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Estimating the cost-effectiveness and return on investment of the Victorian Cardiac Outcomes Registry in Australia: a minimum threshold analysis

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ABSTRACT

Objectives We sought to establish the minimum level of clinical benefit attributable to the Victorian Cardiac Outcomes Registry (VCOR) for the registry to be cost-effective.

Design A modelled cost-effectiveness study of VCOR was conducted from the Australian healthcare system and societal perspectives.

Setting Observed deaths and costs attributed to coronary heart disease (CHD) over a 5-year period (2014–2018) were compared with deaths and costs arising from a hypothetical situation which assumed that VCOR did not exist. Data from the Australian Bureau of Statistics and published sources were used to construct a decision analytic life table model to simulate the follow-up of Victorians aged ≥25 years for 5 years, or until death. The assumed contribution of VCOR to the proportional change in CHD mortality trend observed over the study period was varied to quantify the minimum level of clinical benefits required for the registry to be cost-effective. The marginal costs of VCOR operation and years of life saved (YoLS) were estimated.

Primary outcome measures The return on investment (ROI) ratio and the incremental cost-effectiveness ratio (ICER).

Results The minimum proportional change in CHD mortality attributed to VCOR required for the registry to be considered cost-effective was 0.125%. Assuming this clinical benefit, a net return of $A4.30 for every dollar invested in VCOR was estimated (ROI ratio over 5 years: 4.3 (95% CI 3.6 to 5.0)). The ICER estimated for VCOR was $A49 616 (95% CI $A42 228 to $A59 608) per YoLS. Sensitivity analyses found that the model was sensitive to the time horizon assumed and the extent of registry contribution to CHD mortality trends.

Conclusions VCOR is likely cost-effective and represents a sound investment for the Victorian healthcare system. Our evaluation highlights the value of clinical quality registries in Australia.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Real-world registry data from the Victorian Cardiac Outcomes Registry (VCOR) captured temporal changes in the management of patients undergoing percutaneous coronary intervention (PCI) in Victoria, Australia.
⇒ Improvements in the uptake of radial access PCI and in timely reperfusion of patients with ST elevation myocardial infarction were, in part, attributed to VCOR.
⇒ There was uncertainty around the clinical benefit conferred by VCOR with respect to trends in mortality.
⇒ It was not possible to assess the impact of VCOR on readmissions or patient morbidity or quality of life using the Australian Bureau of Statistics data.

INTRODUCTION

Coronary heart disease (CHD) is a significant cause of morbidity and mortality in Australia. In 2020–2021, the prevalence of CHD in Australia was estimated to be 3% (571 000) of the adult population.[1] Although mortality from CHD has declined significantly since the 1960s, it remains the leading cause of death (approximately 10%) in Australia.[1 2] With regard to disease burden, CHD contributed to 6.3% (10.4 disability-adjusted life years per 10 000 population) of the total disease burden and 2% of hospitalisations in Australia in 2018.[1 3]

Of the prevalent adult population with CHD in 2020–2021, it is estimated that 40% had experienced angina and 74% had suffered acute coronary syndrome (ACS).[1] Percutaneous coronary intervention (PCI) is the preferred means of revascularisation therapy for many patients presenting with ACS based on Australian and international guidelines.[4 5] Across Australia, 48 034 PCIs were performed between 2020 and 2021[1]; in Victoria alone, 48% of all PCIs across Victoria in 2021 were performed for the management of ACS.[6]

The cost burden attributed to the management of CHD, including costs of PCI, is correspondingly high. Based on estimates from the

Australian Institute of Health and Welfare, in 2018–2019, CHD accounted for $A2.35 billion in health expenditure in Australia, representing 2% of total health expenditure.[7] The considerable volume of procedures performed annually, at an estimated average cost per procedure of $A13 293,[8] indicates that PCIs contribute to a significant proportion of costs in the management of CHD. In Victoria alone, the cost burden attributed to PCIs across public hospitals was estimated to be $A72 179 656 in 2017.[9] Importantly, increasing PCI case complexity and procedural volume over time warrants greater adherence to evidence-based guidelines for the management of ACS to improve health systems efficiency and patient outcomes.[9]

Clinical quality registries (CQRs) are increasingly used to improve healthcare processes and adherence to evidence-based guidelines and standards, and reduce the costs attributed to care delivery.[10–13] Through the collection of patient outcomes data for cardiovascular procedures, it is possible to benchmark a hospitals' performance to its peers and adherence to national standards of care and evidence-based guidelines.[10] Additionally, CQRs have significant utility in medical research.[10–12] Previous studies have demonstrated that major improvements to patient outcomes may be attributed to the existence of CQRs.[10] In the context of ACS, patient outcomes have improved considerably over time following the establishment of cardiac CQRs in Sweden, New Zealand, the USA and the UK which have been attributed, in part, to registry operation.[14–18] However, although there are many studies using data from CQRs, few have assessed the clinical and cost impacts attributed to a CQR.[11] This is likely due to difficulties in distinguishing the extent of contribution of CQRs to improved patient outcomes over time versus secular trends in patient management, and in the nomination of an appropriate comparator arm to assess the true costs and benefits attributed to registry operation.[11] In this context, we explored the minimum level of contribution to improved patient outcomes required for the Victorian Cardiac Outcomes Registry (VCOR), a cardiac CQR, to be cost-effective and represent a sound investment for the healthcare system.

METHODS

Model structure

Life table modelling and decision analysis were used to explore the clinical and cost impacts of VCOR against a hypothetical scenario which assumed that VCOR did not exist (No VCOR).[19] Life tables were constructed using age-specific and sex-specific mortality rates for adults aged ≥25 years, based on Victorian population data sourced from the Australian Bureau of Statistics (ABS).[20 21] Each cohort was followed until death, or up to 5 years in the base case. Within each cohort (VCOR or No VCOR), separate life tables were created for 14 age and sex subgroups. Age was stratified into seven 10-year age bands (25–34, 35–44, 45–54, 55–64, 65–74, 75–84, 85+), with the starting age in each subgroup being the weighted average age in the age band.

The clinical and cost outputs for each model were totalled to determine the overall cost-effectiveness attributed to VCOR from the perspective of the Australian healthcare system, assuming a cost-effectiveness threshold of $A50 000 per year of life saved (YoLS). The commonly used willingness-to-pay threshold of $A50 000 per YoLS determined cost-effectiveness[22] and was used in lieu of an official willingness to pay threshold in Australia. We also explored the return on investment (ROI) attributed to the registry from a societal perspective.

Model population

Our base case modelled population was profiled on the total Victorian population aged ≥25 years in each year from 2014 to 2018 using ABS inputs. Data pertaining to the total Victorian population, and mortality in each year from 2010 to 2019, were sourced from the ABS (see online supplemental table 1).[20 21] Although ABS data were available for 2010–2019, our modelled population was profiled to reflect PCIs performed between January 2014 and December 2017 in VCOR. A separate, linked dataset of patient, clinical and procedural characteristics collected by VCOR was made available for the analysis of trends in clinical practice across Victorian hospitals. This dataset was used to inform the extent to which the registry had contributed to changes in CHD mortality over time in the economic model informed by ABS data (see '*Effectiveness of VCOR*' section).

Transition probabilities

Data for estimating the incidence of all-cause mortality, and mortality attributed to CHD (based on International Classification of Diseases 10th revision codes: I20–I25), were sourced for each age and sex subgroup from the ABS[20 21] (table 1 and online supplemental tables 1 and 2).

