

The University of Auckland

# Implementing Home-based Cardiac Rehabilitation in New Zealand

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*Projections for the implementation of a home-based cardiac  
rehabilitation programme to increase participation*

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*A thesis submitted in partial fulfilment of the requirements for the degree of Master of Public  
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## **Abstract**

*Cardiac rehabilitation has been shown to be an effective secondary prevention intervention in the management of cardiovascular disease. The use of CR in New Zealand remains low compared with other western countries. Home-based CR provides an exciting opportunity to increase participation and completion rates for CR at low marginal cost.*

***Aim:** To determine the current rates of participation and completion of CR in New Zealand by MI survivors and project how these may change if a home-based CR programme is offered, along with the financial costs and benefits of such changes.*

***Methods:** A literature review identified current levels of CR utilisation in New Zealand and similar western countries. The economic costs and benefits of CR programmes were sought, along with differences in participation and completion rates associated with hospital-based and home-based programmes. Decision tree models were created which replicated current CR utilisation and hospital readmissions using data from the literature and data provided by a DHB. A model of potential CR utilisation with a home-based CR programme was created and this was used to calculate programme completion, hospital readmission rates and total programme costs.*

***Results:** Using current participation, completion and cost data from two DHBs a cohort of 1,000 MI survivors would lead to 136 people completing the hospital-based CR programme along with 498 readmissions to hospital in the 12 months following discharge. Adding a home-based programme would lead to 543 people completing CR along with 461 readmissions. Total costs would be similar to current levels of \$2.8M per year. Home-based CR could lead to an additional 407 people completing CR per year along with 37 fewer readmissions to hospital. Cost-utility estimates for home-based CR ranged from \$7,000/QALY to \$19,000/QALY while cost-effectiveness was estimated at \$2,500/YLS. Barriers to attending hospital-based CR are greater for those in low socioeconomic groups; home-based CR can reduce these barriers and will likely to lead to greater participation by Māori and Pacific Peoples in this country – two groups who are currently underrepresented.*

***Conclusion:** CR participation and completion rates could be significantly increased by augmenting hospital-based CR with home-based CR. This would not cause a significant change to total programme costs as the costs of greater participation are offset by fewer*

*hospital readmissions. An RCT should be conducted in one District Health Board in New Zealand to measure the effects of home-based CR on participation, completion, hospital readmissions, quality of life, and programme costs. In addition, CR utilisation by underserved groups such as Māori and Pacific Peoples should be examined. DHBs in New Zealand should improve the data collection capacity in CR units and regularly monitor rates of referral, completion, and programme costs.*

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# Table of Contents

Abstract.....	ii
Acknowledgements.....	iv
List of Abbreviations .....	vii
List of Figures .....	viii
List of Tables .....	ix
Chapter 1. Introduction .....	1
Chapter 2. Cardiac Rehabilitation Programmes.....	4
2.1. Hospital-Based Cardiac Rehabilitation.....	7
2.2. Home-Based Cardiac Rehabilitation .....	8
2.3. Participation in Cardiac Rehabilitation .....	10
Chapter 3. Literature Review Methodology .....	12
3.1. Literature Review Aims .....	12
3.2. Search Strategy .....	13
3.3. Search Terms and Inclusion Criteria .....	15
3.4. Quality Assessment.....	16
3.5. Methods Used in Primary Research.....	18
3.6. Procedures for Reporting Participation and Financial Values .....	19
Chapter 4. Literature Review Results.....	21
4.1. Participation Rates .....	21
4.2. Home-based vs. Hospital-based Effects on Participation and Completion .....	25
4.3. Economic Analyses.....	27
4.4. Discussion.....	30
4.4.1. Costs.....	31
4.4.2. Costs Averted .....	32
4.5. Results Compared with Predictions and Prior Assertions.....	32
Chapter 5. Data Analysis Results.....	35
5.1. Baseline CR Characteristics in New Zealand .....	35
5.1.1. Published Participation Rates for Hospital-Based CR .....	35
5.1.2. Participation Rates from DHB-Supplied Data .....	39
5.1.3. CR Completion Rates from Published Data.....	41

5.1.3.1. Completion Rates from DHB-Supplied Data .....	41
5.1.4. Costs of Hospital-Based CR .....	42
5.1.5. Costs of Home-Based CR.....	43
5.1.6. Costs of Readmission to Hospital.....	45
5.2. Potential Participation and Completion with a Home-Based CR Programme .....	49
5.2.1. Potential Participation Rates .....	49
5.2.2. Potential Completion Rates .....	50
5.2.3. Readmission Rates for Hospital and Home-Based Programmes .....	51
5.3. Cost Calculations for Hospital-Based and Home-Based CR Programmes .....	52
5.3.1. Offering Conventional Hospital Based CR.....	53
5.3.2. Offering Hospital-Based CR and Home-Based CR .....	54
5.4. Sensitivity Analyses .....	60
5.5. Benefits of Increased Participation in CR.....	62
5.5.1. Potential Financial, Utility, and Effectiveness Benefits.....	63
Chapter 6. Discussion.....	66
References.....	76

## List of Abbreviations

ADHB	Auckland District Health Board
CABG	Coronary artery bypass graft
CHF	Congestive heart failure
CMDHB	Counties-Manukau District Health Board
CR	Cardiac rehabilitation
DHB	District Health Board
ED	Emergency Department
GP	General practice or General Practitioner
HGA	Heart Guide New Zealand
ICD	International Classification of Disease
LOS	Length of Stay
MI	Myocardial infarction
NDHB	Northland District Health Board
NHF	National Heart Foundation of New Zealand
NZDep	New Zealand Deprivation Index 2006
PTCA	Percutaneous transluminal coronary angioplasty
RCT	Randomised controlled trial
QALY	Quality adjusted life years
THMM	Te Hotu Manawa Māori
UK	United Kingdom
USA	United States of America
WDHB	Waitemata District Health Board
YLS	Years of life saved

## List of Figures

Figure 1. Sequence of cardiac rehabilitation in New Zealand hospitals.....	6
Figure 2. Sample timeline of cardiac rehabilitation events.(7).....	9
Figure 3. Overall participation and completion in cardiac rehabilitation in New Zealand. Reproduced from Doolan-Noble, 2003.(15).....	37
Figure 4. Comparison of readmission costs from DHB 2 for those who complete a CR programme and those who do not.....	47
Figure 5. Comparison of readmission costs from DHB 2 for those who complete a CR programme and those who do not.....	48
Figure 6. Decision tree model for conventional hospital-based cardiac rehabilitation.....	54
Figure 7. Decision tree model for hospital-based CR augmented by home-based CR.....	58

## List of Tables

Table 1 List of internet sites searched.....	14
Table 2 Inclusion criteria .....	16
Table 3 SIGN grading system for evaluating study quality(11) .....	17
Table 4 Drummond’s abbreviated evaluation criteria .....	17
Table 5 Coding fields used for articles .....	19
Table 6 Sample data comparing reporting methods for CR participation .....	20
Table 7 Summary of participation rates for CR from selected literature.....	21
Table 9 Participation and completion rates for studies comparing hospital and home-based CR programmes .....	26
Table 10 Summary of CR costs from selected studies .....	28
Table 11 Hospital-based CR participation rates among all MI survivors from two DHBs during a 6 month period.....	40
Table 12 CR programme completion rates for selected categories of MI survivors .....	42
Table 13 Summary of data and source for conventional hospital-based CR calculations.....	53
Table 14 Decision tree data for home-based CR augmenting a hospital-based programme ...	56
Table 15 CR programme completion rates for selected categories of MI survivors .....	60
Table 16 CR programme completion rates for selected categories of MI survivors .....	61

## Chapter 1. Introduction

Cardiovascular disease is a significant health problem throughout the western world. In Canada, the United States, and Australia cardiovascular disease is the largest contributor to mortality.<sup>(1)</sup> In New Zealand, cardiovascular disease remains one of the leading causes of death, accounting for 40% of all deaths in 2001<sup>(2)</sup>. Additionally, coronary heart disease (CHD) is by far the greatest single cause of death accounting for 23% of all deaths in 2001.<sup>(2)</sup> CVD covers a vast array of conditions affecting the heart, vascular system, along with the brain and other organs. Common conditions resulting from CVD include stroke, ischemic heart disease, and congestive heart failure.<sup>(1)</sup>

Cardiovascular disease causes premature death, suffering and disability, compromises quality of life and often disrupts employment and other activities; the emotional, social and financial costs are high. The New Zealand Health Strategy developed by the Ministry of Health<sup>(3)</sup> prioritises the management of cardiovascular disease in its key population-health objectives. Cardiovascular disease is estimated to account for 11% of the total non-fatal disease burden and for 24% of the total disability-adjusted life years (DALYs) lost by the total population in 1996.<sup>(2)</sup>

Cardiac rehabilitation is a secondary prevention approach aimed at reducing the impact of CVD among those who have the condition. CR has been defined as:

“...coordinated, multifaceted interventions designed to optimize a cardiac patient’s physical, psychological, and social functioning, in addition to stabilizing, slowing, or even reversing the progression of the underlying atherosclerotic processes, thereby reducing morbidity and mortality”.(4)

CR has multiple clinical benefits but until recently in New Zealand, cardiac rehabilitation was provided only in the hospital setting, either during admission (Phase 1), in the immediate 6 to 12 weeks after discharge (Phase 2), or in a long-term community maintenance capacity (Phase 3).(5) Lately, some sites in the country have considered implementing home-based CR programmes in an effort to address the low rates of CR uptake associated with hospital-based programmes. In addition to measuring the clinical impact of these pilot programmes it is important that their financial impact is evaluated also.(6)

Compared with the clinical benefits, the economic impact of CR is less well understood. Few high quality studies have been published which analyse the cost-effectiveness of CR or compare hospital and home-based programmes. While data from early economic studies provided positive economic support for CR,(7-9) a lack of randomisation has confounded the quality of these results. A recent systematic review noted the limited number of published studies available, along with large variation in the resulting cost effectiveness measures between studies.(10) As healthcare expenditure continues to increase in Western countries in parallel with an ageing population, the need for high quality economic data in resource allocation decisions will continue to grow.(6)

This dissertation estimates the increased participation in CR possible through the introduction of a home-based CR programme along with the possible cost associated with such a programme. A home-based CR programme is suggested in order to increase participation in CR so that the well established clinical benefits of CR can be experienced by more people, particularly those at the highest risk of CVD. The dissertation sought to gather CR participation data from the international literature and compare it with participation data from New Zealand. Estimates of the potential gain in participation and completion could then be calculated along with cost estimates from local cost data. This work provides an indication to health funders and providers in New Zealand of the potential impact on CR participation that a home-based CR programme may have, along with the possible costs which may be incurred. The results of this study may be useful with future resource and programme selection decisions.

The remainder of the dissertation is structured as follows. *Chapter Two* delves deeper into the morbidity and mortality impacts of cardiovascular disease in New Zealand and gives greater background to the role of cardiac rehabilitation in the context of secondary prevention. This chapter also presents the similarities and differences between hospital and home-based CR along with the clinical and economic benefits that are possible with these programmes. *Chapter Three* contains the methodology used to identify, screen, and analyse information for the literature review, while *Chapter Four* presents the outcomes of the literature review. *Chapter Five* describes the data analysis results. *Chapter Six* discusses the participation, completion, and financial impact of the home-based CR programme. The dissertation concludes with recommendations for CR delivery in New Zealand based on the research findings in this study.

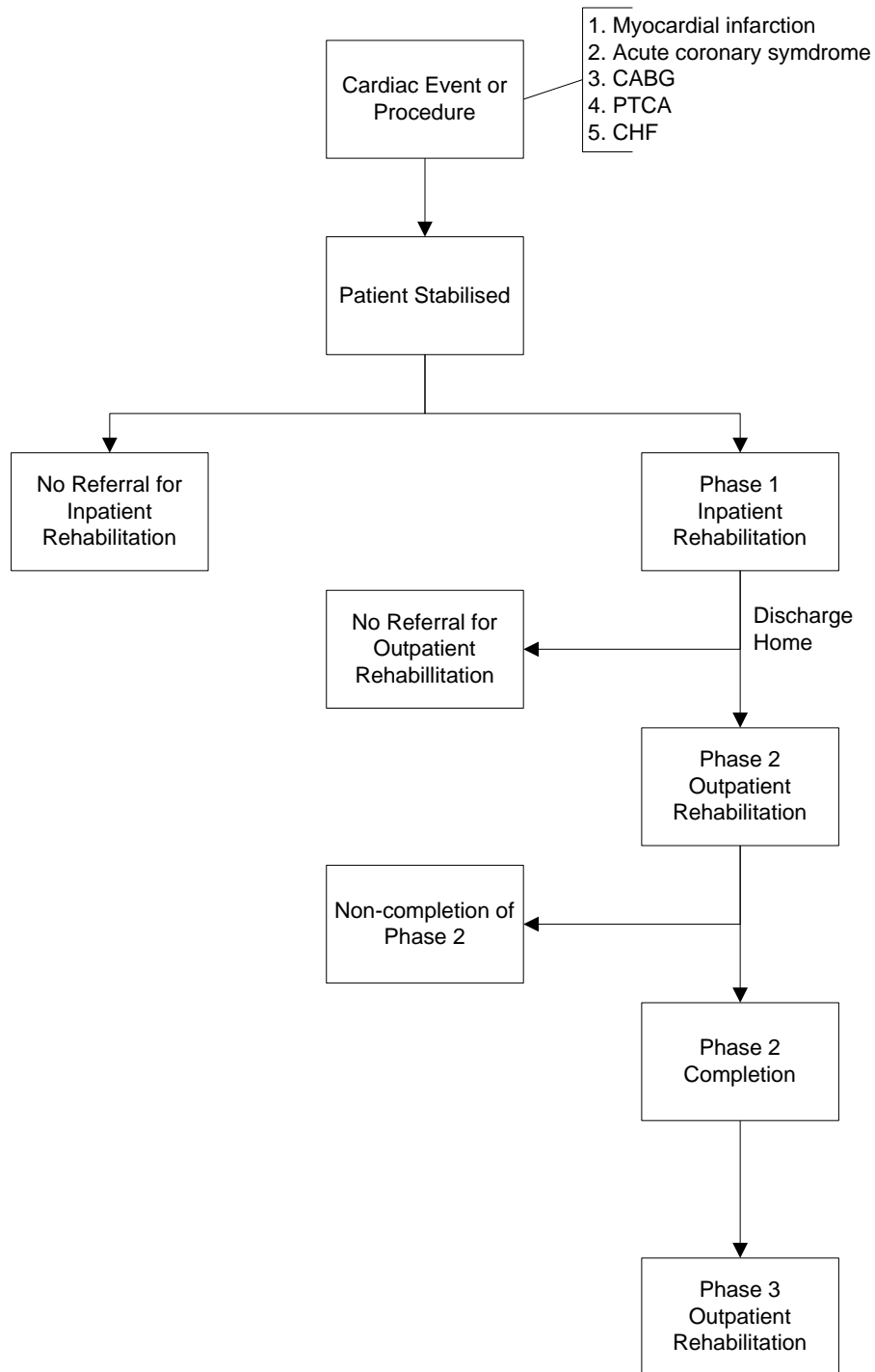
## **Chapter 2. Cardiac Rehabilitation Programmes**

