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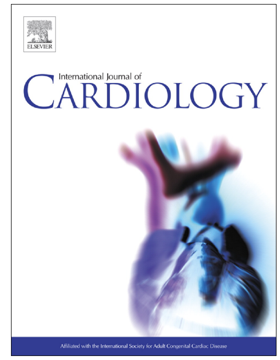

Estimating the health loss due to poor engagement with cardiac rehabilitation in Australia

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PII: S0167-5273(20)30204-7

DOI: https://doi.org/10.1016/j.ijcard.2020.04.088

Reference: IJCA 28577

To appear in: *International Journal of Cardiology*

Received date: 14 January 2020

Revised date: 7 April 2020

Accepted date: 30 April 2020

Please cite this article as: A. Driscoll, S. Hinde, A. Harrison, et al., Estimating the health loss due to poor engagement with cardiac rehabilitation in Australia, *International Journal of Cardiology* (2020), https://doi.org/10.1016/j.ijcard.2020.04.088

Estimating the health loss due to poor engagement with cardiac rehabilitation in Australia

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The authors have no conflicts of interest.

Acknowledgements: Professor Andrea Driscoll is supported by a Heart Foundation Future Leader fellowship (100472) from the National Heart Foundation of Australia.

Key words: cardiac rehabilitation, economic evaluation, myocardial infarction, cost-effectiveness

Abstract

Background

Cardiac rehabilitation (CR) programs are effective in reducing cardiovascular mortality and readmissions. However, most patients are denied the benefits of CR due to low referral rates. Of those patients referred, commencement rates vary from 28.4% to 60%. This paper quantifies the scale of health loss in Australia due to poor engagement with the program, and estimates how much public funding can be justifiably reallocated to address the problem.

Methods

Economic decision modelling was undertaken to estimate the expected lifetime health loss and costs to Medicare. Key parameters were derived from Australian databases, CR registries and meta-analyses. Population health gains associated with uptake rates of 60%, and 85% were calculated.

Results

CR was associated with a 99.9% probability of being cost-effective, even at a cost-effectiveness threshold lower than conventionally applied. Importantly, an average of 0.52 years of life expectancy are lost due to national uptake being below 60% achieved in some best performing programs in Australia, equivalent to 0.28 quality adjusted life years.

The analysis indicates that $12.9 million/year could be justifiably reallocated from public funds to achieve a national uptake rate of 60%, while maintaining cost-effectiveness of CR due to the large health gains that would be expected.

Conclusion

CR is a cost-effective service for patients with coronary heart disease. In Australia, less than a third of patients commence CR, potentially resulting in avoidable patient harm. Additional investment in CR is vital and should be a national priority as the health gains for patients far outweigh the costs.

Introduction

Coronary heart disease (CHD) is the leading cause of death and morbidity in Australia [1]. One in five patients hospitalised with AMI will experience an unplanned readmission within 30 days of discharge for any cause [2]. Cardiac rehabilitation (CR) programs are crucial in ensuring long term patient health and reducing readmissions in these patients. The efficacy associated with CR is well established, with a 26% reduction in CV mortality and 18% reduction in readmissions for patients participating in CR compared to no CR [3]. CR programs are now recommended as standard care post ST-elevated myocardial infarction (STEMI), percutaneous coronary intervention (PCI) and coronary artery bypass surgery (CABGS) in national and international guidelines [4-6]. However, despite these benefits and recommendations, referrals to a CR program and subsequent attendance remains low, with only a third of eligible patients referred to a CR program in Australia [7]. Of those patients referred, only 28% of patients attend CR [7], with a high proportion failing to complete [8]. From an Australian perspective, the lifetime economic costs and life years gained from CR are unknown, with no research confirming the cost-effectiveness of its current provision, with international evidence only recently starting to emerge [9,10].