The likelihood of all-cause or CHD mortality was estimated by dividing the number of deaths (all-cause or CHD-related) in each sex and age subgroup by the Victorian population for each subgroup.[20 21] The likelihood of non-CHD mortality was estimated by subtracting the likelihood of CHD mortality from the likelihood of all-cause mortality.[20 21]

Effectiveness of VCOR

VCOR is a state-wide, ongoing population-based CQR. It was established in 2012 to monitor the performance of cardiac services in hospitals across Victoria.[13 23] The key focus of VCOR currently is on patients undergoing PCI and cardiac implanted electronic devices.[13 23] The economic evaluation was based on estimating the downstream clinical and cost impacts of VCOR relative to a hypothetical scenario in which VCOR did not exist (No VCOR). That is, without VCOR contributing to reductions in CHD mortality over time, the extent to which CHD mortality declined over time would be less. In the absence of efficacy data, the assumed contribution of

Table 1 Input parameters used in the economic model, including trends in CHD mortality over time, costs and the assumed contribution of VCOR to reductions in CHD mortality

	Value				Distribution (variance) for PSA
Parameter	**Males (2014–2018)**	**P value***	**Females (2014–2018)**	**P value***	**Uniform (±20%)**
CHD mortality rate by age group (years)					
25–34	0.00%–0.00%	0.382	0.00%–0.00%	0.357	
35–44	0.01%–0.01%	0.013	0.00%–0.00%	0.071	
45–54	0.04%–0.03%	0.006	0.01%–0.01%	0.283	
55–64	0.10%–0.08%	0.051	0.02%–0.01%	0.073	
65–74	0.21%–0.17%	0.092	0.06%–0.05%	0.121	
75–84	0.61%–0.47%	0.033	0.32%–0.22%	0.023	
85+	2.24%–2.04%	0.106	1.90%–1.42%	0.016	
All	0.09%–0.08%	0.001	0.07%–0.05%	0.016	
Cost of mortality	$A5609				Gamma (α=5609; β=1)
VCOR annual costs	$A600 000				Gamma (α=600 000; β=1)
VoSLY	$A220 262				Gamma (α=220 262; β=1)
Assumed contribution of VCOR to CHD mortality trends†	0.125%				Uniform (0.100, 0.150)

*Based on simple linear regression analyses.
†Based on varying the assumed contribution by increments of 0.025%.
CHD, coronary heart disease; PSA, probabilistic sensitivity analysis; VCOR, Victorian Cardiac Outcomes Registry; VoSLY, value of statistical life year.

VCOR to reductions in CHD mortality over time was varied in the economic model to establish the minimum contribution required for VCOR to be cost-effective. This is justified based on current literature demonstrating that the registry data collection for the purposes of routine health systems benchmarking and feedback is, of itself, likely to contribute to reductions in mortality over time through improvements in clinical practice.[10 12] A similar approach whereby the benefits of the All New Zealand Quality Improvement (ANZACS-QI) programme, a cardiac CQR, was assumed to contribute to temporal trends in patient mortality has been published elsewhere.[12] In brief, this evaluation assumed that the registry contributed to 15% of temporal trends in myocardial infarction (MI)-related mortality and readmissions, based on improved adherence to medications indicated for the secondary prevention of ACS and reductions in time-to-treatment parameters.[12]

Based on data from the ABS, the risk of CHD mortality in Victoria has decreased steadily over the period from 2014 to 2018 (table 1). Notably, the clinical management of CHD has also evolved over time. This may in part be attributed to ongoing benchmarking and feedback through VCOR. First, in the period since VCOR was established, implementation of PCI via radial access (instead of femoral access) has improved considerably.[23] A Cochrane review of PCI via radial versus femoral access concluded that radial access was associated with reductions in major bleeding events, access site complications and mortality in the setting of ACS.[24] This is supported by data from cardiac registries in the USA, the UK and Australia; importantly, a propensity score-matched analysis of radial versus femoral access using VCOR data found that mortality benefits attributed to radial access were maintained over time and for patients with high-acuity (ST elevation myocardial infarction (STEMI)) and non-ACS indications for PCI.[25–28] Second, in addition to improved uptake of radial access PCI, hospital adherence to a door-to-balloon/device time (DBDT) has improved, with all PCI-capable hospitals across Victoria achieving a median DBDT of ≤90 min for patients with STEMI.[23] As with improved uptake of radial access, improved hospital adherence to a DBDT ≤90 min is associated with considerable survival benefits for patients with STEMI.[29] However, it is not possible to quantify the direct contribution of VCOR to the uptake of radial access PCI and improvements to DBDT, and the subsequent reduction in mortality trends downstream. As such, our model estimated the minimum contribution of VCOR to temporal trends in CHD mortality required for VCOR to be considered cost-effective. In brief, the assumed contribution of VCOR to the proportional change in CHD mortality was varied in increments of 0.025% until the incremental cost-effectiveness ratio (ICER) for VCOR versus No VCOR was cost-effective.

Cost inputs

Table 1 summarises the cost inputs used in the economic model. All costs were updated to 2021 values using the Australian Health Price Index and were expressed as Australian Dollars ($A).[30]

Cost of VCOR

VCOR is funded through the Victorian Department of Health, Medibank Private and in-kind funding through

Monash University.[23] Based on the VCOR annual report for 2018, the average annual cost borne by the Victorian Department of Health was $A605 346 for the period from 2014 to 2018 (online supplemental table 3).[31] We therefore assumed the annual cost of registry operation to be $A600 000; this was varied in scenario analyses (see below).

Cost of mortality

There was an absence of relevant data pertaining to the costs of death. As per previous analyses,[12 32 33] we assumed that deaths due to CHD incurred 50% of the costs of CHD hospitalisations. The cost of hospitalisations for CHD was estimated using data pertaining to diagnosis-related groups (DRGs) and their costs for publicly funded case-mix hospitalisations in 2017/18 (online supplemental table 4).[34] This method has been used in similar economic evaluations.[12 32 33] The same cost was applied to deaths due to non-CHD causes.

Cost of a year of life

The value of a statistical life year (VoSLY) was assumed to be $A220 262. This was based on the VoSLY estimated by the Australian Government's Office of Best Practice Regulation of $A213 000 in 2019, adjusted to 2021 values.[35]

Discounting

A discount rate of 5% per annum was applied to years of life lived and costs incurred beyond the first year.[22]

Economic evaluation

The base case economic evaluation involved 14 separate life table models created using ABS data, stratified by sex and age band to represent 5 years of coverage (2014–2018 inclusive) of VCOR. The expected values across sex and age subgroups for the VCOR and No VCOR were aggregated to represent the clinical and cost impacts of VCOR over 5 years for the total Victorian population at risk of mortality from CHD.

The primary cost-benefit analysis estimated differences between the two groups regarding net societal costs. This was defined as the cost of VCOR operation, minus the cost savings attributed to reduced CHD mortality, added to the costs saved by prolonging years of life lived in the cohort. The primary outcome was the net cost attributed to VCOR operation. A key secondary outcome for our study was the ICER for VCOR compared with No VCOR in terms of cost per YoLS.

Statistical analyses

A linked dataset of 32 198 consecutive PCIs conducted in VCOR over a period of 4 years (1 January 2014 to 31 December 2017) was made available for the analysis of changes in clinical practice over time in Victoria. Pearson's χ^2 tests for categorical variables, and univariate linear regression modelling or generalised linear regression modelling for continuous variables, were used to explore differences in patient or procedural trends over time.