Cardiac rehabilitation programmes have evolved in structure during the twentieth century. Initially, those who had suffered a MI were managed by bed rest for 6 weeks in an effort to relieve the healing heart of any undue stress. However, in the 1930s and 1940s it was observed that those who mobilised to the extent of sitting in a chair had better health outcomes. By the 1950s brief episodes of daily exercise lasting no more than 10 minutes were advised.(11) Hellerstein consolidated a multidisciplinary approach to CR in the 1960s, advocating exercise combined with psychological support, education, and risk factor reduction.(12) There is now consensus that cardiac rehabilitation should have a comprehensive approach, empowering the patient to make life long changes related to physical activity levels and improving compliance with pharmacotherapy.(12) Additionally, education should be provided about nutrition and smoking cessation, effective management of psychosocial issues, and ongoing personal follow up and support should be provided (13)

Cardiac rehabilitation after a myocardial infarction has secondary preventative effects on mortality and morbidity. Two meta-analyses (14)(9) have reported a significant reduction in total mortality (20-25%, C.I. 0.75-0.78), and a 20% reduction in cardiovascular mortality in patients who took part. A more recent systematic review (15) concluded that cardiac rehabilitation can promote recovery, enable patients to achieve and maintain better health and reduce the risk of death in people who have heart disease. Cardiac rehabilitation has been shown to improve prognosis and function for people following acute myocardial infarction, before and after revascularisation procedures (e.g. PTCA CABG), for those with stable

angina or heart failure (CHF), and after other specialised interventions such as cardiac transplant. (7, 16-20)

Cardiac rehabilitation may be carried out either as a hospital-based or home-based programme. Hospital-based programmes have been the traditional method of delivery until relatively recently. These two modalities are described in more detail below but CR generally has a three phase structure; Phase I CR involves inpatient education on risk factor reduction, exercise, and nutrition. Typically this information is provided by a hospital or nurse or other relevant staff members. Phase II involves referral to an outpatient programme in the 6-10 weeks following discharge from hospital. Phase II programmes may be based in the hospital or in a person's home.(21) Phase III CR involves regular long-term follow-up and education for months or years. For example, monthly meetings may be held where ongoing risk reduction and exercise are discussed. These Phases are illustrated below.



**Figure 1. Sequence of cardiac rehabilitation in New Zealand hospitals.**

## **2.1. Hospital-Based Cardiac Rehabilitation**

Hospital-based CR programmes are the dominant service option in New Zealand.(5) These programmes are usually made up of common core topics dealing with risk factor reduction, education, and activity. Typically hospital-based programmes begin once an individual is discharged from hospital following an acute cardiovascular event such as a myocardial infarction. Participants usually return to the hospital for scheduled weekly visits over six to twelve weeks, where the rehabilitation programme is delivered in 1-2 hour group sessions involving multidisciplinary contributions from cardiac nurses, physiotherapists, nutritionists, and cardiac specialists.(5, 22)

Each of the 41 centres offering Phase 1 and 2 rehabilitation differs in the format of the service, facilities, equipment, duration of the programmes, and the number of sessions available.(13) For example, an audit of the nutritional component of all formal phase 2 cardiac rehabilitation programmes showed that total time spent on nutritional education varied from 15 minutes to nine hours.(13) Hospital-based CR programmes are usually delivered during weekdays and business hours, and sessions are provided during specific blocks such as morning or afternoon. Consequently, hospital-based programmes offer limited flexibility.

## **2.2. Home-Based Cardiac Rehabilitation**

Home-based CR is a relatively new development both internationally and in New Zealand.

The approach gained traction in the 1990s in the UK culminating in the development of a home-based programme named *The Heart Guide*,<sup>(21)</sup> after research identified the barriers to participation associated with hospital-based CR. These obstacles include the need for transport to hospital, difficulty with parking and personal mobility, and time away from work.<sup>(16, 23, 24)</sup> Home-based CR addresses these issues through home visits and telephone calls provided by a nurse over a six to twelve week time period. The conventional contact plan for a client using *The Heart Guide* is illustrated below.

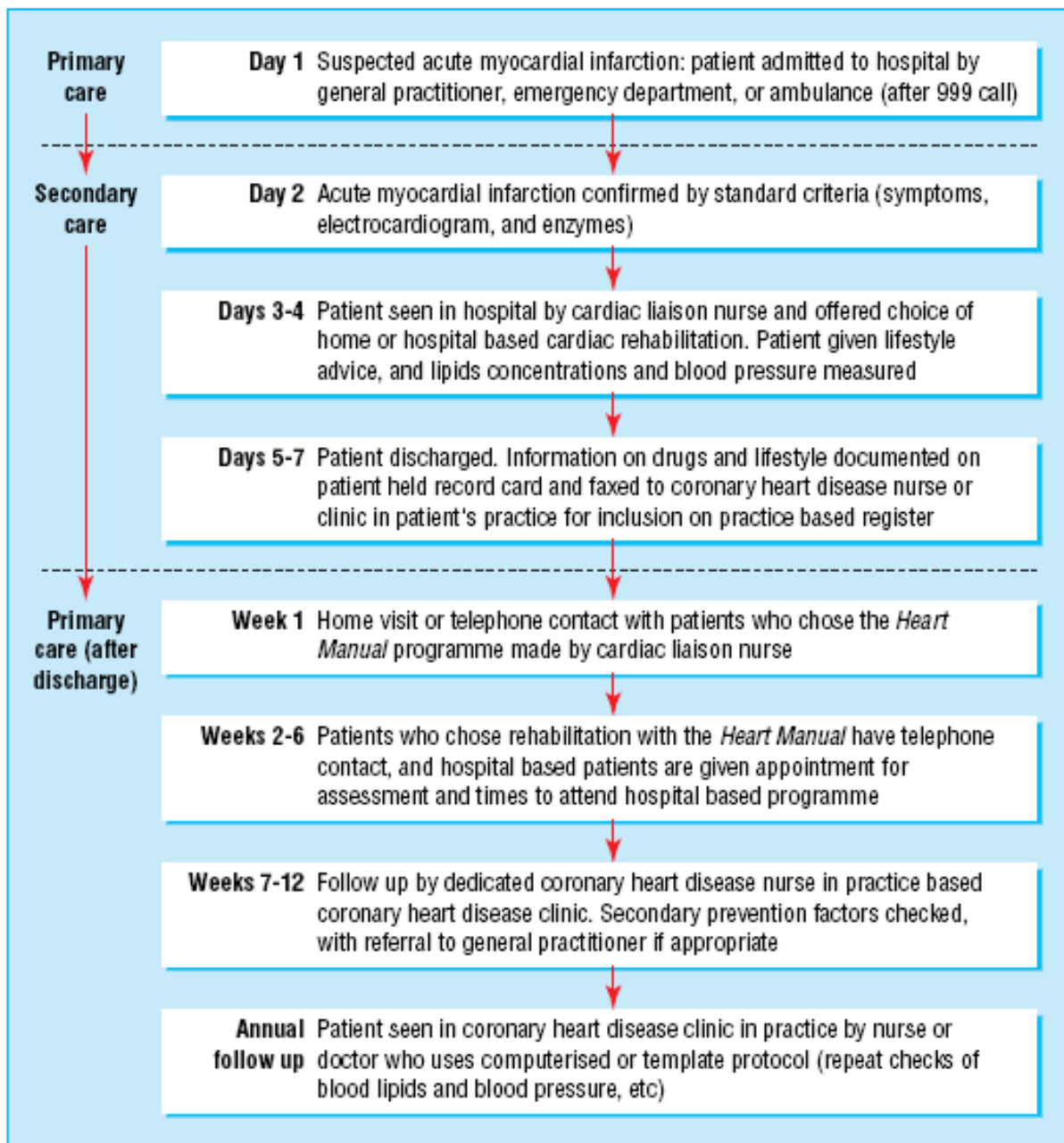


Figure 2. Sample timeline of cardiac rehabilitation events.(25)

Published clinical and economic evaluations of home-based programmes have only occurred recently but research indicates that home-based programmes produce the same clinical outcomes as hospital-based programmes, and may lead to greater overall participation and completion of CR.(10, 26-28) Today, approximately 20% of MI survivors in the UK who participate in CR do so through a home-based CR programme.(29).

### **2.3. Participation in Cardiac Rehabilitation**

Despite proven clinical benefits, participation in CR has been surprisingly low in western countries. At a time of escalating health care technology and costs, CR provides a technically simple and low cost approach to secondary prevention of cardiovascular disease; one recent study ranked CR second only to smoking cessation in cost-effectiveness after an MI.

Typically CR has been provided from a hospital base, with participants using the service after discharge from hospital. In recent times however, hospital-based CR has been augmented by home-based programmes in an effort to address the obstacles created with hospital delivery. Research indicates that similar clinical outcomes result from the two programmes, but that higher overall participation and completion rates may be possible with a home-based programme.

Currently in New Zealand only 36% of eligible patients are being referred to cardiac rehabilitation teams.<sup>(5)</sup> Attendance figures vary by DHB and though these have not been published some overall trends are apparent; older adults, women and those people with a diagnosis of heart failure are less likely to receive a referral. (5, 16, 30, 31) Lacking access to transport was significantly negatively related to attendance at phase 2 (outpatient cardiac rehabilitation programme) and completion of the programme was negatively associated with being under 65 years or over 75 years and belonging to the middle deprivation quintiles, quintiles 3 and 4. (5) There was insufficient sample size in Doolan-Noble's study to identify an association with ethnicity; however, there was a high correlation between deprivation and non-attendance.<sup>(5)</sup> Clearly the present model of delivery is only meeting the needs of a small proportion of eligible people.

New Zealand's rates of CR referral are consistent with international levels. A recent systematic review of referral rates and their determinants found an average of 34% of eligible candidates were referred to CR; rates as low as 10% and as high as 60% were observed with referral rates highest in centres with an automatic referral process for all eligible candidates. Predictors of high CR referral included male gender, age 45-59 years, residing in an urban area, MI survivor, previous participation in CR, and being admitted to a hospital which provided CR. It is unclear why referral to CR is not offered to every eligible person in New Zealand; none of the 41 CR centres reviewed by Doolan-Noble had an automatic referral mechanism in place. At present, referral decisions are made subjectively and are at the discretion of clinical staff.

The barriers to referral in New Zealand could be reduced through several means. First, an automatic referral system could be implemented which refers all those meeting certain diagnostic codes. Those who could not complete a program could then be screened by CR referral staff. Additionally, specific criteria could be developed which provide guidelines for screening candidates; this approach would help to reduce the subjective judgements made at present which are impacting attendance by women, older people, those in rural areas, and those in high deprivation groups. Next, a specific staff position could be identified which is responsible for reviewing and auditing the efficiency of the referral pathway. This would ensure regular feedback on the success of the referral pathway and provide direction for improvements to the system. Finally, a home-based CR programme could help to overcome barriers to participation by rural residents. Overall the goal would be to develop a systems-driven referral process rather than a personality-driven process which currently exists.

## **Chapter 3. Literature Review Methodology**

### **3.1. Literature Review Aims**

The literature review aimed firstly to determine the rate of CR participation in New Zealand compared with other western countries, followed by the determination of typical costs and savings of CR programmes in New Zealand and internationally. This information contributes to the final section of the dissertation where calculations of the costs and benefits of hospital and home-based CR are performed. Search Structure

The literature search was aimed at answering the following research questions in relation to survivors of MI:

1. What is the rate of participation in CR in New Zealand and other western countries?
2. How does a home-based CR programme affect participation and completion of CR?
3. How cost-effective are hospital-based and home-based CR?

In conjunction with participation and cost data from New Zealand, the literature review provides a model for predicting the potential participatory and economic impacts associated with introducing a home-based CR programme to augment a conventional hospital-based programme.

### **3.2. Search Strategy**

A variety of search tools were used including:

1. Electronic databases
2. Web sites and web-based search engines
3. Reference bibliographies
4. Personal contact

Within the electronic databases emphasis was placed on searching Medline and Pubmed for full-text or abstracts of articles from peer-reviewed journals relating to CR participation rates and programme costs. In total, the search strategy involved an analysis of review, full-text and bibliographic databases. Review databases included the Cochrane Collaboration, and Campbell Collaboration. Bibliographic databases included Medline, Pubmed, CINAHL, EMBASE, ECONLIT, and Index New Zealand.

