Rates and patterns of participation in cardiac rehabilitation in Victoria

Vijaya Sundararajan, MD, MPH, Stephen Begg, MS, Michael Ackland, MBBS, MPH, FAPHM, Ric Marshall, PhD

Victorian Department of Human Services

Steve Bunker, PhD

National Heart Foundation

Helen McBurney, PhD

LaTrobe University

Abstract

Background

Cardiac rehabilitation improves functional status and quality of life after a myocardial infarction (AMI), coronary artery bypass graft (CABG) or percutaneous transluminal coronary angioplasty (PTCA). It is currently the recommendation of the National Heart Foundation that all such patients be referred for rehabilitation. Previous pilot data indicate that overall only 22% of patients participate in rehabilitation following a cardiac event, with rates varying according to diagnosis (AMI 14%, CABG 39%, PTCA 20%). Because these pilot data, were based on only 20% of all participating rehabilitation centres in Victoria, a more extensive study was conducted.

Methods

1998 cardiac rehabilitation data from all of the participating centres in Victoria (N=4474) were linked to a subset of the Victorian Admitted Episodes Dataset consisting of all cases of AMI/CABG/PTCA/angina/catheterisation based on their ICD–9 CM codes (N=30,092). Angina and catheterisation codes were included to ensure that all potential candidates for rehabilitation were included in the analysis. The linkage process matched 89% of the observations from the NHF cardiac rehabilitation dataset to the 1998 VAED subset. Linkage was also undertaken with mortality data.

Results

Of the 12,730 cases of AMI/CABG/PTCA, the median age was 68 (25–75, 59–75), with 31% being female. Rates of participation in rehab were 13% for AMI alone, 43% for CABG, and 16% for PTCA alone. Whereas 26% of men participated in rehab, only 17% of women did so. Age was also a factor with those under 70 having lower participation rates. Marital status, absence of comorbid disease, and in particular, the absence of congestive heart failure were also significantly related to participation in cardiac rehabilitation. Outcomes including readmission and mortality will also be discussed.

Introduction

Cardiovascular disease is the leading cause of death in Australia, resulting in more than 40% of all deaths in 1998. It places a large burden on the healthcare system as well, with expenditures approximated at 3.9 billion dollars (Australian) in 1993 to 1994 ((AIHW) 2001).

Cardiac rehabilitation is a proven method for decreasing mortality after myocardial infarction, showing a reduction of all-cause mortality of 25% (Oldridge, Guyatt et al. 1988; Jolliffe, Rees et al. 2001). Current recommendations suggest that cardiac rehabilitation should be offered to all patients following cardiac surgery or acute myocardial infarction (National, Heart et al. 1998). Studies assessing cardiac participations rates are limited, and are usually not population based. An American cross-sectional study found that only 11% of those who had had a myocardial infarction subsequently attended rehabilitation, whereas 23% of those who had had a cardiac bypass did so. In particular, women and individuals over the age of 65 were poor attendees (Thomas, Miller et al. 1996). In a recent Victorian pilot study based on data linkage using attendance records from 8 rural, hospital-based programs and the state's hospital morbidity database, rates of participation were double the American ones (Bunker, McBurney et al. 1999).

After this pilot was completed, the National Heart Foundation developed a project to begin a more population-based data collection from the rehabilitation programs from throughout Victoria. Sixty-six cardiac rehabilitation programs agreed to collect basic information about their rehabilitation attendees in 1998. This dataset, linked to the Victorian Admitted Episodes Dataset and the Victorian Death Registry was able to provide insight into the patterns and predictors of cardiac rehabilitation attendance and the effect of attendance on mortality after a cardiac event.

Methods

Data sources

The Victorian Cardiac Rehabilitation Dataset is based on data collected from 66 outpatient cardiac rehabilitation programs in calendar year 1998. The information collected from each attendee included their date of birth, their Medicare number and suffix, their gender and address, including postal code. Provision of this information was voluntary.

The Victorian Admitted Episodes Dataset is a minimum dataset of acute separations from throughout Victoria (Division 2000). In its original state it is an episode-of-care level dataset, without any unique patient identifier that can group separations into individual cases spanning more than one hospitalisation. However, a process of data linkage using a number of variables has recently transformed the VAED into a case-based, but still anonymous dataset which is useful for longitudinal studies of hospital episodes. For each hospital separation, there are 25 diagnosis fields (ICD–9 and 10), and 25 procedure fields, along with length of stay.

The Victorian Deaths Registry is a subset of the Victorian Registry of Births, Deaths and Marriages and contains information on all deaths in Victoria. Cause of death is also included.

