



# Health-related quality of life following percutaneous coronary intervention during the COVID-19 pandemic

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## Abstract

**Purpose** During the COVID-19 pandemic, widespread public health measures were implemented to control community transmission. The association between these measures and health-related quality of life (HRQOL) among patients following percutaneous coronary intervention has not been studied.

**Methods** We included consecutive patients undergoing percutaneous coronary intervention (PCI) in the state-wide Victorian Cardiac Outcomes Registry between 1/3/2020 and 30/9/2020 (COVID-19 period;  $n = 5024$ ), with a historical control group from the identical period one year prior (control period;  $n = 5041$ ). HRQOL assessment was performed via telephone follow-up 30 days following PCI using the 3-level EQ-5D questionnaire and Australian-specific index values.

**Results** Baseline characteristics were similar between groups, but during the COVID-19 period indication for PCI was more common for acute coronary syndromes. No patients undergoing PCI were infected with COVID-19 at the time of their procedure. EQ-5D visual analogue score (VAS), index score, and individual components were higher at 30 days following PCI during the COVID-19 period (all  $P < 0.01$ ). In multivariable analysis, the COVID-19 period was independently associated with higher VAS and index scores. No differences were observed between regions or stage of restrictions in categorical analysis. Similarly, in subgroup analysis, no significant interactions were observed.

**Conclusion** Measures of HRQOL following PCI were higher during the COVID-19 pandemic compared to the previous year. These data suggest that challenging community circumstances may not always be associated with poor patient quality of life.

**Keywords** COVID-19 · Cardiovascular disease · Percutaneous coronary intervention · Health-related quality of life · Public health

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## Abbreviations

HRQOL	Health-related quality of life
EQ-5D-3L	EuroQol 5-dimensional 3-level questionnaire
PCI	Percutaneous coronary intervention
VCOR	Victorian cardiac outcomes registry
STEMI	ST-elevation myocardial infarction
NSTEMI	Non-ST-elevation myocardial infarction
ACS	Acute coronary syndrome
MACE	Major adverse cardiovascular events
MI	Myocardial infarction
CABG	Coronary artery bypass grafts
BMI	Body mass index
HR	Hazard ratio
OR	Odds ratio
CI	Confidence interval

## Introduction

The COVID-19 pandemic has led to significant obstacles in delivering health care for non-COVID-19 conditions. For patients with cardiovascular disease, several countries identified markedly lower rates of PCI for STEMI and delays in treatment during periods of uncontrolled community COVID-19 transmission [1–5]. Similarly, concerns have been raised regarding appropriate follow up for patients following cardiac conditions with a transition to telehealth-based services. Concerningly, increases in deaths due to ischemic heart disease and cardiac arrest during COVID-19 have been observed in some regions [6, 7].

In Australia, the first two waves of sustained community transmission of COVID-19 during 2020, both occurred in the south-eastern state of Victoria, with a population of 6.4 million people. To address these waves, the Victorian government instituted a variety of strict public health measures, including one of the longest periods of mandatory home-confinement during the pandemic (112 days) [8, 9]. Somewhat uniquely to Victoria, overall case numbers of COVID-19 remained relatively low during the strict lockdown, and full medical services remained available for patients that required admission to hospital. These control measures were undoubtedly successful in eliminating community transmission. However, the impact of these public health measures on health-related quality of life (HRQOL) and care delivery for other health conditions, including cardiovascular conditions, is unclear. Furthermore, there are scant data regarding the impact of the COVID-19 period and public health measures on HRQOL internationally with all studies to date limited to small cohorts and many limited by the lack of a control group [10–26].

This study sought to assess the association between COVID-19 and measures of HRQOL in a large, state-based PCI cohort in Victoria, Australia with comparison to an identical time period 1 year prior. Further, we aimed to determine subgroups that may be more affected by COVID-19 public health measures, including comparing patients from regional areas, where public health measures were less restrictive.

## Methods

This was an observational cohort study of consecutive adult patients undergoing PCI procedures prospectively enrolled in the state-wide Victorian Cardiac Outcomes Registry (VCOR) in Victoria, Australia. Patients were included in the study if they were entered into VCOR

during the defined COVID-19 period (PCI between 1/3/2020 and 30/9/2020; 30-day HRQOL assessment between 30/3/2020 and 29/10/2020), or during the identical period one year prior (PCI between 1/3/2019 and 30/9/2019; 30-day HRQOL assessment between 30/3/2019 and 29/10/2019).

