The Quality and Variability of Cardiac Rehabilitation Delivery: Applying the Canadian Quality Indicators

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ABSTRACT

Purpose: Cardiac care, including cardiac rehabilitation (CR), is most effective if it is high-quality. The aim of this study was to describe CR quality, using the recently-developed Canadian Cardiovascular Society CR quality indicators (QIs). CR site differences in quality were also assessed.

Methods: Secondary analysis was conducted on an observational, prospective, multi-site CR program evaluation cohort. A convenience sample of patients from one of 3 CR programs was approached at their first CR visit, and consenting participants completed a survey. Clinical data were extracted from charts pre and post-program. Of the 30 CR QIs, 21 (70.0%) were assessable: 10 process, 9 outcome and 2 structure QIs.

Results: Of 411 consenting patients, 209 (53.0%) completed CR. The greatest quality was observed for assessment of blood pressure (98.1%), communication with primary healthcare at CR discharge (94.2%), and patient enrollment (94.0%). The lowest quality was observed for wait time from hospital discharge (9.2%), assessments of blood glucose (42.1%), and lipid control (53.0%). Of the 7 QIs that had an established benchmark, quality for 2 (28.6%) was above the benchmark (particularly assessment of blood pressure). Significant site differences were observed in 11 (64.7%) QIs. The magnitude of quality differences between sites was largest for assessment of lipid control (72.6%), assessment of blood glucose control (69.0%), and wait time in median days from referral to enrollment (30.6 days).

Conclusion: There is wide variability in CR program quality, both overall and between CR sites. Quality improvement in particular aspects of CR care is required.

CONDENSED ABSTRACT

Cardiac rehabilitation (CR) will be most effective if it is high quality. Twenty-one quality indicators were assessed in patients from 3 CR programs. The greatest quality was observed for assessment of blood pressure (98.1%), communication with primary healthcare (94.2%), and enrollment (94.0%). Site differences were observed in 11 (64.7%) indicators.

INTRODUCTION

Cardiovascular disease (CVD) is a leading cause of morbidity globally.[1] Effective secondary prevention requires multi-factorial behavioral and risk factor management. Cardiovascular rehabilitation (CR) is a comprehensive outpatient chronic disease management program that is designed to improve CV health. The Canadian Association of Cardiovascular Prevention and Rehabilitation (CACPR) defines CR as being a hospital or community-based program delivered by a multidisciplinary team of healthcare professionals, including a physician, with the following components: appropriate medical assessment including exercise testing; a core element of exercise; patient education; risk factor identification and control, and behavior modification.[2] Participation in CR is related to 25% lower mortality when compared to usual medical care, among other benefits.[3]

These benefits would be optimized when the highest quality secondary preventive care is provided to patients.[4] Care quality refers to a multidimensional construct encompassing evidence-based medicine, safety, equity, timeliness of care, efficiency, and patient-centeredness.[5] The quality of CR is quantified through quality indicators (QIs). Measuring quality using QIs allows researchers and clinicians to quantify the extent to which care is consistent with clinical practice guidelines, and the degree to which care meets available benchmarks. QIs are used to evaluate evidence-based practice performance, including care structure, processes and outcomes.[6] Structure QIs measure the attributes of the physical environment within which care takes place. Process QIs measure the services that are provided to the patient, and outcome QIs measure the health outcome of the patient as a result of the care provided.

While the impact of achieving quality improvement in CR has not been empirically established, there is ample supportive evidence suggesting significant improvements in patient

health outcomes can be achieved.[4,7,8, 9,10,11,12,13] For instance, an acute myocardial infarction (MI) QI is referral to CR,[7] and based on 2005 CR utilization rates post-MI in Ontario Canada, if CR uptake was increased to a 90% benchmark, there would be 135 deaths prevented or postponed, with a 1.3% (95% CI, 1.0-1.6) reduction in CVD mortality.[4] In the United Kingdom where referral rates are much higher than Canada,[9] CR referral (QI-1) itself is associated with greater 1-year survival (HR=0.80, 95%CI, 0.66-0.96).[10] Adjusted analyses examining mortality up to 7.5 years later demonstrated 43% lower mortality (HR=0.57, 95%CI, 0.49-0.67) in patients referred to CR versus those not. Moreover, additional data from Canada suggests that CR completion (QI-37) is associated with an adjusted hazard ratio of 0.57 (95%CI, 0.46-0.66) for mortality.[11] More recent data from the same group demonstrated that improvements in CV fitness of 1 metabolic equivalent of task (MET) though CR participation (QI-17) is associated with 25% lower mortality 1 year later. In fact, mortality was decreased by 13% with each MET increase.[12] Smoking cessation is associated with 36% lower mortality (RR=0.64; 95%CI, 0.58-0.71) in cardiac patients.[13] Given that the QIs were developed based on evidence of their impact on health outcomes, improving our attainment of CR QI benchmarks should accordingly improve patient health outcomes.

QIs for CR have been developed by several national CVD societies specific to their health care delivery systems and Association practice guidelines. The first to develop QIs for CR was the American Association of Cardiovascular and Pulmonary Rehabilitation (AAVCPR),[14,15] followed by a Dutch group.[16] The European Association of Cardiovascular Prevention and Rehabilitation (EACPR) recently published a QI on CR referral.[17] Finally, the Canadian Cardiovascular Society embarked on a process to develop QIs (http://bridge.ccs.ca/index.php/en/),[18] and in collaboration with the CACPR, 30 CR QIs were

developed.[19] Each CR QI was drafted with the following elements: name and definition, numerator, denominator (i.e., reference item or population, exclusions), sources of data, method of calculation, rationale, clinical recommendation(s) with corresponding guideline citations, and challenges to implementation. There is some initial evidence on the reliability of these QIs,[20] and their feasible implementation in the field.[21]

There is only one publication to our knowledge that has utilized any of these QIs to describe the quality of CR.[22] Fourteen of the QIs were assessed in Canada, and wide variation in quality across the indicators was observed. Therefore, the objectives of the current study are to assess more of these CR QIs than has been done previously, and to investigate CR program-level variation in these QIs.