Selection of cases from VAED with cardiac diagnoses or procedures

From the 1998 VAED we selected 30,408 cases of myocardial infarction (infarct), coronary artery bypass grafting (bypass), percutaneous transluminal coronary angioplasty (angioplasty), cardiac catheterisation (catheterisation), and cardiac angina (angina). The cases were based on finding the appropriate ICD–9 code within the first three diagnostic or procedure fields (Table 1). As well, the codes for myocardial infarction and cardiac angina needed to be one of the primary reasons for the hospital separation. Although we were not interested in further analysis of the cardiac catheterisation-only and angina-only cases we included them in our initial case selection in order to capture all cases who may have been eligible for referral to cardiac rehabilitation.

Linkage of the VAED cardiac cases to the Cardiac rehabilitation dataset

The 4,474 cardiac attendees were linked to the 30,408 cases with cardiac diagnoses using a linkage algorithm developed specifically for the two datasets. The linkage variables were: year of birth, day of birth, month of birth, gender, postal code, 8-digit Medicare number and 3-digit Medicare suffix. Eight passes of varying combinations of these variables were used to link the two datasets together.

Linkage of VAED and Victorian Death Registry

In order to link the 30,408 cases of infarct, angioplasty, bypass, catheterisation and angina to the 120,974 deaths in Victoria between Jan 1, 1998 to October 31, 2001, we used 5 passes with varying combinations of year of birth, day of birth, gender, postal code, country of birth and Medicare suffix.

Cardiac rehabilitation participation rate

The cardiac rehabilitation participation rate was based on the number of cardiac cases from the VAED sample who linked to the rehabilitation dataset. Only cases from the VAED who linked to the rehab dataset were considered in the numerator of the participation rate.

Survival from the date of first cardiac diagnosis

Cases in the analysis group were classified as dying within the follow-up period in one of two ways:

1) the cardiac case had an in-hospital death, as detailed in their VAED hospital separation, or 2) the cardiac case matched a record from the death registry.

Survival time for those dying within the follow-up interval was defined as the time in days from the date of the case's first cardiac diagnosis admission date to either the separation date for the in-hospital death or the death date from the death registry.

Survival time for those who did not die in the follow-up (censored cases) was defined as the time interval from their first cardiac diagnosis to October 31, 2001 (the latest data we had from the death registry).

Statistical analysis

After obtaining initial descriptive statistics bivariate analyses were conducted, using the chi-square as the test of significance.

In order to take into consideration measured confounders (factors associated with cardiac rehabilitation attendance which may also have an association with mortality) so that we could obtain an accurate estimate of treatment effect and its relationship to all-cause mortality, we used propensity scoring methods (Rubin and Thomas 1996; Rubin 1997; D'Agostino 1998; Joffe and Rosenbaum 1999).

The propensity score is the conditional probability of treatment, based on a logistic or discriminant model with treatment status as the outcome. In our logistic regression model, attendance at cardiac rehabilitation was the outcome. Age, gender, patient type (public, private, veteran), marital status, diagnostic indication, comorbidity (based on the Charlson-Deyo comorbidity index (Charlson, Pompei et al. 1987; Deyo, Cherkin et al. 1992)), presence of chronic congestive failure during the index admission, type of hospital, emergent/elective index admission, and intensive care unit stay during index admission were the important covariates.

Theoretically, stratifying the analysis group into quintiles (of 20%) each can remove the majority of confounding due to measured factors.

Each quintile represents a group of cases who are comparable in the sum total of their measured covariates such as age and comorbidity. Therefore, assessing the effect of cardiac rehabilitation participation on all-cause mortality within quintile allows us to compare like to like based on all measured factors.

After developing our quintiles we assessed the impact of rehabilitation attendance on mortality using a Cox-proportional hazard model.

All analyses were conducted using SAS 8.2 (SAS Institute 1999).

Ethics

The project was approved by the Department of Human Services (Victoria) Ethics committee.

Results

Linkage of cardiac rehab and VAED

Eighty-five percent of the cardiac rehabilitation attendees were matched to their VAED data (3802/4474). The cardiac attendees who did not match to the VAED did not differ in age or gender from those who did match. The cardiac rehabilitation dataset includes those attending rehab in early 1998 who are not in VAED data as they have had their cardiac event in 1997 and those attending rehab in VIC who may have been hospitalised in NSW – this may in part account for the lower match rate.