## Data sources and setting

VCOR is an Australian, state-wide clinical quality registry, established in 2012, which collects patient-level data on all patients undergoing PCI in the state of Victoria, Australia (including 14 public and 18 private hospitals). The state of Victoria has a population of approximately 6.4 million people and covers an area of 237,000 km<sup>2</sup> in the south-eastern part of Australia. Demographic, clinical, procedural and in-hospital outcome data are recorded on electronic case report forms using standardized definitions for each field. Post-discharge data are obtained via a standardized process involving medical record review and 30-day telephone follow up, and 30-day outcomes collected include major adverse cardiac events (MACE), myocardial infarction (MI), major bleeding, mortality, readmissions, revascularization procedures, and health-related quality of life (HRQOL). Periodic independent audits assess data quality at each participating site. The cumulative result of audits between 2013 and 2019 demonstrate a 98.6% agreement between VCOR data and hospital medical records [27, 28]. Overarching VCOR ethics approval was gained from the Alfred Hospital Ethics Committee (approval 47/12). Approval was gained from each individual hospital's ethics committee prior to participation in the registry. An "opt-out" consent approach is used by participating hospitals, resulting in almost all patients undergoing PCI in the state being enrolled in the registry. A Participant Information Statement is provided detailing the registry processes, rationale and ethics approvals, and registry contact information is provided for patients to withdraw their participation if preferred. Ethics approval for this specific analysis was also gained from the Alfred Hospital Ethics Committee (approval 727/20).

## Health-related quality of life

HRQOL was determined using the EuroQol 5-Dimensional 3-level (EQ-5D-3L) questionnaire completed during telephone follow up at 30 days following PCI. The EQ-5D-3L is a generic measure of HRQOL comprising five dimensions—mobility, self-care, usual activities, pain/discomfort, and anxiety/depression; each of these were assessed on a 3-point ordinal scale [no problems (1 point), some problems (2 points), severe problems (3 points)]. Each dimension is combined to form one score profile out of 243 (3<sup>5</sup>) possible health states ranging from 11111 (perfect health) to 33333

(worst health). This score profile may then be converted into an index score via population specific scoring algorithms using the time trade-off method. The Australian scoring algorithm was used to calculate index scores, with potential values ranging from  $-0.217$  to  $1$ , whereby negative index score values indicate health states perceived to be worse than death [29]. The EQ-5D-3L also includes a single global rating of self-perceived health using a visual analogue scale (VAS) ranging from  $0$ , indicating worst possible health state, to  $100$ , indicating best possible health state.

## Data definitions

Indication for PCI was classified as ST-elevation myocardial infarction (STEMI), non-ST-elevation acute coronary syndrome (NSTEMI), and stable ischemic heart disease (SIHD) presentations according to standard definitions [30, 31]. Geographic remoteness was determined through each patient's residential area postcode using The Accessibility and Remoteness Index of Australia (ARIA)—a geographic accessibility index available through the Australian Bureau of Statistics that divides Australia into five classes of remoteness to reflect relative access to services in non-metropolitan Australia by determining road distance to the nearest urban center [32]. In this system, the five classes of remoteness include 'Major City', 'Inner Regional', 'Outer Regional', 'Remote', and 'Very Remote'. Due to low numbers of 'Remote' and 'Very Remote' patients, these two categories were combined with 'Outer Regional' for the purposes of this study. Socio-economic status (SES) was determined using Socio-Economic indexes for Areas (SEIFA) score, a well-validated system developed by the Australian Bureau of Statistics from data collected in the national Census in 2011 [33]. To determine the SEIFA score, each residential area postcode in the state of Victoria is ranked and placed in deciles based on a combination of factors including household income, unemployment rate, home and motor vehicle ownership, educational level, and non-English speaking background. For this study, the SEIFA score was divided into quintiles, with the 1st quintile including patients living in the lowest 2 SEIFA score deciles (most disadvantaged) and the 5th quintile including patients living in the highest 2 SEIFA score deciles (least disadvantaged). In the subgroup analysis, 'lower SES' was defined as patients within SEIFA deciles 1–5. Procedural success was defined as the successful treatment of all lesions and the absence of any major in-hospital complications.

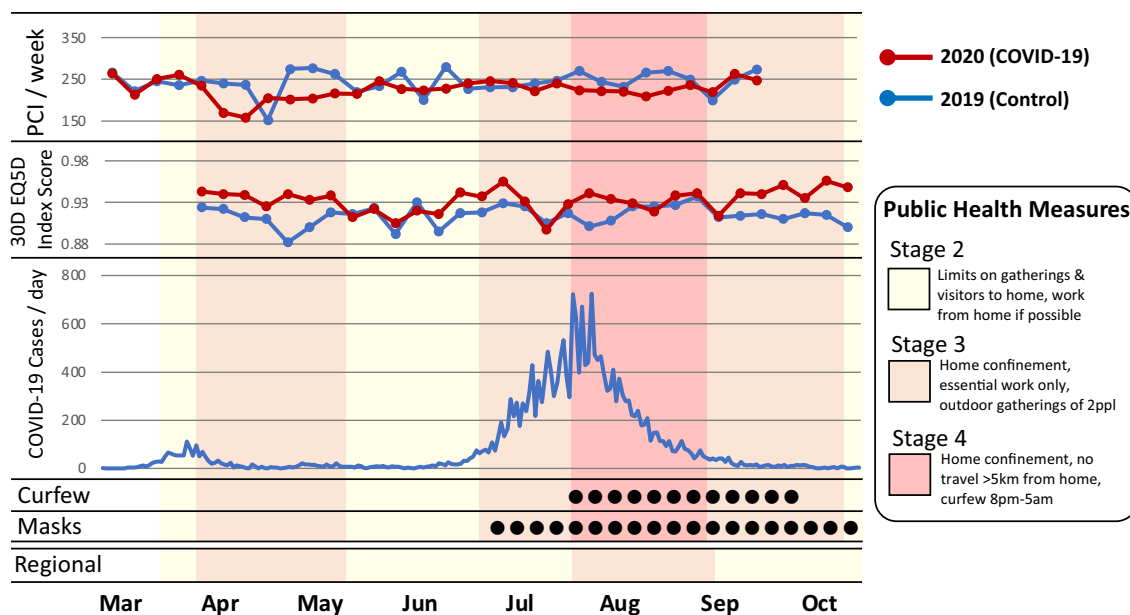
## Selection of time periods and COVID-19 variables

