Effect of Cardiac Rehabilitation Referral Strategies on Utilization Rates

A Prospective, Controlled Study

Sherry L. Grace, PhD; Kelly L. Russell, MSc; Robert D. Reid, PhD, MBA; Paul Oh, MD, FRCPC; Sonia Anand, MD, PhD, FRCPC; James Rush, PhD; Karen Williamson, PhD; Milan Gupta, MD; David A. Alter, MD, PhD, FRCPC; Donna E. Stewart, MD, FRCPC; for the Cardiac Rehabilitation Care Continuity Through Automatic Referral Evaluation (CRCARE) Investigators

Background: Although cardiac rehabilitation (CR) has been shown to reduce mortality and is a recommended component in clinical practice guidelines, CR referral and utilization rates remain low. Referral strategies have been implemented to increase CR use but have yet to be compared concurrently. To determine the optimal strategy to maximize CR referral, enrollment, and participation, we evaluated 3 referral strategies compared with usual care: "automatic" only via discharge order or electronic record, health care provider liaison only, or a combined approach.

Methods: In this prospective controlled study, 2635 inpatients with coronary artery disease from 11 Ontario, Canada, hospitals using 1 of the 4 referral strategies completed a sociodemographic survey, and clinical data were extracted from medical charts. One year later, 1809 participants completed a mailed survey that assessed CR utilization. Referral strategies were compared using generalized estimating equations to control for effect of hospital.

Results: Adjusted analyses revealed referral strategy was significantly related to CR referral and enrollment ($P<.001$). Combined automatic and liaison referral resulted in the greatest CR use (odds ratio [OR], 8.41; 85.8% referral, 73.5% enrollment), followed by automatic only (OR, 3.27; 70.2% referral, 60.0% enrollment), and liaison only (OR, 3.35; 59.0% referral, 50.6% enrollment), compared with usual referral (32.2% referral, 29.0% enrollment). The degree of CR participation did not differ by referral strategy among referred participants (mean [SD] percentage of classes attended, 82.87% [27.20%]; $P=.88$).

Conclusions: Automatic referral combined with a patient discussion can achieve among the highest rates of CR referral reported. Wider adoption of such strategies could ensure that 45% more patients being treated for cardiac disease would have access to and realize the benefits of CR.

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CARDIOVASCULAR DISEASE (CVD) remains the leading cause of mortality worldwide,[1] and this is chiefly attributable to modifiable risk factors such as hypertension, dyslipidemia, obesity, smoking, unhealthy diet, and a sedentary lifestyle.[2] Cardiac rehabilitation (CR) offers a comprehensive approach to chronic disease management, by addressing these risk factors. Indeed, there is sound evidence demonstrating that CR participation significantly reduces morbidity and mortality by approximately 25% over 1 to 2 years when compared with usual care.[3,4] In a more recent population-based study,[5] a mortality reduction of 21% to 34% was demonstrated among elderly CR users of diverse sociodemographic backgrounds. Furthermore, CR participation has been shown to reduce morbidity and mortality to a similar degree as statins, aspirin, and β-blockers.[3,6] Based on this evidence, CR is recommended as the standard of care in clinical practice guidelines for acute coronary syndromes and revascularization,[7,8] among other cardiac populations.[7,9,10] Performance measures have also been developed.[7]

However, prescribing CR alongside cardiovascular medications recommended in clinical practice guidelines is not standard practice, as evidenced by data from the United States, Canada, and the United Kingdom demonstrating that 70% to 80% of eligible patients being treated for cardiac disease do not receive CR after hospital discharge.[11,12] While the reasons are multifactorial, arguably one of the chief reasons CR utilization is so low is referral failure.[13] Automatic referral interventions have been designed to overcome this barrier, whereby standard CR referral orders are implemented for eligible patients.[14] Findings from a recent review[15] revealed that automatic

Author Affiliations are listed at the end of this article.
Group Information: Members of the CRCARE group are given at the end of this article.

