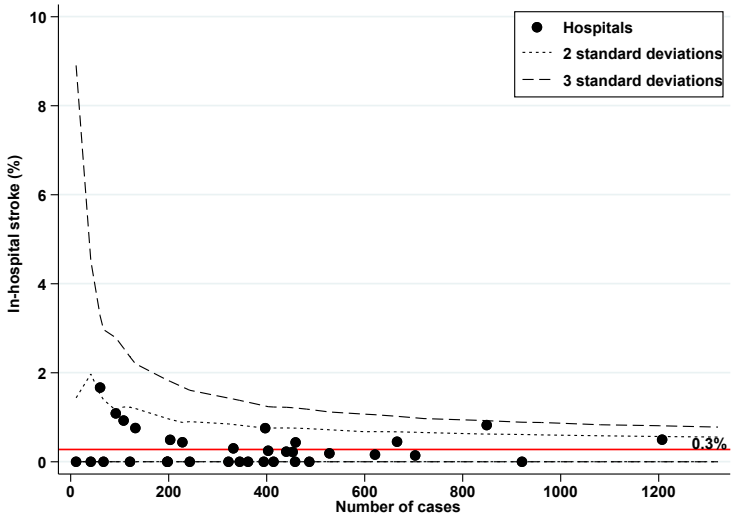
Table 24: Selected clinical features and outcomes associated with emergency CABG surgery

Presentation	Emergency CABG (N=34)
	N (%)
STEMI	15 (44.1)
Shock and/or intubated OHCA	2 (5.9)
Complex lesions (Type C)	18 (52.9)
Chronic total occlusion	1 (2.9)
Unprotected left main PCI	1 (2.9)
PCI performed in hospitals without on-site surgery	7 (20.6)
In-hospital outcomes	N (%)
Mortality	2 (5.9)
New MI	1 (2.9)
Major bleeding	2 (3.2)
Stroke	0 (0)
Definite and probable stent thrombosis	0 (0)

In-hospital stroke

Rates of in-hospital stroke are presented separately rather than as a component of the composite endpoint of major adverse cardiac and cerebrovascular events (MACCE) rates for the first time. Figure 29 shows that the overall stroke rate was 0.3%, with a range of 0% to 1.7% across hospitals. This compares favourably with national and international registry series. The most recent report from Queensland Cardiac Outcomes Registry (QCOR) [28] noted a stroke rate of 0.4% in 2020, while the British Cardiovascular Intervention Society (BCIS) [29] reported a stroke rate of 0.08% in their 2019-2020 report. There was a total of 34 stroke events, 29 of which were haemorrhagic strokes. There were no outlier hospitals with respect to in-hospital stroke incidence.

Figure 29: Rates of in-hospital stroke by hospital



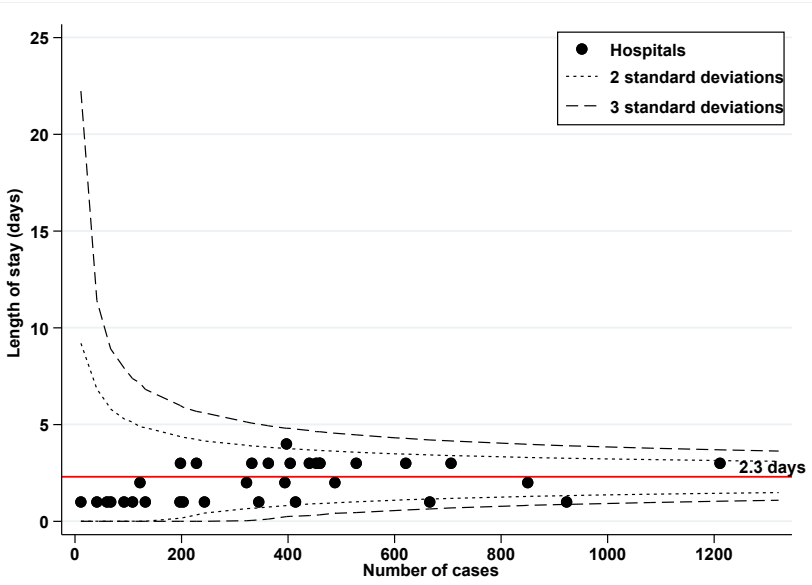
Length of stay

The median length of stay varied by clinical presentation, ranging from 1 day for patients undergoing PCI for elective non-ACS indications up to 4 days for STEMI PCI cases. Patients treated with PCI for NSTE-ACS had a median length of stay of 3 days. Median length of stay was shorter among patients treated in private hospitals (3 days public vs 2 days private).

A total of 347 PCI cases (2.8%) were discharged on the same day of their PCI - a number that has remained largely unchanged over the past several years [30]. Same day discharge was more common in the public sector where it accounted for 4.1% of cases compared with the private sector where the rate was 1.1% of the PCI caseload. The rate of same day discharge among Victorian PCI centres remains much lower than observed in international series [31].

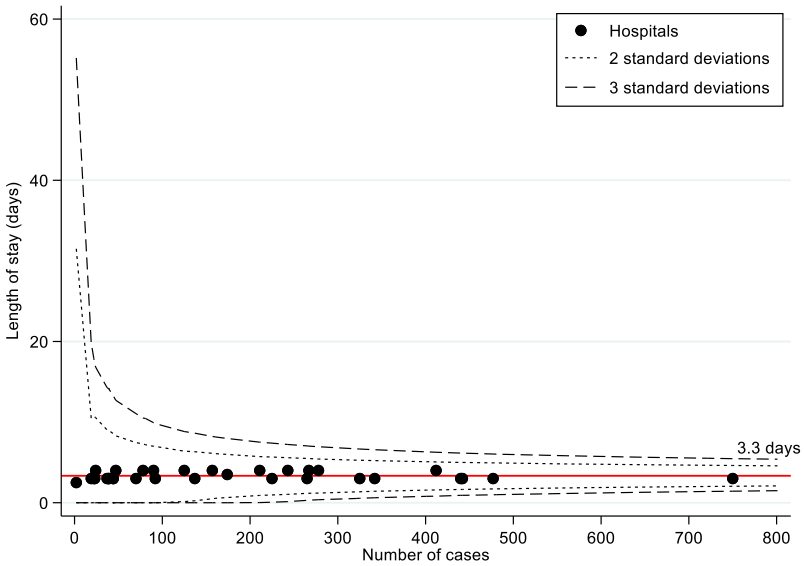
Figure 30 compares the median length of stay by hospital. All hospitals' median length of stay were within control limits. There was no apparent relationship between median length of stay and hospital volume.

Figure 30: Median length of stay by hospital



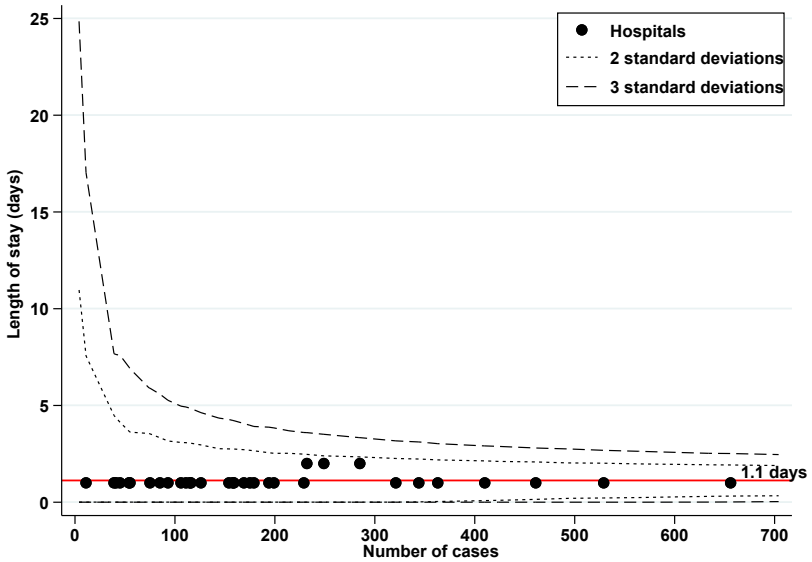
We have previously observed that the majority of the variation in length of stay occurs among non-elective admissions for ACS conditions. We therefore separately benchmarked hospitals' performance with respect to length of stay for ACS and non-ACS presentations. Figure 31 shows median length of stay for ACS cases (STEMI, NSTEMI and unstable angina). The range was 3-4 days and all hospitals were within control limits.

Figure 31: Length of stay by clinical presentation: ACS cases



With respect to non-ACS cases, the range in length of stay was 1-2 days and there were no outlier hospitals (Figure 32).