The internet search engine Google Scholar (<http://scholar.google.com>) was used with the terms described in the ‘Search Terms’ section. Other sites that were searched are listed below in Table 1.

**Table 1 List of internet sites searched**

1	Cardiac Rehabilitation Association of New Zealand	<a href="http://www.cranz.co.nz">http://www.cranz.co.nz</a>
2	The British Heart Foundation	<a href="http://www.bhf.org.uk">http://www.bhf.org.uk</a>
3	The National Heart Foundation	<a href="http://www.nhf.org.nz">http://www.nhf.org.nz</a>
4	The American Heart Association	<a href="http://www.americanheart.org">http://www.americanheart.org</a>
5	New Zealand Ministry of Health	<a href="http://www.moh.govt.nz">http://www.moh.govt.nz</a>
6	World Health Organization	<a href="http://www.who.int/en">http://www.who.int/en</a>
7	New Zealand Health Information Service	<a href="http://www.nzhis.govt.nz">http://www.nzhis.govt.nz</a>
8	The Heart Manual	<a href="http://www.theheartmanual.com">http://www.theheartmanual.com</a>

As literature was reviewed from the database and internet search, a list of relevant articles was also created from their associated bibliography sections. Relevant journals included The Journal of Cardiopulmonary Rehabilitation, Journal of the American College of Cardiology, Journal of Public Health, International Journal of Cardiology, Circulation, The New Zealand Medical Journal, and The Medical Journal of Australia.

Personal contact was made with prominent research leaders who were identified during the literature search. Requests for assistance and direction toward relevant literature were made to the following people:

1. Professor Robert Lewin – Professor of Rehabilitation, University of York, England.
2. Professor Philip Ades – University of Vermont College of Medicine, United States of America.
3. Professor Neil Oldridge – Professor of Medicine, Comprehensive Cardiovascular Care Group, University of Wisconsin School of Medicine and Public Health, United States of America.

A conical approach was used to narrow the search for relevant literature from very broad sources (large electronic databases such as Medline and Pubmed) to a focal point provided by expert opinion on additional literature or unpublished studies. This approach provided a balance of older and more recent or unpublished work.

### **3.3. Search Terms and Inclusion Criteria**

Similar search terms were used to search bibliographic databases and web sites. Free text word searches included the following terms either individually or with AND/OR/NOT operators: cardiac rehabilitation, referral, attendance, participation, completion, rate, cost, price, cost-effectiveness, cost-benefit, efficiency, comparison, economic evaluation.

Initially, review articles and systematic reviews were sought, with subsequent broadening of the search criteria to individual studies.

All relevant literature published between 1980 and 2008 was included in this analysis.

Inclusion criteria were selected with the aim of prioritising peer-reviewed literature, particularly those with large sample populations in RCTs with specific cost criteria stated. Information not meeting inclusion criteria was excluded. Inclusion criteria are listed below in the table below.

**Table 2 Inclusion criteria**

Question 1 and 2 (from Section 3.1)	Question 3(from Section 3.1)
<ol style="list-style-type: none"><li>1. English language</li><li>2. Publication date after 1980</li><li>3. Peer-reviewed publication or other reliable source</li><li>4. CR eligibility criteria explicit</li><li>5. Publication specifies if one or more of referral, attendance, participation or completion is measured.</li><li>6. Study population is clearly defined (sample size, location, age)</li><li>7. If a journal article, the full-text article was available</li></ol>	<ol style="list-style-type: none"><li>1. English language</li><li>2. Publication date after 1980</li><li>3. Peer-reviewed publication or other reliable source.</li><li>4. Cost components are explicit.</li><li>5. Costing process is explicit.</li><li>6. Economic benefits are clearly described.</li><li>7. The use of nominal or real values is explicit.</li><li>8. The full-text article was available.</li></ol>

### **3.4. Quality Assessment**

The quality of information gained for the literature review was assessed using two grading methods including the Scottish Intercollegiate Guidelines Network (SIGN) scale,(32) and Drummond’s ‘Checklist for Assessing Economic Evaluations’.(6) The paucity of economic evaluation literature available for CR in general and home-based CR in particular meant that a relatively lenient SIGN threshold of 2- and above was used (see Table 3).

**Table 3 SIGN grading system for evaluating study quality(32)**

Levels of Evidence	
1++	High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias.
1+	Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias.
1-	Meta-analyses, systematic reviews, or RCTs with a high risk of bias.
2++	High quality systematic reviews of case control or cohort or studies. High quality case control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal.
2+	Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal.
2-	Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal.
3	Non-analytic studies, e.g. case reports, case series.
4	Expert opinion.

Individual studies which focused solely on economic evaluation of CR were assessed against Drummond's 'Checklist for Assessing Economic Evaluations'.(6) Where a study did not comply with at least 50% of the 10 checklist items listed below it was discarded from further analysis in the literature search.

**Table 4 Drummond's abbreviated evaluation criteria**

1	Was a well-defined question posed in answerable form?
2	Was a comprehensive description of the competing alternatives given?
3	Was the effectiveness of the programmes or service established?
4	Were all the important and relevant costs and consequences for each alternative identified?
5	Were costs and consequences measured accurately in appropriate physical units?
6	Were costs and consequences valued credibly?
7	Were costs and consequences adjusted for differential timing?
8	Was an incremental analysis of costs and consequences of alternatives performed?
9	Was allowance made for uncertainty in the estimates of costs and consequences?
10	Did the presentation and discussion of study results include all issues of concern to users?

### **3.5. Methods Used in Primary Research**

Three main methods were observed in the literature on CR participation. Firstly, a retrospective cohort approach was taken whereby all those meeting specific ICD admission codes during a predetermined period were analysed for CR participation. The second approach used in studies involved a real-time cohort approach which actively followed those with cardiovascular disease who were admitted to hospital and subsequently referred to CR. A third method involved a review or audit of surveillance and monitoring data from CR centres (5, 17, 33). The cost of CR was commonly determined by survey responses from centres offering CR. Although the length of CR programmes varied in different centres, costs were typically derived from 6-12 week programmes providing up to 36 rehabilitation sessions.(7)

The benefits of CR may be numerous depending on the perspective taken. This dissertation has assumed the perspective of a DHB and therefore excludes the costs and benefits incurred by a health consumer, primary care costs and total societal costs. Studies used in this dissertation involved those which measured the economic benefit of CR in terms of averted secondary care costs such as ED presentations, rehospitalisation and subsequent interventions such as pacemaker placement or bypass grafting. The economic benefits of CR were derived from either observational studies or randomised trials comparing those who participated in CR with those who did not.

A total of 17 articles describing CR participation and 12 providing economic analysis were reviewed and coded. The coding fields are summarised in Table 4.

**Table 5 Coding fields used for articles**

General Information	Report Identification, Author, Title, Source, Date Published, Search Strategy, SIGN grade, Study Setting, Geographic location
Participant Information	Study size for (1) Intervention group and (2) Control group, Eligibility criteria, Exclusion criteria, Ethnicity, Age, SES status, Pre-existing cardiac conditions
Methodology	Study design, Study duration, CR variable measured (e.g. eligibility, referral, participation, attendance, completion), Nominal or real values used, Costing methodology described (Y/N),
Outcomes	Participation (or other) rate, Cost of CR (Total, Programme, Per person, Per session), Averted costs (Total, \$ / YLS, Averted hospitalisation, Averted ED presentation, Averted intervention)

### **3.6. Procedures for Reporting Participation and Financial Values**

Rates of CR usage were reported in various ways in the literature. Reported rates were found to relate to either the percentage referred, enrolled, attending, participating in, or completing CR. “Attending” and “participating” were used synonymously in the literature. Participation rate has been used in this dissertation to describe the percentage of candidates who have been referred to a CR programme and have attended one or more sessions, out of the total cohort eligible for referral.

Analysis revealed that several studies reported participation rates as a percentage of those “referred” rather than of those “eligible”. This convention overestimates the level of CR when compared with calculations of those eligible as described below.

**Table 6 Sample data comparing reporting methods for CR participation**

	CVD patients	Eligible	Referred	Participate	Calculation	Participation Rate
“Percentage of referrals” method	150	100	50	25	25 / 50	50 %
“Percentage of eligible” method	150	100	50	25	25 / 100	25 %

Where the participation rate of those referred has been given in a study, the participation rate of those “eligible” has been calculated manually to enable comparison between studies and countries. Although this calculation introduces systematic error, it does provide a means of comparing studies on a similar index. Due to the challenges of comparing currencies across various time periods, financial values are given in nominal terms. No currency or inflation adjustments to 2008 values have been attempted.

## Chapter 4. Literature Review Results

### 4.1. Participation Rates

In total, 17 articles were reviewed which described CR participation rates, including two from New Zealand. Twelve of the articles met the search and inclusion criteria. Participation rates were derived directly and indirectly from the literature (see Table 7) (\* indicates study measured those ‘referred’, all other studies measured ‘participation’).

**Table 7 Summary of participation rates for CR from selected literature**

Primary Author	Year	Location	Participation Rates (%)				
			Overall	MI	CABG	PTCA	Angina
King(34)	1999	Canada	28.4				
Goto(35)	2003	Japan		21.0			
Doolan-Noble(5)	2004	New Zealand	15.9				
Parks(22)	2000	New Zealand	17.2				
Scott*(36)	2003	Australia	29.0				
Bethell(33)	2006	UK	28.5	25.0	75.0	20.0	
Ayala(37)	2003	USA		29.5			
Evenson(38)	1998	USA		47.0	59.0	43.0	21.0
Thompson*(29)	2001	USA	15.0				
Witt(39)	2004	USA		55.0			
Witt(40)	2005	USA		29.5			
Bunker(41)	1999	Australia	32.0	27.2	53.1	10.3	21.0

CR participation rates in New Zealand were available from only two studies. These were both conducted within the last 10 years with one being a national audit of the majority of CR centres in the country (30 out of a total of 38 sites). Similarly, a national estimate was derived from a review in the United Kingdom. Multi-centre participation rates were also obtained for Japan, the United States of America (USA), and Australia. . Multi-centre participation rates were also obtained for Japan(35), the USA(24, 39), and Australia.(41) Several studies gave participation rates for various conditions such as heart failure, PTCA, and CABG. A focus on overall participation rates has been attempted rather than participation by individual conditions.

Participation rates in New Zealand were found to be 15.9% and 17.3% from the 1999 and 2004 studies respectively. These rates are at the low end of measured referral across the studies selected and only Thompson's 15% referral rate was similar.(29) Overall, participation rates ranged from 15.9% in New Zealand(5) to 32% in Australia.(41) The New Zealand study of multiple CR centres has not been repeated, unlike the United Kingdom where monitoring is conducted on a two yearly basis.(33)

Significant variation in the level of participation for MI survivors was noted. Participation ranged from a low of 21%(35) in Japan to a high of 55%(39) in the United States demonstrated by Witt in 2004. Witt's 2005 study(24) revealed significantly lower rates of CR participation of 29%. The considerable difference was hypothesised to be due to low levels of private insurance coverage among the population used in the 2005 study.(24)

Only one of the two New Zealand studies permitted calculation of CR participation for MI survivors.(5) Through discussion with the study's lead author a CR participation rate of 49% for MI survivors was established. This rate compares favourably with results from the United States and places New Zealand higher than Australia, Japan, and the UK. However, results from single studies are prone to variation and should be viewed with caution. Additional research would help to clarify the level of CR participation by MI survivors in New Zealand.

The studies reviewed here tend to measure participation rates at a fixed point in time. Participation may have changed over time (as seen in the United Kingdom estimates) such that participation may be higher or lower if measured again.(33) Additionally, a country may trend towards particular types of care, with a long-serving programme such as CR overlooked for more modern sophisticated interventions. Because of the paucity of studies estimating national participation rates, the levels of participation listed here should be open to revision when larger and more representative data become available.

Although these studies represent a collection of data from different countries and times they are all likely to be affected by common factors. Generally women are far less likely to participate in CR than men, as are those over the age of 65 or those from ethnic minorities.(5, 24, 39) In contrast, males under the age of 65 are most likely to attend CR.(5, 31) Additionally those who have had an MI or undergone percutaneous transluminal coronary angioplasty (PTCA) or a coronary artery bypass graft (CABG) are more likely to attend CR.(5){Jackson,2005) Based on a review of multiple studies, Witt(24) categorised the factors affecting participation into four different groups; patient oriented, provider oriented, systems oriented, and society oriented. These are summarised below along with potential solutions for

these barriers. Home-based CR is frequently cited as a solution to various barriers to participation (see Table 8).