To explore changes in clinical practice over time, the population was stratified by sex and indication for PCI: non-ACS reasons, unstable angina, non-ST elevation myocardial infarction (NSTEMI) and STEMI. Backward stepwise logistic regression with a p value threshold of 0.10 was used to identify the following potential confounders of radial access, and DBDT ≤90 min: age (<75 years and ≥75 years); in-hours hospital arrival (between 08:00 and 18:00 hours on a workday); cardiogenic shock or intubated out-of-hospital cardiac arrest; left ventricular ejection fraction; medicated diabetes mellitus; peripheral vascular disease; cerebrovascular disease; chronic oral anticoagulation therapy; prior coronary artery bypass grafting; previous PCI; use of glycoprotein IIb/IIIa inhibitors; use of thienopyridine or ticagrelor; estimated glomerular filtration rate; required mechanical ventricular support; lesion complexity (American College of Cardiology/American Heart Association type A/B1 vs type B2/C lesions); unprotected left main PCI; chronic total occlusion PCI and in-stent restenosis PCI.[36 37] Multivariable logistic regression models with adjustment for key predictors identified in stepwise regression were used to explore annual trends in radial access and DBDT metrics. The results of these analyses were used to justify the assumption that VCOR is likely to contribute to small reductions in CHD mortality over time.

To explore trends in CHD mortality over time using mortality data from the ABS, simple linear regression modelling was performed with the year as the independent variable, and CHD mortality as the dependent variable. A p value <0.05 was considered statistically significant.

The economic evaluation was performed with Microsoft Excel; STATA V.14 (StataCorp, College Station, Texas, USA) was used to explore changes in clinical practice over time.

Sensitivity analyses

A series of one-way sensitivity analyses were undertaken to determine the impact of uncertainty around key model parameters. Input parameters varied individually in deterministic sensitivity analyses, while other variables were maintained at base case values to estimate the impact of parameters on cost-benefit/cost-effectiveness. Key parameters assessed were the time horizon, the assumed contribution of VCOR to CHD mortality trends, costs assumed for CHD mortality and the VoSLY. Additionally, a scenario analysis was performed, whereby the proportional contribution of VCOR to temporal trends in CHD mortality was assumed to be equivalent to the mortality benefit attributed to ANZACS-QI. Based on the assumed contribution of 15% to the observed temporal trend in MI-related mortality, ANZACS-QI prevented 36 MI-related deaths over a 4-year period in the total New Zealand ACS population (N=59 280).[12] On extrapolation of this benefit to the wider population at risk of CHD mortality in Victoria (N=4 017 397), the assumed

contribution to the temporal reduction in CHD mortality was set to 0.5% for VCOR in this scenario analysis.

A probabilistic sensitivity analysis (PSA) was undertaken using 10 000 iterations to assess uncertainty in the model input parameters simultaneously. The input parameters, variations and corresponding distributions are presented in table 1. As variance in mortality rates and costs were not available, methodology employed by Briggs *et al* was applied.[19] CHD mortality rates assumed uniform distributions (applying 20% variance from the input variable), while gamma distributions were applied to costs (where the variance was equal to the mean/input value).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

VCOR population

Data from 32 198 consecutive PCIs in Victoria over a 4-year period (1 January 2014 to 31 December 2017) were used to explore the impact of VCOR on clinical practice. Baseline and procedural characteristics of the VCOR population are presented in online supplemental tables 5 and 6.

The cohort was predominately male (77.0%), overweight or obese (76.2%) undergoing PCI for ACS (50.9%) in public hospitals (63.2%).

The results of multivariable modelling on changes in radial access and DBDT over time are presented in online supplemental table 7.

The likelihood of patients managed through femoral access decreased annually across all non-ACS and ACS indications for PCI ($p<0.001$). For patients undergoing primary PCI for STEMI, the likelihood of timely reperfusion (DBDT ≤90 min) increased annually by at least 15% across both sexes ($p<0.05$).

Economic analysis of the total Victorian population

The impact of varying the assumed contribution of VCOR on the ICER and the ROI are presented in figure 1 and online supplemental figure 1, respectively.

The minimum proportional change in CHD mortality attributed to VCOR required for the registry to be considered cost-effective was 0.125% (figure 1). Table 2 presents the base case analysis in terms of the overall clinical and cost impacts attributed to 5 years of full coverage of VCOR for the Victorian population aged ≥25 years from 2014 to 2018 at this level of registry contribution (0.125%) to CHD mortality trends.

Over this period, a total of 19 065 CHD-related deaths occurred across Victoria. Based on the assumption that VCOR contributed to 0.125% of the temporal change in CHD mortality over time, the clinical benefit attributed to VCOR was the prevention of 23 CHD-related deaths and 53 (discounted) years of life saved. A total of $A120 783

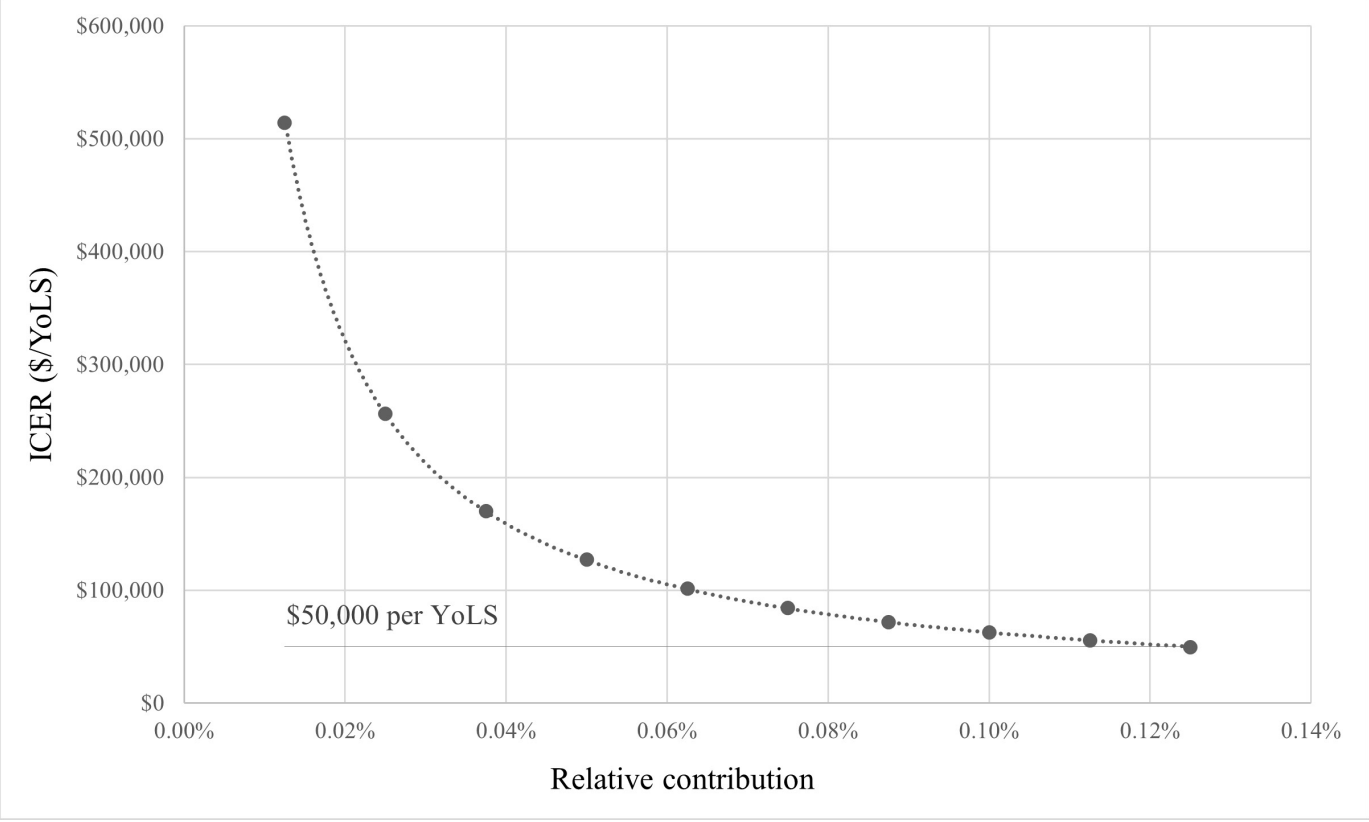

Figure 1 Relative contribution of Victorian Cardiac Outcomes Registry (VCOR) to coronary heart disease mortality trends versus VCOR cost-effectiveness. ICER, incremental cost-effectiveness ratio; YoLS, year of life saved.