METHODS

Design

A CR program evaluation cohort was utilized for this secondary analysis. This study was observational, and prospective in design. Approval from the research ethics review boards at each of the 3 CR sites as well as York University was received. Data from participants who were recruited into one of 3 CR programs between July 2010 and February 2014 were used in this study. Data from the first two assessment points (i.e., corresponding to CR intake and discharge approximately 6 months later for those who stayed in the program) were analyzed for the purposes of this study.

Setting

The cohort consisted of participants from 3 CR sites in the Greater Toronto Area, Canada. The sites are identified only by number for confidentiality. Table 1 describes the attributes of each site. Two of the programs are offered at no charge to participants, while the third has a minimal charge for those who have coverage or can afford it. Two of the CR

programs were located adjacent to community hospitals within a suburban setting, while the other was located within an academic hospital in an urban setting.

All 3 programs offered CR in accordance with CACPR Guidelines.[2] Each offered an initial group education session prior to an individual intake assessment. The program located in an academic hospital (Site 1) offered 90 minute twice-weekly classes, for a duration of 4 months. The community CR programs offered 60-90 minute twice-weekly classes, and one 90 minute weekly class, respectively, for 6 months. All three programs offered education classes, on-site exercise programs, dietary counselling for groups or individuals, smoking cessation referrals, and psychosocial assessment/support.

Procedure

At their first CR visit for patient education, patients were approached to solicit informed consent. Participants were asked to complete a self-administered survey in paper or online format.

Participants enrolling in the CR program completed an intake assessment as part of their standard care. This included risk factor assessment, an exercise stress test, and blood work (e.g. lipid panel, glycated hemoglobin or $HbA1_c$). This assessment protocol was repeated at the end of CR for those who completed the program (i.e., patient must have attended at least some of the CR intervention components and have had a formal re-assessment by the CR team at the conclusion of the CR intervention).[19] CR charts for all consenting participants were audited at expected CR discharge to ascertain program participation and to record available discharge asssessment data.

To assess the structure QIs, written program policies were audited and clinicians were interviewed at each of the 3 CR sites. Two structure QIs were measured in this study: one measured whether the program had an emergency response strategy, and the other whether the program had medical director supervision (Table 2).

Participants

This convenience sample consisted of all consenting participants referred to the 3 CR programs. Participants were referred to the CR programs with the following cardiac diagnoses or procedures: acute coronary syndrome, chronic stable angina, or stable heart failure, as well as percutaneous coronary or valvular intervention, coronary artery bypass graft (CABG) ± valve surgery, cardiac transplantation, or mild non-disabling stroke.[2] The inclusion criterion was that participants were deemed eligible to complete CR following the intake assessment (i.e. no co-morbidities identified or indications from the exercise stress test that would preclude CR participation). Participants who were not proficient in the English language were excluded from the study.

Measures

Sociodemographic characteristics of the sample were assessed through forced-choice items in the pre-test survey. Clinical data were extracted from CR referral forms, as well as CR intake and discharge assessments, where available. This included: previous cardiac diagnoses, referral and intake dates, referral indications, age, sex, comorbid conditions, cardiac medications, cardiac risk factors (e.g. lipids, blood pressure, blood glucose, Body Mass Index, and waist circumference), as well as program participation and completion. Peak Metabolic Equivalents of Task (METs) were obtained from the graded exercise stress tests. The change from intake to the discharge assessment was computed to assess QI-17, namely increase in exercise capacity.

Quality Indicators

Twenty-one out of the 30 CR QIs were assessable within the study: 10 process (QI-2a, 2b, 3, 5, 13, 14, 15, 16, 26, 30), 9 outcome (QI-7, 8, 9, 10, 12, 17, 18, 24, 37), and 2 structure (QIs 31, 32; see Table 2). Eleven of these had not been assessed in the Canadian QI paper.[22] Full specifications of how the QIs are assessed (i.e. numerator and denominator) is available elsewhere.[19] Each process and outcome QI were assessed using the CR charts. Seven of the QIs had established benchmarks to which performance could be compared.[4,19,23]

The definitions of QIs 2a, 3, 5, 7-12, 26, and 30 were slightly modified due to what data was available. Specifically, QI-2a measured wait time from hospital discharge to enrollment in all participants, not just those who were eligible and were in-patients. For QI-3, the percentage of participants who enrolled and underwent an intake assessment was captured, not who attended any first visit (as all participants had already attended an initial visit during which time they were invited to participate in the study). For QI-5, we assessed whether they received any education, not whether self-management was offered specifically (however the sites informed us that self-management is part of the education curriculum). For QIs 7-12, we did not capture contraindications to, or appropriateness for prescription of the medications. QIs- 26 and 30 captured patients who received, instead of were referred to, a smoking cessation or stress management intervention, respectively.

In regards to the structure QIs, the strategy in place to enable prompt defibrilliation (e.g. accessible “crash cart”, automated external defibrillator, code blue policies), and current Basic Cardiac Life Support certification of all clinical staff, was reviewed for QI-31. For QI-32, medical director supervision was determined by reviewing the program’s organizational chart and the job description of the most senior physician, if available.

Statistical Analyses

IBM SPSS version 22 was used.[24] Sociodemographic and clinical characteristics of participants were computed and described. These were compared by site using analysis of variance (ANOVA) with post-hoc least significant differences (LSD) tests. A p-value of <0.05 was defined as a significant difference between groups.

Retention for the discharge assessment was calculated. The sociodemographic and clinical characteristics at intake of the retained and non-retained samples in terms of graduation from the program were compared using Chi-square and Student's t-test analyses as applicable.

For the first objective, each of the QIs were described. As per denominator definitions,[19] some QIs were assessed only in those who completed CR (i.e., QIs- 5, 7, 8, 9, 10, 12, 17, 18, 26, 30, 34, and 37). To test the second objective, ANOVA was utilized to analyze differences on each QI (dependent variable) by CR site (independent variable), again with post-hoc LSD tests where significant.