**Table 8 CR participation barriers and potential solutions (Reproduced from Witt, 2005 (24))**

<b>Barrier</b>	<b>Solution</b>
<b>Patient Oriented</b>	
Geography	Increase number of CR sites Provide home-based CR
Age, gender, race	Patient education
Revascularisation	Enhanced insurance coverage
Financial issues (includes lack of insurance, employment, low socioeconomic status)	Cost reduction measures Subsidisation measures
Lack of motivation	Patient education
Anxiety, depression	Disease treatment (pharmacological and/or psychological)
Comorbid diseases	Programme modification to enhance ease of participation Broaden range of activities offered Provide home-based CR
<b>Provider Oriented</b>	
Specialty, lack of referral	Educate physicians Increase CR programme visibility
<b>Systems Oriented</b>	
Scheduling interfering with activities of daily living	Broader schedules Modify offered times based on patient preference Home-based CR
Dislike of CR programme format	Increase activity choices offered Modify offered times based on patient preference
Poor adherence	Reminders Case management strategies
CR scaled back/cut due to budget constraints	Home-based CR
Increasing co-pays for preventive services	Patient education regarding importance Measures to cut costs or subsidise CR
Lack of CR as healthcare quality measure	Lobby government organisations
<b>Society Oriented</b>	
Diet and lifestyle trends	Patient education Community-based incentive programmes

## **4.2. Home-based vs. Hospital-based Effects on Participation and Completion**

A total of 16 articles comparing home-based CR with hospital-based CR were found.(20, 21, 25, 27, 28, 42-52) Of these, 12 involved a comprehensive home-based CR programme as opposed to a programme comprising only exercise or psychosocial elements. Eight of the 12 studies focussed on MI survivors, and only two of the remaining eight studies contained adequate detail on programme adherence and completion.(25, 26)

Articles were found through either bibliographic databases or a review of relevant references involved in a systematic review published by Jolly in 2006.(28) The final two articles were all published after 2002. One of the two articles related to a randomised controlled trial comparing hospital and home-based CR (Cornwall Heart Attack Rehabilitation Management (CHARMS) study).(27) Another recent RCT which was not included because of insufficient participation and completion data did investigate specific reasons for non-completion of CR and these are discussed below.(26) The second of the two selected articles was an audit of MI survivors using either hospital-based CR or the Heart Manual in the UK.(25)

Dalal's 2003{Dalal,2003} study provided the most detail on programme participation and completion rates as shown in Table 9. During the 12 month audit a total of 106 MI survivors took part in the study with 33% choosing hospital-based CR and 44% selecting home-based CR. 87% of home-based participants completed the programme while only 49% of hospital-based participants attained programme completion. Dalal's later study involved an RCT comparing hospital and home-based CR and reported in separate papers detailing clinical

outcomes and cost-effectiveness.(27) A total of 72 participants were randomised in the study with 32 assigned to hospital-based CR and 40 in the home-based CR group. 73% of the home-based group completed the CR programme while another 75% of those in the home-based preference arm of the study completed the programme (see Table 9).

**Table 9 Participation and completion rates for studies comparing hospital and home-based CR programmes**

Study	Design	Participants	Hospital-based CR		Home-based CR	
			Participation	Completion	Participation	Completion
Dalal (2003)	Audit	106	35 (33%)	17 (49%)	47 (44%)	41 (87%)
Dalal (2007)	RCT	104 (45%)	32 (44%)	Not reported	40 (56%)	29 (73%)
	Preference arm	126 (55%)	47 (48%)	Not reported	51 ((52%)	38 (75%)

The reasons for non-completion of home-based CR programmes were unclear. Reasons for non-completion of hospital-based CR programmes have been investigated by several researchers with drop-out rates commonly in the 20-50% range. (16, 23, 28, 53, 54) Common factors predicting adherence to a CR programme include 1) a hospital physician's endorsement of a CR programme and the physician's attitude toward the effectiveness of the programme, 2) physical accessibility of the programme, 3) access to transportation, 4) high participant self-efficacy, 5) high social support, 6) high socioeconomic status, and 7) high education. Strong predictors of non-completion include 1) distance to the programme, 2) lack of an insurance programme which pays for CR. Also, women and those with multiple comorbidities were less likely to complete a CR programme. (24, 54)

Jolly's RCT(26) found that reasons for non-completion were very individualised and were usually based on only one significant factor such as a comorbid condition like arthritis impeding activity. For example, home-based participants of the study who did not complete the programme cited a lack of motivation to exercise alone as a common barrier.

### **4.3. Economic Analyses**

A total of 12 articles describing economic analyses of CR were located. The majority of articles were sourced through database searches, the remainder through the bibliographies of relevant selected articles. Seven articles described the costs of CR in detail. Two of those articles were RCTs which were used to determine the cost-effectiveness of CR compared with no care. Five articles calculated the costs averted when CR is undertaken.

The costs of CR in several western countries are summarised in the table below. All values have been adjusted to reflect 2007 United States dollars using international exchange rates and domestic consumer price indices. No New Zealand studies were found which described the costs of CR or the averted costs which could be avoided such readmission to hospital. Listed costs are averages for all those participating in a programme. Studies which only described costs for a single condition (e.g. MI) were omitted. Net incremental cost refers to the total cost above the cost of providing the CR programme.

**Table 10 Summary of CR costs from selected studies (all values have been converted to 2007 US dollars).**

Author	CR Cost per person	Net Incremental Cost	Country	Cost per QALY	Cost per YLS	Net Averted Costs
Oldridge 1993(9)	1,134	689	USA	13,200	31,280	445
Ades 1997*(11)	3,630	1,214	USA	-	-	2,415
Raftery 2005(26)	2,103	281	UK	2,273	10,262	-483
Ades 1992(7)	-	-	USA	-	1,826	1,092
Briffa 2005*(55)	647	589	Australia	39,658	-	-367
Collins 2001(56)	1,212	-	Australia	-	-	-

\*Study design was an RCT

United States Bureau of Labour Statistics <ftp://ftp.bls.gov/pub/special.requests/cpi/cpiiai.txt>

CR costs ranged from \$647 per person in (55) to US\$3,630.(7) CR was noted to be most expensive in an older United States study at US\$3,630 per person.(7) CR was least expensive in Australia at \$647 per participant.(55) Oldridge gave the most detailed description of CR costs including component costs for a Provider (including overhead, staff, and resource costs), and for a participant.(57)

The costs of CR in these studies are likely to have risen, making comparison with present day costs in New Zealand difficult. Furthermore, the cost of CR between different countries varies greatly due to differing approaches to resourcing taken in different countries. The United States tended to have the highest costs for CR. However, the cost data give a reasonable range for CR costs but the studies give a poor description of detailed component

costs; hence, programmes could not be compared on the basis of component costs. Additionally the duration of CR programmes and the number of visits provided varied greatly (from a low of 16 to a maximum of 36) making comparison difficult.

Although averted costs may be wide-ranging depending on the perspective taken, the article by Ades takes a hospital perspective. (Ades, 1992) Consequently, averted or reduced costs include Emergency Department presentations, admission to hospital, and cardiac interventions such as CABG or PTCA. Because of the perspective taken, averted costs do not include variations in GP utilisation or pharmaceutical consumption.

Other studies have taken a broader view and have estimated the additional productivity (from an earlier return to employment) for the national economy and GDP. (Picard, 1989 #183) The calculations in this dissertation are based on a hospital perspective and the articles reviewed take the same perspective. The averted costs which may result from CR participation were summarised in Table 7. Ades has stated that even when CR participants are re-hospitalised their length of stay (LOS) is shorter and they are less likely to require expensive cardiac interventions or procedures whilst in hospital. (7) Additionally, CR participants return to paid employment faster than non-participants. (58) However, two randomised studies failed to find any net positive economic benefit or significant difference in rehospitalisation costs, LOS, or interventions required when comparing those who had taken part in CR with those who had not. (9) (55)

As with the costs of CR, averted costs are influenced by many factors. First, studies from the United States have advantages of accuracy due to the itemised nature of health insurance billing, but the costs may also be higher as a more defensive form of medicine is practiced in that country. Next, inflation may have increased many of the hospital-related costs listed in the table, although this may be counterbalanced somewhat by a declining trend in LOS. In summary, comparisons of costs and averted costs across different studies are problematic due to changes in costs, inflation, and medical practice across time and between countries but these studies do provide a model for estimating the economic impacts of CR participation using local data from New Zealand.

#### **4.4. Discussion**

The review identified significant differences in CR participation rates in developed countries. This ranged from a high of 32.4% in the UK(33) to levels as low as 15.9% in New Zealand.(5) The UK was the only country to report a replicated time series of CR participation rates and was found to vary between a low of 25% in 1998 and a high of 32.4% in 2000,(17, 33) with participation trending downwards in recent years. In Australia participation rates vary between states and across time. In Victoria participation was found to be 32% in 1999, while in Queensland, participation was 29% in a 2003 study.(36, 55)

In New Zealand, only two studies were published which described CR participation. An Auckland study in 1999 showed participation rates of 17.3% (22) while a more recent national audit indicated overall part rates of 15.9%.(5)

#### **4.4.1. Costs**

There were only a small number of studies describing the costs of CR. Among the studies, a lack of detail was common, however, it was assumed that the cost studies from the United States were likely to be very accurate considering the market model of healthcare provision in that country. Cost studies from the United Kingdom generally gave an overall total for the cost of CR on a programme or per-person basis but did not elaborate on the specific components of a programme. Therefore, the costs listed for the various programmes provide only an approximate comparison; the lack of detailed cost descriptions means that costs may be lower because of lower resource use or contact time. There were no published cost studies for CR using New Zealand data.

#### **4.4.2. Costs Averted**

A limited number of published studies analysed averted costs. Building on previous research, an early study by Ades attributed a lower likelihood of subsequent CVD-related rehospitalisation for those people who had completed a CR programme.(7) Additionally, the study indicated that CR attendees also had a shorter LOS when readmitted to hospital and required fewer medical and surgical interventions (e.g. angioplasty or stent placement). However, the comparison groups were not randomised and differed significantly in age, occupation and other significant confounding factors. A later study by Oldridge which randomised subjects found no difference in the subsequent rehospitalisation and medical/surgical intervention rate between those who had participated in CR and those who had not.(8) More recent randomised studies from other researchers have confirmed a lack of difference in averted hospitalisations and interventions between CR and control groups.(55) There were no published economic studies which examined the potential costs averted from CR using New Zealand data.

#### **4.5. Results Compared with Predictions and Prior Assertions**

It was expected that the rate of CR would be increasing, given the comparatively low cost of CR for relatively high clinical benefit compared with other interventions. (10, 26, 59) In the UK however, CR rates have steadily decreased over the past decade. Unfortunately, the UK was the only country which had published a study of CR participation rates over time.(33) Studies from other countries were a snapshot of CR participation at a single point in time.

Only two studies from New Zealand were available and neither of these were a time series.(5, 22) Each was a snapshot and it was not possible to determine if CR was increasing or decreasing in this country.

The UK time-series review reported a participation rate only one third of that set in the UK's National Service Framework. The two published NZ studies reported CR rates similar to those of the UK study and it is possible that a similar pattern of stagnant or decreasing participation is occurring in this country. The authors of the UK study have speculated on possible reasons for decreasing CR rates. These include the lack of a national plan for CR, the informal unstructured nature of eligibility assessment and referral for CR, and insufficient funding and incentives for purchasers and providers to access or deliver CR.(33)

It was expected that there would be a lower rate of rehospitalisation, complications, and interventions among those who had completed a CR programme. This could provide an overall net positive financial benefit to providers and funders if the costs of CR are low enough and the averted costs high enough. Two randomised studies found no difference in readmission costs, LOS, or intervention rates between those who have completed CR and those who have not.(27, 55) However, differences in readmission rates were observed in those studies. Ades calculated a net saving of CR at US\$739 using a non-randomised sample of participants.(7) However, Oldridge's (60)more rigorous randomised trial found the net cost of CR to be US\$310, with no difference in secondary care utilisation in the first year after a myocardial infarction. Briffa calculated a net cost of A\$395 for CR participation.(55)

The literature review has highlighted the need for reliable time series data to gain an accurate picture of CR participation rates rather than point estimates which are prone to fluctuate. The 2003 multicentre audit of CR in New Zealand(5) provides a good baseline measure of CR rates, and this approach could be used to assess CR rates on an ongoing basis. This would provide the most accurate measure of CR participation and comparison with time series data in other countries.

Additionally, the review emphasised the gap in local economic evaluation of CR. Further research is required to accurately measure the cost of CR in different centres and to determine averted costs exist for CR participants. The rehospitalisation and intervention rate for CR participants should also be determined. If there are no significant averted costs then CR programmes could be assessed on the basis of cost for a given clinical benefit.

## **Chapter 5. Data Analysis Results**

This chapter presents the results of the data analyses. The aim of these analyses is to determine the costs and participation changes after implementing a home-based CR programme with a hypothetical annual cohort of 1000 MI survivors. A four-step approach has been used which firstly involves the determination of current CR participation rates in New Zealand followed secondly by estimates of the potential levels of participation and completion of CR. Third, the costs of a home-based CR programme are presented based on data from the literature review along with local cost estimates provided by a DHB. Fourth, the costs associated with increased participation in CR are calculated, along with potential benefits derived from changes in readmission rates. The analyses take the perspective of a DHB and do not include the costs that are incurred by a CR participant. These would be lower for home-based CR participants as transport and parking costs are not incurred.

### **5.1. Baseline CR Characteristics in New Zealand**

#### **5.1.1. Published Participation Rates for Hospital-Based CR**

As described in the literature review, only two articles describing participation rates in this country have been published. The first article was published in 1999 and summarises CR participation rates at the country's largest hospital.(22) An overall CR participation rate of 17.2% was given but the article did not differentiate CR participation rates by the type of discharge diagnosis. Consequently it was not possible to determine the participation rates for

various discharge diagnoses such as MI, CHF, CABG, or PTCA. Because other studies have shown distinct differences in participation rates for various discharge diagnoses(5) the data from the 1999 article were not used in the decision tree model. However the overall participation rate was compared with Doolan-Noble's 2004 study which provided overall CR participation rates along with participation by discharge diagnosis.(5)

The 2004 study by Doolan-Noble(5) identified an overall referral rate to Phase I CR of 36% in New Zealand, while 83% of those referred to Phase I CR were then referred to Phase II CR. More important, the article also provided a comparison of CR participation rates for various cardiac discharge diagnoses. The study is a collection of voluntary audit data from multiple CR sites from around the country rather than the single-site point estimate given in the Auckland study by Parks.(22) The participant flow diagram from the original article of Doolan-Noble has been reproduced below.