Linkage of VAED and Victorian Death Registry

5,292 matches were found between the VAED and the death registry. This, in conjunction with deaths identified only from the VAED, resulted in a total of 5772 deaths from the 30,408 cases (19% of the analysis sample died within the follow-up period).

Forty-seven percent of all deaths occurred in-hospital, with 19% of these in-hospital deaths not identified by the match with the death registry. Extrapolating this to the whole analysis sample, we estimate that up to 9% of all deaths may not be captured by our linkage.

Cardiac rehabilitation participation rates

In our analysis we have focused only on the 12,730 cases with infarction (N=6,137), bypass (N= 3,495) and angioplasty (N=3,126).

Rates of participation varied by cardiac diagnosis and procedure (Figure 1 and Table 2). Whereas only 13% of those with an infarct participated, 30% of those with an infarct who had undergone an angioplasty and 41% of those with an infarct and a bypass participated in a rehabilitation program. Forty-three percent of cases who had undergone a bypass alone participated, while those with both a bypass and angioplasty participated at rates of 48%. Only 16% of those who only had an angioplasty participated in rehabilitation.

Age was also an important factor associated with cardiac rehabilitation participation (Figure 2). Participations rates peaked in the 50–59 year age group at 30% and then dropped off after the age of 70 years.

Other factors also influenced attendance, such as gender, presence of non-cardiac comorbidity, presence of chronic congestive failure, marital status and type of hospital of index admission.

Propensity score quintiles

Quintile 1 includes cases most likely to receive rehabilitation whereas Quintile 5 contains those least likely.

The quintiles differed in the proportion of cases attending rehabilitation as well as mortality, indicating that the propensity score, a composite of all the covariates, was a confounder with an association with both the exposure, attendance at rehabilitation, and the outcome, mortality (Table 3).

Association between participation in cardiac rehabilitation and all-cause mortality (Figure2)

In quintile 1, the oldest and most ill group, participation in cardiac rehabilitation reduced all-cause mortality by 70%. This continued in quintiles 2 through 4. In quintile 5, the youngest and least ill group, participation in cardiac rehabilitation reduced all-cause mortality by 35%.

Discussion

This preliminary analysis of our linkage project has brought together three diverse datasets from Victoria in order to provide insight into the participation rates of cardiac rehabilitation after major cardiac events and the benefit of such participation in terms of its impact on mortality. In our analysis sample of 12, 730 cases with myocardial infarction, cardiac bypass or percutaneous angioplasty, 23% attended cardiac rehabilitation overall. This percentage varied by diagnosis/procedure, age, gender, comorbidity, marital status and the type of hospital for the index admission.

Cases who had had a cardiac bypass participated at rates above 40%, whereas those with an infarction or angioplasty alone participated one-third to one-half as frequently. Cases with multiple cardiac diagnoses/procedures attended at higher rates than those with single reasons for referral.

Age showed a strong association with attendance, with a sharp decline after the age of 70, despite the fact that 45% of our analysis sample was over this age. Women also appeared to attend less often, even after controlling for other factors in a multiple logistic regression model. Admission to a teaching or private hospital also appeared to be related to attendance.

Attendance at cardiac rehabilitation was associated with a substantial reduction in all-cause mortality in our analysis. Interestingly, the elderly and those with comorbidities benefit more than those who are younger and healthier.

Our analysis is subject to information bias due to misclassification and confounding due to the non-random assignment of treatment. The linkage rate for the VAED-cardiac rehabilitation dataset was 85%, with potentially 15% of those who attended rehabilitation being misclassified as non-attendees. This bias will tend to underestimate the raw participation rates, but given that it is not associated with other factors such as age or gender, will not tend to bias the patterns of cardiac rehabilitation attendance amongst the covariate groups.

The potential misclassification of up to 9% of those who were thought to be alive at the end of follow-up may also lead to bias. This misclassification will be non-differential in that it will be randomly distributed between the attendees and non-attendees.

Both of these potential biases will tend to shift the results toward the "Null Hypothesis" of no difference in the survival of those who attended cardiac rehabilitation in comparison to those who did not. With cardiac rehabilitation attendees misclassified as non-attendees, the treatment effect observed from our analysis will be less than it may actually be, were we able to accurately classify all of our cases. In the same vein, the random misclassification of vital status will also move the effect size toward the Null (Mertens 1993; Grimes and Schulz 2002).