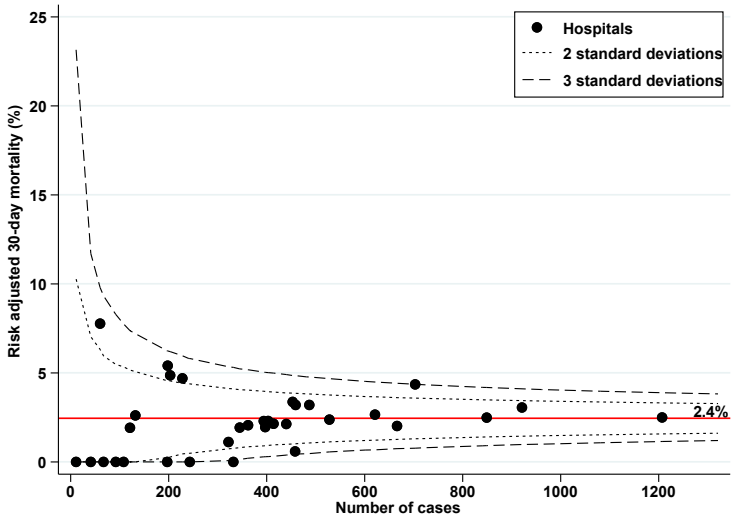
Figure 32: Length of stay by clinical presentation: Non-ACS cases



30-day risk adjusted mortality

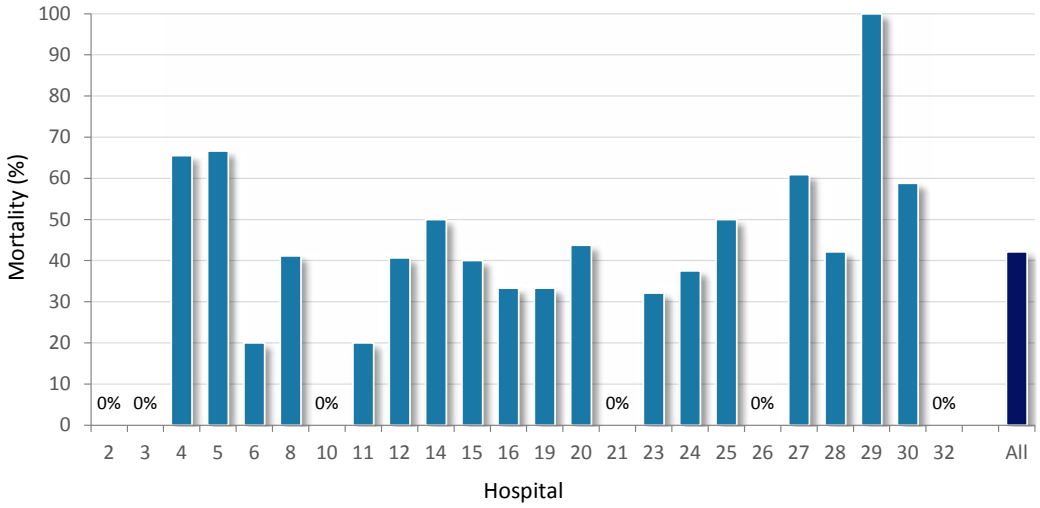
The risk adjusted 30-day mortality was 2.4%. All participating hospitals were within control limits (Figure 33). No apparent relationship between risk adjusted mortality and hospital volume was evident.

Figure 33: Risk adjusted 30-day mortality rates by hospital



Looking separately at the high acuity conditions of cardiogenic shock and out-of-hospital arrest, the unadjusted 30-day mortality rates for cardiogenic shock and/or intubated OHCA cases by hospital are shown in Figure 34. The mean mortality rate was 39%, ranging from 0% to 100%. Several hospitals did not treat any cardiogenic shock and/or intubated OHCA cases. As observed in previous reports, the hospitals with either very low or high mortality tended to have low numbers of cardiogenic shock and or intubated OHCA cases.

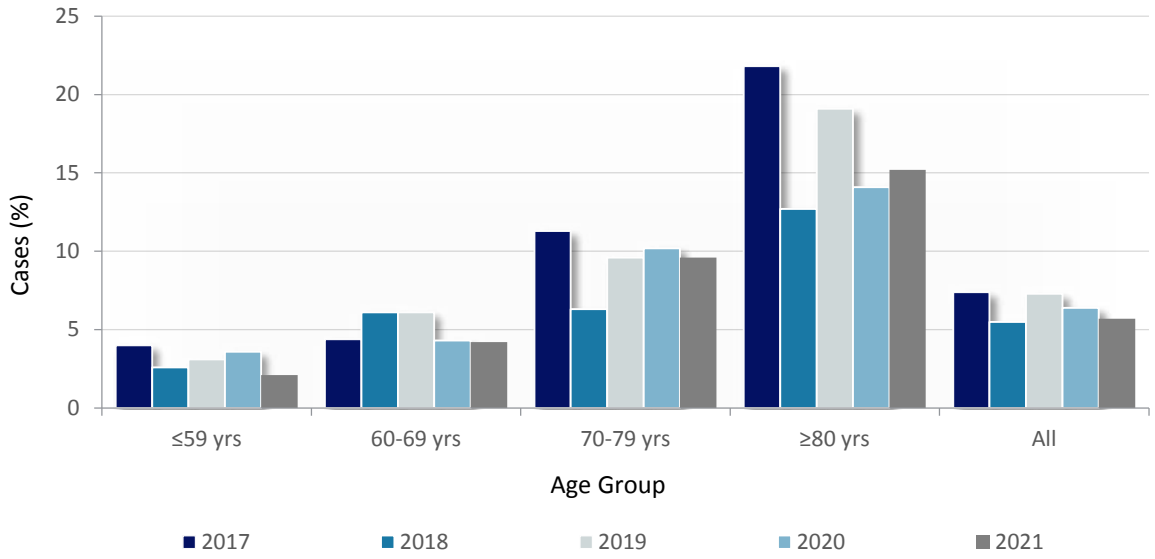
Figure 34: 30-day mortality rates for cardiogenic shock and/or intubated OHCA patients by hospital



Hospital	2	3	4	5	6	8	10	11	12	14	15	16	19	20	21	23	24	25	26	27	28	29	30	32	ALL
Cases (N)	2	4	29	6	5	17	2	5	32	2	15	3	48	16	1	28	16	2	1	23	19	2	17	4	299

For patients who presented with STEMI, the overall 30-day mortality rate was 5.7%, comparable to a large international series [32]. A comparison of 30-day mortality rates for STEMI by age over a 5-year period is shown in Figure 35. There was a clear stepwise increase in mortality with age, with the ≥80 years age group having the highest mortality overall.

Figure 35: 30-day mortality for STEMI by age group



30-day major cardiac and cerebrovascular events (MACCE)

The composite endpoint of major adverse cardiac and or cerebrovascular events (MACCE) combines the adverse outcomes of death, new or recurrent myocardial infarction or stent thrombosis, target vessel revascularisation and stroke. The components of MACCE, for both in-hospital and 30-day timepoints, are shown in Table 25. Events after discharge occurred for all MACCE components. The overall 30-day MACCE rate was 3.6% - similar to the previous year.

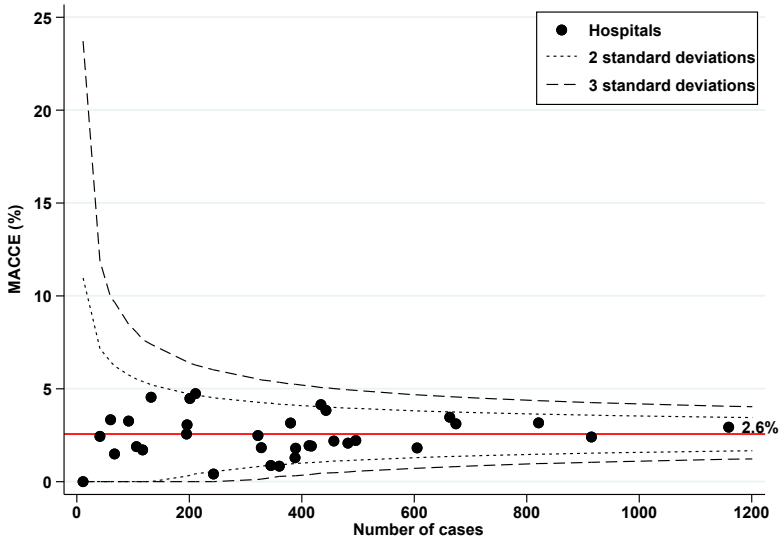
Table 25: Major adverse cardiac and cerebrovascular event rates

MACCE component**	In-hospital events	30-day events*
	N (%)	N (%)
Mortality	172 (1.4)	224 (1.8)
Myocardial infarction	46 (0.4)	114 (0.9)
Stroke	34 (0.3)	52 (0.4)
Definite stent thrombosis	25 (0.2)	43 (0.3)
Probable stent thrombosis	2 (<0.1)	7 (0.1)
Target vessel revascularisation (TVR)†	66 (0.5)	148 (1.2)
MACCE	283 (2.3)	447 (3.6)

**30-day events reported include in-hospital events.*
†TVR refers to any 'unplanned' PC/ or CABG revascularisation of the target vessel.
***Cases with multiple procedures were excluded to avoid mortality being counted more than once (n=10).*
Categories are not mutually exclusive.

Excluding the high-risk conditions of cardiogenic shock or out-of-hospital cardiac arrest that are known to have higher than average MACCE events, the MACCE rate fell to 2.6%.

Figure 36: 30-day MACCE (excluding cardiogenic shock/OHCA) rates by hospital

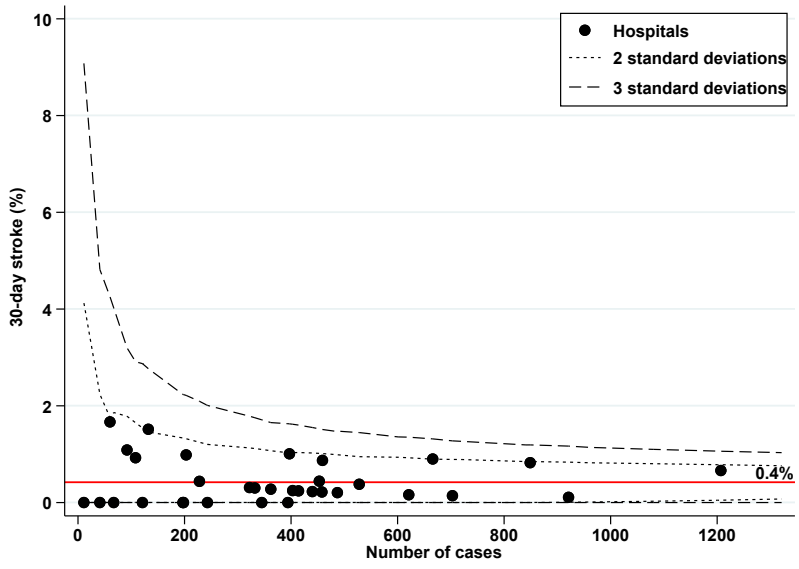


Excludes all cardiogenic shock/OHCA cases (N=300).