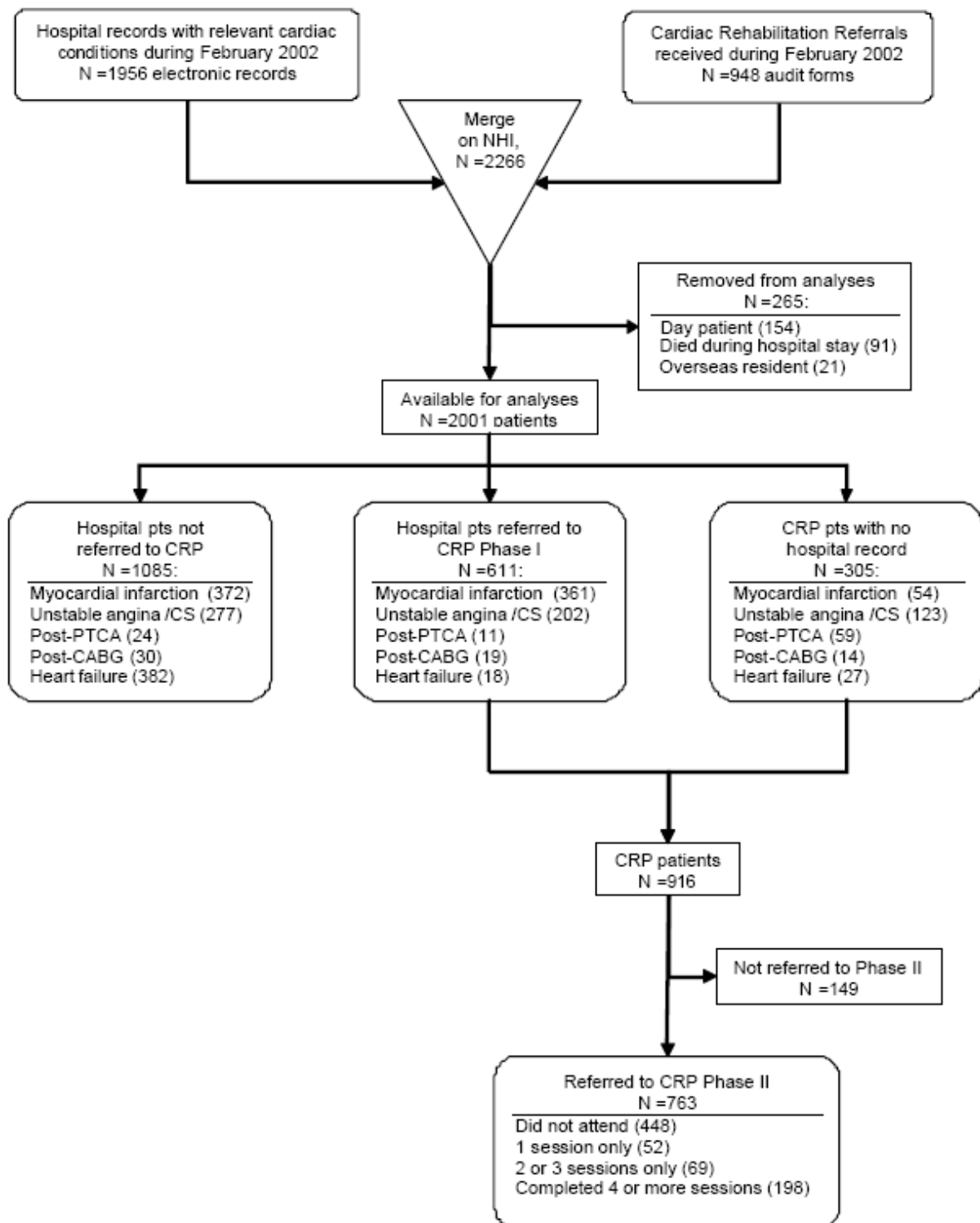


Figure 3. Overall participation and completion in cardiac rehabilitation in New Zealand. Reproduced from Doolan-Noble, 2003.(5)

The data in the preceding diagram permit the calculation of the CR participation rate for MI survivors referred to Phase I CR as a subset of the overall group. The participation rate for MI survivors was calculated from among those referred to Phase I CR from hospital; primary care referrals were not included in the calculations. Unfortunately the article does not facilitate the determination of MI survivors discharged from hospital who were then referred to Phase II CR as this subset became mixed with those referred to Phase II CR but with no hospital record. This group may have been referred from general practice or private hospitals. These calculations are described below.

The referral rate of MI survivors from hospital to Phase I was calculated to be 49%. It is likely that a smaller proportion was referred to Phase II CR but it is not possible to separate hospital-based referrals to Phase II from those originating from other sources. Overall, 83% of all those referred to Phase I were referred to Phase II CR. Applying this ratio to MI survivors referred to Phase I CR would give an overall Phase II referral rate of 40%. Although this figure is at the upper end of rates for MI survivors when compared with the international literature there are no other reliable referral data for MI survivors in New Zealand. In its favour, the study compiled data from multiple sites across the country which provides a more reliable estimate of referral rates than single site studies. The referral and participation rate data from Doolan-Noble's study was augmented by recent participation rate data supplied by two DHBs.

### **5.1.2. Participation Rates from DHB-Supplied Data**

CR participation data were obtained from two North Island DHBs. The specific DHBs are not identified herein for reasons of commercial and operational sensitivity. These two sites provided hospital-based CR but did not offer home-based CR during the time of data collection. Data were sought for all those who were discharged from hospital with a primary diagnosis of ICD code i21. This code includes myocardial infarction in addition to related MI subtypes of the i21 code. Data access was approved by the relevant DHB internal research committees. Ethical approval was not required; based on the Multi-region Ethics Committee guidelines for programme impact assessment.<sup>(61)</sup> Furthermore, the DHB data did not permit individual identification of clients and no contact with CR participants was made. The data spanned a 6 month period and included the overall number of MI survivors eligible for CR along with the number of MI survivors who participated in CR. Participation was defined as taking part in at least 1 session of CR. The participation rate average was used in the decision tree analysis.

The DHB data facilitated the calculation of demographic characteristics for CR participants. These variables included age, gender, ethnic group, and NZDep level. Consequently, it was possible to determine which groups were currently being underserved by conventional hospital-based CR programmes. The hospital-based participation data are summarised below.

**Table 11 Hospital-based CR participation rates among all MI survivors from two DHBs during a 6 month period.**

Site	Participation Rate (%)	
	All MI Survivors	Māori MI Survivors
DHB 1	39.9	33.3
DHB 2	30.5	26.4
<b>Average</b>	<b>33.9</b>	<b>27.5</b>

The data for Māori MI survivors represent a proportion of all Māori rather than of the total group of survivors. For example, in the first DHB 11 (33.3%) of the 33 Māori MI survivors referred participated in hospital-based CR. In DHB 2, 33 (26.4%) of the 127 Māori MI survivors participated in hospital-based CR. The participation rates for Māori are lower than those for non-Māori.

The averages are weighted towards DHB 2 which had a larger number of cases (554) than DHB 1 (313 cases) during the study window. The DHBs used different methods to record programme participation. DHB 2 had converted to electronic records during the period of data collection and DHB 1 continued to use a paper-based recording system.

Neither of the DHBs performed an audit of their data on a routine basis; these data represent a retrospective snapshot rather than an ongoing review of performance. Therefore these values are unlikely to represent values greater than the average found in other parts of the country. The CR referral rate calculations were compared with RCTs which examined

hospital and home-based programmes. The completion rate estimates are provided in the decision tree models along with their original source study.

### **5.1.3. CR Completion Rates from Published Data**

As with the participation data, completion rates in New Zealand were calculated from the single published study by Doolan-Noble.<sup>(5)</sup> The study did not facilitate the calculation of completion rates by ethnicity but did enable the calculation of overall programme completion rates for MI survivors undertaking hospital-based CR. However, the completion rate estimate from the Doolan-Noble study incorporates MI survivors from both the public hospital and other sources such as GP referrals and private hospitals. In total, 763 MI survivors were referred to Phase II CR. Using a completion definition of 4 or more sessions of CR a total of 198 individuals completed Phase II CR. This completion rate of 26% is consistent with values observed in other studies described in the literature review.

#### **5.1.3.1. Completion Rates from DHB-Supplied Data**

The DHB data enabled calculation of the overall CR completion rates along with those for Māori. The results are summarised below and are used in the decision tree model to calculate the total cost of baseline CR participation. Programme completion was defined as attendance at four or more CR sessions. The variance in programme completion rates between DHBs may reflect the different data capture systems at each site; the paper-based system at DHB 1

was likely to contain more omissions and errors compared with the electronic system at DHB 2.

**Table 12 CR programme completion rates for selected categories of MI survivors**

Site	Programme Completion Rate (%)	
	All MI Referrals	Māori MI Referrals
DHB 1	43.2	54.5
DHB 2	26.6	18.2
<b>Average</b>	<b>33.7</b>	<b>27.3</b>

#### **5.1.4. Costs of Hospital-Based CR**

It was not possible to determine the cost of CR in New Zealand from the published literature as no relevant studies had been published. Similarly, discussion with the two DHBs involved in providing participation and completion rate data revealed that CR programme costs were not routinely calculated or readily available. Calculations were performed by a data analyst at DHB 2 to give a broad estimate of the cost of CR per session per client. This figure comprised the total cost for the CR unit divided by the number of person-sessions delivered and gave a figure of \$130 per session per client, or \$520 per programme of four CR sessions per client. Although this figure is a rough approximation no other reliable estimates had been published or were readily available for New Zealand programmes.

Other estimates of CR programme costs for hospital-based programmes have been discussed in the literature review section. The recent RCT by Briffa provides a detailed description of hospital-based CR costs in Australia. This study gave a total CR cost per client of A\$694(55). This figure aligns closely with that estimated in DHB 2 and costs in New Zealand and Australia are likely to be broadly similar. The slightly higher cost in Australia may be due to increased labour costs. The DHB estimate for hospital-based CR of \$520 has been used as the proxy cost of CR in New Zealand until more accurate figures are published.

In summary, CR participation rates of 33.9% have been used for all MI survivors with rates of 27.5% for Māori. Programme completion rates of 33.7% have been used overall and 27.3% for Māori. The cost of a programme of four sessions of CR has been estimated at NZ\$520 per client. Potential CR participation and completion levels with a home-based CR programme complementing the hospital-based programme are now presented.

#### **5.1.5. Costs of Home-Based CR**

Calculating the potential cost of a home-based CR programme in New Zealand was attempted in three different ways. First, a search of the literature was performed for any New Zealand studies of home-based CR programme costs; none were detected. Second, the review of international published literature gave an indication of the ratio of programme costs between hospital and home-based programmes. This ratio of cost difference could be applied to the programme costs for hospital-based CR obtained from DHBs to estimate a home-based programme cost in New Zealand. The New Zealand and Australian health systems are

broadly similar; therefore, it was assumed for the purposes of analysis that home-based CR costs would be similar.

Third, the total home-based CR programme contract cost estimated by a DHB was divided by the projected throughput of the programme to determine a cost per client for the home-based programme. Based on these variables, a per client cost of \$500 was estimated for home-based participants. This value is similar to the hospital-based CR cost described in section 6.1.3 of \$520 per participant. The literature comparing hospital and home-based programmes found either a very small difference or no significant difference between the two options in cost.

The New Zealand CR programme cost used in the decision tree calculations was based on the DHB hospital-based programme cost of \$520 per client. This figure is slightly higher than the home-based programme contract cost of \$500 per client. However, Taylor(59) has observed that hospital and home-based programmes do not differ significantly in their delivery costs. Consequently, the \$520 per client programme delivery cost was used for both hospital and home-based clients in the analyses. This figure has been adjusted to a maximum of \$700 in the sensitivity analyses in line with Briffa's (55) recent Australian RCT citing hospital-based programme delivery costs.

International cost data for a home-based programme was derived from a RCT using the Heart Manual in the United Kingdom.(27) This study did not show any statistically significant difference in cost between the hospital and home-based programmes. As a result it was

assumed that the cost of a home-based programme in New Zealand would be similar to the hospital-based programme currently being delivered in the sample DHBs.

#### **5.1.6. Costs of Readmission to Hospital**

Readmission costs were derived through two methods. First a review of the local and international literature was completed to identify point estimates for readmission costs. The literature helped to compare readmission costs for those who completed a programme and those who did not. In addition a comparison between readmission costs for home and hospital participants was attempted. As with other economic data there were no published New Zealand studies which described readmission costs for CR participants.