Table 2 Results of the base case economic model, assuming that VCOR contributed to 0.125% of the temporal change in CHD mortality

Parameter	Overall (N = 4 017 397)		Difference
	VCOR	No VCOR	
Clinical outcomes, n (%N)			
CHD deaths	19 065 (0.47%)	19 089 (0.48%)	–23
Non-CHD deaths	140 455 (3.50%)	140 452 (3.50%)	3
Total deaths	159 520 (3.97%)	159 540 (3.97%)	–20
Years lived*	17 887 125	17 887 072	53
Cost outcomes			
VCOR*	$2 727 570	–	$2 727 570
CHD deaths*	$98 517 938	$98 638 721	–$120 783
Non-CHD deaths*	$722 495 795	$722 480 855	$14 941
Total health cost*	$823 741 304	$821 119 575	$2 621 728
VoSLY*	$3 939 854 066 111	$3 939 842 427 479	$11 638 633
ICER ($/YoLS)* (point value, 95% CI)†	$49 616 ($42 228 to $59 608)		
ROI ratio* (point value, 95% CI)†	4.3 (3.6 to 5.0)		

All costs are expressed in Australian dollars ($A).
*Results discounted at an annual rate of 5%.
†Estimated from probabilistic sensitivity analysis.
CHD, coronary heart disease; ICER, incremental cost-effectiveness ratio; ROI, return on investment; VCOR, Victorian Cardiac Outcomes Registry; VoSLY, value of statistical life year.

was saved over this period due to the prevention of CHD mortality. This was balanced against a higher incidence of non-CHD mortality in the VCOR cohort (because the risk of non-CHD death was not assumed to have changed by VCOR), which incurred an additional cost of $A14 941. The total cost of VCOR was $A2 727 570 (discounted). Hence, the net cost of VCOR from the perspective of the Australian healthcare system was $A2 621 728 (discounted). The ICER associated with VCOR was $A49 616 per YoLS (95% CI $A42 228 to $A59 608). From a broader, societal perspective, the savings attributed to VCOR were $A11 638 633 based on an assumed VoSLY of $A220 262. The ROI ratio, which is the ratio of the total cost savings to the total costs of VCOR, was 4.3 (95% CI 3.6 to 5.0), that is, for every $A1.00 invested in VCOR, a return of $A4.30 was delivered.

Table 3 presents the results of sensitivity analyses in terms of ICERs, net societal costs attributed to VCOR operation and ROI.

The model was most sensitive to the assumed time horizon, and the extent to which VCOR contributed to mortality trends in Victoria. Across each scenario, VCOR represented a positive ROI. The results of the PSA are presented in figure 2.

Based on the results of the PSA, the majority (97.5%) of iterations fell below an ICER of $A60 000 per YoLS.

DISCUSSION

Our economic evaluation found that the minimum contribution to the proportional change in CHD mortality over time required for VCOR to be cost-effective was 0.125%. That is, for VCOR to be considered cost-effective from the perspective of the Australian healthcare system, the registry would need to prevent 23 CHD-related deaths between 2014 and 2018 (5 years inclusive), through benchmarking and health systems quality improvement. In lieu of data pertaining to the direct impacts of VCOR operation on CHD mortality, our analyses suggest that VCOR is likely to be cost-effective on the basis of the comparatively small CHD mortality benefits (23 deaths over 5 years) required for the registry to fall within the widely established willingness-to-pay threshold of $A50 000 per YoLS.[22] Since the establishment of VCOR, there has been a considerable increase in hospital uptake of PCI via radial access.[6 38] Furthermore, the likelihood of patients with STEMI being managed with timely reperfusion had increased annually throughout the period of 2014–2018.[6 38] These trends in improved patient management are facilitated through VCOR benchmarking and health systems feedback and are likely to contribute to the reduction in cardiac mortality observed across Victoria.[23 25 39] Lastly, data from VCOR have informed research exploring disparities in the management of ACS to further drive improvements in cardiac care and subsequently, reduce CHD mortality across Victoria.[40 41]

Our findings are in accordance with similar economic evaluations previously conducted in Australia and New Zealand.[12 42] The ROI estimated for five CQRs in Australia varied from 2.0 to 7.0 based on improvements in key performance indicators (KPIs) unique to each registry.[42]

Table 3 Results of deterministic scenario analyses

Scenario	Net cost*	ROI ratio*	ICER ($/YoLS)*
Base case†	$14 260 361	4.3	$49 616
Time horizon (starting year 2014)			
1	$1 236 407	1.2	$185 866
2	$3 575 677	2.2	$99 280
3	$6 685 471	3.0	$71 341
4	$10 311 267	3.7	$57 648
Time horizon (starting year 2015)			
1	$1 236 668	1.2	$185 785
2	$3 556 760	2.1	$100 185
3	$6 623 705	3.0	$72 297
4	$10 183 945	3.6	$58 642
5	$14 097 331	4.2	$50 315
Contribution to trends (base case: 0.125%)			
Lower (0.10%)	$11 953 831	3.4	$62 521
Upper (0.15%)	$16 566 876	5.2	$41 013
ANZACS-QI (0.50%)	$48 856 609	17.2	$10 902
VoSLY (base case: $220 262)			
Lower (–25%)	$11 350 703	3.2	$49 616
Upper (+25%)	$17 170 019	5.4	$49 616
Cost of VCOR (base case: $600 000)			
Lower (–25%)	$13 578 468	5.7	$36 712
Upper (+25%)	$14 942 253	3.4	$62 521

All costs are expressed in Australian dollars ($A).
*Results discounted at an annual rate of 5%.
†Starting year 2014, 5-year time horizon.
ANZACS-QI, All New Zealand Acute Coronary Syndrome Quality Improvement programme; ICER, incremental cost-effectiveness ratio; ROI, return on investment; VCOR, Victorian Cardiac Outcomes Registry; VoSLY, value of statistical life year.

Similarly, a cost-effectiveness analysis of the ANZACS-QI programme found a positive ROI (1.53) over 1 year of evaluation, which improved considerably after expanding the time horizon to 5 years (7.49).[12] The collection of data by ANZACS-QI has been used for addressing suboptimal adherence to guidelines in the management of ACS identified across New Zealand district health boards. In evaluating the cost-effectiveness and ROI attributed to ANZACS-QI, improvements in KPIs contributed to reductions in patient mortality and readmissions observed over the period of evaluation (2013–2016), and the registry was both cost-effective and represented a sound investment for the New Zealand healthcare system.[12 43]

Additionally, there is considerable evidence of improved patient outcomes as a result of interventions attributed to cardiac CQR benchmarking and health systems feedback in the UK and Sweden.[15 44 45] Data collected by the British Cardiovascular Intervention Society were of considerable utility for informing clinical practice in the setting of PCI, allowing for the identification of variable uptake in radial access across hospitals, delays in PCI for patients with NSTEMI and a low rate of same-day discharge for patients undergoing elective PCI.[44] Changes to these parameters are likely to improve patient outcomes and efficiency in the delivery of health services for cardiac care.[24 39 46] Similarly, mortality from CHD in Sweden declined considerably between 1995 and 2014 due to changes in the evidence-based management of NSTEMI and STEMI based on data collected as part of the Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART) CQR.[15 45] Such changes have been facilitated through ongoing quality improvement and benchmarking through SWEDEHEART and other, well-established CQRs.[15 45]