RESULTS

Respondent Characteristics

Of the participants approached, 411 consented. Figure 1 shows the participant flow diagram. Table 3 displays the pre-CR sociodemographic and clinical characteristics of the cohort by site. Participants significantly differed by marital status, racial /ethnic background, peak METs, CABG surgery as a referral indication, the risk factors dyslipidemia and hypertension, and medication use (i.e. Acetylsalicyclic Acid [ASA], statins, beta-blockers, anti-coagulants, and other cardiac medications).

CR charts were available for 394 (96.1%) participants at post-test. Of these, 209 (53.0%) completed a discharge assessment, and were thus considered to have completed the program (Figure 1). Characteristics of those who graduated and those who did not, are shown in Table 4.

Participants who completed CR were significantly less likely to have been referred due to arrhythmia, and more likely to have been prescribed ASA at hospital discharge. No other differences were observed.

CR Quality

QI findings (percentages or median days for QI-2b) are displayed in Table 5. Of the 7 QIs for which there exists an established benchmark, quality for 2 (28.6%) of the indicators exceeded the benchmark (QIs 3 enrollment and 13 assessment of blood pressure).

For QIs without an established benchmark, performance was highest for: medical director oversight (QI-32), documented emergency response strategy (QI-31), communication with the primary healthcare provider at discharge (QI-34), receipt of patient education (QI-5), assessment of adiposity (QI-15), and receipt of a stress management intervention (QI-30). QIs for which performance was observed to be below 50% were (in ascending order): wait time from hospital discharge to enrollment (QI-2a), prescription of other anti-platelets at discharge (QI-8), and assessment of blood glucose control (QI-16; the latter has a benchmark).

Differences in CR quality by site are also displayed in Table 5. QIs which had an insufficient sample size for analysis at the site level (i.e. less than 2 cases) were excluded. These indicators were: smoking cessation support (QI-26; due too few smokers), programs with medical director oversight (QI-31), programs with a documented emergency response strategy (QI-32), and stress management (QI-30; due to no internal stress management component at site 1). Thus, 17 (81.0%) QIs were analyzed. Significant differences in performance between sites were observed for 11 (64.7%) QIs. Exceptions were QIs- 2a, 3, 8, 12, 13, and 34. The magnitude of quality differences between sites was largest for assessment of lipid control (72.6%), followed by assessment of blood glucose control (69.0%), and wait time from referral to enrollment in median days (30.6 days).

DISCUSSION

There are gaps between what we know to be effective CR care and the care we provide. Results of this study demonstrate that efforts are needed to improve CR quality in some areas, and that it varies considerably across programs. Quality was greatest for the 2 CR structure indicators, assessment of blood pressure control, communication with primary care, enrollment and patient education and was lowest for wait times, assessment of blood glucose, and lipid control.

Quality in terms of wait-time from hospital discharge to enrollment was the lowest of all indicators assessed. Reduction in wait times could be achieved by targeting the referral stage. Systematic strategies have proven to reduce wait times by ensuring patients are referred as inpatients prior to hospital discharge, not weeks later at an outpatient visit.[25,26] Lack of capacity for new patients, or lack of human resources to process referrals received could also explain the unduly long wait times observed. The wait times observed are disconcerting, given emerging evidence of the negative impact of prolonged waits on many outcomes from cardiac remodeling to program enrollment.[26,27,28]

Program completion could be improved, given that a dose-response association exists between CR adherence and mortality.[11] Rates of CR completion have not been summarized in a meta-analysis to date, but a review by our group suggested that, as opposed to completion, CR drop-out rates range from 12-56%.[29] Interventions to improve CR adherence have been recently reviewed.[30] Of the 8 trials identified, only 3 had a significant effect in increasing adherence. These interventions included self-monitoring of activity, action planning and tailored counselling by CR staff. Although the root causes of low CR adherence are multifactorial and complex, these interventions could be applied to optimize patient outcomes.

Low assessment of blood glucose and lipids may be explained in that CR staff aim to avoid duplicate testing to save costs to the health care system. These tests may have already been completed by another of the patients' healthcare providers. This could be overcome where electronic medical records could be shared between specialist, generalist and CR providers to ensure programs have access to such results. Alternatively, the patients may have reported that they do not have diabetes, or staff may have observed that their lipids were well-controlled pharmacologically.

Cardiac medication use post-CR was surprisingly low, particularly in relation to a 90% target as applied by Wijeysundera et al.[4]. Their benchmark was concededly an estimate, however such a benchmark is nearly met in other outpatient settings.[31] Given individual indications and contraindications were not taken into consideration in this study, the prescription of certain drugs may not have been appropriate for all patients (e.g., in post-myocardial infarction patients only those with poor left ventricular function and heart failure are indicated for a beta-blocker). The data was recorded from program charts, and likely reflects patient report to CR staff of medications taken, as medication prescription is usually undertaken by a patient's specialist rather than these CR programs. It is hoped that the post-program communication from the CR program to the patients' primary care provider (which was frequent) lists their medications and recommendations for medication additions and changes in accordance with guidelines.

Upon comparison of the QI findings from this study to those obtained from the Canadian Cardiac Rehab Registry (CCRR),[22] similarities and differences were observed. Indicators that were fairly consistent in the CCRR and in this study, respectively, were: QI-13 assessment of blood pressure control (90% versus 98%), QI-15 assessment of adiposity (85% versus 88%), QI-17 increase in exercise capacity by one-half MET by end of program (68% versus 69%), and QI-

16 assessment of lipid control (41% versus 42%). Inconsistencies were seen in some indicators as well. Assessment of blood glucose was about half the rate in the CCRR as was observed herein (23% vs. 42%).