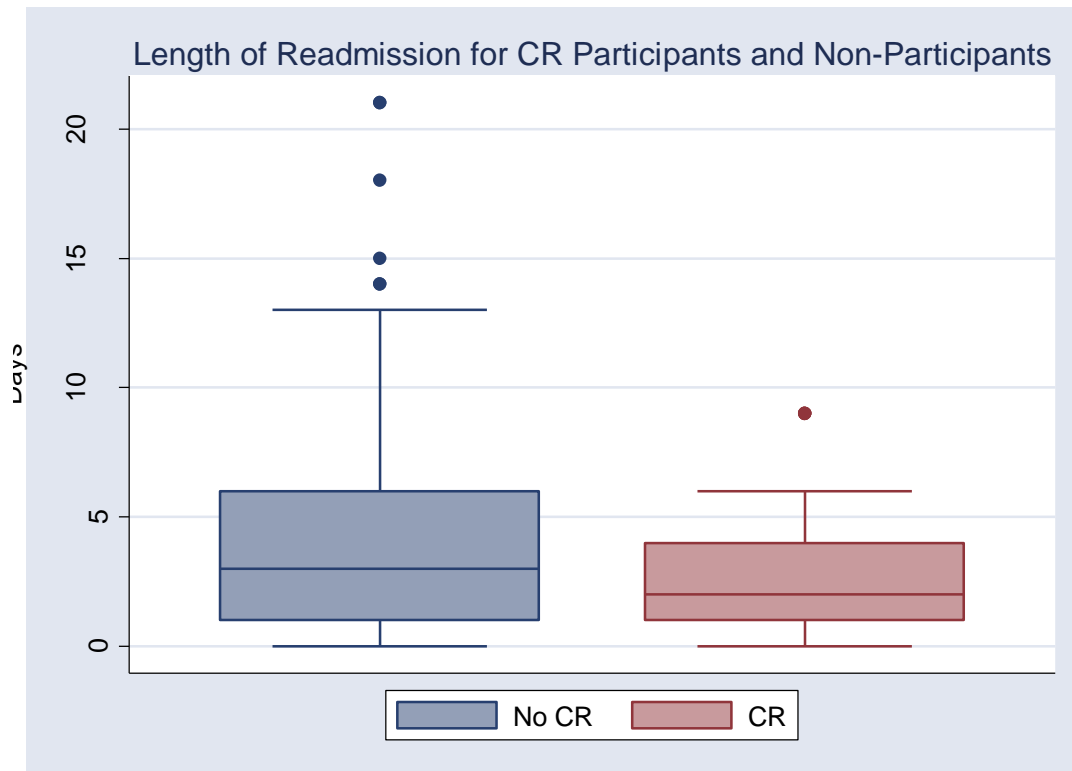
The international literature provided a selection of readmission cost data. Five studies provided readmission data for those who completed a hospital programme and those who did not. An early study by Ades (7) in 1992 found that those who completed CR had lower hospital readmission costs. However, the groups were not randomised and differed significantly on key variables such as initial diagnosis, comorbidities, smoking status, and employment field. A 1997 randomised trial by Oldridge indicated no significant difference in hospital readmission costs between those who completed hospital-based CR and those who did not complete any program. A systematic review by Ades in 1997 again suggested that participation in CR was associated with lower hospital readmission costs but this premise was based on non-randomised studies.

Two recent studies provide a more robust comparison of readmission rates and costs for CR participants and non-participants. An Australian RCT by Briffa published in 2005(55) found no significant difference in readmission costs between hospital CR participants and non-participants in the 12 months following discharge from hospital. Similarly, a RCT from the UK published in 2007(59) found no significant difference in readmission costs between hospital and home-based programme participants. Based on the published literature the readmission costs for CR programme participants and non-participants were assumed to be the same. Similarly, based on Taylor's 2007 RCT(59), readmission costs for home and hospital participants were assumed to be the same. New Zealand values for readmission costs were derived from DHB 2 as described below.

The second method for estimating readmission costs was based on data supplied by DHB 2. The cost of readmission over the 12 months following discharge for an MI was collected for a cohort of MI survivors for DHB 2. The data was gathered for a group whose initial admission to hospital occurred during a 6 month period in 2006. The data included the cost of admission through the Emergency Department, placement in a coronary care unit and recovery in a medical ward. Furthermore, the cost of any additional intervention such as PTCA or CABG was included. Costs were categorised by CR programme completion status and indicated clear differences between those who completed a CR programme and those who did not.

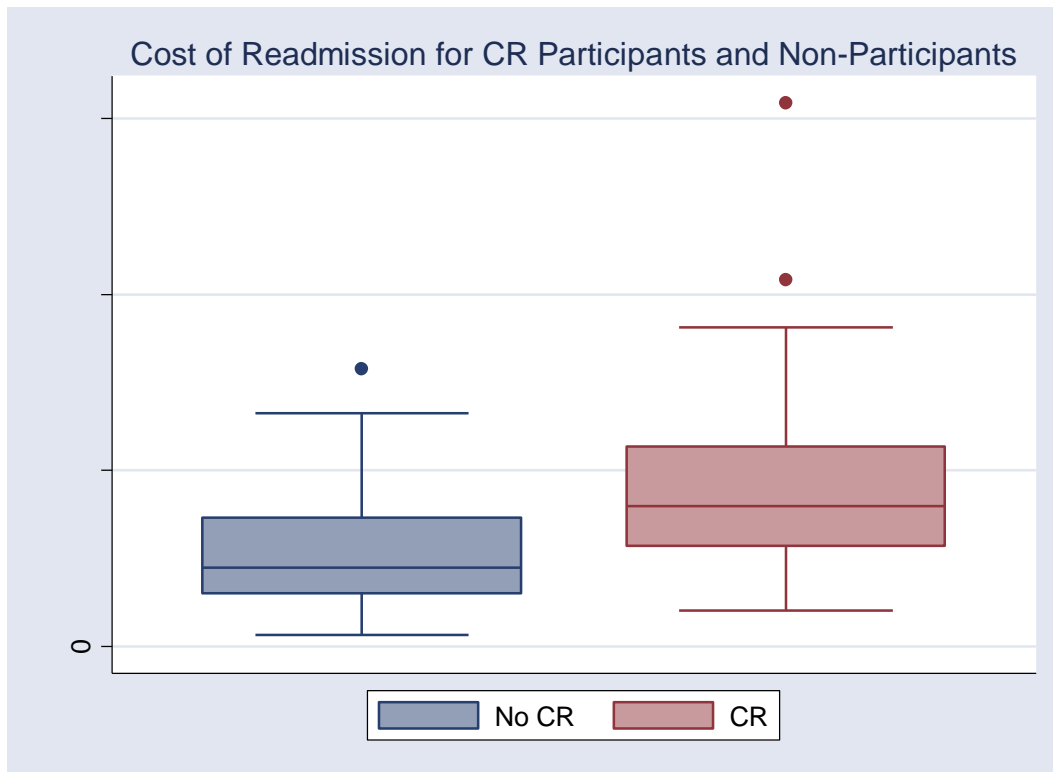
A total of 176 MI survivors were readmitted to hospital in the 12 months following discharge. Of these, 119 had not completed any CR programme whilst 57 (32.4%) had completed a programme. For those who completed a CR programme the LOS during readmission ranged from 0 to 9 days (a stay of 0 days indicates the person was seen and discharged the same day

without staying overnight). The mean LOS was 2.6 days with a median of 2 days. For non-participants the LOS ranged between 0 and 21 days, with a mean of 4.3 days and median of 3 days. The box plot below compares CR participants and non-participants.



**Figure 4. Comparison of readmission costs from DHB 2 for those who complete a CR programme and those who do not.**

The cost of readmission for CR participants ranged between \$2,030.10 and \$30,855.59, whilst the median cost of readmission was \$7,959.79 with a mean cost of \$9,025.08. Among non-participants the cost of readmission ranged between \$668.17 and \$15,773.90. The median cost of readmission for this group was \$4,499.21 while the mean cost was \$5,265.89. These data are illustrated below and possible reasons for the difference in readmission costs between CR participants and non-participants are explored in Chapter 6.



**Figure 5. Comparison of readmission costs from DHB 2 for those who complete a CR programme and those who do not.**

Overall CR participants had a shorter length of stay than non-participants, but CR participants had a more costly readmission than non-participants. This difference appeared paradoxical. The potential reasons for this contradiction are explored in the discussion section.

The readmission cost of \$5,265.89 was used in the decision tree models as the readmission cost for both participants and non-participants. Although this figure was derived from non-participants several studies indicate lower costs of readmission rather than the higher values obtained from the sample from DHB 2.(7, 9, 11, 55, 57, 59) Also, as stated previously

Briffa's(55) 2005 RCT showed no statistical difference in readmission costs between those who completed a CR programme and those who did not; in that study CR participants generated a readmission cost of A\$2,276 whilst non-participants generated \$2,257 in costs. On this basis, the readmission figure obtained from a New Zealand DHB for non-participants (\$5,265.89) was used for both programme participants and non-participants in the decision tree models.

## **5.2. Potential Participation and Completion with a Home-Based CR Programme**

The potential rate of completion for both hospital and home-based CR programmes was derived from the literature. The DHBs which provided cost and participation data were unable to provide completion rates for their existing hospital based programmes. Consequently these figures were estimated from RCTs comparing hospital and home based programmes. The client information management systems for CR remain relatively underdeveloped; one of the DHBs contributing data to this study had only started compiling electronic client records for CR participants in 2007. The second DHB continued to use paper-based records for participants.

### **5.2.1. Potential Participation Rates**

The literature review section identified studies which highlighted the impact of home-based CR on overall participation and completion levels. Multiple studies have demonstrated

increased participation and completion rates when a home-based programme is available. These increased participation rates have been translated into the decision tree analyses. Unfortunately, none of the studies provided sufficient detail to determine the impact that a home-based CR programme would have on raising participation and completion rates among underrepresented groups such as ethnic minorities, women, and those in low socioeconomic groups.

To estimate the increase in overall participation after introduction of a home-based CR programme, the proportion of change observed in Dalal's 2003 comparison of hospital and home-based rehab was used.<sup>(25)</sup> Dalal's study noted 44% of CR participants took part in the home-based option whereas 33% of those eligible for CR undertook the hospital-based programme. Only 23% of eligible candidates did not take part in any CR programme. Among the home-based programme participants 87% completed the programme whereas only 49% of hospital-based participants completed the programme. It is acknowledged that arguments for more or less change among these groups are valid but a single ratio of change has been used for all groups to simplify calculations. These rates are altered in the sensitivity analyses.

### **5.2.2. Potential Completion Rates**

Programme completion rates were derived from the limited number of studies available which measured programme completion rates when a hospital and home-based programme were provided at the same hospital for MI survivors. These have been presented in the literature review section but to maintain consistency with the participation rate values,

Dalal's 2003 rates of completion for home-based CR and hospital-based CR have been used.<sup>(25)</sup> Completion rates of 87% were observed for home-based CR with 49% completing the hospital-based programme. The home-based programme completion rates of 49% were significantly higher than those currently observed in DHBs, particularly DHB 2. It is possible that the greater compliance observed is due to ease of access and the lack of direct costs incurred by the hospital-based participants for transport and parking. Additional reasons include the flexibility of home-based appointments around other commitments such as employment. Increased hospital-based programme completion rates may be due to a Hawthorne effect on those making referrals and those delivering the programmes. Finally, hospital-based CR completion rates are likely to increase when home-based CR is offered due to a selection effect whereby those who may have attended hospital-based CR but only partially completed the programme now attend a home-based programme which is more suited to their needs and provides a better means to overcoming access barriers.

Completion rates are particularly important because the full clinical benefit of CR is not observed in those who only partially complete a programme. For example, Ades showed that hospital readmission rates among those who did not fully complete all the planned sessions of a CR programme were the same as those who did not complete a programme at all.<sup>(7)</sup> In summary, partial completion of a programme appears to lead to the same outcomes as not taking part in any programme at all.<sup>(7)</sup>

### **5.2.3. Readmission Rates for Hospital and Home-Based Programmes**

Readmission rates for hospital and home-based programmes were derived from studies comparing the two programmes implemented at a single site. A 2007 study by Taylor found that the two programmes did not produce a statistically significant difference in readmission rates(59), but did lead to a lower number of readmissions compared with those who did not take part in any CR programme.(55)

In line with Briffa's 2005 RCT, a readmission rate of 34% was used for those who completed a CR programme (either hospital or home-based); a readmission rate of 40% was used for those who did not take part in any programme. For those who started a programme but did not complete it, the readmission rate for those who did not complete a programme was used.(7)

### **5.3. Cost Calculations for Hospital-Based and Home-Based CR Programmes**

The cost of existing hospital-based CR was calculated to give a baseline estimate of current costs, throughput, and completion for a DHB with an annual cohort of 1000 MI survivors. This was followed by calculations for the same sized cohort but with a home-based CR option added to the hospital-based programme and encompassing the increased programme participation and completion rates observed in other studies when home-based CR is added.

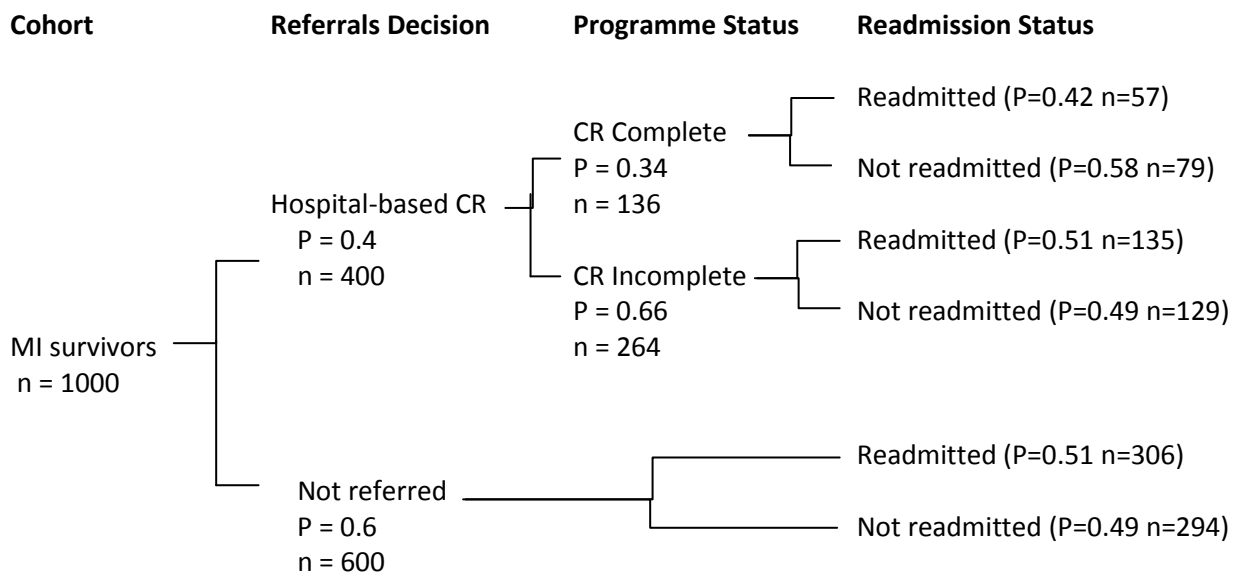
### 5.3.1. Offering Conventional Hospital Based CR

Data from the literature review and DHBs were used to calculate the cost and rates of participation and completion for conventional CR; the data are summarised below.