Traditional CR programs in Australia comprise of face-to-face sessions with one hour of supervised exercise and one hour of education on pre-determined topics conforming to national standards [11-14]. A recent paper by Astley, Chew, Keech, Nicholls et al. analysed data of 49 909 patients admitted to hospitals in South Australia with a STEMI, PCI or CABGs between 2013-2015 [7]. Of these, 15 089 (30.2%) people were referred to CR post-discharge, however, only 28.4% of those referred attended the first session [7]. Several strategies have been implemented to improve the rate of uptake of CR, unfortunately, to no avail. Despite improving access through increasing the number of programs and flexibility in mode of delivery, the rate of uptake remains low [8]. In seeking to increase uptake, it is important to consider the health benefits that could be achieved if uptake rates approach the international gold standard of 85%, and therefore the investment that could be justified in achieving increased uptake.

Using Australian data to update an existing model of CR [15], this paper will: a) determine the cost-effectiveness of CR programs over a lifetime as they are currently delivered, to explore if the current provision represents a justifiably use of limited health care resources, b) determine the health care budget that can be justifiably reallocated to achieve current uptake targets whilst maintaining cost-effectiveness, c) explore how the costs and health outcomes (life years and quality adjusted life years, QALYs) accrue over time to understand how the short term cost of providing CR compares to the long term health gains.

Methods

A pragmatic search of the literature relating to cost-effectiveness of CR programs and for CR parameters used in the existing model, from an Australian context, was undertaken. Only a small number of studies were identified for use in this cost-effectiveness analysis. A comprehensive Cochrane review was also used to inform the analysis as it explored the impact of CR on four outcomes: recurrent MI, revascularisation with either a PCI or CABGs or mortality [3].

Population

There are an estimated 62 400 acute coronary events annually in Australia resulting in hospitalisation or death [1]. The National Heart Foundation of Australia recommend that all patients with CHD are referred to a CR program [11]. However, the proportion of patients nationally that are appropriate for referral is unknown due to a lack of national data. State-specific data, however, indicates a referral rate to CR of 30% [7]. The modelled cohort started at the age of 65 and had a male to female ratio of 0.74 to be indicative of current national programme demographics [7].

Intervention

CR programs comprise of 8-12 weeks of supervised prescribed exercise, behaviour change interventions to improve cardiac risk factor profile and psychosocial wellbeing. Health education about their condition and associated comorbidities together with self-management are key components of an effective CR intervention. There is a large degree of heterogeneity between length of programs and models of delivery such as face-to-face, group sessions, home-based programs and web-based programs. Studies have shown there are no statistically significant differences in psychosocial and physical fitness outcomes in CR programs utilising supervised group-based programs compared to self-delivered programs (home-based or web-based programs) [16,17]. Despite this heterogeneity in program delivery, the core components of CR programs strive to comply with the national standards [11-14].

Model structure

In economic evaluation, decision analytical models are used to determine the cost-effectiveness of an intervention [18], in this case CR. An existing Markov cohort model comprising of four states (death, revascularisation with PCI or CABG or recurrent MI) was adapted to explore the impact of CR on the health of patients and costs over a lifetime, from an Australian health system perspective (figure I [15]). Patients entered the model 'well' post CHD event and referral to CR. Two options are then available: attends CR or does not attend. Subsequently, patients transition into one of three branches: die, stays out of hospital or admitted to hospital with recurrent MI with no revascularisation or revascularisation with PCI or CABG. Probabilities of patients transitioning between these states differs according to whether these patients attended CR or not. The transition probabilities that determine the rate that patients move between the states is primarily informed by an international Cochrane review [3]. In all of these branches, patients can die from cardiovascular disease (CVD), surgical or procedural mortality (PCI or CABG) or any cause. The model was constructed in MS Excel.