Site Differences

This study was the first to examine QI differences between CR sites. For approximately two-thirds of the QIs, significant site differences were observed. These findings are worrisome, as they suggest that some of the sites are providing much lower quality care than their counterparts. Differences may have arisen from variation in program intensity (i.e., session frequency and duration, leading to greater or lesser opportunity to risk factor assessment or increases in exercise capacity), levels of resources or staff complement at each program, and in provider practice. For example, Site 3 may have had shorter wait times in comparison to Sites 1 & 2 because they have a fee-based service and hence can appropriately resource their program to meet patient demand.

Another explanatory factor could be the lack of standardization in charts and charting practices across the CR sites. This explains why Site 2 performed more poorly in terms of medication than the other sites. They have an electronic CR record developed for their site, and there have been challenges with the medication module leading to less staff charting. Site 2 also reports being more reliant on primary health care providers for assessments of lipids and blood glucose control in comparison to the other sites, in an effort to avoid duplication in testing and the associated costs to the health care system.

Adherence and completion amongst patients at Site 3 was the lowest, perhaps because patients were subject to a fee every month or that the program offered the most sessions of the 3 programs. Patients who were unable to pay may have been deterred from attending, and hence

also achieved less improvement in exercise capacity. However as the results showed, patients differed significantly between sites in terms of their sociodemographic and clinical characteristics at intake. Thus this likely also contributed to the site differences in quality observed.

Implications

Improvement initiatives are needed to increase quality where it was low, and also to reduce CR site variation. Indeed, some organizations have developed CR standards[17,32] which, where implemented, may reduce variability. Moreover, a recent American study demonstrated how a series of quality improvement activities, namely program policy changes as well as patient educational materials and incentives, significantly improved CR program session attendance among graduating patients.[24] CR programs could also form a "community of practice" to share best practices enacted by high-performing programs with lower-performing ones.

Limitations

Caution is warranted when interpreting the findings. First, the representativeness of the cohort is unknown, as the CR sites did not record which patients were approached to participate but declined. As well, consenting patients may have had particular psychological characteristics, such as high motivation and perseverance, that set them apart from patients who did not, and this could have affected the results. Thus, selection bias may be at play. More broadly, the majority of cardiac patients indicated for CR are not referred, and hence the findings will only be generalizable to those who are referred and ultimately attend an initial CR session.

Second, the generalizability of the findings for the 14 QIs which required CR discharge data is not known, considering only 60% of the patients completed the program. The retained

cohort did not differ greatly from those lost to follow-up however. However, these QIs should be interpreted with caution as they may be under or over-inflated.

Third, modifications to the definitions of QIs 2a, 3, 5, 7-12 26, 30 may have influenced the results observed. For QI-2a, including all patients, not just eligible patients, could have led to under-estimation of the number of patients who accessed CR within 30 days. For QI-3, using patients who had already attended one visit at the site may have over-estimated the QI finding. QIs 7-12 are likely under-estimated as indications and contraindications were not considered. So for example, anti-platelets would be indicated for the third of patients who had a percutaneous coronary intervention. Finally, modifications for QIs-26 and 30 may have under-estimated the QIs, because patients may not have followed through on referral to these services. Overall, due to the secondary use of data, not all of the QI exclusions were assessed. Therefore, some of the findings should be interpreted with caution.

Fourth, the number of programs was very small for the structure QIs, and hence these findings should not be over-interpreted. Finally, the generalizability of the study results to other CR programs is unknown, particularly to CR programs with differing payment models, and location (e.g. rural).

CONCLUSION

CR quality was particularly high with regard to assessment of blood pressure, communication with the patients' primary healthcare providers at discharge, and patient enrollment. In contrast, quality was very poor in the following areas: wait time from hospital discharge, assessments of blood glucose, and lipid control. Site differences in quality were observed for two-thirds of the QIs, with the greatest differences observed for assessment of lipid control, blood glucose control, and wait time from referral to enrollment. This suggests the need

for greater standardization to ensure the best health outcomes for all patients. Methods of increasing quality could include systematic referral, use of electronic patient records across the continuum of care, and better inter-provider communication regarding use of evidence-based cardiac medications.

REFERENCES

1. Mendis S, Puska P, Norrving B. *Global Atlas on cardiovascular disease prevention and control*. (Mendis S, Puska P, Norrving B, eds.). Geneva, Switzerland:World Health Organization; 2011.

2. Stone JA, Arthur HM. (Eds). *Canadian guidelines for cardiac rehabilitation and cardiovascular disease prevention: Translating knowledge into action*. 3rd ed. (Stone JA, ed.). Winnipeg, Manitoba, Canada: Canadian Association of Cardiac Rehabilitation; 2009.

3. Anderson LJ, Taylor RS. Cardiac rehabilitation for people with heart disease : An overview of Cochrane systematic reviews. *Int J Cardiol*. 2014;177(2):348–361.

4. Wijeysundera HC, Mitsakakis N, Witteman W, et al. Achieving Quality Indicator Benchmarks and Potential Impact on Coronary Heart Disease Mortality. *Can J Cardiol*. 2011;27:756 –762

5. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, D.C.: National Academy Press; 2001.

6. Donabedian A. Quality assessment and assurance: unity of purpose, diversity of means. *Inquiry*. 1988;25(1):173–192.

7. Tu JV, Khalid L, Donovan LR, Ko DT. Indicators of quality of care for patients with acute myocardial infarction. *CMAJ*. 2008;179(9):909–915.

8. Kerr CR. Benefits and expected outcomes of the Pan-Canadian Data Definitions and Quality Indicators projects. *Can J Cardiol*. 2010;26(8):405–406.

9. Turk-Adawi K, Sarrafzadegan N, Grace SL. Global availability of cardiac rehabilitation. *Nat Rev Cardiol*.2014;11(10):586-596.

10. Lewinter C, Bland JM, Crouch S, et al. The effect of referral for cardiac rehabilitation on survival following acute myocardial infarction: a comparison survival in two cohorts collected in 1995 and 2003. *Eur J Prev Cardiol*. 2014;21(2):163–171.