A comparison of 30-day MACCE rates, excluding cardiogenic shock and/or OHCA by hospital is shown in Figure 36. All hospitals were within control limits.

The overall stroke rate at 30 days was 0.4%, a slight increase from the in-hospital stroke rate. In the period between hospital discharge and 30 days there was 2 additional haemorrhagic strokes, 9 additional ischaemic strokes and a further 7 strokes where the type was not recorded. A comparison of 30-day stroke rates by hospital in Figure 37. All hospitals were within control limits.

Figure 37: Rates of 30-day stroke by hospital



30-day stent thrombosis

For the purposes of this registry, reported stent thrombosis rates refer to either a “definite” event (acute coronary syndrome presentation and angiographic or pathologic confirmation of stent thrombosis) or a “probable” event (unexplained death within 30 days or target vessel myocardial infarction without angiographic confirmation of stent thrombosis). The 30-day rates of both definite stent thrombosis and probable stent thrombosis were low and similar to previous years (Table 25).

30-day rehospitalisation

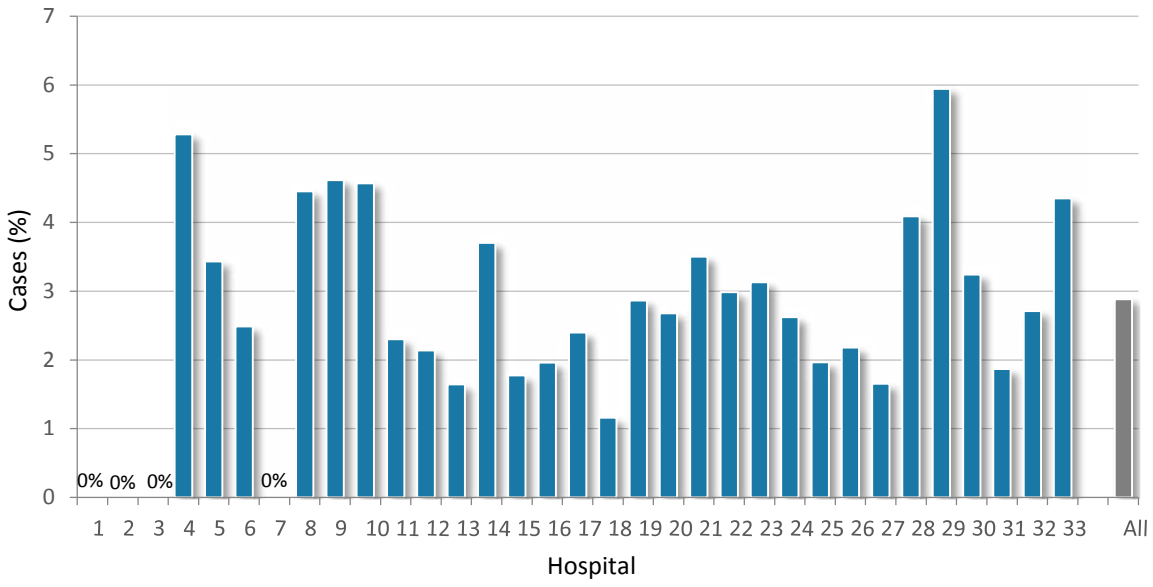
Rates of rehospitalisation within 30 days of discharge following PCI declined further in 2021 (10.8% in 2021 vs 12% in 2020 vs 13.3% in 2019). Underlying cardiac conditions accounted for over two-thirds of rehospitalisations (68%), with 60% of these cases being planned re-admissions (Table 26). The rate of unplanned cardiac rehospitalisations - considered a measure of quality and hospital performance - was 2.9%, which was lower than in previous years (3.5% in 2020, 3.1% in 2019 and 3.7% in 2018). The overall rate of 30-day rehospitalisation was higher in the private sector however the rate of unplanned cardiac rehospitalisation was lower. This is a trend that has been consistent over time.

Table 26: Rehospitalisation rates by hospital sector

	All patients (N=12,251)	Public (n=6,778)	Private (n=5,473)
	N (%)	N (%)	N (%)
Rehospitalisations	1319 (10.8)	661 (9.8)	658 (12.0)
Non-cardiac rehospitalisations	428 (3.5)	263 (3.8)	165 (3.0)
Cardiac rehospitalisations	891 (7.1)	398 (5.9)	493 (9.0)
Unplanned cardiac rehospitalisations	352 (2.9)	207 (3.1)	145 (2.6)
Planned cardiac rehospitalisations	539 (4.4)	191 (2.8)	348 (6.3)

A comparison of the rates of unplanned cardiac rehospitalisation by hospital is shown in Figure 38. While there was variation among hospitals, the range narrowed compared with the previous year (0%-5.9% in 2021 vs 0%-9.7% in 2020).

Figure 38: 30-day unplanned cardiac rehospitalisation rates by hospital

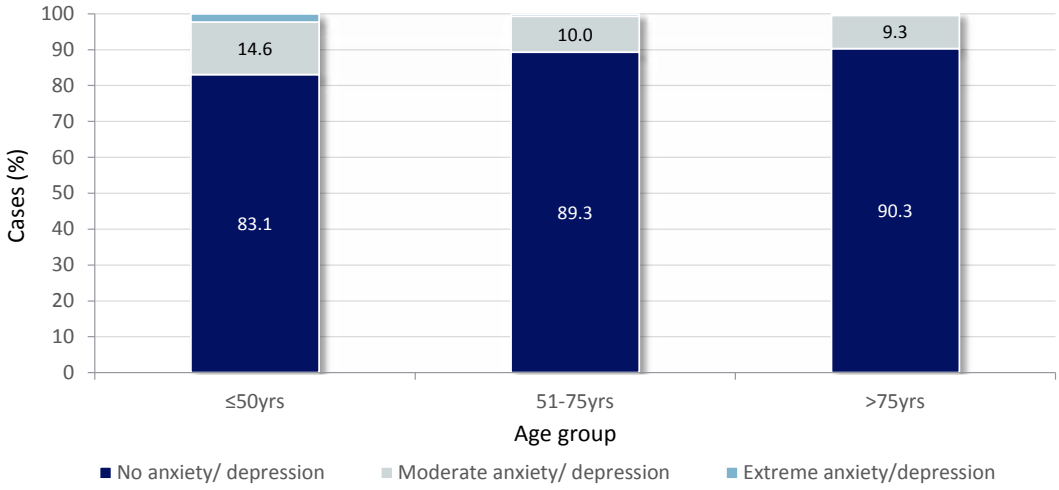


Quality of life

VCOR utilises the EQ-5D – a validated patient self-assessed quality of life (QoL) tool – to determine health-related QoL metrics at 30-day follow-up [33]. Responses were completed in 71% of cases, similar to previous reports, with a number of hospitals unable to conduct the questionnaire because of resource capacity constraints. Patients were asked to assess their mobility, ability to perform usual domestic and personal care tasks, level of pain or discomfort and whether they experienced any anxiety or depression.

The median rating score for a patient's own health status at 30 days post discharge was 80 out of 100 (IQR:70, 90), similar to previous years. One-third of patients reported experiencing at least some anxiety/depression. Patients ≤50 years reported higher rates of moderate and extreme anxiety/depression (Figure 39).

Figure 39: EQ-5D responses to anxiety/depression by age group



We have previously observed differences in QoL metrics between patients with low and high socio-economic status (SES), with higher perceived problem rates for several domains among patients with lower SES, although overall assessment of the quality of their own health status was higher among lower SES patients. In 2021, patients with higher SES scored better in all domains of quality of life, with lower rates of problems with mobility, personal care, usual activity, pain and anxiety and depression, and unlike in 2020, patients with higher SES also scored themselves higher at their assessment of their own health status (Table 27). A similar effect for all the various quality of life components was noted among patients from metropolitan and non-metropolitan settings, with metropolitan-based patients having fewer perceived problems. However, non-metropolitan patients scored themselves slightly higher than metropolitan patients when assessing their own overall health status following PCI.

Table 27: Patients reported experience by socio-economic status and in non-metro/metro

Quality of Life components	Low SES (n=1,672)	High SES (n=5,638)	Non-metro (n=2,136)	Metro (n=5,118)
	%	%	%	%
Some problem with mobility	11.1	10	10.9	10
Some problem with personal care	4.7	3.7	4.3	3.8
Some problem with usual activity	13.9	12.2	13.3	12.3
Moderate pain/discomfort	11.5	9.3	10.9	9.5
Moderate/extreme anxiety/depression	12.3	10.5	12.3	10.4
Assessment of own health status (score 0-100)	78.3	79.1	79.2	78.6

Cardiac Implantable Electronic Devices (CIED)

Background

VCOR commenced data collection for cardiac implantable electronic devices (CIED's) in 2018 with the focus on implantable cardiac defibrillators (ICD) and cardiac resynchronisation therapy (CRT). ICD's are devices that provide an internal electric shock to the heart to effectively treat abnormal and potentially lethal ventricular arrhythmias, whereas CRT's involve synchronised pacing of the left and right ventricles of the heart in patients with diseased heart muscle (cardiomyopathy) resulting in improvement in signs and symptoms of heart failure. Currently 13 hospitals contribute data to this module, including 9 public and 4 private hospitals (Table 28).