See Figure I (markov model structure)

The cost-effectiveness analysis was conducted from an Australian health care perspective with a lifetime time horizon and a six-month cycle length. All costs and outcomes were discounted annually by 5%, as per Australian guidelines [19]. The incremental cost-effectiveness ratio (ICER) was compared to an estimate of marginal productivity ($28 033/QALY) as calculated by Edeny, Afzali, Cheng, & Karnon [20] for an Australian population as well as the conventionally applied cost-effectiveness threshold of $50 000/QALY [21]. The threshold estimates the point at which an increase in uptake of CR is no longer considered cost-effective for the health system to fund on the grounds of the QALY gain it provides.

Model parameters

To populate the model, evidence is drawn from a variety of different sources, including the Queensland CR registry [22], Australian population data [23] and an analysis of South Australian CR programs from an administrative dataset [7]. Parameters used to inform the base-case analysis are provided in Table 1 in the Supplementary Appendix. The results of the meta-analysis by Anderson et al. [3] provided many of the parameter estimates which were converted from risk ratios to transition probabilities. Other data sources used to estimate model parameters are listed in Table II in the Supplementary Appendix.

Quality of life was applied as a state specific decrement to an age-adjusted healthy population of QoL scores [27].

Costs

The unit costs were sourced from the National Hospital Cost Data Collection from the Independent Hospital Pricing Authority (IHPA) [28]. The cost of CR was unavailable in Australia so the cost was sourced from the UK NHS, as used in the original Markov model [15], and then converted to Australian dollars (AUD) using purchasing power parity [29].

The NACR report showed only 76% of patients completed a CR program [9]. There is a large degree of variability in timing of when a patient withdraws from the program. Australian data regarding the timing of withdrawal was not available so a fractional cost was unable to be applied. To ensure a conservative approach to costing, in the base case analysis, the cost of CR was applied to all patients regardless of whether they completed the full program, as would occur if a patient failed to complete a cohort programme. Furthermore, as a conservative assumption we assumed that any patient who failed to complete the full program received no health benefits.

Sensitivity analysis

A probabilistic sensitivity analysis (PSA) was conducted to explore uncertainty in the input parameters [30]. This approach incorporated the uncertainty reported in the meta-analysis by Anderson et al. [3] about the effectiveness of CR. Distributions were applied to the parameters within the model (see Table II) and Monte Carlo simulation used to generate 3000 iterations of costs and QALYs. The probability of CR being cost-effective was determined, along with the justifiable expenditure to increase the uptake of CR.

Results

CR was associated with an average of 8.58 life years (undiscounted) compared to 8.06 life years in people who did not participate in CR. This implies a life expectancy increase to 73.58 years in those undertaking CR (from 73.06) in the base-case cohort. CR also had higher discounted costs and QALYs compared to no CR (Table I). CR was considered cost-effective with a mean ICER of $6096/QALY with 98.7% probability of being cost-effective with high certainty at a cost-effectiveness threshold of $28 033 [20]. At the conventional threshold of $50 000 [21], CR continued to be cost-effective with a mean ICER of $6000 and 99.9% probability of being cost-effective. Scatterplots of the probabilistic simulations for completion and non-completion of CR, based on a 28.4% uptake rate, are provided in the Supplementary Appendix (figure Ia and Ib).

Insert table I: Cost-effectiveness of CR

Effect of Increasing CR attendance

Estimates of the lifetime health gains for those engaging in CR over one year (QALYs) and justifiable expenditure to reach a target attendance rate of 59.6% and 85% (assuming current completion rates) are shown in Table II. The uptake rate of 59.6% was taken from the Queensland Cardiac Outcomes registry (QCOR) [22] for CR and therefore represents an achievable Australian target, and 85% an international gold standard uptake rate for CR programs [31]. The lifetime health gain was calculated by combining the increment required to reach target, estimated annual eligible population and the QALY gained per person commencing CR (Table II).

With a current national uptake rate of 28.4% [7], the average health gained for reaching the target of 59.6% [22] would be 0.28 QALY per person referred to CR. The justifiable cost is an estimate of the funding that can be reallocated from elsewhere in Medicare to achieve the uptake target given the relative cost-effectiveness of CR compared to the marginal productivity of the healthcare system. The estimated total justifiable expenditure for the whole population is $12,908,207/year if CR uptake was to increase to 59.6% (Table II). If the uptake rate is further increased to 85%, there is a greater total health gain of 794 QALY gain for reaching target at a justifiable cost for the whole population of $23,416,812/year.