In Australia alone, several cardiac CQRs have been established across a variety of settings. These include condition-specific registries, such as the Australian Resuscitation Outcomes Consortium for out-of-hospital cardiac arrest, and the Australian and New Zealand Society of Cardiac and Thoracic Surgeons Database Programme as well as VCOR, a cardiac devices or procedures-focused registry.[47] The considerable VoSLY assumed in our methodology, coupled with the high mortality burden

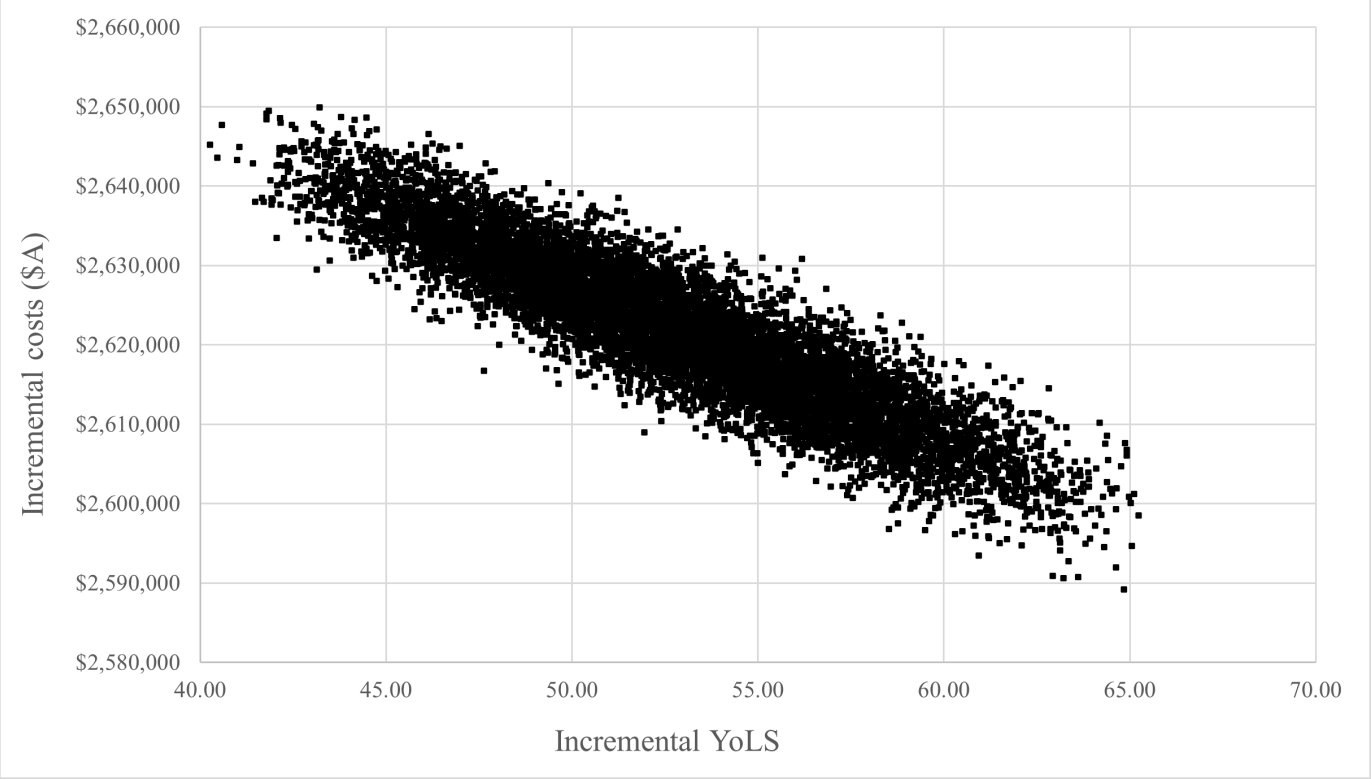

Figure 2 Results of the probabilistic sensitivity analysis. $A, Australian dollars; YoLS, year of life saved.

of cardiovascular diseases globally, is likely to offset the substantial costs attributed to establishing and maintaining cardiac CQRs. Our findings set precedence for similar evaluations to be performed internationally to support CQR uptake and investment, and emphasises the importance of registry development in consideration of KPIs which contribute to improved patient outcomes and ultimately, ROI.[47]

LIMITATIONS

A key limitation to our analysis was the uncertainty around the clinical benefit conferred by VCOR with respect to the observed trend in mortality. Hence, we explored the minimum contribution to temporal reductions in CHD mortality required for VCOR to be cost-effective, based on the assumption that registry benchmarking and feedback contribute to a small proportion of temporal reductions in CHD mortality. Importantly, in scenario analyses whereby the benefit of VCOR was lowered from an already small value, the ICER increased slightly ($A49 616 per YoLS to $A62 521 per YoLS) and was still associated with positive ROI. Furthermore, 97.5% of iterated ICERs in the PSA fell below $A60 000 per YoLS; while no formally published value for cost-effectiveness has been established in Australia, the Choosing Interventions that are Cost-Effective programme of WHO defines interventions with a cost per quality-adjusted life year or YoLS less than one gross domestic product (GDP) per capita as 'very cost-effective'.[48] As the current GDP per capita in Australia is $A89 743 (or US$61 977 assuming US$1=$A1.45 in 2021), our analyses demonstrate that VCOR is likely to be very cost-effective.[48–50] Second, it was not possible to assess the impact of VCOR on readmissions for recurrent ACS, and on patient morbidity and quality of life through ABS data. Hence, our analyses were limited to capturing the mortality benefit attributed to VCOR. However, KPIs pertaining to patient morbidity, including major adverse cardiac and cerebrovascular events, hospital length-of-stay and in-hospital unplanned revascularisation, had remained stable and were relatively low throughout the period of evaluation.[38 51] Readmissions for ACS in Victoria had also remained stable over time.[23 52] Therefore, incorporating the potential cost and clinical impacts attributed to other trends in clinical practice or the reporting of KPIs outside of DBDT for patients with STEMI by VCOR, would not have changed our findings in a substantial manner. Additionally, there is a lack of robust data pertaining to quality of life following ACS in Australia, which limited analyses on the impact of VCOR on patient morbidity.[53] Third, cost inputs for patient mortality were based on DRG estimates that were constant across age, sex and ACS indications. This was in lieu of robust, bottom-up cost data.[12 32 54] However, sensitivity analyses found that the economic model was robust to the costs of hospitalisations.

CONCLUSION

VCOR represents a sound investment for the Victorian healthcare system. Based on the assumption that VCOR benchmarking and feedback contributed to a small

proportion of the observed reduction in CHD mortality over time, the registry is associated with cost savings at the societal level. Additionally, VCOR is cost-effective from the perspective of the healthcare system.