Table 28: Participating Victorian CIED hospitals

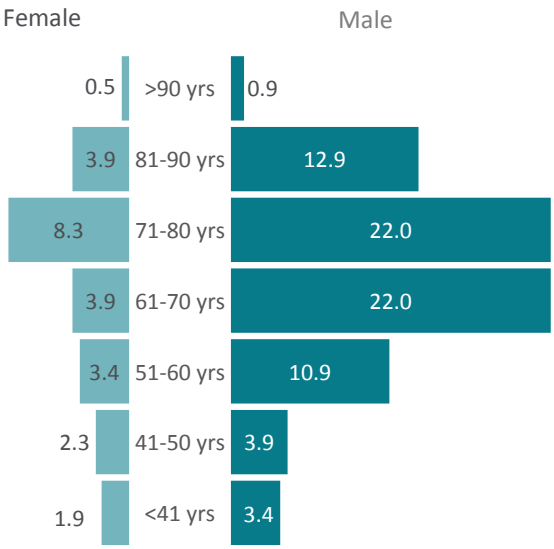
Victorian CIED hospitals	Hospital type	2018	2019	2020	2021
Alfred Hospital	Public	●			
Austin Hospital	Public	●	●	●	●
Ballarat Base Hospital	Public		●	●	●
Bendigo Hospital	Public		●	●	●
Box Hill Hospital	Public		●	●	●
Cabrini Hospital Malvern	Private		●	●	●
Footscray Hospital	Public	●	●	●	●
Frankston Hospital	Public		●	●	●
Jessie McPherson Private Hospital	Private		●	●	●
Monash Heart	Public	●	●	●	●
Mulgrave Private Hospital	Private	●	●	●	●
The Royal Melbourne Hospital	Public	●	●	●	●
Sunshine Hospital	Public	●	●	●	●
Western Private Hospital	Private			●	●

Table Legend: • A contributing data.

Patients and procedures

Despite COVID-19 effects on elective non-urgent cases throughout 2021, there was a 15% increase in the number of CIED-related procedures compared with the previous year. Of the 746 CIED cases that were performed, the average age of the patients was 67+14 with 74% were male (Figure 40). Just over half (56%) of cases were first implants, 37% of cases were for generator replacement, the remaining cases included new lead only in 3% while system explant and revision accounted for 4% of cases. The majority (69.6%) of all procedures were performed electively.

Figure 40: Age and sex distribution of patients undergoing CIED

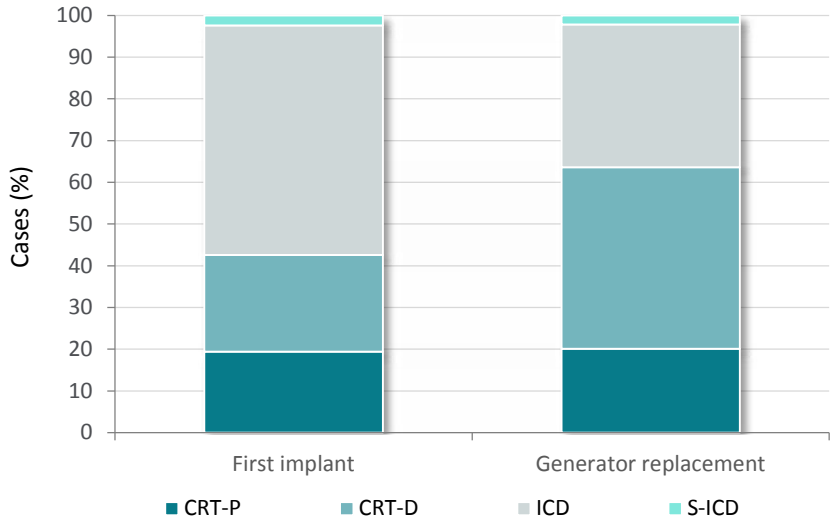


Device types

The 4 types of CIED devices that are monitored by VCOR are:

- ICD – implantable cardioverter defibrillator without any concomitant CRT functionality
- S-ICD – implantable cardioverter defibrillator implanted subcutaneously (never combined with CRT)
- CRT-D – implantable cardioverter defibrillator combined with CRT
- CRT-P – pacemaker with CRT functionality (no defibrillator functionality)

Figure 41: Device type – first implant and generator replacement



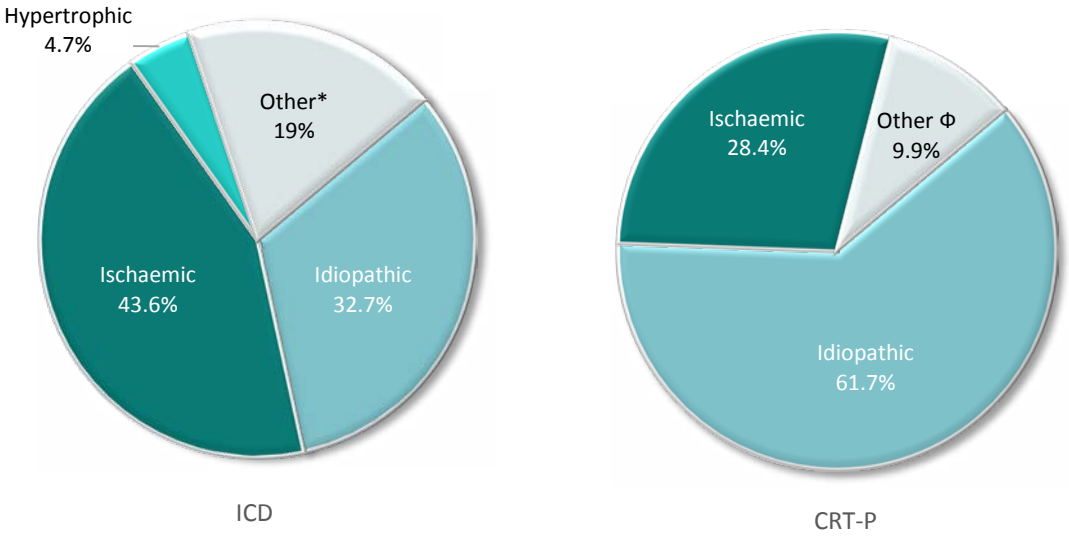
ICD devices (ICD, S-ICD and CRT-D) represent the majority of first implants (82%) and 78% of the generator replacements. (Figure 41). As in previous years, the majority (92.4%) of devices utilising CRT (CRT-P and CRT-D) were implanted in the left pre-pectoral region.

Only a small proportion (3.4%) were implanted in the right sub-pectoral region and 3.4% in the left sub-pectoral position. Similarly, the majority (85.3%) of the ICD's without CRT capabilities were placed in the left pre-pectoral region.

Cardiomyopathy aetiology

Cardiomyopathy is the major underlying cardiac condition in most patients who require an ICD and/or CRT. Figure 42 shows the aetiology of the cardiomyopathy among patients undergoing their first CIED implant. For ICD implants, ischaemic heart disease accounted for 43.6% of cases whereas among patients requiring CRT without defibrillator functionality, ischaemic heart disease was the cause in just 28.4% of patients. In the majority of CRT-P cases (61.7%), the cause of any underlying cardiomyopathy was not known.

Figure 42: Aetiology in patients undergoing first CIED implant



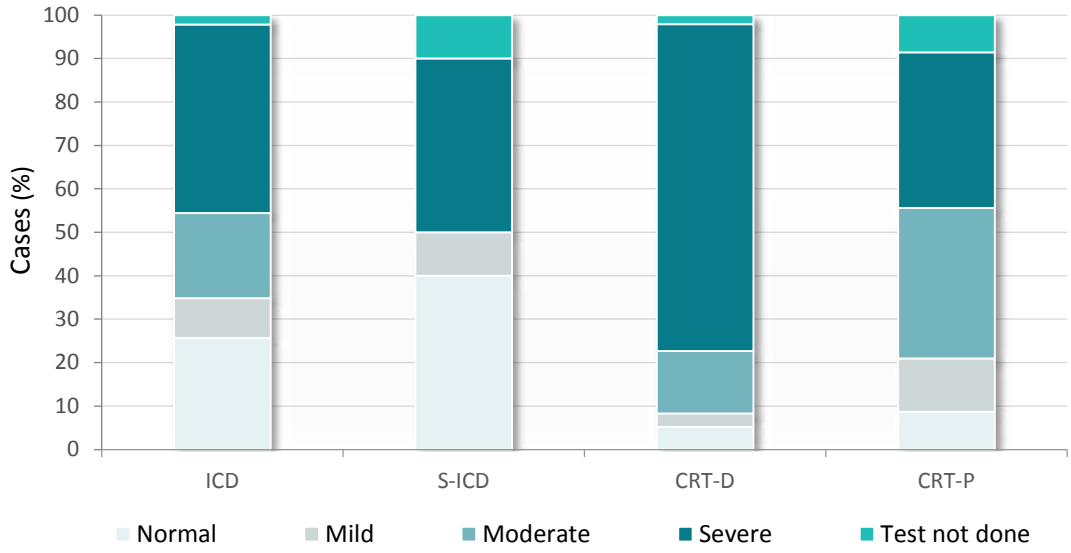
** Includes Familial/congenital & Idiopathic ventricular fibrillation.*
Φ Includes Valvular, Familial/congenital & Structural normal heart.