Insert table II Annual health gain and justifiable costs of reaching specific target uptake rates

If a 59.6% uptake of CR was achieved, our analysis suggests this would result in a reduction of 823 hospital admissions and 536 deaths avoided over 10 years. When this is increased to 85% uptake target, this would result in a reduction of 1,493 hospital admissions and 972 deaths avoided.

Trends in cumulative undiscounted costs and outcomes over the lifetime of the average patient are displayed in Figures II demonstrating how the short-term additional cost of CR compares to the longer-term cost and health outcomes. Figure IIb shows an initial higher cost for CR, however, both groups (CR vs no CR) are followed by a period of similar cumulative costs, as the CR patients have less interventions due to better health. Over time, the two lines separate due to the CR patients living longer, and therefore experiencing more health care costs. For both the life years (Figure IIa) and QALYs (Figure IIc), the two groups are similar for the first five years after the event, as there are few deaths in either arm, however beyond this the additional health gains from CR are realised and the two curves separate.

Figure IId shows the combined impact of these changes in cumulative costs and health outcomes over time, with the initial high relative cost of CR resulting in an ICER beyond cost-effectiveness thresholds. However, within five years the significant health gains of CR and similar costs between the two arms leads to an ICER well below the threshold.

Insert figure II comparison of no CR to CR over a lifetime

Discussion

To our knowledge this is the first study to evaluate the lifetime cost-effectiveness of CR based on Australian data. CR was cost-effective with high certainty and a mean ICER of $6096/QALY, well below recent estimates of the marginal productivity of Medicare or the conventionally applied cost-effectiveness threshold. Patients participating in CR experience greater health benefits over a lifetime compared to patients who do not. This economic model suggests if the uptake of CR was increased to 59.6% then it could potentially reduce hospitalisation by 823 episodes and 536 fewer deaths over 10 years. The justifiable expenditure also provides decision makers with an estimate of the funding that can be reallocated to invest in improving the uptake rate. This evaluation provides important economic data that can be used in a business case advocating for return on investment in CR programs and to justify further research on interventions to increase the uptake of CR [32].

De Gruyter, Ford & Stavreski, [33] conducted a cost benefit analysis of CR programs in Victoria, Australia. They found there was a net financial saving of $46.7-$86.7 million over 10 years with an uptake of 30%, 50% and 65%. There are some distinctive differences between this study and De Gruyter et al.'s study [33]. Firstly, they conducted a cost-benefit analysis using a simple decision tree. The mortality rates used by De Gruyter et al. [33] were based on a single centre study conducted in 1998 rather than the results of a meta-analysis as in the current analysis. De Gruyter et al. [33] used a time horizon of 10 years compared to a lifetime time horizon in the current evaluation. Their decision tree comprised of two transition states of hospitalisation or no hospitalisation. In the current study, there were four transition states: dies, stays out of hospital or admitted to hospital with recurrent MI with no revascularisation or revascularisation with PCI or CABG.

This evaluation has shown the health benefits and costs associated with improving the uptake of CR. In addition to improving the rate of uptake, it is equally important to ensure that completion rates are also high to ensure maximisation of health benefits. A recent meta-analysis showed that an increase in interventions to promote adherence to CR programs also resulted in a 13% increase in completion rates [34]. An International Council and Canadian Association of Cardiovascular Prevention and Rehabilitation position statement made three strong recommendations to increase enrolment: nurses to promote CR to their patients (strong level of evidence), particularly face-to-face (strong level of evidence) and part of the CR program could be delivered remotely (weak level of evidence) [32].