The fact that we observed such strong treatment effects indicates that these biases did not obscure the underlying effects. However, given that our observational analysis is subject to confounding due to the non-random assignment of treatment, there is still a chance that the treatment effect we observe for cardiac rehabilitation is due to factors other than cardiac rehabilitation attendance. In order to minimise such potential confounding due to measured factors, we used propensity scoring methods, which are able to remove greater than 90% bias due to these measured factors. However, unmeasured confounders may still be playing a role in the large treatment effects we have observed.

To address this issue, we will be conducting a formal sensitivity analysis, which will help us define how robust our results are to the presence of a putative unmeasured confounder.

The implications of our findings are strong. Cardiac rehabilitation may be under-utilised by groups which may benefit most from it: the elderly, women, those with comorbid disease and those without access to teaching and private hospitals.

Eligible diagnosis or procedure	ICD-9 codes
Acute myocardial infarction	410
Coronary artery bypass grafting	361
Percutaneous transluminal coronary angioplasty	360
Cardiac catheterisation	3721, 3722, 3723
Cardiac angina	4111, 4118, 4130, 4131, 4139, 4140

Table 1 ICD–9 codes used for case selection.

	Percentage participating in cardiac rehabilitaion	p-value*
Entire sample, N=12,730	24%	
Age		<0.0001
30-39	26%	
40-49	29%	
50-59	30%	
60-69	29%	
70-79	21%	
80-89	6%	
90+	1%	
Gender		<0.0001
Male	26%	
Female	17%	
Marital Status		<0.0001
Current	27%	
Never	19%	
Former	15%	
Cardiac diagnosis/procedure		<0.0001
Infarct alone	13%	
Infarct/Angioplasty	30%	
Infarct/Bypass	41%	
Bypass alone	43%	
Bypass/Angioplasty	48%	
Angioplasty alone+	16%	
Comorbidity		<0.0001
None	26%	
1	22%	
2 or more	14%	
Congestive Cardiac Failure		<0.0001
No	26%	
Yes	11%	
Intensive Care Unit, Index Admission		<0.0001
No	22%	
Yes	27%	
Emergent Admission, Index Admission		<0.0001
No	27%	
Yes	20%	
Hospital-Type, Index Admission		<0.0001
Teaching Hospital	25%	
Private Hospital	28%	
Other**	12%	

Table 2 Rates of cardiac rehabilitation attendance by important covariate factors.

*Chi-square

**Other hospital type includes Area, Large Regional, Local and Regional General hospitals.

	Quintile 1	Quintile 5
Median Age	82	64
Comorbidity	52%	28%
Chronic Congestive Failure	45%	3%
Predicted probability of attending rehabilitation*	<12%	>37%
Percentage actually attending rehabiliation	5%	46%
3-Year Survival	51%	94%

Table 3 Comparison of Quintiles 1 and 5.

*Probability from logistic regression model.

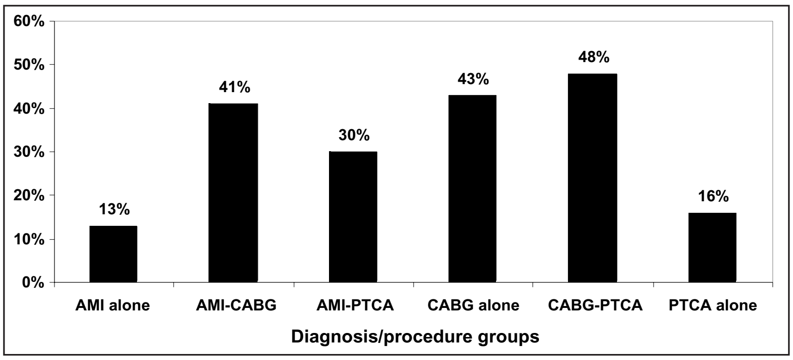

Figure 1 Rates of participation in cardiac rehabilitation by cardiac diagnosis/procedure