Left ventricular function

The presence of significant left ventricular (LV) impairment is one of the key clinical characteristics that is considered when considering implantation of an ICD or CRT-P. Other characteristics such as the underlying cardiac condition, severity of heart failure symptoms, a history of previous cardiac arrest and the presence of certain ECG changes are also assessed, but left ventricular function is typically one of the most important determinants used when evaluating whether devices were implanted for appropriate indications.

Figure 43 demonstrates the ranges of left ventricular function among patients undergoing their first implants for each of the 4 categories of CIED monitored in the registry. The greatest proportion of cases with either moderate or severe left ventricular dysfunction (90%) was seen in patients receiving CRT-D. Patients receiving ICD also had a majority of cases with moderate or severe LV impairment, although the proportion of cases with moderate LV dysfunction was greater than in CRT-D. S-ICD cases had yet another profile with substantially more patients with normal LV function. This corresponds to the selective nature of S-ICD usage which tends to be in younger patients, often for primary prevention and in whom there is no expected need for backup pacing or CRT functionality. Patients requiring CRT-P without concomitant defibrillator therapy are also a select group, with a greater proportion of cases with either mild or just moderate LV dysfunction.

Figure 43: Left ventricular function by CIED type (first implants only)



Indications for CIED therapy

ICDs

ICDs (with or without CRT functionality) are generally implanted for primary or secondary prevention of sudden cardiac death. In 2021, 52% of ICDs were implanted for primary prevention with ischaemic cardiomyopathy the underlying condition in 46% of these cases. Just over half (52%) of ICD implants for secondary prevention were for ventricular tachycardia, while 40% were for prior ventricular fibrillation.

Cardiac resynchronisation therapy

National practice guidelines stipulate that appropriate criteria for CRT use include QRS width ≥120 milliseconds, severe left ventricular dysfunction and New York Heart Association (NYHA) Class II-III symptoms [34]. Similar to previous years, 90% of CRT-D patients had a QRS width ≥120 milliseconds, 75% had severe left ventricular dysfunction and 89% had an NYHA Class score of II or greater. Compliance with the CRT inclusion criteria was lower among the CRT-P implant group - particularly the proportion of patients with an LVEF <35% (Table 29).

Table 29: Inclusion criteria for CRT by device type

	CRT-D (N=97)	CRT-P (N=81)
	N (%)	N (%)
QRS width ≥120 msec	87 (90)	63 (78)
Severe left ventricular dysfunction (LVEF<35%)	73 (75)	29 (36)
NYHA Class II or greater	85 (89)	72 (90)

Assessing the strength of recommendation for CIED therapy

Utilising a series of algorithms based on national and international guidelines providing appropriate use criteria [35, 36], VCOR has developed a series of flow charts that provide an evidence-based grading of the strength of recommendation for the particular category of CIED therapy (ICD or CRT) for each of a number commonly encountered clinical scenarios. These flow charts were upgraded to the latest versions of the guidelines for this report to ensure that the most up-to-date evidence base was applied to each case assessment. The flow charts were reviewed and endorsed by the VCOR CIED Expert Working Group.

An example of one of these flowcharts is shown in Figure 44. Based on these flowcharts, the strength of the recommendation for each CIED implantation (+, ++ or +++ strength grade) was determined.

The flowchart-related clinical scenarios that were utilised (5 for ICD therapy and 3 for CRT therapy) when determining the strength of recommendation for CIED therapy were:

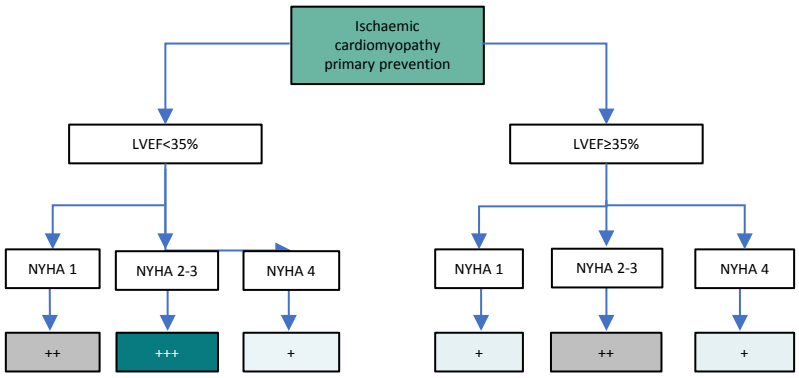
For ICD therapy (ICD, S-ICD and CRT-D):

1. Secondary prevention – prior ventricular fibrillation, sustained VT or cardiac arrest
2. Unexplained syncope
3. Primary prevention – with known Ischaemic cardiomyopathy
4. Primary prevention – with known non-ischaemic cardiomyopathy
5. Primary prevention – with known underlying cardiac-related genetic condition

For CRT therapy (CRT-D and CRT- P):

6. CRT for ischaemic cardiomyopathy with LVEF <35%
7. CRT for non-ischaemic cardiomyopathy with LVEF <35%
8. CRT in setting of pre-existing or anticipated need for RV pacing

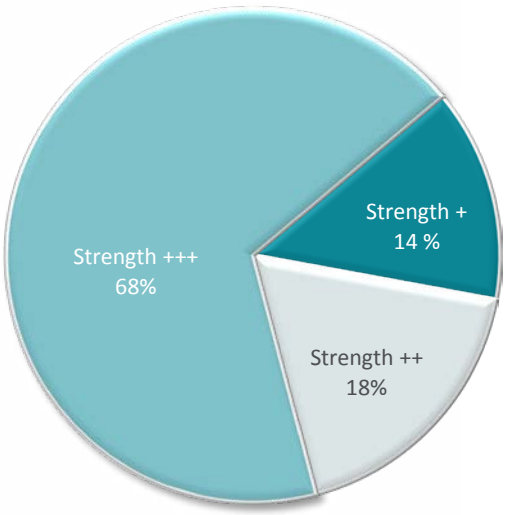
Figure 44: Flowchart for primary prevention - with known ischaemic cardiomyopathy



It is important to point out that this form of analysis is intended to provide a measure of the weight of evidence behind the implantation of the device in a particular patient rather than make a judgement of whether the insertion of the device was appropriate or not. Its design is similar to the grade strength of recommendation used in national and international practice guidelines. A weak or "strength +" recommendation does not mean to imply that the device was implanted inappropriately. We recognise that flow charts cannot adequately account for individual patient complexity that influences clinician decision making. There will be many circumstances where it is entirely appropriate to implant a CIED even when the formal assessment of the indication for its implantation receives a "strength +" recommendation. The function of this analysis is primarily as a quality assurance tool for hospitals and clinicians to monitor practice and to provide an overall evaluation of their management and the strength of the evidence base supporting their clinical decision making.

Figure 45 shows the proportions of strength +, strength ++ and strength +++ recommendation for ICD implantation (ICD, CRT-D and S-ICD) for the total cohort of ICDs (n=325). A strength ++ or strength +++ recommendation was present in 86% of cases of implantable defibrillator therapy.

Figure 45: Strength of recommendation for ICD therapy



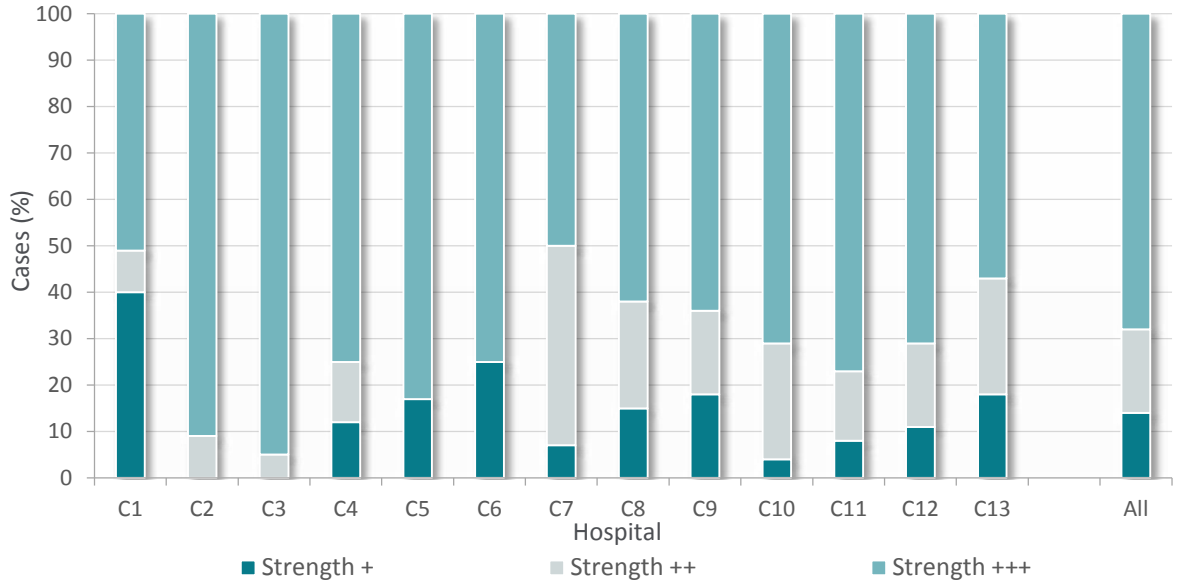
The strength of recommendation was analysed by type of ICD device (Table 30). Two-thirds of ICD and CRT-D devices had a strength +++ recommendation. In contrast, subcutaneous ICDs had a greater proportion of cases with a strength ++ rather than a strength +++ recommendation for use. However, it is acknowledged that S-ICDs are most often used in a select group of patients- typically younger with no need for pacing backup or in patients with a high risk of infection or with no endovascular option. As a result, individual patient factors likely play a much larger role in selecting an S-ICD and these clinical decisions cannot be adequately represented in the flow chart method for determining strength of recommendation. Additionally, S-ICD case numbers were low, suggesting that results should be interpreted with caution.