11. Martin BJ, Hauer T, Arena R, et al. Cardiac rehabilitation attendance and outcomes in coronary artery disease patients. *Circulation*. 2012;126(6):677–687.

12. Martin BJ, Arena R, Haykowsky M, et al. Cardiovascular fitness and mortality after contemporary cardiac rehabilitation. *Mayo Clin Proc*. 2013;88(5):455–463.

13. Critchley JA, Capewell S. Mortality risk reduction associated with smoking cessation in patients with coronary heart disease: a systematic review. *JAMA*. 2003;290(1):86–97.

14. Thomas RJ, King M, Lui K, Oldridge N, Piña IL, Spertus J. AACVPR/ACC/AHA 2007 performance measures on cardiac rehabilitation for referral to and delivery of cardiac rehabilitation/secondary prevention services. *J Cardiopulm Rehabil Prev*. 2007;27(5):260–290.

15. Thomas RJ, King M, Lui K, Oldridge N, Piña IL, Spertus J. AACVPR/ACCF/AHA 2010 Update: Performance measures on cardiac rehabilitation for referral to cardiac rehabilitation/secondary prevention services: A report of the American Association of Cardiovascular and Pulmonary Rehabilitation and the American College of Cardiology Foundation /American Heart Association Task Force on Performance Measures (Writing

Committee to Develop Clinical Performance Measures for Cardiac Rehabilitation). *Circulation*.2010;122:1342-1350.

16. Van Engen-Verheul M, Kemps H, Kraaijenhagen R, De Keizer N, Peek N. Modified Rand method to derive quality indicators: a case study in cardiac rehabilitation. *Stud Health Technol Inform*. 2011;169:88–92.

17. Piepoli MF, Corrà U, Adamopoulos S, et al. Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery: A Policy Statement from the Cardiac Rehabilitation Section of the European Association for Cardiovascular Prevention & Rehabilitation. *Eur J Prev Cardiol*. 2012;21(6):664–681.

18. Tu JV, Abrahamyan L, Donovan LR, Boom N. Best practices for developing cardiovascular quality indicators. *Can J Cardiol*. 2013;29(11):1516–1519.

19. Grace SL, Poirier P, Norris CM, Oakes GH, Somanader DS, Suskin N. Pan-Canadian development of cardiac rehabilitation and secondary prevention quality indicators. *Can J Cardiol*. 2014;30(8):945–948.

20. Thomas RJ, Chiu JS, Goff DC, et al. Reliability of abstracting performance measures: results of the cardiac rehabilitation referral and reliability (CR3) project. *J Cardiopulm Rehabil Prev*. 2014;34(3):172–179.

21. Grace SL, Tan Y, Oh P, Aggarwal S, Unsworth K, Suskin N. Feasibility of assessing two cardiac rehabilitation quality indicators. *J Cardiopulm Rehabil Prev*. 6 Aug 2015;Epub.

22. Grace SL, Parsons TL, Duhamel TA, Somanader DS, Suskin N. The Quality of Cardiac Rehabilitation in Canada: A Report of the Canadian Cardiac Rehab Registry. *Can J Cardiol*. 2014;30(11):1452-1455.

23. Grace SL, Chessex C, Arthur H, et al. Systematizing inpatient referral to cardiac rehabilitation 2010: Canadian Association of Cardiac Rehabilitation and Canadian Cardiovascular Society joint position paper endorsed by the Cardiac Care Network of Ontario. *Can J Cardiol*. 2011;27(2):192–199.

24. IBM Corp. IBM SPSS Statistics for Windows: Version 22.0. Armonk, NY: 2013.

25. Grace SL, Scholey P, Suskin N, et al. A prospective comparison of cardiac rehabilitation enrollment following automatic vs usual referral. *J Rehabil Med*. 2007;39(3):239–245.

26. Russell KL, Holloway TM, Brum M, Caruso V, Chessex C, Grace SL. Cardiac rehabilitation wait times: effect on enrollment. *J Cardiopulm Rehabil Prev*. 2011;31(6):373–377.

27. Collins C, Suskin N, Aggarwal S, Grace SL. Cardiac rehabilitation wait times and relation to patient outcomes. *Eur J Phys Med Rehabil*. 2015;51(3): 301-309.

28. Marzolini S, Blanchard C, Alter DA, Grace SL, Oh P. Delays in referral and enrolment are associated with mitigated benefits of cardiac rehabilitation after coronary artery bypass surgery. *Circ Cardiovasc Qual outcomes*; in press.

29. Turk-Adawi KI, Grace SL. Narrative review comparing the benefits of and participation in cardiac rehabilitation in high-, middle- and low-income countries. *Heart Lung Circ*. 2015;24(5):510–520.

30. Karmali KN, Davies P, Taylor F, Beswick A, Martin N, Ebrahim S. Promoting patient uptake and adherence in cardiac rehabilitation. *Cochrane database Syst Rev*. 2014;6:CD007131.

31. Chan PS, Oetgen WJ, Buchanan D, et al. Cardiac performance measure compliance in outpatients: the American College of Cardiology and National Cardiovascular Data Registry's PINNACLE (Practice Innovation And Clinical Excellence) program. *J Am Coll Cardiol*. 2010;56(1):8–14.

32. Cardiac Care Network of Ontario. *Standards for the Provision of Cardiovascular Rehabilitation in Ontario*.2014. http://ccn.on.ca/ccn_public/uploadfiles/files/CCN_Cardiovascular_Rehab_Standards_2014.pdf.

33. Pack QR, Johnson LL, Barr LM, et al. Improving cardiac rehabilitation attendance and completion through quality improvement activities and a motivational program. *J Cardiopulm Rehabil Prev*. 2013;33(3):153–159.