The first Australian case of COVID-19 was identified on the 25th January 2020, with the World Health Organization declaring COVID-19 a 'Public Health Event of International

Concern' on the 30th January and a pandemic on the 11th March. In Victoria, Australia, home confinement was first introduced on 30th March 2020 in the setting of the first wave of community transmission, which occurred from early March until late May (peak new daily cases 111 people on 28th March 2020). The second wave in Victoria lasted from mid-June until mid-October (peak new daily cases 725 people on 5th August 2020). For this study, we selected 1st March 2020 as the start date for the COVID-19 period until 30th September 2020. HRQOL data was collected 30 days after PCI, therefore representing a period from 30th March 2020 (the first date of home confinement in Victoria) until 29th October 2020 (at the completion of the second Victorian wave). For most of the pandemic, a four tier system of public health measures was instituted by the Victoria government ranging from Stage 1 (no or minimal restrictions) to Stage 4 (home confinement); see Fig. 1 and Supplemental Table S1. COVID-19 variables included in the study were determined from Victorian Department of Health and Human Services press releases and included number of new daily COVID-19 cases within Victoria and public health restriction stage. For each patient, restriction stage was determined at the time of HRQOL assessment (i.e. 30 days following PCI) and were specific to whether they lived in a metropolitan or regional area (restrictions were frequently different between metropolitan and regional areas).

## Statistical analysis

Continuous data are expressed as mean  $\pm$  SD or median (IQR), as appropriate, and are compared using the Student's *t* test or Mann–Whitney *U* test. Categorical variables are presented as number (percentage) and are compared using the Pearson's Chi-square test. Multivariable analysis was performed to determine whether the COVID-19 period was independently associated with EQ-5D-3L visual analogue scale or index scores at 30 days after PCI. In addition to time period, 15 other clinically relevant variables were screened for inclusion in the model, and variables with a *P* value of  $<0.25$  in univariable analysis were entered into a linear regression using complete case analysis. For the EQ-5D-3L VAS model, variables included were time period, age, sex, body mass index, ACS, ejection fraction  $\leq 40\%$ , diabetes, peripheral vascular disease, prior stroke, prior CABG, prior PCI, eGFR, SES, and regional/remote status. For the EQ-5D-3L index score model, variables included were time period, age, sex, ACS, cardiogenic shock, out-of-hospital cardiac arrest (OHCA), ejection fraction  $\leq 40\%$ , diabetes, peripheral vascular disease, prior stroke, prior CABG, eGFR, SES, and regional/remote status. Subgroup analysis was performed using multivariable linear regression adjusted for the same variables to determine whether there were any significant interactions among specific subgroups



**Fig. 1** Timeline of health-related quality of life and PCI during the COVID-19 period and control period in Victoria, Australia. Number of state-wide PCI performed per week (top) and weekly mean EQ5D index score 30 days after PCI (second from top) in relation to new daily COVID-19 cases (middle) and public health measures (shaded background) during the COVID-19 pandemic in Victoria, Australia (2020). The red lines indicate during the COVID-19 period (2020)

while the blue lines show data from the identical period 12 months earlier (2019). Regional restrictions outside metropolitan Melbourne were different for the latter half of the period studied and are shown at the bottom. Compulsory mask mandates and curfew public health measures are shown by the black dots (second to bottom). Further details regarding public health measures at each stage of restrictions in Victoria are presented in the supplemental material

for the observed associations between time period and 30-day HRQOL. To support clinical interpretation of these data, we also defined four ordinal categories in line with previous studies that have correlated EQ5D VAS and index scores with severity of ischemic heart disease symptoms [34]. The following cut-offs were used representing HRQOL being high (VAS 90–100, index 1.0), moderate (VAS 75–89, index 0.75–0.99), low (VAS 60–74, index 0.6–0.74), or very low (VAS < 60, index < 0.6). Statistical analysis was conducted using Stata version 14.2 for Windows (College Station, Texas, USA) and R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria) with figures created using the ggplot2 visualization package. All calculated *P* values were 2 sided, and a *P* value < 0.05 was considered statistically significant.