referral strategies resulted in referral rates of 34% to 85%, and enrollment rates of 19% to 78%. While the results of the American Heart Association's "Get With the Guidelines" program in particular are compelling given the beneficial effects demonstrated at approximately 100 institutions (88% referral to CR or exercise counseling),[16] other referral strategies have been identified, and to our knowledge no studies have yet to prospectively and concurrently compare the effects of these strategies on utilization in a controlled multicenter study. The present study addressed this gap in its comparison of 4 CR referral strategies (ie, automatic, liaison [discussion with health care provider or peer], combined automatic and liaison, vs "usual" referral) to determine their effects on CR referral and utilization. It was hypothesized that the combined strategy of automatic and liaison referral would result in the greatest rates of CR referral and utilization.

METHODS

DESIGN AND PROCEDURE

The nature of the study design was prospective and observational, assessing comparative effectiveness across the following 4 referral strategies: (1) automatic referral using electronic patient records or standard discharge orders as a systematic prompt before hospital discharge; (2) liaison referral, whereby the referral is facilitated through a personal discussion with a health care professional (ie, nurse or physiotherapist) and/or peer graduate (at the bedside or in some cases by telephone shortly after discharge); (3) a combination of both; or (4) "usual" referral at the discretion of health care providers. Results of the Ontario (Canada) CR Pilot Project[17] show that where referred, patients are most frequently referred by their cardiologist at an outpatient postdischarge visit. Applications to all participating institutions' research ethics boards were granted approval.

Medically stable cardiac inpatients from 11 community and academic hospitals between Windsor, Sudbury, and Ottawa, Ontario, were approached to participate during 2006 to 2008. Site recruiters were trained centrally by the principal investigator to standardize the recruitment process. The CR services are covered through provincial health insurance in this jurisdiction. The sites were chosen based on reported implementation of CR referral strategies in the Ontario CR Pilot Project.[17] Key informant interviews with all willing CR programs that reported instituting referral strategies were conducted to quantify strategies previously implemented at referring acute care institutions.[18] Three cardiac wards used an automatic referral strategy, 6 used liaison (ie, 3 nurses, 1 nurse practitioner, 1 physiotherapist, and finally 1 nurse practitioner, physiotherapist, and peer graduate), 5 used combined automatic and liaison (ie, 3 nurses, 1 nurse practitioner, and 1 nurse practitioner and physiotherapist), and 2 used usual referral. Of note, the peer graduate referral strategy used on one ward was initiated approximately 15 years prior by former patients who had undergone coronary artery bypass graft (CABG) surgery and who had attended CR. They formed a strong volunteer program and approached surgery inpatients at the bedside to promote and advocate CR. Therefore, overall there were 16 wards from 11 hospitals, of which 5 hospitals had 2 cardiac wards (ie, surgery vs other), and each ward used a different referral strategy.

On providing informed consent, eligible patients completed a sociodemographic survey. Clinical data were extracted from medical charts. Participants were then mailed a follow-up survey 1 year later, assessing self-reported CR referral, enrollment, and participation. Based on Dillman's method[19] to maximize retention rate, our 4 patient contacts were as follows: (1) a questionnaire mailing including a motivational cover letter, (2) a thank you/reminder postcard sent 2 weeks after the questionnaire, (3) a replacement questionnaire sent to nonrespondents 4 weeks later, and (4) a final telephone contact.

PARTICIPANTS

A total of 2635 stable cardiac inpatients were recruited. Inclusion criteria were a confirmed diagnosis of acute coronary syndrome diagnosis, having undergone percutaneous coronary intervention (PCI) or CABG, having a concomitant diagnosis of heart failure or arrhythmia, eligibility for CR based on guidelines of the Canadian Association of Cardiac Rehabilitation,[20] and proficiency in English, French, or Punjabi (surveys were translated into each of these languages). Diagnosis of acute coronary syndrome was confirmed through patient medical chart indication of detailed history, focused physical examination, diagnostic electrocardiogram changes, and/or troponin levels above the 99th percentile of normal. Patients were excluded if they had participated in CR within the past 2 years or had a clinically significant orthopedic (ie, total joint replacement), neuromuscular (ie, Parkinson disease), visual (ie, blindness), cognitive (eg, debilitating stroke, dementia), or nondysphoric psychiatric condition (eg, schizophrenia) documented in their medical chart that precluded CR participation.