Figure 1: Patient Flow diagram

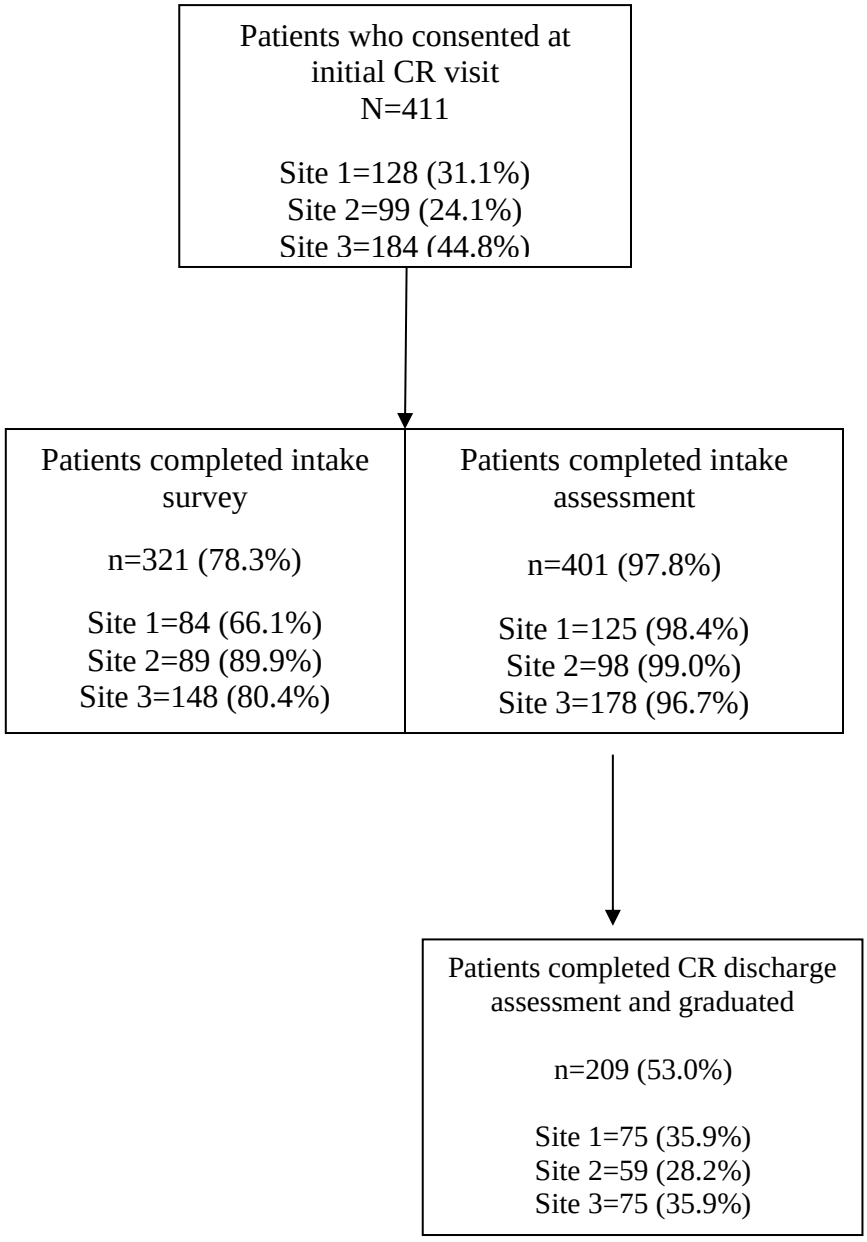

Table 1: Attributes of Cardiac Rehabilitation Sites Studied

	Site 1	Site 2	Site 3
Duration (months)	4	6	6
Annual volume	400	700	550
Academic vs. Community	Academic	Community	Community
Frequency of sessions per week	2	1	2
Systematic inpatient referral	Yes	Yes	No
Costs	Free	Free (educational materials cost $100)	$55CDN+tax/month

Table 2: Description of the CR QIs assessed in this study

QI#	Domain	Name	Definition	Type
CR-2a	Referral, access, and wait times	CR wait time from hospital discharge	% CR eligible inpatients who enrolled within 30 days after hospital discharge*	Process
CR-2b		CR wait time from referral to enrollment	Median days between receipt of referral to patient enrollment	Process
CR-3		CR enrollment	% patients who enrolled and underwent an intake assessment*	Process
CR-7	Secondary prevention: assessment, risk stratification and control	Medication: ASA	% CR patients who were prescribed ASA at program discharge*	Outcome
CR-8		Medication: Other Anti-platelet	% CR patients prescribed anti-platelet agents other than ASA at program discharge*	Outcome
CR-9		Medication: Beta-Blockers	% CR patients prescribed beta-blockers at program discharge*	Outcome
CR-10		Medication: Statins	% CR patients prescribed statins at program discharge*	Outcome
CR-12		Medications: ACE-i/ARB	% CR patients prescribed ACE-i or ARBs at program discharge*	Outcome
CR-13		Assessment of blood pressure	% CR patients with assessment of blood pressure control	Process
CR-14		Assessment of lipids	% CR patients with assessment of lipid control	Process
CR-15		Assessment of adiposity	% CR patients with assessment of adiposity	Process
CR-16		Assessment of blood glucose	% diabetic patients with assessment of blood glucose control ($HbA1_C$)	Process
CR-17	Behaviour change, program adherence & psychosocial education	Increase in exercise capacity	% CR patients with one-half MET increase in exercise capacity by end of program	Outcome
CR-18		Adherence to CR program	% prescribed exercise sessions completed	Outcome
CR-26		Smoking cessation support	% current or recent smokers who received smoking cessation support*	Process
CR-30		Stress management	% patients who received a stress management intervention*	Process
CR-5		Self-management	% CR patients who received self-management education*	Process

		education		
CR-31	CR program model and structure	Medical Director supervision	% CR programs that have a physician medical director providing oversight	Structure
CR-32		Emergency response strategy	% CR programs with a documented emergency response strategy and appropriately qualified staff	Structure
CR-34	Discharge transition, linkage & communication	Communication with PHCP	% CR patients with a documented communication between program and PHCP	Outcome
CR-37		CR Program completion	% patients enrolled in CR who completed the program	Outcome

CR= Cardiac Rehabilitation
ASA= Acetylsalicyclic Acid
ACE-i= Angiotensin Converting Enzyme-inhibitor
ARB= Angiotensin Receptor Blocker
MET= Metabolic Equivalent of Task
PHCP= Primary Health Care Provider
$HbA1_C$= Glycated Hemoglobin
*QI definition slightly modified.