## Results

A total of 14,581 procedures were entered into the VCOR registry during the defined periods (7042 during the COVID-19 period and 7539 during the control period). Of these, 310 patients (146 COVID-19 period; 164 control period) died within 30 days of their PCI and were excluded. Of the remaining cohort, 4206 patients (1872 COVID-19 period; 2334 control period) did not have any measures of

30-day HRQOL recorded and were also excluded, leaving 5024 patients in the COVID-19 period and 5041 patients in the control period (Supplemental Fig. S1). Differences in patient characteristics between patients with missing QOL data undergoing PCI in the COVID-19 period compared to the control period are shown in Supplemental Table S2, and differences in patient characteristics between patients with and without available QOL data for both groups are shown in Supplemental Table S3. A timeline of public health measures during the first two COVID-19 waves in Victoria, Australia in relation to weekly PCI numbers and mean weekly 30-day EQ-5D-3L index scores is shown in Fig. 1. EQ-5D-3L index scores were on average higher among patients undergoing PCI during the COVID-19 period. There were no patients in Victoria, Australia who underwent PCI while actively infected with COVID-19 during the study period.

## Patient characteristics

During the COVID-19 period, patients undergoing PCI were on average younger and rates of non-ST-elevation ACS, STEMI, and impaired left ventricular ejection fraction ( $\leq 40\%$ ) were higher than during the control period, Table 1. Procedural success, length of stay, and 30-day outcomes (including major adverse cardiac events and

**Table 1** Patient characteristics and outcomes

	COVID-19 <sup>a</sup> <i>n</i> = 5024	Control <sup>a</sup> <i>n</i> = 5041	<i>P</i>
<i>Demographics</i>			
Age (years)	68 ± 11	68 ± 12	0.002
< 60 years old	1319 (26%)	1197 (24%)	0.015
60–69 years old	1473 (29%)	1475 (29%)	
70–79 years old	1470 (29%)	1582 (31%)	
≥ 80 years old	762 (15%)	787 (16%)	
Female	1193 (24%)	1249 (25%)	0.228
BMI (kg/m <sup>2</sup> )	29 ± 5	29 ± 5	0.938
ARIA			0.002
Major City	3667 (74%)	3538 (71%)	
Inner regional	1058 (21%)	1212 (24%)	
Outer regional/remote	246 (5%)	253 (5%)	
SEIFA quintile			0.071
1 (most disadvantaged)	525 (11%)	510 (10%)	
2	575 (12%)	675 (13%)	
3	1024 (21%)	997 (20%)	
4	1481 (30%)	1473 (29%)	
5 (least disadvantaged)	1366 (27%)	1348 (27%)	
Diabetes	1144 (23%)	1204 (24%)	0.130
Prior stroke	166 (3.3%)	184 (3.7%)	0.345
PVD	145 (2.9%)	170 (3.4%)	0.162
eGFR < 60 ml/min/1.73m <sup>2</sup>	1029 (20%)	956 (19%)	0.081
Prior PCI	1780 (35%)	1766 (35%)	0.671
Prior CABG	293 (6%)	369 (7%)	0.003
<i>Presentation</i>			
Indication			
Stable IHD	2634 (52%)	2951 (59%)	< 0.001
NSTEMACS	1481 (29%)	1344 (27%)	0.002
STEMI	908 (18%)	746 (15%)	< 0.001
OHCA	50 (1.0%)	59 (1.2%)	0.398
Cardiogenic shock	51 (1.0%)	41 (0.8%)	0.286
EF ≤ 40%	591 (13%)	517 (11%)	0.020
<i>Outcomes</i>			
Procedural success	4752 (95%)	4741 (94%)	0.244
Length of stay (median,IQR)	2 (1–4)	2 (1–4)	0.815
Rehospitalization (30 days)	559 (11%)	647 (13%)	0.008
MACE (30 days)	63 (1.3%)	84 (1.7%)	0.085
Stroke (30 days)	13 (0.3%)	11 (0.2%)	0.677

Data are presented as number (%) or mean ± SD unless otherwise indicated

*BMI* body mass index, *ARIA* Accessibility and Remoteness Index of Australia, *SEIFA* Socio-economic indexes for Areas, *PVD* peripheral vascular disease, *OSA* obstructive sleep apnea, *eGFR* estimated glomerular filtration rate, *MI* myocardial infarction, *PCI* percutaneous coronary intervention, *CABG* coronary artery bypass grafts, *IHD* ischemic heart disease, *NSTEMACS* non-ST-elevation acute coronary syndrome, *STEMI* ST-elevation myocardial infarction, *OHCA* out-of-hospital cardiac arrest, *EF* ejection fraction, *MACE* major adverse cardiac events

<sup>a</sup>COVID-19 period includes patients undergoing PCI in Victoria, Australia between 1/3/20 until 30/9/20, while the control period includes patients undergoing PCI between 1/3/19 until 30/9/19

stroke) were similar between the COVID-19 and control periods. However, rehospitalization rates within 30 days were lower during the COVID-19 period.