Table 30: Strength of recommendation for ICD therapy by form of therapy

Strength of Indication	CRT-D (N=92)	ICD (N=223)	S-ICD (N=10)
	N(%)	N(%)	N(%)
Strength +++	64 (69)	155 (69)	3 (30)
Strength ++	10 (11)	42 (19)	6 (60)
Strength +	18 (20)	26 (12)	1 (10)

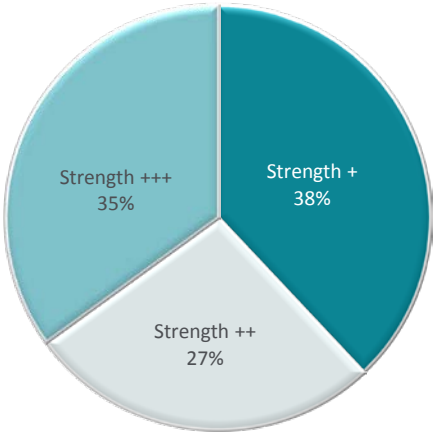
Figure 46 compares the strength of recommendation for defibrillator therapy (ICD, CRT-D or S-ICD) by hospital. In all hospitals, a strength +++ recommendation was present in at least 50% of cases.

Figure 46: Strength of recommendation for ICD therapy by hospital



A breakdown of cases strength +, strength ++ or strength +++ recommendations for CRT (n=169), incorporating CRT-D and CRT-P is presented in Figure 47. A strength +++ or strength ++ recommendation was present in 62% cases of CRT implantation.

Figure 47: Strength of recommendation for CRT therapy



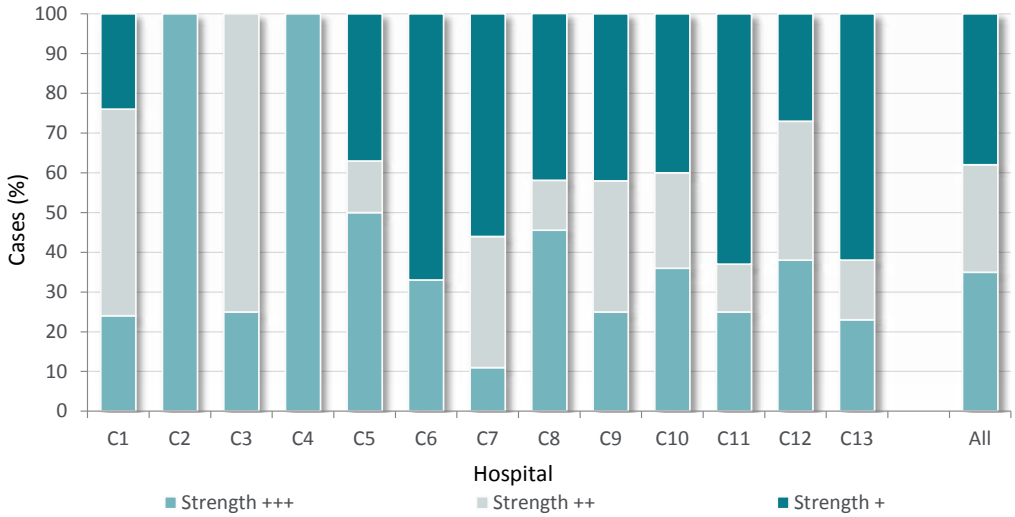
The proportion of CRT-D cases with a strong recommendation for use was higher compared to CRT-P (Table 31). Overall, CRT devices had a greater proportion of cases with a strength + recommendation compared to ICD devices.

Table 31: Strength of indication for CRT by device type

Strength of Indication	CRT-D (N=95)	CRT-P (N=74)
	N(%)	N(%)
Strength +++	41 (43)	18 (24)
Strength ++	22 (23)	23 (31)
Strength +	32 (33)	33 (45)

Hospitals' benchmarking data are presented in Figure 48. The proportion of strength +++ or strength ++ recommendations varied among hospitals for CRT implantation (range 43%-100%). However, some hospitals had very low case numbers suggesting that strength of recommendation for CRT at these sites should be interpreted with caution.

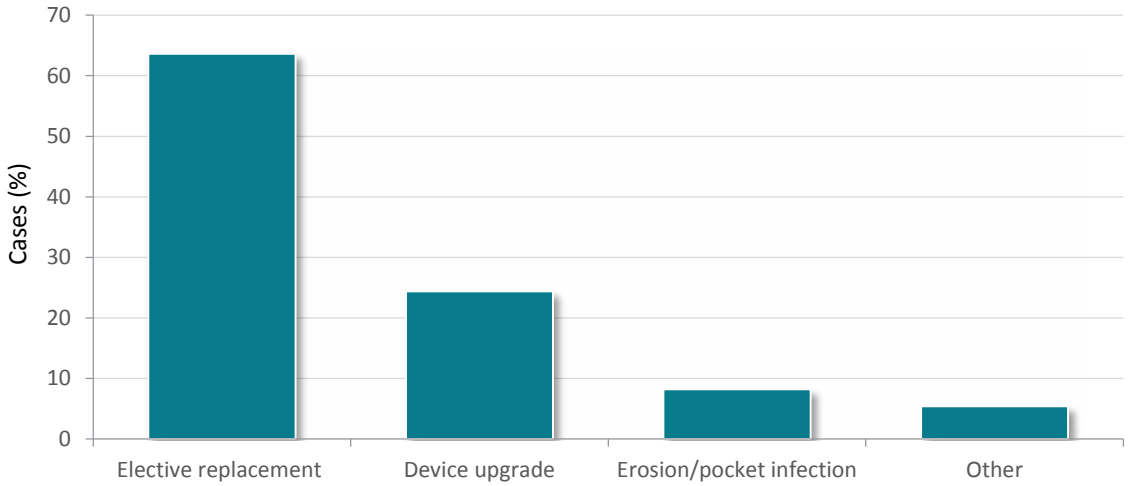
Figure 48: Strength of indication for CRT by hospital



Replacements and revisions

The majority of CIED generator replacements shown in Figure 49 were for elective replacements. Device upgrade accounted for 24% of cases, while erosion/pocket infection was the indication for 8% of generator replacements.

Figure 49: Indications for generator replacement, explant or revision



Outcome measures

The key performance indicators (KPIs) used to monitor and benchmark hospital performance in relation to CIED therapy included:

- In-hospital mortality
- 30-day mortality
- Successful device implantation without in-hospital complications
- 30-day unplanned cardiac readmissions
- 30-day device related re operations
- 30-day device related infection rate

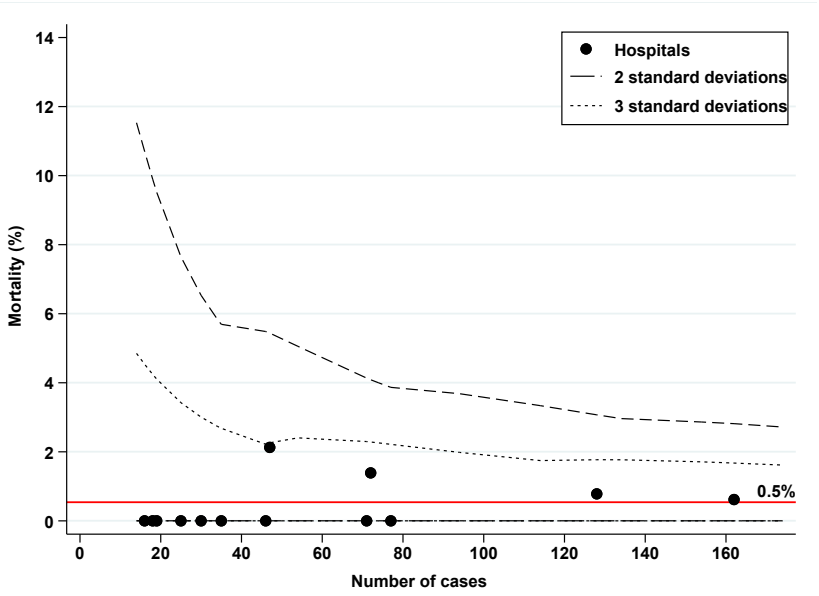
In-hospital mortality

There were 3 in-hospital deaths in 2021. Two of these were cardiac-related deaths and 1 device-related.

30-day mortality

The 30-day mortality rate was 0.5%, the same as in the previous year. All hospitals were within control limits with no outlier sites. There was no apparent relationship between case volume and 30-day mortality rates (Figure 50).