Table 3: Pre-CR Sociodemographic and Clinical Characteristics of Participants by CR Site

Characteristic	Site 1 (n=128, 31.1%)	Site 2 (n=99, 24.1%)	Site 3 (n=184, 44.8%)	p
Sociodemographic				
Age (mean±SD years)†	64.2±10.9	65.8±10.4	63.9±10.1	0.33
Sex (% male)†	84 (67.2)	69 (69.7)	133 (72.3)	0.63
Marital status				
Married, common-law	52 (40.6)†††§§§	68 (68.7)†††	116 (63.0)§§§	<0.001
Single, separated, divorced	20 (15.6)§§	14 (14.1)†	11 (6.0)†§§	0.01
Widowed	9 (7.0)	6 (6.1)	20 (10.9)	0.29
Education (% university or higher)	63 (49.2)	55 (55.6)	99 (53.8)	0.60
Racial / Ethnic background				
North American	38 (29.7)††	48 (48.5)††§§§	40 (21.7)§§§	<0.001
Southern European	7 (5.5)	5 (5.1)	20 (10.9)	0.11
British Isles (e.g., British, Scottish, Irish)	5 (3.9)†	13 (13.1)†	15 (8.2)	0.04
Other	78 (60.9)†††	33 (33.3)†††§§§	109 (59.2)§§§	<0.001
Work status (% retired)	36 (28.1)	42 (42.4)	67 (36.4)	0.08
Clinical†				
Previous cardiac diagnosis (% yes)	14 (10.9)	13 (13.1)	12 (6.5)	0.16
Peak METs§ (mean±SD)	7.8±3.2††	6.5±2.9††	7.1±2.7	0.007
Referral Indication (% yes)				
Percutaneous Coronary Intervention	53 (44.9)	42 (45.2)	58 (33.5)	0.07
Coronary Artery Disease	41 (34.7)	21 (23.1)	65 (37.6)	0.06
Myocardial Infarction	23 (19.5)	25 (27.2)	52 (30.2)	0.12
Coronary Artery Bypass Graft Surgery	20 (16.9)†§§	30 (33.0)†	59 (33.9)§§	0.004
Arrhythmia	11(9.3)	7 (7.8)	18 (10.5)	0.78
Other	17 (13.3)	11 (11.1)	25 (13.6)	0.83
Risk Factors (% yes)				
Dyslipidemia	85 (80.2)†††ΔΔ	46 (58.2)†††§§§	162 (95.3)§§§ΔΔ	<0.001
Hypertension	69 (60.5)†††§§§	76 (82.6)†††	145 (84.8)§§§	<0.001
Obesity	48 (49.0)	36 (40.4)	70 (39.8)	0.31
Diabetes	26 (25.7)	22 (25.9)	29 (17.3)	0.15
Current Smoker	6 (7.6)	4 (4.7)	4 (2.7)	0.25
Cardiac Medications (% yes)				

ASA	82 (70.7)	46 (58.2)††	131 (74.9)††	0.03
Statins	89 (76.7)††	44 (55.7)††§§§	140 (80.9)§§§	<0.001
Beta-blockers	94 (81.0)^{†††Δ}	42 (53.2)†††§§	122 (70.1)^{§§Δ}	<0.001
ACE-inhibitors	58 (50.0)	29 (36.7)†	90 (52.0)†	0.07
Calcium antagonists	26 (22.4)†	8 (10.1)†	24 (13.9)	0.05
Anti-platelets	39 (30.5)	25 (25.3)	56 (30.4)	0.61
Anti-coagulants	23 (19.8)†††	10 (12.7)	10 (5.8)†††	0.001
Other anti-platelets	14 (10.9)	4 (4.0)	14 (7.6)	0.16
Other	75 (58.6)^{††ΔΔΔ}	42 (42.4)††§§§	144 (78.3)^{§§§ΔΔΔ}	<0.001

†source is medical chart (hospital or cardiac rehabilitation program).
§from pre-CR graded exercise stress test.

†p<0.05, ††p<0.01; †††p<.001; §p<0.05, §§ p<0.01; §§§ p<.001; ^{Δ}p<0.05, ^{ΔΔ}p<0.01, ^{ΔΔΔ}p<0.001

ASA= Acetylsalicyclic Acid; ACE=Angiotensin Converting Enzyme; MET=Metabolic Equivalent of Task; SD=Standard Deviation.

Table 4: Pre-CR Sociodemographic and Clinical Characteristics of Participants by CR Completion Status