### Health-related quality of life

All measures of HRQOL were higher for patients undergoing PCI during the COVID-19 period compared to the control period, including EQ-5D-3L VAS (80.5 vs. 79.0,  $P < 0.001$ ) and index score (0.93 vs. 0.91,  $P < 0.001$ ), as well as for each of the five individual EQ-5D-3L components (mobility, self-care, usual activities, pain/discomfort, anxiety/depression; all  $P < 0.01$ ), Table 2. The distribution of EQ-5D-3L VAS and index scores for the COVID-19 cohort and the control cohort are depicted in Fig. 2.

**Table 2** Health-related quality of life at 30 days following PCI

	COVID-19 <i>n</i> = 5024	Control <i>n</i> = 5041	<i>P</i>
<i>EQ-5D summary scores</i>			
Visual analogue score	80.5 ± 14.9	79.0 ± 16.0	0.0002
Index score	0.93 ± 0.13	0.91 ± 0.15	< 0.0001
<i>EQ-5D individual components</i>			
Mobility			0.013
No problems	4552 (91%)	4481 (89%)	
Some problems	445 (9%)	528 (11%)	
Confined to bed	13 (0.3%)	19 (0.4%)	
Self-care (wash/dress)			0.002
No problems	4826 (96%)	4772 (95%)	
Some problems	168 (3.4%)	237 (4.7%)	
Unable to perform	11 (0.2%)	13 (0.3%)	
Usual activities			0.002
No problems	4423 (88%)	4322 (86%)	
Some problems	536 (11%)	639 (13%)	
Unable to perform	42 (0.8%)	56 (1.1%)	
Pain or discomfort			< 0.0001
None	4467 (89%)	4271 (86%)	
Moderate	520 (10%)	689 (14%)	
Extreme	24 (0.5%)	33 (0.7%)	
Anxiety/depression			< 0.0001
None	3888 (88%)	3579 (85%)	
Moderate	469 (11%)	562 (13%)	
Extreme	47 (1.1%)	49 (1.2%)	

Summary scores are presented as mean ± SD, individual components are presented as number (%)

*EQ-5D-3L* EuroQol 5-Dimension 3 Level, *PCI* Percutaneous Coronary Intervention

### Multivariable analysis

In multivariable analysis, undergoing PCI during the COVID-19 period was independently associated with higher 30-day EQ-5D-3L VAS score ( $\beta$  1.13, 95% CI 0.26–2.00,  $P = 0.011$ ) and index score ( $\beta$  0.017, 95% CI 0.011–0.023,  $P < 0.001$ ). Other variables associated with higher HRQOL scores included higher socio-economic status, higher eGFR (VAS only), and regional/remote residence (VAS only). Variables associated with lower 30-day HRQOL scores included age (VAS only), female sex, body mass index (VAS only), acute coronary syndromes, ejection fraction  $\leq 40\%$ , diabetes, peripheral vascular disease (index only), prior stroke, prior CABG (index only), and prior PCI (VAS only) (see Table 3).

### Categorical analysis

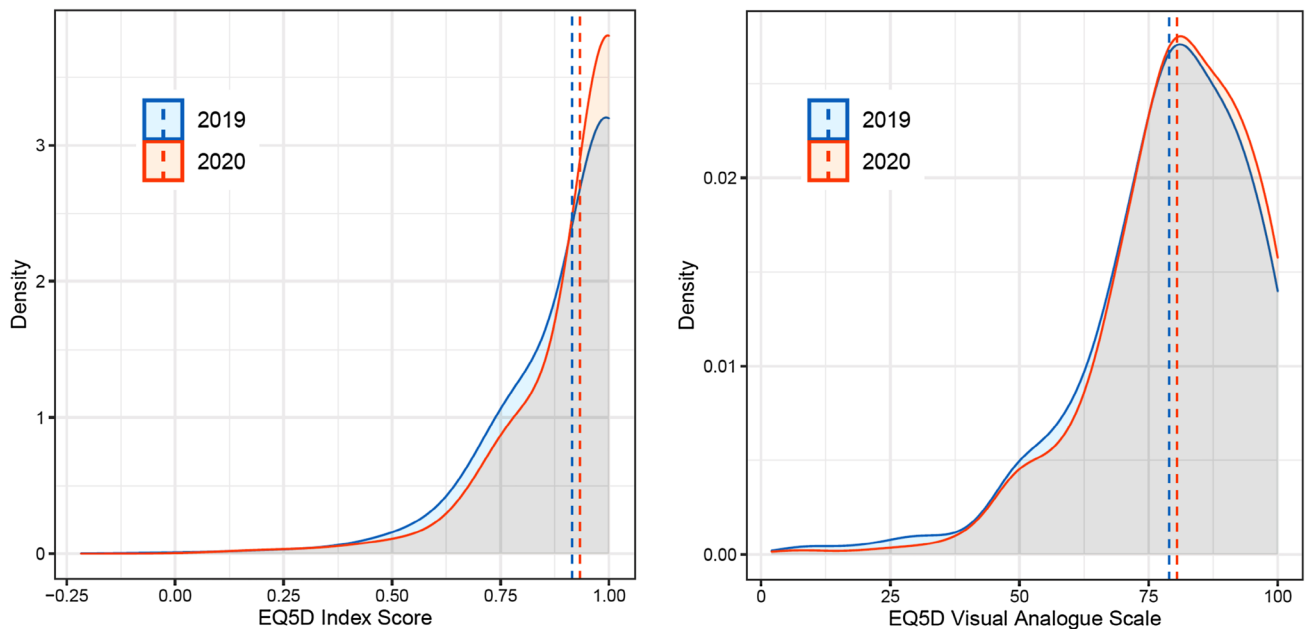
Categorical analysis demonstrated significant differences in EQ-5D-3L VAS and index score categories at 30 days following PCI between patients during the COVID-19 period and control period (Fig. 3, blue panel). These differences persisted when separated by metropolitan or regional status despite differing public health restriction measures between the two regions. When limited to patients in the COVID-19 cohort, no differences were observed between stage of public health restrictions and categories of HRQOL, including when stratified by metropolitan and regional status (Fig. 3, red panel).