MEASURES

Sociodemographic and Clinical Characteristics

Self-reported sociodemographic variables assessed in the survey provided to inpatients included marital status, education level, ethnocultural background, family income, and work status. These variables were dichotomized using a median split as follows: marital status (married: yes/no), education level (some postsecondary: yes/no), ethnocultural background (white: yes/no), family income (≥CaD $50 000: yes/no), work status (retired: yes/no). Patients were asked at the time of recruitment whether they lived within a 30-minute drive of a hospital and were coded as rural if they responded "no." Sociodemographic data obtained from the medical chart included date of birth and sex.

With regard to clinical characteristics, the patient survey included the Duke Activity Status Index[21] to assess functional status. Finally, the nature of the cardiac condition or procedure (ie, myocardial infarction, PCI, CABG, heart failure, arrhythmia, valve repair/replacement), as well as presence of CVD risk factors (ie, family history, hypertension, dyslipidemia, diabetes mellitus, body mass index, smoking), and comorbidities were also obtained from the medical chart.

Independent Variable: CR Referral Strategy

Prior to study initiation, meetings with the clinical staff from all inpatient units were held to understand and quantify the process of CR referral on each ward. A meeting with one of the investigators was also held to finalize and verify the following 4 referral strategies: (1) automatic, (2) liaison, (3) a combination of both, or (4) "usual" referral at the discretion of a health care provider.

Dependent Variables: Cardiac Rehabilitation Referral, Enrollment, and Participation

Participants self-reported whether or not they were referred to cardiac rehabilitation and to which site, whether they attended a CR intake assessment (ie, enrollment), and whether

or not they participated in CR by providing an estimate of the percentage of prescribed sessions they attended.

STATISTICAL ANALYSES

Sociodemographic and clinical characteristics of participants by retention status and by referral strategy were compared using χ^2 analyses for categorical variables and analysis of variance (ANOVA) for continuous variables, followed by post hoc Bonferonni tests where applicable.

A descriptive examination of CR referral, enrollment, and participation was performed by referral strategy, and then χ^2 analysis and ANOVA were used to test for significant differences, as applicable. Since the dependent variables were categorical in nature, any missing data were coded as "99" and not included in the analyses. Next, only patients who reported CR referral were selected, and these analyses were repeated to test for significant differences by referral strategy in enrollment and participation among those referred. Bonferonni post hoc tests were again computed as appropriate. Finally, generalized estimating equations (GEEs) were computed to take into consideration the nested nature of patients within hospitals, while controlling for the sociodemographic and clinical differences identified herein with a $P < .05$, to test for differences in CR referral and enrollment by referral strategy in the whole sample. $P < .05$ was considered statistically significant for all tests. Missing data were handled using list-wise deletion. SPSS statistical software (version 17.0; SPSS Inc, Chicago, Illinois) was used for all analyses.

RESULTS

RESPONDENT CHARACTERISTICS

Of the 5767 inpatients approached, 2635 consented to participate, and 1449 were ineligible (a 61.0% response rate). At 1 year after recruitment, 1809 individuals completed the follow-up survey, and 389 (14.8%) were deemed ineligible (a 80.5% retention rate). Reasons for ineligibility were as follows: they could not be contacted (n = 246 [63.2%]), were deceased (n = 107 [27.5%]), were too ill to participate (n = 8 [2.1%]), or there were other reasons (n = 28 [7.2%]).