**Table 13 Summary of data and source for conventional hospital-based CR calculations**

<b>Item</b>	<b>Value</b>	<b>Source</b>
<b>Costs</b>		
Hospital-based CR programme	\$520	DHB 2
Hospital readmission cost (programme attendee)	\$5265.89	DHB 2 (non-randomised)
Hospital readmission cost (non-attendee)	\$5265.89	DHB 2 (non-randomised)
<b>Rate Data</b>		
CR referral rate	40%	Doolan-Noble 2004 (5)
CR programme completion rate	34%	Doolan-Noble 2004 (5)
Readmission rate (programme attendee)	42%	DHB 2 (non-randomised)
Readmission rate (non-attendee)	51%	DHB 2 (non-randomised)

The figures from the table were used in a decision tree to estimate the CR completion rate, costs, and hospital readmission rate when a hospital-based CR programme alone is offered.



**Figure 6. Decision tree model for conventional hospital-based cardiac rehabilitation.**

Using these values a total of 136 participants were calculated to complete the hospital-based CR programme while 264 did not, despite starting. Because the staffing costs of the programme were fixed and resource use in the group sessions did not reduce if initial participants were later absent, those who started but did not complete the programme would not have any effect on the cost of the service. Consequently, providing the hospital-based CR service for 400 participants results in 136 completing the programme from a cohort of 1000 MI survivors, and a total service cost of approximately \$2.8M which includes programme delivery costs along with the cost of 498 readmissions. The calculations were repeated with the variation of a home-based programme option added to the conventional home-based programme.

### 5.3.2. Offering Hospital-Based CR and Home-Based CR

Locally supplied values were used as the first choice in the decision tree base-case analysis. If a local value was not available, values from Australian studies have been used under the assumption that the health systems and costs across the two countries are likely to be very similar. This practise helped to overcome the significant differences between countries such as the components making up CR along with the varying treatment cultures between countries mentioned in the literature review chapter. Financial values in the table below have not been adjusted for inflation and exchange rates except where indicated. Local values have been used for readmission costs but these figures are derived from a non-randomised sample i.e. the group which took part in CR may have had higher readmission costs resulting from early symptom awareness leading to early intervention; these symptoms may go unrecognised in those who do not complete a CR programme.

**Table 14 Decision tree data for home-based CR augmenting a hospital-based programme**

<b>Variable</b>	<b>Value</b>	<b>Source</b>
<b>Costs (\$NZ unless otherwise specified)</b>		
Hospital-based CR programme	*\$520	DHB 2
	AUS\$694	Briffa 2005 (55)
	£200	Taylor 2007 (59)
	£157	Jolly 2007(26)
Home-based CR programme	*\$520	Based on no statistical difference between home and hospital programme costs(59)
	\$500	DHB 2 contract estimate
	£170	Taylor 2007 (59)
	£198	Jolly 2007(26)
Hospital readmission cost (CR programme attendee)	\$9,025.08	DHB 2 (non-randomised)
	AUS\$2276	Briffa 2005 (55)
	£3266	Taylor 2007 (59)
Hospital readmission cost (non-attendee)	*\$5265.89	DHB 2 (non-randomised)
	AUS\$2257	Briffa 2005 (55)
	US\$1936	Ades 1992(7)
<b>Rate Data</b>		
CR referral rate	*77.4%	Dalal (25)
	43%	Jolly 2007(26)
Home-based CR participation rate	*57.3%	Dalal 2003(25)
	40.4%	Dalal 2007(27)
Hospital-based CR participation rate	*42.7%	Dalal 2003(25)
	37.3%	Dalal 2007(27)
Home-based CR programme completion rate	*87%	Dalal 2003(25)
	96%	Jolly 2007(26)
Hospital-based CR programme completion rate	*49%	Dalal (25)
	56%	Jolly 2007(26)
Readmission rate (programme attendee)	*42%	DHB 2 (non-randomised)
	44.6%	Briffa 2005 (55)
Readmission rate (non-attendee)	*51%	DHB 2 (non-randomised)
	55.4%	Briffa 2005 (55)
*indicates that the value was used in the base case analysis		

Data from the tables and calculations in Sections 6.1 and 6.2 which encompassed both hospital and home-based programmes were entered into a decision tree which modelled both hospital and home programmes offered simultaneously. The model is illustrated below.

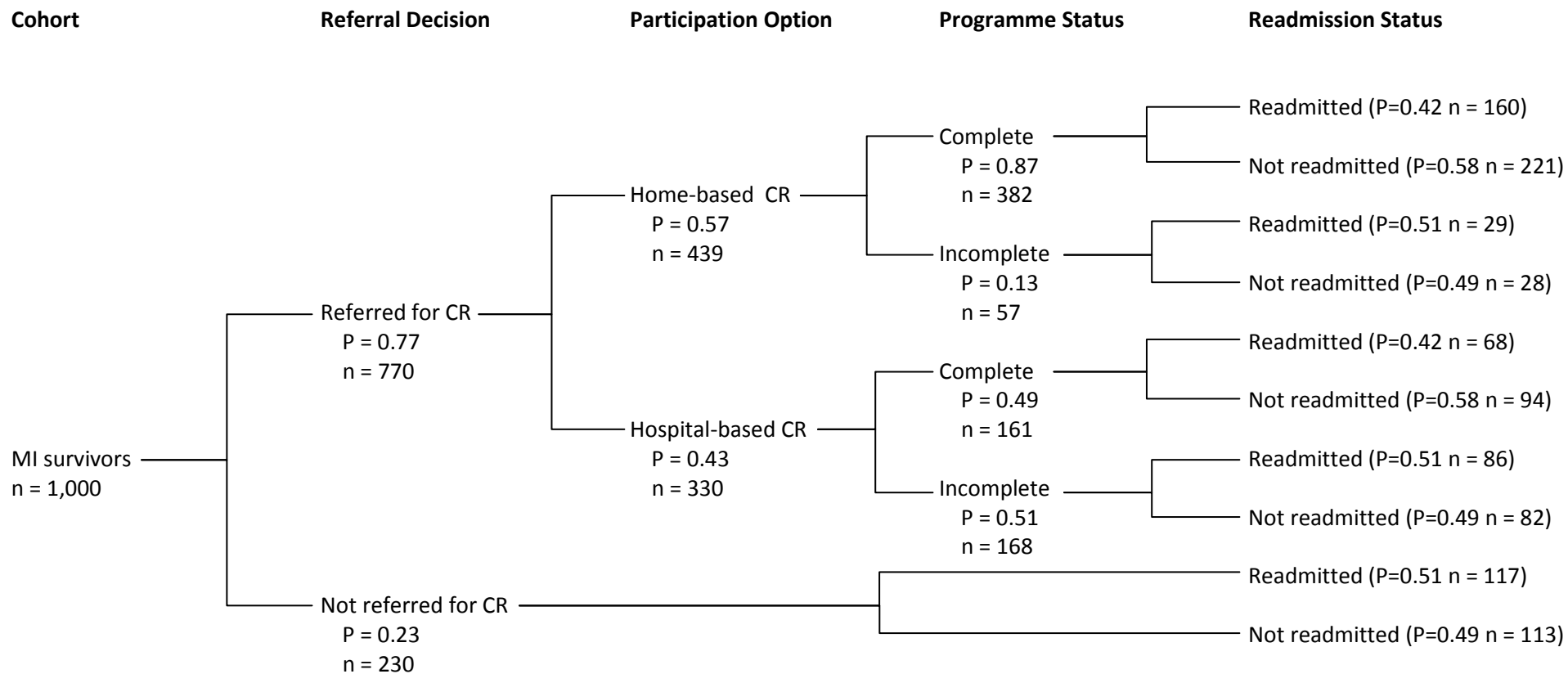


Figure 7. Decision tree model for hospital-based CR augmented by home-based CR.

The decision tree model above assumes that more people are referred to CR after addition of the home-based option as observed by Dalal.(25) The analysis indicates that adding a home-based programme to an existing hospital-based programme could result in programme completion for 543 individuals from an original cohort of 1000 MI survivors.

The additional 407 people completing CR represents a significant increase on the 136 individuals completing a programme when only a hospital option is offered. Furthermore, with the lower hospital readmission rate associated with CR completion a lower overall number of hospital readmissions result. It is estimated that a total of 461 readmissions would result when both programmes are offered. In comparison, 498 readmissions are estimated when a hospital-based programme alone is offered. The difference of 37 readmissions is largely due to the lower number of people taking up and completing a CR programme when a hospital-based programme alone is offered. The model used a per person readmission cost of \$5,265.89 for both programme attendees and non-attendees. This assumption is derived from Briffa's recent observation of a lack of difference in readmission costs between programme attendees and non-attendees.(55) Total costs incurred when offering both home and hospital programmes would be \$2.82M. In comparison, the hospital only option is estimated to cost only \$1,000 more. The savings generated from lower readmissions are offset by programme costs incurred for the higher number of CR participants. The summarised costs, CR completion, and readmission results are shown below.

**Table 15 CR programme completion rates for selected categories of MI survivors**

Group	Number of people	Number of Readmissions	Cost of Readmissions (\$000)	Programme Cost (\$000)
<b>Hospital-based Programme Only</b>				
Programme complete	136	57	301	\$2,829
Programme incomplete	264	135	709	
No programme	600	306	1,611	
Total		498	\$2,621	
<b>Hospital and Home-based Programmes Offered</b>				
Programme complete	543	228	1,201	\$2,828
Programme incomplete	225	115	604	
No CR	230	343	617	
Total		461	\$2,423	

## 5.4. Sensitivity Analyses

There is considerable uncertainty about the validity of some of the values used in the base case. Adjustments were therefore made to several of the main variables in the model to test the results of the model for sensitivity to change. The CR referral rate, home CR completion rate, readmission rate, and cost of home CR were changed to align with values from other published studies of CR. The results are summarised below.

**Table 16 CR programme completion rates for selected categories of MI survivors**

Scenario	Number Completing CR	Number of Readmissions	Cost of Readmissions (\$000)	Total Programme Cost (\$000)
Base case	543	461	2,423	2,828
CR referral rate of 40%(5)	359	485	2,552	2,759
Home CR completion rate of 96% (26)	584	457	2,515	2,936
Programme attendee readmission rate of 45%, Non-attendee readmission rate of 55% (55)	543	496	2,604	3,010
Cost of home CR of \$700 per person	543	461	2,427	2,907

All of the scenarios which were tested had the effect of raising the total CR programme cost above the base case apart from lowering the CR referral rate to 40%. At this rate the programme costs become lower than the costs of the increased number of hospital readmissions. However, significantly fewer people complete a CR programme at this referral rate.

The model was not very sensitive to a higher rate of home CR completion of 96% in line with Dalal's more recent 2007 study.(27) The absolute number of participants completing the home CR programme changed slightly whilst readmissions also changed a small amount (4 fewer readmissions). Increasing the readmission rates to match a recent Australian RCT(55) increased the number of readmissions by 8% and raised the total programme cost above \$3M. However, raising the cost of home CR to \$700 per person did not lead to the same overall

programme cost; total programme costs were only \$79k greater than the expected \$520 cost of home CR.

## **5.5. Benefits of Increased Participation in CR**

Increased CR participation can result in both economic and health outcome benefits. The financial benefits of increased CR participation are mainly derived from lower rehospitalisation rates among CR participants. Other financial benefits are also possible. For example, CR participants have been observed to require fewer cardiac procedures compared with non-participants. Ades(7) found that CABG and PTCA rates were lower among those who had completed a CR programme. Procedure rates are lower where risk factor reduction occurs among CR participants or where education on symptom recognition results in early assistance being sought from primary care before a problem escalates.

The beneficial health outcomes associated with CR include quality of life improvements, and reduced mortality. Although this dissertation is limited to the calculation of financial benefits it is acknowledged that health outcome assessment is equally important in programme funding decisions; the decision to fund a home-based CR programme should not be based on financial criteria alone.

### **5.5.1. Potential Financial, Utility, and Effectiveness Benefits**

As stated, a key area of potential financial benefit for a DHB lies in the lower readmission rate resulting from greater CR participation. The literature review identified a lower readmission rate for those who completed a CR programme compared with those who did not.(27, 55) These lower readmission rates were used in the decision tree model to estimate the cost of readmissions before and after the introduction of a home-based CR programme. Although benefits may also accrue to a DHB if readmission costs are lower for CR participants as some researchers have suggested(7), this assumption has not been used in this study. Rather, the same cost of readmission was used for both programme participants and non-participants. This assumption aligns with recent studies which have not detected a statistically significant difference in readmission costs for programme participants and non-participants; to be more precise, the two paths (programme participation or non-participation) differ in readmission rates – CR participants being less likely to be readmitted to hospital.(7, 55) But when either is readmitted they are likely to have similar readmission costs.(55)

Based on these calculations it is possible that 407 more people would complete CR when a home-based programme is offered compared with a hospital-based programme option alone. Although there is an additional cost associated with providing a home-based programme the potential savings resulting from the lower hospital readmission rate for CR participants help to offset this cost.