### Subgroup analysis

In subgroup analysis among clinically relevant variables for the EQ-5D-3L VAS and index scores, with adjustment for variables included in the main multivariable analysis, no significant interactions were observed for age, sex, STEMI indication, socio-economic status, or region (Supplemental Fig. S2).

### Discussion

In this state-wide study, we assessed HRQOL among patients following PCI during the COVID-19 pandemic in Victoria, Australia. The major findings can be summarized as follows: (1) state-wide PCI numbers were marginally lower during COVID-19, mainly relating to lower rates of PCI for stable angina syndromes, but in-hospital and 30-day outcomes remained unchanged; (2) all measures of HRQOL 30 days following PCI were higher during the COVID-19 period compared to the identical period one year prior; (3) differences in HRQOL persisted among both metropolitan and regional patients in spite of differing public health measures; and (4) within the COVID-19 cohort, HRQOL was not



**Fig. 2** Distribution of health-related quality of life scores 30 days following PCI during the COVID-19 pandemic (red) and the identical period one year prior (blue). The left panel shows the distribution of EQ5D index scores 30 days following PCI demonstrating higher scores during the COVID-19 period. The dotted lines indicate the

mean for each group (red indicating the COVID-19 period and blue indicating the control period). The right panel shows similar results for EQ5D visual analogue scale scores. EQ5D = EuroQol 5-Dimensional score (color figure online)

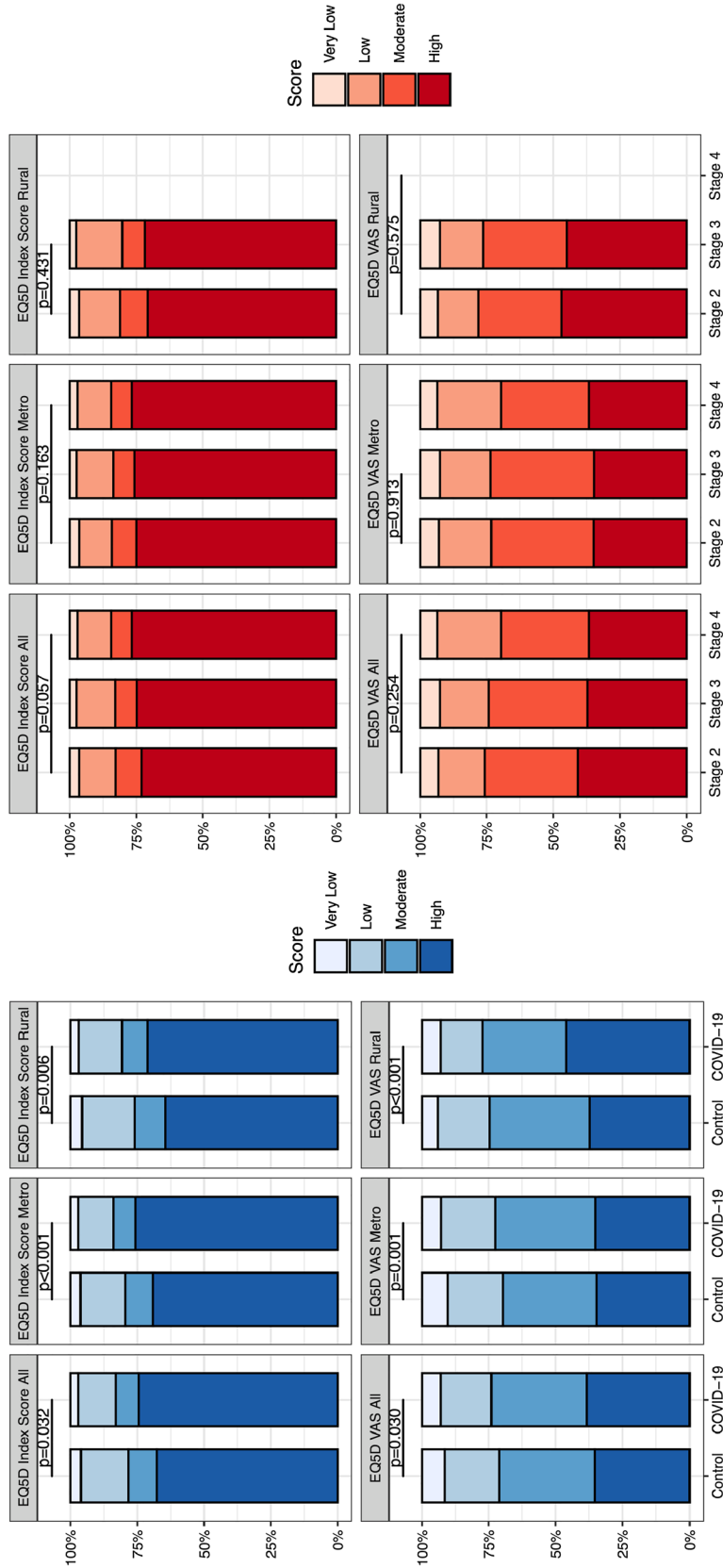
**Table 3** Variables associated with health-related quality of life scores at 30 days following PCI