Figure 50: 30-day CIED related mortality



Successful device implantation without in-hospital complications

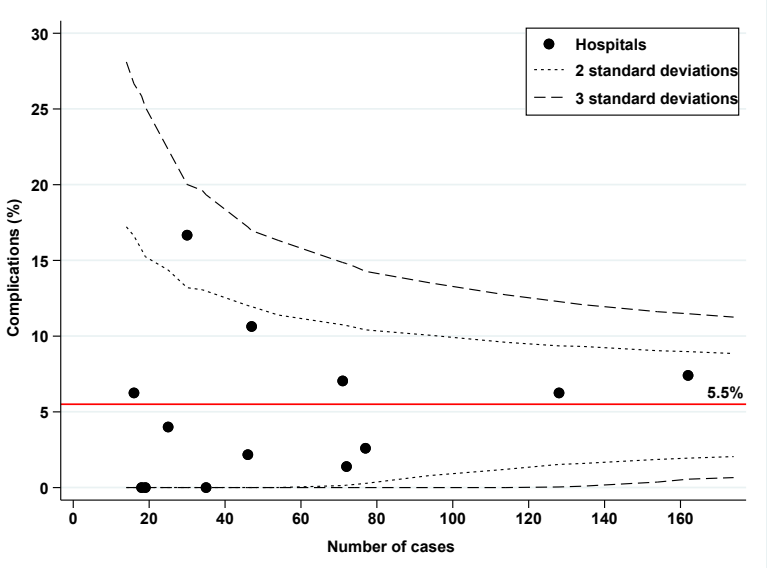
The majority of all CIED devices (94.5%) were successfully implanted without any in-hospital complications. In the small number of cases that complications occurred, the type of problems encountered included severe hypotension, wound haematoma, lead dislodgement, cardiac arrest and pain requiring intervention (Table 32).

Table 32: In-hospital complications by hospital and device type

Hospital	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	Total
	N	N	N	N	N	N	N	N	N	N	N	N	N	N (%)
CRT-P n (%)	1	0	0	0	0	0	0	0	4	2	1	1	0	9 (6.6)
CRT-D n (%)	0	1	1	1	0	0	0	1	0	1	0	1	1	7 (3.2)
ICD, n (%)	1	4	0	0	0	0	0	9	1	3	0	3	0	21 (6.5)

There were no outliers for in-hospital complications as shown in Figure 51.

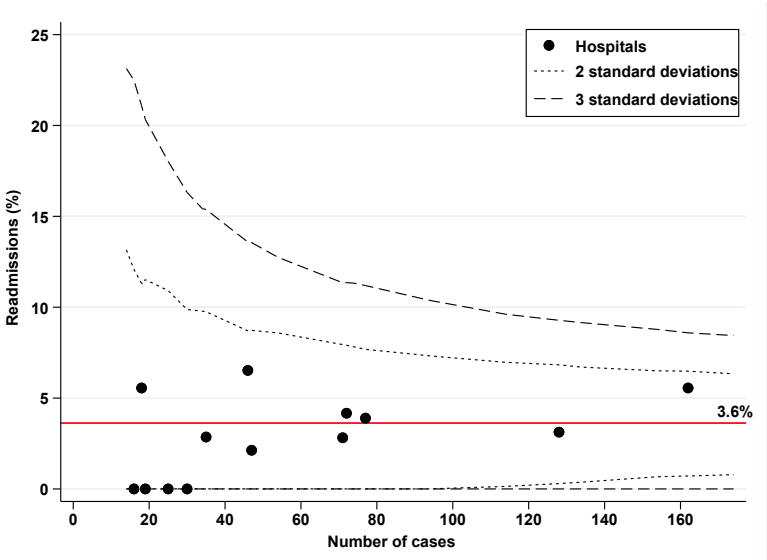
Figure 51: In-hospital rates of CIED related complications



30-day unplanned cardiac readmissions, device-related reoperations and infections

The 30-day unplanned cardiac admission rate was 3.6%. The 30-day device-related reoperation rate was 1.5% and the 30-day device-related infection rate was 1.2%.

Figure 52: 30-day rates of CIED related unplanned cardiac readmissions



Rates of these adverse outcomes were broadly similar to the previous year and all hospitals were within control limits for each of these performance indicators (Figures 52-54).

Figure 53: 30-day rates of CIED related reoperations

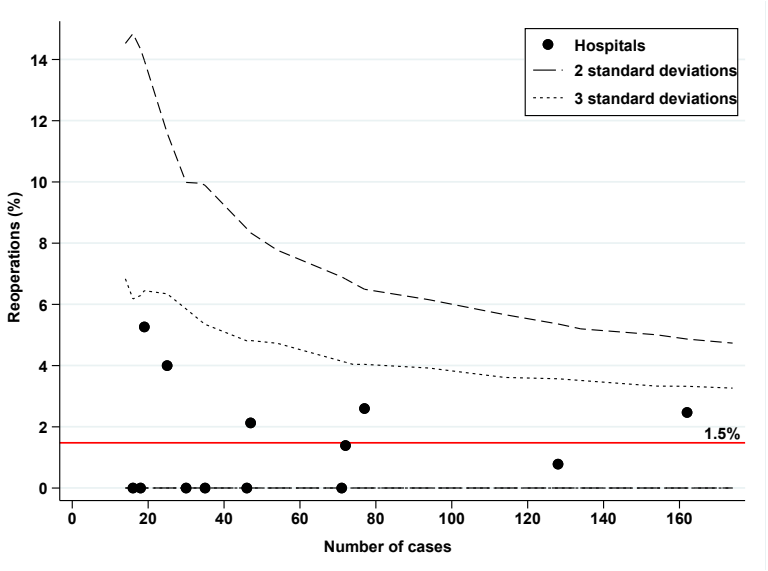
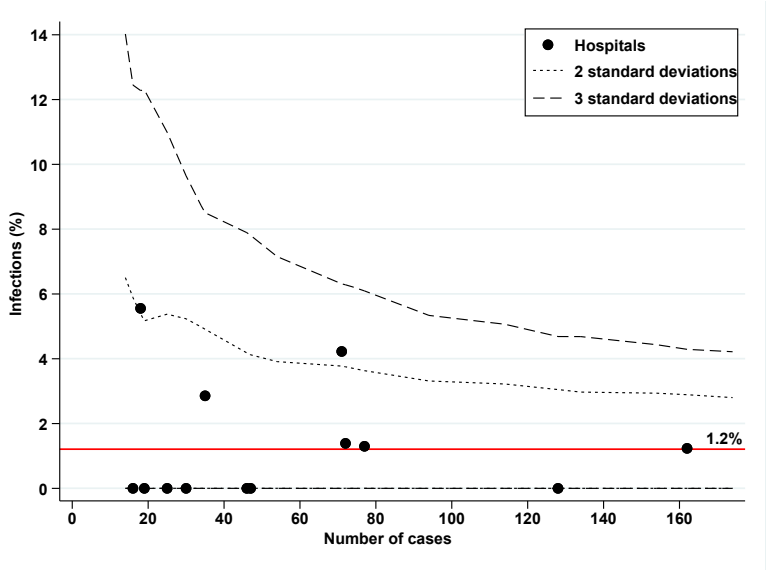


Figure 54: 30-day rates of CIED related infections



Summary

In this fourth annual report from the VCOR CIED module, participating sites and other key stakeholders have been able to monitor their CIED-related clinical activity and compare the characteristics of their patient cohorts with similar hospitals. VCOR has enhanced its assessment of the strength of recommendation for CIED therapy, with over two-thirds of ICD implants having a strength +++ recommendation, whereas CRT had a strength +++ recommendation in 35% of cases. Hospitals were able to benchmark their own particular profiles in relation to strength of recommendation with their peer hospitals and assess their results with accepted key performance outcome measures. Overall, the case volume increased in 2021 and generally good adherence to practice guidelines was observed. VCOR hopes to increase the number of participating sites in this module in future years.

Future Directions

The challenges that the COVID-19 pandemic has encumbered the Victorian cardiology community are set to continue in coming years. Yet, the Australian Government has drawn up a National Plan to transition the country's response to COVID-19. The plan lays out a path for "opening back up" with a vaccination consolidation phase and then ultimately, a post-vaccination phase that aims to minimise cases in the community without the need for burdensome restrictions [37]. In a recent editorial, Duckett and Sutton highlighted that the Australian Government roadmap still left issues around a successful recovery phase unresolved [38]. They point out that specific effort will be required to ensure that the resilience of the whole community - especially those at greatest disadvantage - is nurtured and supported and burnout of the workforce avoided. The challenges facing the community include mental health effects, catching up with episodes of care that have been deferred either by the health system or by the patients themselves and the ever-present threat of new virus variants.

While our health system will need to continue to effectively deal with the pandemic and all its challenges, VCOR is looking towards the future with plans to continue to innovate and provide ever greater value to participating hospitals, clinicians and other key stakeholders. In 2021, Safer Care Victoria (SCV) implemented its new Centres of Excellence Framework (July 2021) that incorporates 4 population-based Centres of Excellence (CoEs) [39]. Cardiac care sits within the Chronic and Prevention Centre of Excellence. There are many synergies between this new organisational framework and VCOR including the promotion of evidence-based guidance, the delivery of key quality and safety information to the health sector and implementation of improvement initiatives to deliver measurable and sustained positive outcomes. VCOR also has a close working relationship with the Victorian Agency for Health Information (VAHI) that has included the provision of several reports related to topical issues such as the cardiac care-related impacts of the COVID-19 pandemic. VCOR looks forward to further developing these links in coming years.