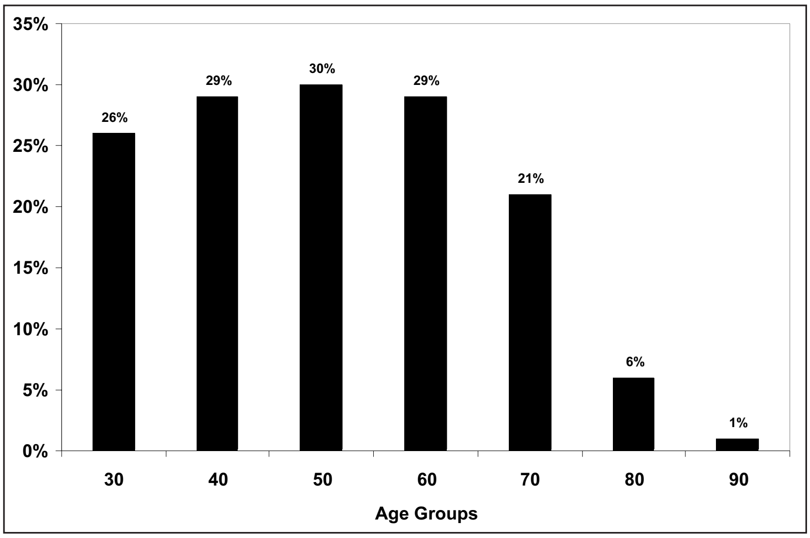

Figure 2 Rates of participation in cardiac rehabilitation by age groups.

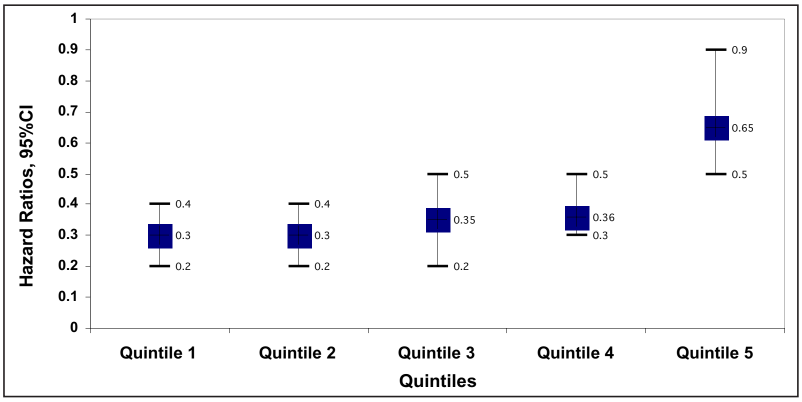

Figure 3 Risk of death (all-cause mortality) and participation in cardiac rehabilitation, by Quintile, hazard ratios and 95% Confidence Intervals.

References

Australian Institute of Health and Welfare (2001). Heart, stroke, and vascular diseases – Australian facts 2001. Canberra, AIHW, National Heart Foundation of Australia, National Stroke Foundation of Australia.

Bunker, S. and McBurney H., et al. (1999). "Identifying participation rates at outpatient cardiac rehabilitation programs in Victoria, Australia." J Cardiopulm Rehabil 19(6): 334–8.

Charlson, M.E., Pompei P., et al. (1987). "A new method of classifying prognostic comorbidity in longitudinal studies: development and validation." J Chronic Dis 40(5): 373–83.

D'Agostino, R.B., Jr. (1998). "Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group." Stat Med 17(19): 2265–81.

Deyo, R.A., Cherkin D.C., et al. (1992). "Adapting a clinical comorbidity index for use with ICD–9-CM administrative databases." J Clin Epidemiol 45(6): 613–9.

Victorian Government Department of Human Services (2000). The Victorian Admitted Episodes Dataset: An Overview April 2000. Melbourne, Acute Health Division.: 61.

Grimes, D.A. and Schulz K.F. (2002). "Bias and causal associations in observational research." Lancet 359(9302): 248–52.

Joffe, M.M. and Rosenbaum P.R. (1999). "Invited commentary: propensity scores." Am J Epidemiol 150(4): 327–33.

Jolliffe, J.A., Rees K., et al. (2001). "Exercise-based rehabilitation for coronary heart disease." Cochrane Database Syst Rev(1): CD001800.

Mertens, T.E. (1993). "Estimating the effects of misclassification." Lancet 342(8868): 418–21.

National Heart Foundation of Australia., et al. (1998). National Heart Foundation of Australia: Recommendations for cardiac rehabilitation. Canberra,

Oldridge, N.B., Guyatt G.H., et al. (1988). "Cardiac rehabilitation after myocardial infarction. Combined experience of randomized clinical trials." Jama 260(7): 945–50.

Rubin, D.B. (1997). "Estimating causal effects from large data sets using propensity scores." Ann Intern Med 127(8 Pt 2): 757–63.

Rubin, D.B. and Thomas N. (1996). "Matching using estimated propensity scores: relating theory to practice." Biometrics 52(1): 249–64.

SAS Institute. (1999). SAS 8.2. Cary, North Carolina.

Thomas, R.J., Miller N.H., et al. (1996). "National Survey on Gender Differences in Cardiac Rehabilitation Programs. Patient characteristics and enrollment patterns." J Cardiopulm Rehabil 16(6): 402–12.