Based on the calculated increases in participation and completion rates associated with offering a home-based CR programme it is expected that the proportion of Māori completing a CR programme would increase significantly as this group is more likely to be in low socioeconomic strata and to encounter difficulties with transport and access. The absolute increase in numbers completing a CR programme would therefore depend on the demographic profile of the DHB. To date, no studies have been published which review the increased uptake among underrepresented groups associated with home-based CR.

Home-based CR also has positive cost-utility benefits. Cost-utility calculations were calculated using domestic costs for CR and international estimates of quality adjusted life years (QALY) gained from CR. QALY data in the published literature for CR were limited but three robust studies were found which listed QALY values; all three studies were RCTs. The QALY values after 12 months ranged from a low of 0.026 in a 2005 Australian study(55) to 0.06 in a 2007 study from the UK,(59) to a high of 0.071 in a study from 1993 in the United States.(57) At a cost of \$500 per home-based CR participant these QALY values give cost-utility results of \$19,200, \$8,300, and \$7,000/QALY respectively.

The years of life saved (YLS) through CR participation were determined from a meta-analysis of 22 RCTs.(11) The resulting cost-effectiveness value of 0.202 YLS over 15 years combined with the participant cost for home-based CR of \$500 in New Zealand gave a value \$2,500/YLS. The lower cost of home-based CR in New Zealand relative to the United States make this value seem low compared to other published studies. A more accurate comparison would encompass purchasing power parity adjustments between countries. Overall however, these cost-effectiveness and cost-utility results make CR a positive health resource

investment relative to other options for MI survivors such as angioplasty, CABG, and statins.(11) In parallel, the great benefit of home-based CR is its ability to significantly increase the number of people participating in CR overall.

## **Chapter 6. Discussion**

The dissertation set out to answer several questions. First, the current level of CR in New Zealand was to be identified, so that comparison with rates in similar countries such as Australia, the UK, and the USA could be made. These figures would determine if any changes to New Zealand's current methods of CR delivery were warranted. Second, the rates of CR participation and completion achieved when a home-based CR programme is added to an existing hospital-based CR programme were to be determined. These figures would give an indication of the potential rates of CR attainable if DHBs provided a home-based CR programme to augment the conventional hospital-based programmes currently being offered. Third, the potential costs and benefits of adding home-based to hospital-based CR were to be calculated. Where relevant, the potential impact of programme changes on Māori was examined.

Data on the current levels of CR participation and completion by MI survivors in New Zealand were severely limited. This made it difficult to answer some of the research questions accurately. Only two articles had been published describing CR rates in New Zealand. One of the two studies(22) summarised participation rates in New Zealand's largest hospital but did not delineate MI from other diagnostic categories; it was not possible to base an assessment of current participation rates by MI survivors on that study, but overall the article indicated very low levels of CR participation and completion.

The remaining quantitative study(5) on New Zealand CR rates permitted determination of the participation and completion rates of MI survivors only indirectly. Using data provided in the paper the programme participation and completion rates for MI survivors were estimated. The calculations indicated that participation and completion rates in New Zealand for MI survivors were relatively high compared with international standards. The article did not facilitate analysis of the data for Māori CR participants. Consequently, information on CR rates was sought from two DHBs in the North Island of New Zealand.

Two North Island DHBs provided data on Māori and non-Māori CR participation and completion rates for 2006. This information was used to determine baseline levels of CR participation to augment that provided in Doolan-Noble's study. In addition, the data was used to determine the participation and completion rates for Māori MI survivors; this was not possible from Doolan-Noble's work. The rates of participation and completion were significantly lower than those recorded in Doolan-Noble's study. For example, the average overall CR participation rate for Māori was 27.5% across the two DHBs. Participation rates for non-Māori averaged 33.9%. These figures aligned closely with results from Australia and the UK.

The rate of completion in hospital-based CR by Māori MI survivors was significantly lower than the general population. The average CR completion rate for Māori participants was 27.3%. So despite having a higher burden of CVD and higher mortality from CVD, fewer Māori entered a CR programme compared with non-Māori. This group were also less likely to complete a CR programme once it was started. This pattern embodied the inverse care law

in action. The data provided by DHBs gave a clear indication of the low overall participation and completion rates in CR along with particularly low rates for Māori.

The low rates of CR completion detected by retrospective analysis contrasted with the higher rates published in Doolan-Noble's multicentre audit. The prospective audit of Doolan-Noble relied on CR facilitators completing a questionnaire for CR participants which may have led to multiple errors including selection and observer bias.(62) The retrospective review of DHB participation and completion data gave results similar to recent Australian studies (36, 41, 55) and a longitudinal review of CR rates in the UK.(33)

It was calculated that offering a home-based programme alongside a hospital-based programme would cost slightly less than existing CR does. Hospital-based CR alone costs approximately \$2,829M per year, and total programme costs may be \$2,828M per year after a home-based programme is added. The lower cost is due to the reduced readmission rate associated with CR completion i.e. 461 people would be readmitted to hospital in the year following initial discharge compared with 498 at present. Furthermore, the clinical benefits of CR would be enjoyed by more people – 543 would complete CR with a home-based option available compared with 136 at present, an increase of 407 people. These results strongly support the implementation of home-based CR based on the assumptions modelled – home-based CR results in greater effectiveness (increased completion and reduced readmissions) at the same or lower cost.

The model assumed that a greater overall number of people would take part in CR. However, without testing these assumptions in New Zealand it is possible that overall participation may remain unchanged and some participants simply shift from hospital to home-based CR. This possibility is not supported by the few existing studies available; Dalal(25) and others(59) have found that offering a home-based option for CR tends to increase overall participation rather than just reshuffle existing attendance. In the unlikely event that overall CR participation and completion rates are unchanged it is likely that overall program costs may remain similar to current levels or increase slightly in the short term due to the nature of fixed price contracts with Providers. A state of no change in overall participation could be detected within the first year of offering a home-based option if regular monitoring of programme utilisation and readmissions was conducted.

It is possible that many of the additional participants would come from currently underrepresented groups such as Māori and those in low SES groups but the available studies do not provide sufficient information to verify these expectations. Once home-based programmes are delivered it will be possible to test this hypothesis. The literature did not focus on underutilisation by specific ethnic groups or those in low socioeconomic strata and so it was difficult to estimate the increased participation attainable by groups such as Māori. It is expected that a high proportion of the increased participation and completion in CR will come from Māori and low SES groups who face greater barriers to participate in CR. However, without a targeted approach home-based CR may not reduce inequalities between Māori and non-Māori but may lead to greater overall numbers from both groups experiencing the secondary prevention benefits of CR.

The hospital readmission cost used in the base case analysis was ascertained through data supplied by a New Zealand DHB. Paradoxically the cost of readmission for those who had completed a CR programme was greater than those who had not completed any programme. Review of published studies reveals that this is not usually the case. Although rates of readmission may vary with CR participation, there was no significant difference in readmission cost between CR participants and non-participants in a 2005 Australian RCT(55) or a cost-effectiveness analysis from the UK.(59) The differences observed in the DHB-supplied sample are likely to be due to a lack of randomisation. This feature results in confounding from age, ethnicity, socioeconomic, and co-morbidity differences between the groups.(62)

Using a higher readmission cost for programme participants would have significant implications for the viability of both hospital and home-based CR. The financial benefits of increased participation in CR would be greatly diminished - the readmission cost for a CR participant was almost twice that of a non-participant in the DHB-supplied data. Consequently, the increased participation in CR associated with home-based CR would result in both additional programme costs of approximately \$520 per person, but also significantly higher readmission costs incurred by the higher number of CR participants. A brief analysis suggested that the overall programme cost would increase by almost \$1M if the readmission cost for CR participants was increased from \$5,265.89 to \$9,025.08. As stated previously, this scenario is unlikely; several studies have shown no significant difference in readmission costs between participants and non-participants.(55, 59)

Several potential benefits were possible from offering a home-based CR programme. First, the addition of a home-based programme is likely to lead to greater overall participation and completion in CR among all those eligible. The numerous clinical benefits achievable through participation in CR have been well studied and with the current low participation rates these clinical benefits are not being realised. Second, there is the potential to increase exposure to CR among those carrying the greatest burden of CVD. The data supplied from two DHBs indicate that Māori are underrepresented at hospital-based CR despite being greatly overrepresented in CVD statistics. Third, home-based CR provides greater flexibility in the location and times that CR is performed. Barriers to participation in CR include time away from work, the need for transport, costs associated with transport and parking, and the fixed delivery times of programmes. Those living greater distances from CR centres or in predominantly rural regions such as Northland or the Waikato are particularly vulnerable.

Increased CR participation has the potential to reduce the number of readmissions to hospital. This premise was verified with the modelling completed herein. As the proportion of the population over the age of 65 increases in parallel with greater healthcare spending<sup>(3)</sup> the need for interventions which reduce demand on secondary care services will gain greater importance. The model suggests that the number of hospital readmissions could be lowered from 498 to 461, with more people overall completing CR, and that this could be achieved at the same or slightly lower programme costs than at present.

Despite the potential financial benefits suggested by the model it is acknowledged that a net financial benefit may not materialise for a DHB implementing a home-based CR programme for multiple reasons. One of the most likely includes the unmet health need among those

currently underrepresented in CR.(63-66) Numerous studies have identified a correlation between lower socioeconomic status and greater morbidity and mortality at every age group.(67-71) Therefore, attendance at CR may result in increased awareness of unmet health needs among both health providers and participants which would have previously gone unaddressed. As a result, new CR participants may recognise symptoms or conditions requiring further medical care which would not have been dealt with in the past. In a condition such as CVD with multifactorial aetiology this situation is even more likely.

Limitations of this study include the sparse number of studies from New Zealand which document the rates of participation and completion of CR. The literature search revealed only two studies and these encompassed a variety of CVD conditions rather than MI in particular. Consequently, the calculations used to establish the rate of CR for MI survivors were an indirect method; the author did not have access to the original data from Doolan-Noble's multicentre audit. Thus, recent CR participation and completion rates were augmented by a brief audit of two CR centres in New Zealand covering a six month period. These DHB-supplied data indicated lower CR participation and completion rates than calculations using Doolan-Noble's study, but these rates were more closely aligned with results from Australia and the UK.(17, 33, 55)

An additional limitation lies in the way that cost data were derived. As stated, only two participation studies from New Zealand were found; however, no economic analyses of CR in New Zealand had been published at all. Consequently, New Zealand cost data were obtained from a single DHB. The cost per client taking part in hospital-based CR was determined by calculating the total overhead costs of the hospital-based CR programme and dividing this

figure by the number of CR sessions provided. This approach neglects the various specialties that contribute part-time to CR such as occupational therapy, physiotherapy, and specialist time. Furthermore, it would have been helpful if the CR cost per client could be corroborated by at least one other CR site. The lack of comparison data means that other point estimates may vary greatly from that used in this study.

The cost estimate used to determine the cost per client for home-based CR was similarly prone to variability. Although comparisons can be made with published international data the lack of a range of programme cost estimates in New Zealand again means the cost estimate used in the decision tree models was from a single source. The figure calculated from the DHB data may be inaccurate as the estimate is based on maximum throughput being achieved by the programme. If the provider engages fewer people in the CR programme then the cost per client will be higher than the value used in the decision tree models used here.

The cost calculations only take the perspective of the DHB and do not include costs incurred by other parties. Individuals participating in hospital-based CR face significant costs associated with car ownership, travel, and parking which our analyses did not include. These costs may be a significant burden encountered by hospital-based CR participants but were not included in this review. These costs would raise the cost per person undertaking hospital-based CR. Similarly, the models used in this dissertation did not account for other societal costs such as time away from work. Participating in CR has been associated with a shorter time to return to work;(57, 58, 72) therefore, including these benefits would reduce the overall cost to society of providing a CR programme. The benefits of returning to work faster

may include increased business productivity, lower business costs associated with paid sick leave, and less time for a person on a sickness benefit.(72)

This study provides a starting point for future research into CR in New Zealand. Future research could be used to test the decision tree modelling conducted for this dissertation. The optimal study design would be a randomised controlled trial which mirrors the recent studies from the UK(26, 27, 59) and Australia(55) referred to in this dissertation. These studies provided both a home-based option and a hospital-based option and compared the two along with matched controls who did not take part in any CR programme. This research could be used to test for greater overall participation and completion, differences in clinical outcomes, and variation in quality of life outcomes. Additionally, conducting the research in New Zealand would help to ascertain the actual participation and completion rates recorded by Māori and those in low socioeconomic groups who are most impacted by CVD.(71) It would be prudent to pilot a home-based programme in a single DHB first. This would facilitate process mapping of the various components of CR in addition to focussing on the programme itself.

Any clinical trial of home-based CR in New Zealand should also include an economic evaluation. The data available to conduct such an analysis in New Zealand are currently limited; no economic studies of CR have been published in this country using New Zealand data. The accuracy of the cost data used in the decision tree modelling of this study is uncertain, but at this stage few alternative sources of accurate financial data exist. Although the two DHBs contributing data to this study reported a lack of systematic and accurate cost

accounting for CR, an economic evaluation conducted alongside a RCT would help improve the accuracy of cost estimates for the study arms.

This study has shown that adding a home-based CR option to a hospital-based programme may lead to increased overall participation in CR. The clinical benefits of CR may thereby be experienced by more of those in need and in particular by those especially burdened by CVD. Providing home-based CR programmes by providers who target high risk groups may therefore be a suitable way of engaging those most affected by CVD, and currently most neglected by treatment. Delivering home-based CR in this way may help to realise the Ministry of Health's priority objectives of reducing the impact of CVD and also of reducing health inequalities. Furthermore, the model suggests that greater clinical benefit and less secondary care utilisation could be achieved for a low marginal cost.

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