Limitations

There were several limitations associated with the economic evaluation. A lack of national Australian CR data was problematic, necessitating the use of data from international sources including meta-analysis [3] and the UK National Audit of Cardiac Rehabilitation (NACR) [9]. The cost of CR was taken from NACR and a previous cost-effectiveness analysis [15]. Purchasing power parity was used to convert this cost to Australian dollars [29]. The use of purchasing power parity is a more rigorous method of currency conversion than exchange rates as it excludes cost of living and profits from traded goods compared to a straight conversion of sterling pounds to Australian dollars, but cannot consider differences in the average CR programme delivered. National Australian data is vital in order to truly estimate population health gains, to facilitate an improved understanding of the utilisation and uptake of CR in Australia.

The model structure potentially over simplifies outcomes associated with an acute coronary/ STEMI event as outcomes associated with stroke, heart failure, arrythmias, multimorbidity and long-term disability were not included. However, the meta-analysis that was used to inform the parameters (Table II) did not include these outcomes.

Conclusion

CR is a cost-effective strategy for patients' post-discharge from an acute coronary event due to low costs with high health benefits. Additional investment into CR is warranted to increase rates of uptake. If CR uptake was increased to 60% our analysis estimates an additional 438 QALYs would be gained for every annual cohort of CR patients, as estimated $12.9 million could be reallocated within Medicare to achieve this target. Additional investment in CR is a national priority particularly as the health gains for CHD patients far outweigh the costs. Improving outcomes in these patients can be achieved by additional investment in increasing the uptake of CR post-discharge.

Acknowledgements: Professor Andrea Driscoll is supported by a Heart Foundation Future Leader fellowship (100472) from the National Heart Foundation of Australia.

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Author statement:

Andrea Driscoll: conceptualisation, methodology, formal analysis, investigation, resources, writing original draft, writing review and editing, **Sebastian Hinde:** conceptualisation, methodology, formal analysis, investigation, resources, supervision, writing review and editing; **Alexander Harrison:** conceptualisation, formal analysis, resources, writing review and editing; **Laura Bojke:** conceptualisation, methodology, supervision, writing review and editing; **Patrick Doherty:** conceptualisation, supervision, writing review and editing.

Figure I: Schematic of economic model

Figure II comparison of no CR to CR over a lifetime

Figure a: Number of life years comparing no CR to CR over a lifetime

Figure b: Comparison of undiscounted costs of no CR with CR over a lifetime

Figure c: Comparison of QALYs over a lifetime

Figure d: Changes in ICER over a lifetime

Table I: Cost-effectiveness of CR

Current initiation	No CR		CR		Incremental		ICER/QALY	Probability CE/QALY
	Disc Cost	Disc QALY	Disc cost	Disc QALY	Disc cost	Disc QALY		
28.4%	$25,062	4.91	$26,762	5.19	$1,700	0.28	$6,096	0.987

CR=cardiac rehabilitation

Disc= discounted

QALY= Quality adjusted life years

ICER= Incremental Cost-effectiveness ratio

Table II: Annual health gain and justifiable costs of reaching specific target uptake rates

Current initiation	Increment to target 65%	Eligible population	Health gain for reaching target, QALY per person of CR	Total QALY gain for reaching target	LY gains	Justifiable expenditure to reach target while cost-effective	
						Per person	Whole population
Target rate of 59.6%							
28.4%	31.2%	5030	0.28	438	8.58	$8,225	$12,908,207
Target rate of 85%							
28.4%	56.6%	5030	0.28	794	8.58	$8,225	$23,416,812
59.6%	25.4%	5030	0.28	356	9.89	$8,225	$10,508,605

CR=cardiac rehabilitation

Disc= discounted

LY= life years

QALY= Quality adjusted life years

ICER= Incremental Cost-effectiveness ratio

Highlights

- Cardiac rehabilitation (CR) is effective in reducing mortality and readmissions
- Most patients are denied the benefits of CR due to low referral rates
- In this economic analysis, CR was cost-effective with a mean ICER of $6096/QALY
- Patients in CR programs experience greater health benefits over a lifetime
- 60% uptake of CR will lower readmissions by 823 events and 536 deaths over 10 years