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Supplementary Table 1: Trends in mortality over time

Mortality		**Year**									
Sex	**Age group (years)**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
CHD Mortality											
Males	25 - 34	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	35 - 44	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
	45 - 54	0.04%	0.04%	0.03%	0.03%	0.04%	0.04%	0.04%	0.03%	0.03%	0.04%
	55 - 64	0.10%	0.10%	0.07%	0.07%	0.10%	0.08%	0.08%	0.07%	0.08%	0.11%
	65 - 74	0.24%	0.22%	0.18%	0.19%	0.21%	0.18%	0.17%	0.17%	0.17%	0.22%
	75 - 84	0.78%	0.72%	0.63%	0.58%	0.61%	0.57%	0.59%	0.54%	0.47%	0.52%
	85+	2.87%	2.90%	2.47%	2.40%	2.24%	2.38%	2.24%	2.06%	2.04%	1.90%
	All	0.10%	0.10%	0.09%	0.09%	0.09%	0.09%	0.09%	0.08%	0.08%	0.09%
Females	25 - 34	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	35 - 44	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	45 - 54	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.01%
	55 - 64	0.02%	0.02%	0.01%	0.01%	0.02%	0.02%	0.02%	0.02%	0.01%	0.02%

Mortality		**Year**									
Sex	**Age group (years)**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
	65 - 74	0.08%	0.08%	0.07%	0.06%	0.06%	0.06%	0.06%	0.06%	0.05%	0.06%
	75 - 84	0.43%	0.41%	0.34%	0.32%	0.32%	0.30%	0.27%	0.28%	0.22%	0.24%
	85+	2.37%	2.25%	2.11%	1.92%	1.90%	1.90%	1.71%	1.68%	1.42%	1.41%
	All	0.09%	0.09%	0.08%	0.07%	0.07%	0.07%	0.06%	0.06%	0.05%	0.06%
Non-CHD Mortality *											
Males	25 - 34	0.07%	0.07%	0.07%	0.06%	0.07%	0.07%	0.06%	0.06%	0.05%	0.08%
	35 - 44	0.11%	0.11%	0.10%	0.09%	0.12%	0.12%	0.12%	0.10%	0.10%	0.15%
	45 - 54	0.23%	0.21%	0.19%	0.22%	0.22%	0.23%	0.21%	0.20%	0.19%	0.26%
	55 - 64	0.53%	0.51%	0.50%	0.48%	0.51%	0.51%	0.48%	0.46%	0.44%	0.53%
	65 - 74	1.37%	1.38%	1.25%	1.24%	1.27%	1.28%	1.19%	1.20%	1.15%	1.25%
	75 - 84	4.23%	4.23%	3.99%	3.87%	3.87%	3.87%	3.86%	3.52%	3.34%	3.72%
	85+	12.29%	12.63%	11.92%	11.48%	11.94%	12.54%	11.90%	12.19%	11.27%	12.56%
	All	0.56%	0.57%	0.54%	0.54%	0.57%	0.58%	0.57%	0.55%	0.52%	0.61%

Mortality		**Year**									
Sex	**Age group (years)**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Females	25 - 34	0.03%	0.03%	0.02%	0.03%	0.04%	0.02%	0.03%	0.03%	0.02%	0.03%
	35 - 44	0.06%	0.07%	0.07%	0.06%	0.07%	0.07%	0.07%	0.06%	0.06%	0.07%
	45 - 54	0.15%	0.17%	0.15%	0.15%	0.15%	0.15%	0.15%	0.15%	0.14%	0.17%
	55 - 64	0.35%	0.35%	0.34%	0.33%	0.35%	0.33%	0.34%	0.32%	0.33%	0.35%
	65 - 74	0.87%	0.87%	0.82%	0.80%	0.85%	0.85%	0.83%	0.83%	0.78%	0.85%
	75 - 84	2.88%	2.84%	2.85%	2.76%	2.74%	2.84%	2.72%	2.66%	2.42%	2.66%
	85+	10.80%	10.76%	10.83%	10.57%	10.75%	11.41%	10.80%	11.04%	10.41%	11.23%
	All	0.55%	0.56%	0.56%	0.55%	0.56%	0.58%	0.56%	0.56%	0.53%	0.58%

CHD = coronary heart disease

[*] Based on subtracting the likelihood of CHD mortality from the likelihood of all-cause mortality

Supplemental Table 2: Trends in CHD mortality over time used in the economic model.

Parameter	**Value**						
	Age group (years)	**Year**					
		2014	**2015**	**2016**	**2017**	**2018**	**P-value***
CHD Mortality Trend (Males)	25 - 34	0.00%	0.00%	0.00%	0.00%	0.00%	0.382
	35 - 44	0.01%	0.01%	0.01%	0.01%	0.01%	0.013
	45 - 54	0.04%	0.04%	0.04%	0.03%	0.03%	0.006
	55 - 64	0.10%	0.08%	0.08%	0.07%	0.08%	0.051
	65 - 74	0.21%	0.18%	0.17%	0.17%	0.17%	0.092
	75 - 84	0.61%	0.57%	0.59%	0.54%	0.47%	0.033
	85+	2.24%	2.38%	2.24%	2.06%	2.04%	0.106
	All	0.09%	0.09%	0.09%	0.08%	0.08%	0.001
CHD Mortality Trend (Females)	25 - 34	0.00%	0.00%	0.00%	0.00%	0.00%	0.357
	35 - 44	0.00%	0.00%	0.00%	0.00%	0.00%	0.071
	45 - 54	0.01%	0.01%	0.01%	0.00%	0.01%	0.283

Parameter	**Value**						
	Age group (years)	**Year**					
		2014	**2015**	**2016**	**2017**	**2018**	**P-value***
	55 - 64	0.02%	0.02%	0.02%	0.02%	0.01%	0.073
	65 - 74	0.06%	0.06%	0.06%	0.06%	0.05%	0.121
	75 - 84	0.32%	0.30%	0.27%	0.28%	0.22%	0.023
	85+	1.90%	1.90%	1.71%	1.68%	1.42%	0.016
	All	0.07%	0.07%	0.06%	0.06%	0.05%	0.016

CHD = coronary heart disease

* Based on simple linear regression analyses

Supplementary Table 3: VCOR funding over time

Fund	**Year**			
	2014	**2015**	**2016**	**2017**
Medibank Private	$300,000	-	-	-
DHHS	$509,466	$460,202	$834,815	$616,900
Total	$809,466	$460,202	$834,815	$616,900

DHHS = Department of Health and Human Services

Source: VCOR Annual Report 2018 [31]

Supplementary Table 4: Derivation of costs associated with mortality

Source	DRG	DRG Description	Number of discharges	Cost
NHCDC Round 22 [34]	F05A	CRNRY BYPSS+INV INVES, MAJC	602	$72,146
	F05B	CRNRY BYPSS+INV INVES, MINC	1,010	$51,816
	F06A	CRNRY BYPSS-INV INVES, MAJC	831	$62,580
	F06B	CRNRY BYPSS-INV INVES, INTC	1,683	$44,195
	F06C	CRNRY BYPSS-INV INVES, MINC	1,594	$37,227
	F10A	INTERVENTIONAL CRNRY PR + AMI, MAJC	2,884	$22,632
	F10B	INTERVENTIONAL CRNRY PR + AMI, MINC	12,581	$11,613
	F60A	CIRC DIS+AMI-INVA INV PR	9,435	$8,089
	F60B	CIRC DIS+AMI-INVA INV PR,T<5D	7,920	$3,667
	F66A	CORONARY ATHEROSCLEROSIS, MAJC	1,771	$6,911
	F66B	CORONARY ATHEROSCLEROSIS, MINC	8,825	$1,908
	F72A	UNSTABLE ANGINA, MAJC	1,713	$5,845

	F72B	UNSTABLE ANGINA, MINC	7,567	$2,382

AMI = acute myocardial infarction; CIRC = circulatory; CRNRY = coronary; INV = invasive; INVES = investigation; DRG = diagnosis-related group; MAJC = major complexity; MINC = minor complexity; PR = procedure

Supplementary Table 5: Characteristics of patients undergoing PCI across Victorian hospitals (VCOR)