Characteristic	Did not Complete CR (n=185; 47.0%)	Completed CR (n=209; 53.0%)	Total N=394	P
Sociodemographic				
Age (mean±SD years)†	63.7±10.9	65.4±9.7	64.5±10.4	0.18
Sex (% male)†	96 (69.6)	151 (72.2)	286 (70.1)	0.34
Marital status				
Married, common-law	75 (54.3)	130 (62.2)	236 (57.4)	0.09
Single, separated, divorced	13 (9.4)	22 (10.5)	45 (10.9)	0.44
Widowed	16 (11.6)	12 (5.7)	35 (8.5)	0.04
Education (% university or higher)	71 (51.4)	112 (53.6)	217 (52.8)	0.39
Racial / Ethnic background				
North American	40 (29.0)	68 (32.5)	126 (30.7)	0.28
Southern European	13 (9.4)	14 (6.7)	32 (7.8)	0.23
British Isles (e.g., British, Scottish, Irish)	14 (10.1)	18 (8.6)	33 (8.0)	0.38
Other	71 (51.4)	109 (52.2)	220 (53.5)	0.49
Work Status (% retired)	43 (31.2)	80 (38.3)	145 (35.3)	0.11
Clinical†				
Previous cardiac diagnosis (% yes)	13 (9.4)	21 (10.0)	39 (9.5)	0.50
Peak METs§ (mean±SD)	7.24±2.6	7.17±3.0	7.17± 2.9	0.08
Referral Indication (% yes)				
Percutaneous Coronary Intervention	47 (34.8)	87 (42.9)	153 (39.8)	0.09
Coronary Artery Disease	47 (34.8)	62 (30.8)	127 (33.2)	0.26
Myocardial Infarction	31 (23.0)	53 (26.4)	100 (26.2)	0.28
Coronary Artery Bypass Graft Surgery	36 (26.9)	61 (30.0)	109 (28.5)	0.31
Arrhythmia	17 (12.7)	13 (6.5)	36 (9.5)	0.04
Other	23 (16.7)	26 (12.4)	53 (12.9)	0.17
Risk Factors (% yes)				
Dyslipidemia	110 (85.9)	149 (80.5)	293 (82.5)	0.14
Hypertension	106 (79.7)	146 (73.4)	290 (76.9)	0.12
Obesity	58 (43.9)	79 (42.0)	154 (42.4)	0.41
Diabetes	34 (26.4)	37 (20.2)	77 (21.8)	0.13

Current Smoker	6 (5.8)	7 (4.3)	14 (4.5)	0.39
Cardiac Medications (% yes)				
ASA	83 (63.4)	144 (73.5)	259 (70.0)	0.04
Statins	98 (75.4)	144 (73.8)	273 (74.2)	0.43
Beta-blockers	86 (66.2)	141 (72.3)	258 (69.9)	0.14
ACE-inhibitors	62 (47.7)	92 (47.2)	177 (48.1)	0.51
Calcium antagonists	25 (19.2)	25 (12.8)	58 (15.8)	0.08
Anti-platelets	42 (30.4)	61 (29.2)	120 (29.2)	0.45
Anti-coagulants	9 (6.9)	26 (13.3)	43 (11.7)	0.05
Other anti-platelets	9 (6.5)	17 (8.1)	32 (7.8)	0.37
Other	97 (70.3)	129 (61.7)	261 (63.5)	0.06

*$p<0.05$ based on results of t-test or chi-square, as applicable.
†source is medical chart (hospital or cardiac rehabilitation program).
§from pre-CR graded exercise stress test.

ASA= Acetylsalicyclic Acid; ACE=Angiotensin Converting Enzyme; MET=Metabolic Equivalent of Task; SD=standard deviation.

Table 5: Quality Indicator Findings overall and by CR program

QI# and Name	Overall Indicator Finding (%)	Available Benchmark	CR Site			p*
			Site 1 (n=128, 31.1%)	Site 2 (n=99, 24.1%)	Site 3 (n=184, 44.8%)	
2a- CR wait time from hospital discharge◊	9.2	n/a	10.2	8.3	n/a	0.62
2b- CR wait time from referral to enrollment (median days)	35	n/a	59.9†††	50.3§§§	29.3†††§§§	<0.001
3- CR enrollment◊	94.0	70%[23]	89.8	94.9	95.7	0.10
7- Medication: ASA◊‡	70.0	90%[4]	70.7	58.2††	74.9††	0.03
8- Medication: Other Anti-platelet◊‡	33.5	n/a	26.4	38.8	37.0	0.27
9- Medication: Beta-Blockers◊‡	69.9	90%[4]	81.0†††Δ	53.2†††§§	70.1§§Δ	<0.001
10-Medication: Statins◊	74.2	90%[4]	76.7††	55.7†††§§§	80.9§§§	<0.001
12- Medications: ACE-i/ARB◊‡	51.8	90%[4]	58.9	38.8	53.4	0.09
13- Assessment of blood pressure	98.1	90%[19]	98.7	100.0	96.0	0.22
14- Assessment of lipids	53.0	n/a	76.2†††	19.3†††§§§	91.9§§§	<0.001
15- Assessment of adiposity	87.8	n/a	71.9†††§§§	93.9†††	95.7§§§	<0.001
16- Assessment of blood glucose	42.1	90%[19]	70.7†††§§§	1.7†††ΔΔΔ	45.3§§§ΔΔΔ	<0.001
17- Increase in exercise capacity‡	69.1	n/a	65.7†	82.4†§§	59.7§§	0.01
18- Adherence to CR program‡	64.1	n/a	71.4§§§	77.0†††	57.0†††§§§	<0.001
26- Smoking cessation support◊‡	66.7	n/a	100	0	50	-
30- Stress management◊‡	81.3%	n/a	0	10	96.2	-
5- Self-management education◊‡	90.8%	n/a	80.0§§†††	98.3†††	95.9§§	<0.001
31- Medical Director supervision	100.0%	n/a	100	100	100	-
32- Emergency response strategy	100.0%	n/a	100	100	100	-

34- Communication with PHCP‡	94.2%	n/a	95.7	91.1	94.6	0.58
37- CR Program completion‡	60.2%	n/a	71.4§§§	73.8†††	46.3†††§§§	<0.001

$^{◊}$quality indicator assessed, but definition applied deviates from original specification.
‡ QI required outcome data for computation

*based on Analysis of Variance

†p<0.05, ††p<0.01; †††p<.001; §p<0.05, §§p<0.01; §§§p<.001; ^{Δ}p<0.05, ^{ΔΔ}p<0.01, ^{ΔΔΔ}p<0.001 for site differences based on post-hoc Least Significant Differences test.

n/a=not available
- excluded from statistical analysis due to too few cases.

CR= Cardiac Rehabilitation
ASA= Acetylsalicyclic Acid
ACE-i= Angiotensin Converting Enzyme-inhibitor
ARB= Angiotensin Receptor Blocker
PHCP= Primary Health Care Provider