Variable	EQ-5D visual analogue scale			EQ-5D index score		
	$\beta$	95% CI	<i>P</i>	$\beta$	95% CI	<i>P</i>
COVID-19 period (2020)	1.13	0.26 to 2.00	0.011	0.017	0.011 to 0.023	<0.001
Age	-0.07	-0.12 to -0.02	0.005	0.000	0.000 to 0.000	0.314
Sex (Female)	-2.85	-3.90 to -1.81	<0.001	-0.025	-0.033 to -0.018	<0.001
Body mass index	-0.21	-0.30 to -0.11	<0.001			
Acute coronary syndrome	-1.71	-2.61 to -0.80	<0.001	-0.014	-0.021 to -0.008	<0.001
Cardiogenic shock				-0.002	-0.035 to 0.031	0.921
OHCA				-0.029	-0.062 to 0.005	0.095
EF $\leq$ 40%	-1.82	-3.16 to -0.48	0.008	-0.013	-0.022 to -0.003	0.012
Diabetes	-2.28	-3.34 to -1.23	<0.001	-0.016	-0.023 to -0.008	<0.001
PVD	0.62	-2.01 to 3.24	0.648	-0.030	-0.049 to -0.012	0.001
Prior stroke	-3.27	-5.76 to -0.78	0.010	-0.032	-0.050 to -0.015	<0.001
Prior CABG	0.42	-1.50 to 2.33	0.669	-0.014	-0.028 to -0.001	0.042
Prior PCI	-0.66	-1.61 to 0.28	0.169			
eGFR	0.02	0.00 to 0.04	0.014	0.000	0.000 to 0.000	0.098
Socio-economic status <sup>a</sup>	0.35	0.17 to 0.54	<0.001	0.002	0.001 to 0.003	0.006
Regional/remote	3.76	2.74 to 4.78	<0.001	-0.005	-0.013 to 0.002	0.175

Relevant clinical variables with a *P* < 0.25 in univariable analysis were included in a multivariable linear regression demonstrating an independent association between undergoing PCI during the COVID-19 period and higher health-related quality of life scores at 30 days in comparison to the identical period 1 year prior

OHCA out-of-hospital cardiac arrest, EF ejection fraction, PVD peripheral vascular disease, CABG coronary artery bypass surgery, PCI percutaneous coronary intervention, eGFR estimated glomerular filtration rate

<sup>a</sup>Socio-economic Indexes for Areas (SEIFA) decile (i.e. each decile higher on the SEIFA index is associated with a 0.35 unit increase in EQ5D visual analogue scale score)



**Fig. 3** Categorical analysis of health-related quality of life following PCI. Left panel (blue) compares EQ5D index score (top) and visual analogue scale (bottom) between patients undergoing PCI during the COVID-19 period compared to the control period showing significantly higher EQ5D scores across all patients (left) and separated by metropolitan (middle) and regional/rural (right) status. Right panel (red) compares health-related quality of life scores across stages of public health restrictions in the COVID-19 cohort ( $n=5024$ ) demonstrating no differences in HRQOL between stages, including when separated by metropolitan and regional status (color figure online)



different when stratified by stage of public health restrictions. To our knowledge, this is the first large, population-based study with a historical control group to demonstrate higher patient-perceived health status during a period of highly challenging community circumstances.