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
Age						<0.001
Mean (SD)	65 (11.59)	65 (11.50)	66 (11.80)	66 (11.64)	66 (11.6)	
Median (IQR)	66 (17)	66 (17)	66 (17)	67 (17)	66 (16)	
Age group (years), n (%N)						
< 75	5,392 (77.0%)	5,881 (76.8%)	6,291 (74.7%)	6,725 (73.8%)	24,289 (75.4%)	
≥ 75	1,615 (23.1%)	1,780 (23.2%)	2,126 (25.3%)	2,388 (26.2%)	7,909 (24.6%)	
Aboriginal/Torres strait Islander, n (%N)						<0.001
Yes	31 (0.4%)	28 (0.4%)	28 (0.3%)	52 (0.6%)	139 (0.4%)	
No	6,814 (97.3%)	7,266 (94.8%)	8,107 (96.3%)	8,356 (91.7%)	30,543 (94.9)	
Unknown	162 (2.3%)	367 (4.8%)	282 (3.4%)	705 (7.7%)	1,516 (4.7%)	

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
Sex, n(%N)						0.039
Male	5,462 (78.0%)	5,936 (77.5%)	6,482 (77.0%)	6,938 (76.1%)	24,818 (77.1%)	
Female	1,545 (22.0%)	1,725 (22.5%)	1,935 (23.0%)	2,175 (23.8%)	7,380 (22.9%)	
BMI, n (%N)						<0.001
Underweight (<18.5 kg/m2)	37 (0.5%)	40 (0.5%)	72 (0.9%)	59 (0.7%)	208 (0.7%)	
Normal (18.5 -24.9 kg/m2)	1,533 (21.9%)	1,678 (21.9%)	1,778 (21.1%)	2,017 (22.1%)	7,006 (21.8%)	
Overweight (25 – 29.9 kg/m2)	2,882 (41.1%)	3,014 (39.3%)	3,335 (39.6%)	3,596 (39.5%)	12,827 (39.8%)	
Obese (≥30 kg/m2)	2,445 (34.9%)	2,777 (36.3%)	3,128 (37.2%)	3,368 (37.0%)	11,718 (36.4%)	
Missing	110 (1.6%)	152 (2.0%)	104 (1.2%)	73 (0.8%)	439 (1.4%)	
Public/private hospital status, n (%N)						
Public	4,424 (63.1%)	4,838 (63.2%)	5,225 (62.1%)	5,858 (64.3%)	20,345 (63.2%)	0.027
ACS type, n (%N)						0.024

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
UA	580 (8.3%)	590 (7.7%)	623 (7.4%)	577 (6.3%)	2,370 (7.4%)	
NSTEMI	1,663 (23.7%)	1,793 (23.4%)	2,026 (24.1%)	2,050 (22.5%)	7,532 (23.4%)	
STEMI	1,465 (20.9%)	1,561 (20.4%)	1,674 (19.9%)	1,797 (19.7%)	6,497 (20.2%)	
Cardiogenic shock, n (%N)	142 (2.0%)	181 (2.4%)	214 (2.5%)	189 (2.1%)	726 (2.3%)	0.087
Intubated OHCA, n (%N)	72 (1.0%)	81 (1.1%)	100 (1.2%)	110 (1.2%)	363 (1.1%)	0.623
Pre-procedure cardiac arrest, n (%N)	123 (1.8%)	119 (1.6%)	128 (1.5%)	111 (1.2%)	481 (1.5%)	0.042
LVEF grade, n (%N)						0.003
Normal	3,488 (49.8%)	3,840 (50.1%)	4,382 (52.1%)	4,703 (51.6%)	16,413 (51.0%)	
Mild	1,008 (14.4%)	1,291 (16.9%)	1,238 (14.1%)	1,337 (14.7%)	4,874 (15.1%)	
Moderate	487 (7.0%)	551 (7.2%)	664 (7.9%)	642 (7.0%)	2,344 (7.3%)	
Severe	215 (3.1%)	241 (3.2%)	289 (3.4%)	296 (3.3%)	1,041 (3.2%)	
Missing	1,809 (25.8%)	1,738 (22.7%)	1,844 (21.9%)	2,135 (23.4%)	7,526 (23.4%)	

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
Medicated diabetes, n (%N)	1,532 (21.9%)	1,795 (23.4%)	1,848 (22.0%)	1,979 (21.7%)	7,154 (22.2%)	0.034
Peripheral vascular disease, n (%N)	244 (3.5%)	279 (3.6%)	326 (3.9%)	311 (3.4%)	1,160 (3.6%)	0.386
Cerebrovascular disease, n (%N)	228 (3.3%)	310 (4.1%)	272 (3.2%)	368 (4.0%)	1,178 (3.7%)	0.002
Chronic oral anticoagulant therapy, n (%N)	294 (4.2%)	347 (4.5%)	465 (5.5%)	754 (8.3%)	1,860 (5.8%)	<0.001
Previous CABG, n (%N)	601 (8.6%)	625 (8.2%)	681 (8.1%)	689 (7.6%)	2,596 (8.1%)	0.126
Previous PCI, n (%N)	2,350 (33.5%)	2,805 (36.6%)	3,013 (35.8%)	3,284 (36.0%)	11,452 (35.6%)	0.001
Dialysis, n (%N)	72 (1.0%)	83 (1.1%)	121 (1.4%)	103 (1.1%)	379 (1.2 %)	0.072
Renal transplant, n (%N)	21 (0.3%)	21 (0.3%)	25 (0.3%)	29 (0.3%)	96 (0.3%)	0.965
Renal replacement therapy, n (%N)	2 (0.0%)	6 (0.1%)	7 (0.1%)	3 (0.0%)	18 (0.1%)	0.305
Fibrinolytic therapy, n (%N)	197 (2.8%)	240 (3.1%)	266 (3.2%)	259 (2.8%)	962 (3.0%)	0.417
eGFR Mean (SD)	91.85 (37.11)	92.21 (37.78)	91.80 (38.61)	90.42 (38.04)	91.53 (37.9)	0.011

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
Median (IQR)	87.47 (47.34)	88.26 (48.28)	87.47 (47.71)	86.35 (46.73)	87.36 (47.6)	
eGFR, n (%N)						0.039
Normal (≥90 ml/min/1.73m^2)	5,255 (75.0%)	5,752 (75.1%)	6,277 (74.6%)	6,596 (72.4%)	23,880 (74.2%)	
Moderate (30 – 89 ml/min/1.73m^2)	1,133 (16.2%)	1,251 (16.3%)	1,338 (15.9%)	1,488 (16.3%)	5,210 (16.2%)	
Severe (<30 ml/min/1.73m^2)	133 (1.9%)	163 (2.1%)	216 (2.6%)	227 (2.5%)	739 (2.4%)	
Missing	486 (6.9%)	495 (6.5%)	586 (7.0%)	802 (8.8%)	2,369 (7.4%)	

ACS = acute coronary syndrome; BMI = body mass index; CABG = coronary artery bypass graft; eGFR = estimated glomerular filtration rate; LVEF = left ventricular ejection fraction; NSTEMI = Non-ST-elevation myocardial infarction; OHCA = out-of-hospital cardiac arrest; STEMI = ST-elevation myocardial infarction; UA = unstable angina;

There were 1 missing case for medicated diabetes status, 4 for out-of-hospital cardiac arrest, 1 for in-hospital pre-procedure cardiac arrest, 3 for

peripheral vascular disease, 2 for cerebrovascular disease or chronic oral anticoagulant therapy and 1 for renal transplant.