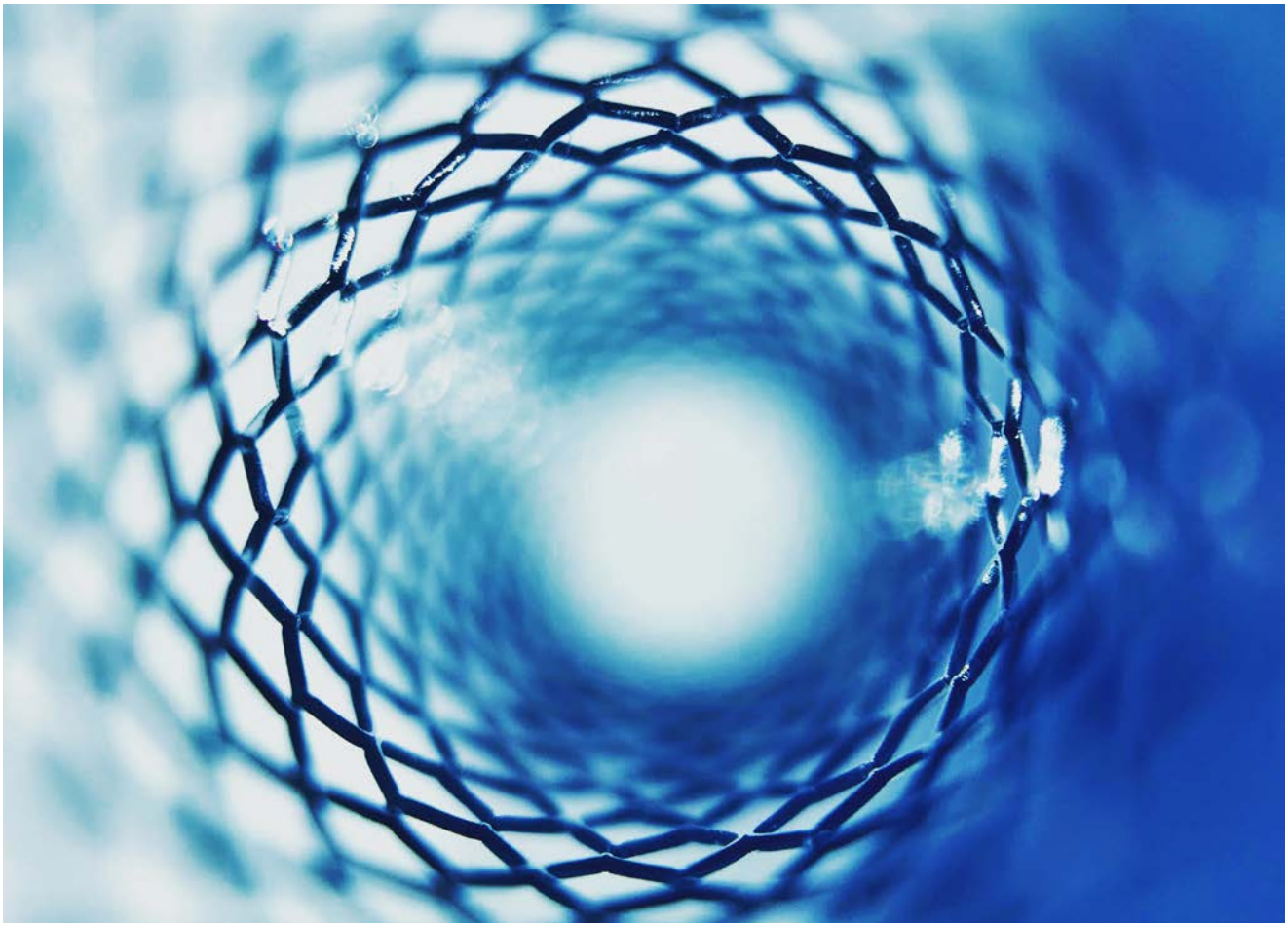
The update of the VCOR dataset was completed in 2021 and we anticipate that the new and refined data elements will enhance the quality of our data and the utility of our reports to hospitals and the health system overall. VCOR also undertook a more comprehensive review of referrals to cardiac rehabilitation. The results suggest that further effort is required to continue to improve referral rates to cardiac rehabilitation. VCOR is supporting a planned new research project that will utilise registry and Victorian Government administrative data to assess the attendance and completion rates for cardiac rehabilitation programs. We believe that this project will lead to valuable insights and hopefully, improved uptake and completion rates for a wide range of cardiac patients.

VCOR plans to continue its own advocacy roles with ongoing engagement and involvement with several external organisations including the Australian Clinical Trials Alliance (ACTA). ACTA is the national peak body supporting and representing clinical quality registries and VCOR has representation on various committees including the Registry Special Interest Group and the Annual Registry Science Meeting Organising Committee. VCOR is also closely engaged with the National Cardiac Registry (NCR) – a federally funded clinical quality registry aimed at providing a national perspective to quality assurance and benchmarking of cardiac procedures. Currently, VCOR has strong representation on the NCR Steering Committee, and with the NCR Management Team based at Monash University, close ties between the two organisations have developed and flourished.

Additionally, VCOR has engaged with Safer Care Victoria to support its push for the expansion of registry modules into greenfield areas such as the monitoring of radiofrequency ablation for atrial fibrillation (AF). This technically advanced procedure has the potential to significantly improve the quality of life of people suffering with symptomatic AF. Yet, it is costly and carries a risk of significant morbidity. Its place in cardiovascular therapeutics, the appropriateness of its use and the outcomes from this procedure are all important issues that need to be considered and analysed to guide the best use of this relatively new cardiac therapy.

Our research interests continue to expand with several new projects planned for the coming year and another PhD thesis commencing based on VCOR-sourced data. A number of these new initiatives relate to areas that are completely new for us including artificial intelligence and machine learning techniques. VCOR welcomes and encourages collaborations with researchers both at a local level and those based external to our organisation who have an interest in clinical quality registry-related research and endeavour.

In the end though, our principal mission is to try to eliminate unwanted variation in the quality of cardiovascular care delivered to Victorians. As a clinical quality registry, VCOR is primarily concerned with monitoring and reporting on the performance and outcomes of our hospitals and highlighting areas for improvement in service delivery. With the registry expected to exceed 100,000 cases by mid-2022, VCOR has matured into a well-established clinical quality registry with multiple activities around quality assurance, epidemiology, public health, clinical research and health advocacy. Yet, we still maintain our focus on ensuring that patients needing cardiovascular care in Victoria receive the kind of care that is evidence-based, appropriate for their needs and is at the highest levels of quality and safety.



Glossary

ACC/AHA	American College of Cardiology and the American Heart Association
ACEI	Angiotensin-Converting Enzyme Inhibitors
ACS	Acute Coronary Syndrome
ARB	Angiotensin Receptor Blockers
ARIA	Accessibility and Remoteness Index of Australia
BARC	Bleeding Academic Research Consortium
BB	Beta adrenergic Blockers
BMI	Body Mass Index
BPM	Beats Per Minute
BVS	Bio-resorbable Vascular Scaffold
CABG	Coronary Artery Bypass Graft
CBVD	Cerebrovascular disease
CIED	Cardiac Implantable Electronic Devices
COPD	Chronic Obstructive Pulmonary Disease
CPAP	Continuous Positive Airway Pressure
CRT	Cardiac Resynchronisation Therapy
CSANZ	Cardiac Society of Australia and New Zealand
CTO	Chronic Total Occlusion
DAPT	Dual Antiplatelet Therapy
DBT	Door-to-balloon time
DEPM	Department of Epidemiology & Preventive Medicine
DES	Drug Eluting Stent
DHHS	Department of Health & Human Services
ECG	Electrocardiograph
ECMO	Extracorporeal Membrane Oxygenation
FFR	Fractional Flow Reserve
IABP	Intra-Aortic Balloon Pump
ICD	Implantable Cardiac Defibrillator
IQR	Inter Quartile Range
IVL	Coronary intravascular lithotripsy
IVUS	Intravascular Ultrasound
KPI	Key Performance Indicator
LOS	Length of stay
LTF	Lost to follow-up
LVEF	Left Ventricular Ejection Fraction
MACCE	Major Adverse Cardiac and Cerebrovascular Event
MACE	Major Adverse Cardiac Event
MI	Myocardial Infarction
NCR	National Cardiac Registry
NDI	National Death Index
NHMRC	National Health & Medical Research Council
NRI	New Renal Impairment
NSTE-ACS	Non ST-elevation acute coronary syndrome
NSTEMI	Non ST-elevation myocardial infarction
NYHA	New York Heart Association
OCT	Optical Coherence Tomography
OHCA	Out of Hospital Cardiac Arrest
PCI	Percutaneous Coronary Intervention
PHN	Pre-hospital notification
POBA	Plain Old Balloon Angioplasty
PPE	Personal Protective Equipment
PVD	Peripheral Vascular Disease
SCV	Safer Care Victoria
SBT	Symptom onset-to-balloon-time
SDT	Symptom onset-to-door-time
SD	Standard Deviation
SDD	Same day discharge
SEIFA	Socio Economic Indexes for Areas
SES	Socio Economic Status
STEMI	ST-elevation myocardial infarction
TVR	Target Vessel Revascularisation
UAP	Unstable Angina Pectoris
VAHI	Victorian Agency for Health Information
VCOR	Victorian Cardiac Outcomes Registry

Publications and presentations in 2021

Publications

Alrawashdeh A, Nehme Z, Williams B, Smith K, Brennan A, Dinh DT, Liew D, Lefkovits J, Stub D. Impact of emergency medical service delays on time to reperfusion and mortality in STEMI. *Open Heart.* 2021 May;8(1):e001654.

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