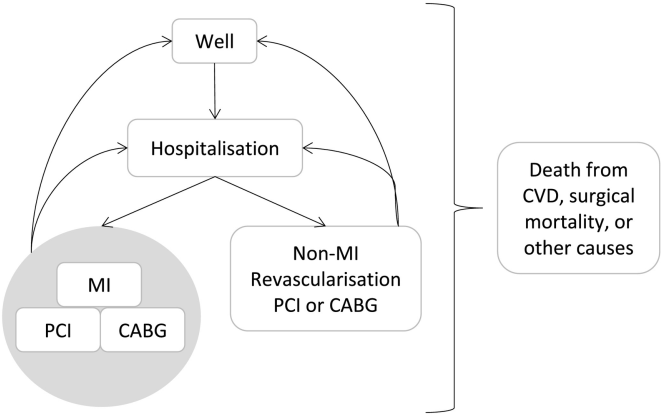
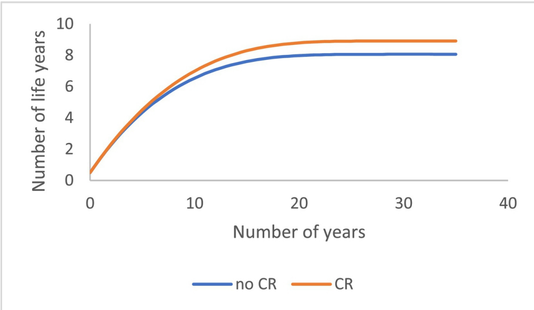
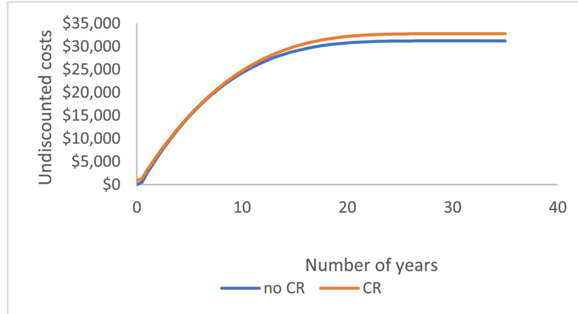

Well
Hospitalisation
MI
PCI
CABG
Non-MI
Revascularisation
PCI or CABG
Death from
CVD, surgical
mortality, or
other causes

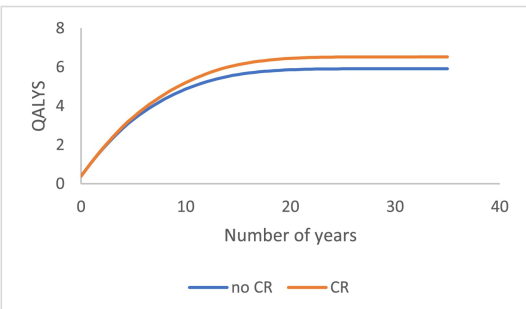
Figure 1



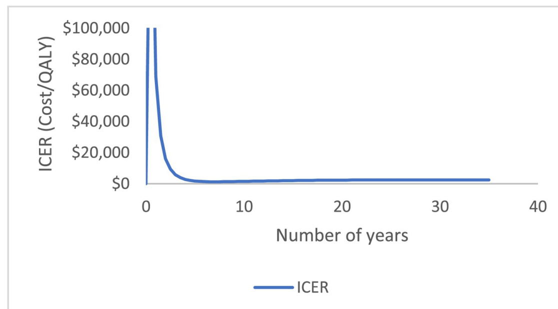
a: Number of life years comparing no CR to CR over a lifetime



b: Comparison of undiscounted costs of no CR with CR over a lifetime



c: Comparison of QALYs over a lifetime



d: Changes in ICER over a lifetime

Figure 2