* P-value for year-to-year trend

Supplementary Table 6: Procedural characteristics of PCI across Victorian hospitals (VCOR)

Variable	**Year**					**P-value***
	2014 (N = 7,007)	**2015 (N = 7,661)**	**2016 (N = 8,417)**	**2017 (N = 9,113)**	**Total (N = 32,198)**	
Access site, n (%N)						<0.001
Brachial	17 (0.2%)	11 (0.1%)	7 (0.1%)	11 (0.1%)	46 (0.1%)	
Radial	2,608 (37.2%)	3,443 (44.9%)	4,626 (55.0%)	5,555 (61.0%)	16,232 (50.4%)	
Femoral	4,382 (62.5%)	4,207 (54.9%)	3,784 (45.0%)	3,547 (38.9%)	15,920 (49.4%)	
Medications (pre/during procedure), n (%N)						<0.001
Glycoprotein IIb/IIIa inhibitor	915 (13.1%)	853 (11.1%)	768 (9.1%)	737 (8.1%)	3,273 (10.2%)	
Thienopyridine or Ticagrelor	5,843 (83.4%)	6,240 (81.5%)	6,729 (80.0%)	7,113 (78.1%)	25,925 (80.5%)	
Aspirin	5,751 (82.3%)	6,754 (88.5%)	7,707 (91.9%)	8,666 (95.4%)	28,878 (90.0%)	
Antithrombin	6,057 (87.5%)	6,815 (90.3%)	7,452 (89.2%)	8,389 (92.8%)	28,713 (90.1 %)	
Lesion characteristics						

Multi-lesion disease, n (%N)	1,275 (18.2%)	1,557 (20.3%)	1,714 (20.4%)	2,001 (22.0%)	6,547 (20.3 %)	<0.001
Treated vessel(s), n (%N)						
Left main coronary artery	111 (1.6%)	122 (1.6%)	160 (1.9%)	180 (2.0%)	573 (1.8%)	0.123
Multivessel disease, n (%N)	425 (6.07%)	525 (6.85%)	593 (7.05%)	708 (7.77%)	2,251 (6.99%)	<0.001
Unprotected left main PCI, n (%N)	58 (0.8%)	66 (0.8%)	103 (1.2%)	120 (1.3%)	347 (1.1%)	0.003
Chronic total occlusion, n (%N)	290 (4.1%)	358 (4. 7%)	334 (4.0%)	342 (3.8%)	1,324 (4.1%)	0.023
In-stent restenosis, n (%N)	440 (6.3%)	501 (6.5%)	515 (6.1%)	519 (5.7%)	1,975 (6.1%)	0.139
Device used, n (%N)						
BMS only	1,277 (18.2%)	1,056 (13.8%)	663 (7.9%)	359 (3.9%)	3,355 (10.4%)	<0.001
Any DES	5,256 (75.0%)	5,934 (77.5%)	7,211 (85.7%)	8,139 (89.3%)	26,540 (82.4%)	<0.001
POBA only	451 (6.4%)	580 (7.6%)	493 (5.9%)	603 (6.6%)	2,127 (6.6%)	<0.001
Door to balloon time metrics[†]						
Door-to-balloon time [minutes, median (IQR)]	68 (40)	71 (53)	67 (49)	62 (44)	67 (49)	<0.001
Door-to-balloon/device time group, n (%N)						

≤ 90 min	259 (29.8%)	286 (31.3%)	268 (27.6%)	247 (21.7%)	1,060 (27.2%)	<0.001
>90 min	607 (69.9%)	624 (68.3%)	704 (72.4%)	888 (78.2%)	2,823 (72.6%)	
Missing	3 (0.35%)	4 (0.4%)	0 (0.0%)	1 (0.09%)	8 (0.2%)	
Post-procedural characteristics						
Lesion success, n (%N)	406 (5.8%)	568 (7.4%)	471 (5.6%)	575 (6.3%)	2,020 (6.3%)	<0.001
Procedure success, n (%N)	6,381 (91.1%)	6,861 (89.6%)	7,688 (91.3%)	8,294 (91.0%)	29,224 (90.8%)	<0.001
New renal impairment, n (%N)	138 (2.6%)	186 (3.3%)	179 (3.0%)	260 (4.1%)	763 (3.3%)	<0.001
Length-of-stay						
Median (IQR)	2 (3)	2 (3)	3 (3)	2 (3)	2 (3)	0.208
Referred to cardiac rehab, n (%N)	4,684 (68.2%)	5,669 (75.2%)	6,284 (76.1%)	6,529 (72. 9%)	23,166 (73.3%)	<0.001

BMS = bare metal stent; DES = drug-eluting stent; PCI = percutaneous coronary intervention; POBA = plain old balloon angioplasty; STEMI = ST-elevation myocardial infarction

* P-value for year-to-year trend

† Excluding all inter-hospital transfer arrivals and patients with STEMI onset while a current in-patient

Supplementary Table 7: Changes in radial access and DBDT over time

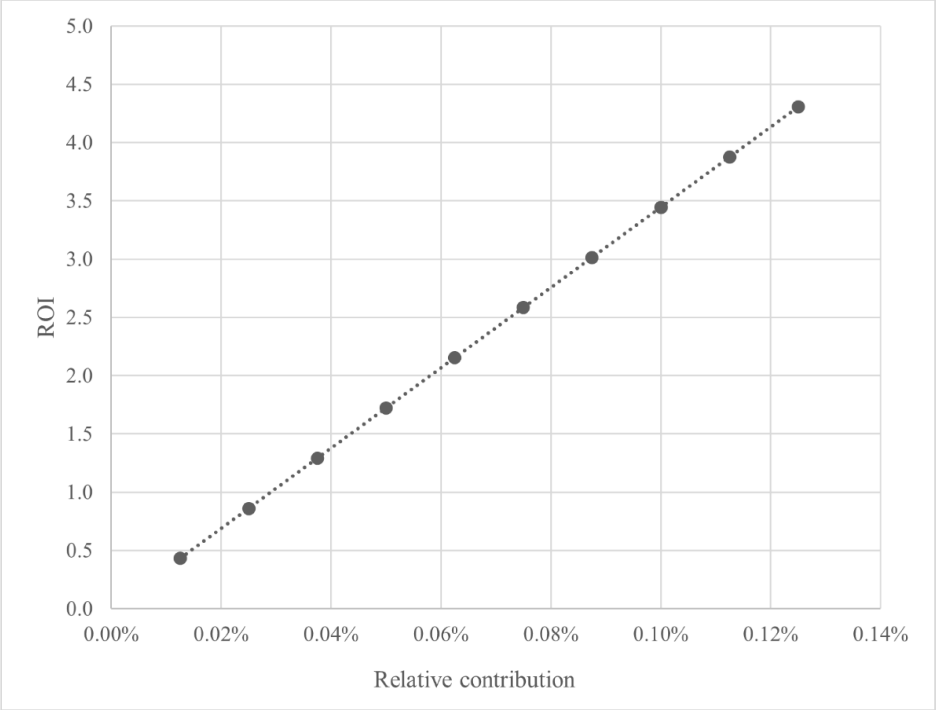
Parameter	**OR (95% CI)***	**P-value**
Likelihood of Femoral Access		
STEMI		
Males	0.65 (0.62 0.69)	<0.001
Females	0.73 (0.66 0.82)	<0.001
NSTEMI		
Males	0.70 (0.66 0.74)	<0.001
Females	0.74 (0.67 0.81)	<0.001
UA		
Males	0.72 (0.65 0.80)	<0.001
Females	0.73 (0.63 0.85)	<0.001
Non-ACS		
Males	0.72 (0.70 0.75)	<0.001
Females	0.74 (0.70 0.80)	<0.001
Likelihood of DBDT ≤ 90 minutes †		
Males	1.15 (1.07 1.24)	<0.001
Females	1.17 (1.01 1.36)	0.035

ACS = acute coronary syndrome; DBDT = door-to-balloon/device time; NSTEMI = non-ST-elevation myocardial infarction; OR = odds ratio; STEMI = ST-elevation myocardial infarction; UA = unstable angina

* Adjusted for key confounding variables

† Primary PCI for STEMI presentations excluding all inter-hospital transfer arrivals and patients with STEMI onset while a current in-patient

Supplementary Figure 1: Return on investment versus relative contribution to CHD mortality trends



ROI = return on investment