During the first two waves of COVID-19 community transmission in Victoria, Australia, the state government instituted prolonged and wide-reaching public health measures aimed at suppressing, and if possible eliminating, community disease transmission [9]. The first period of mandated home-confinement lasted for 42 days and the second period lasted 112 days—one of the longest periods of strict home-confinement aimed at controlling COVID-19 community transmission anywhere in the world [8]. Each of these periods was successful at eliminating community transmission. During these strict measures, new daily COVID-19 case numbers remained relatively low in comparison to other countries (peak 111 during the first wave and peak 725 per day during the second wave), and in a state of 6.4 million people, individuals had a relatively low likelihood of being personally affected by COVID-19 infection. The current study therefore largely represents the impact of strict home-confinement measures on HRQOL following PCI rather than the impact of uncontrolled COVID-19 community transmission. Importantly, no patients included in the study had active COVID-19 infections at the time of their PCI procedure.

In this study, we demonstrated improved HRQOL among patients with cardiovascular disease 30 days following PCI during the COVID-19 period. This observation was sustained across all individual components of the EQ-5D score, and unaffected by geographic region or stage of public health restrictions. Several studies have assessed the impact of COVID-19 on quality of life among the general population and specific patient populations. So far, these studies have been limited by significantly smaller cohort sizes, with many also limited by a lack of a comparative control group. In the general population, COVID-19 has had a mixed or negative impact on HRQOL. Measures of anxiety and depression were worse in most studies across multiple different countries [10–14, 16]. However, in some studies measures of self-perceived health were not affected, and resilience, social networking and interconnectedness improved [15, 17–19]. In specific disease populations, one large observational cohort study ( $n = 1613$ ) routinely collected HRQOL (EQ-5D) data among patients following hand surgery and compared the COVID-19 period with an identical period from 2018 to 2019 [22]. No meaningful differences in HRQOL were observed. Other studies have been limited by small cohort sizes and often no comparative group, showing neutral (inflammatory bowel disease, cancer) [20, 21, 23], mixed (Alzheimer's) [24], or negative (common variable immuno-deficiency, Parkinson's disease)

[25, 26] impacts of COVID-19 on HRQOL among various disease populations.

Early during the COVID-19 pandemic, concerns were raised regarding maintaining adequate delivery of cardiac care [2]. Several countries noted marked decreases in rates of PCI for STEMI and heart failure admissions during periods of uncontrolled community transmission [2–5, 35]. Similarly, rates of diagnostic testing for cardiac disease were reduced, and access to rehabilitation, family supports and prompt clinic review following a cardiovascular admission have been impacted [36, 37]. Our study represents a unique set of circumstances, whereby despite strict prolonged home-confinement measures, there were low rates of COVID-19 infection in the community, and full cardiac services were available to patients that ended up in hospital. It is worth noting that there were higher rates of STEMI and NSTEMI, possibly representing a tendency for patients with stable angina to delay presentation until ACS during the pandemic. At the peak of the 2nd wave in Victoria, there was a preference to defer non-urgent PCI procedures and patients were required to undergo COVID-19 screening prior to non-emergent procedures. However, overall, PCI numbers were only marginally reduced compared to 1 year prior, early outcomes were unchanged, and all individual components of HRQOL were higher. This apparent higher QOL is likely multifactorial, but may be related to a period of forced home respite rather than feeling pressured to quickly return to their usual responsibilities (although this point is speculative). Moreover, although in-person clinics and rehabilitation services were disrupted, several studies have shown high patient satisfaction and higher attendance rates among patients following up with telehealth services [38, 39]. At the commencement of this study, we hypothesized (as others may have) that HRQOL was likely to be adversely impacted by COVID-19. Therefore, the results of this study were surprising to us, but overall should be reassuring to patients, clinicians, and public health officials.

## Limitations

This study has several limitations. First, the study may not be generalisable to other jurisdictions that enforced public health measures during COVID-19. Our data reflect HRQOL outcomes in a specific state-wide region of Australia. These data are influenced by specific public health measures, daily COVID-19 case numbers, government services, financial supports for hardship related to the pandemic, and local practices of cardiac care. Substantial financial supports were available for Australians that were unemployed during the pandemic, which may have led to less financial stress than in other countries. Furthermore, these results might be vulnerable to collider bias, for example, a person's decision to present to hospital for a PCI procedure might have been

influenced by their quality of life as well as the COVID-19 period. Second, approximately one quarter of the cohort did not have any measure of HRQOL and were therefore excluded—nonetheless, among patients with missing data, baseline characteristics were similar between the COVID-19 and control groups (Supplemental Tables S2 and S3). The EQ-5D-3L tool is well validated, but is only a measure of HRQOL rather than being a disease specific measure, and is known to have a significant ceiling effect and therefore a difference in HRQOL between periods among patients with higher HRQOL scores may not have been elicited from this study.

## Conclusions

In this large, state-wide, observational cohort study, HRQOL among cardiac patients undergoing PCI was higher during the COVID-19 period compared to 1 year prior. Overall, the study highlights the resilience of PCI populations during the pandemic despite strict public health measures aimed at controlling community transmission of COVID-19. These data suggest that difficult circumstances may not always be associated with poor patient quality of life.

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**Data availability** The data underlying this article may be shared on reasonable request to the VCOR data custodian (Professor Chris Reid) in accordance with Monash University policies.

## Declarations

**Conflict of interest** All authors declare that they have no conflict of interest to disclose.

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