Table 1 displays participant characteristics by retention status. As shown, retained participants were more likely to be married, have undergone CABG, and less likely to smoke or have diabetes mellitus than nonretained participants. Patients who declined to participate were more likely to be younger, working, of nonwhite race, a current smoker, and have diabetes mellitus and were less likely to be married and have undergone CABG or valve surgery than retained participants.

Table 2 displays in-hospital sociodemographic and clinical characteristics by referral strategy. As shown, participants differed significantly by referral strategy in age, sex, race, family income, physical activity status, body mass index, index cardiac condition, and presence of risk factors (ie, diabetes mellitus, family history, hypertension).

EFFECT OF CR REFERRAL STRATEGY

Participants were referred to 1 of 52 CR programs (including private and community-operated programs). Of those participants reporting that they were not referred to CR, 15.4% reported they were provided a reason. **Table 3** displays CR referral and utilization by referral strategy. Unadjusted analyses showed that referral strategy was significantly related to referral and enrollment. Post hoc tests revealed significantly greater CR referral for all referral strategies when compared with usual practice ($P < .001$ for all comparisons). Moreover, the combined referral strategy was related to significantly greater referral and enrollment than either the automatic or liaison strategy alone ($P < .05$). Finally, CR referral and enrollment rates for the ward with health care provider and peer referral were 56.7% and 50.0%, respectively.

The CR enrollment among patients who reported being referred did not significantly differ by referral strategy ($P = .34$). Finally, there was also no significant difference in percentage of prescribed CR sessions attended among those referred based on referral strategy ($P = .88$).

Table 4 displays the results of the GEEs, with odds ratios for CR referral and enrollment by referral strategy. Using GEEs to control for hospital site as well as sociodemographic and clinical characteristics shown to differ significantly by retention status and referral category displayed in Table 1 and Table 2, referral strategy was found to be significantly related to referral and enrollment (Wald statistics = 24.28, $P < .001$; and 13.62, $P < .01$, respectively). Combined automatic and liaison referral was found to result in the largest degree of CR referral and enrollment, followed by automatic only, and liaison only. In addition to referral strategy, age, family income, and having coronary artery bypass surgery were significant predictors in both models, along with Duke Activity Status Index (referral only), and heart failure and education (enrollment only).

COMMENT

Despite its known benefits, CR remains highly underutilized, primarily due to low rates of referral.[13,22-24] Recently, quality improvement initiatives have been implemented to increase CR uptake, including innovative referral strategies.[15] To our knowledge, the present study is the first prospective, multicenter comparison of CR referral, enrollment, and participation rates following 4 different inpatient referral strategies defined as automatic only, liaison only, combined automatic and liaison, and usual. Controlling for the effect of hospital, combined automatic and liaison referral resulted in an 8-fold increase in the likelihood of referral when compared with usual referral at the discretion of the physician, with over 70% of patients enrolling in these evidence-based programs. Regardless of referral strategy, once referred, CR participation rates were consistently above 80% of prescribed sessions.

The rates of CR referral and enrollment observed in this study are encouraging. Four acute care sites were able to achieve a referral rate of over 85%, meeting the unrealized[25] targets set in 2000 in the National Service Framework for Coronary Heart Disease in the United Kingdom.[26] The only other published target of which we are aware is in Ontario, where a goal of 40% enrollment has been established.[27] Our results show that this Ontario target can be easily exceeded by each referral strategy tested but that a combined strategy is optimal. These results are concordant with the only studies published to date investigating the effect of combined referral strategy on en-

Table 1. Sociodemographic and Clinical Characteristics by Retention Status

Characteristic	Patients, No. (%)				*P* Value
	Retained (n=1809)	Ineligible (n=389)	Declined (n=437)	Total (n=2635)	
Sociodemographic					
Age, mean (SD),y	65.4 (10.4)	66.6 (13.1)	61.8 (12.2) $P<.001$[a]	65.0 (11.2)	<.001
Female sex	452 (25.0)	130 (33.5) $P<.01$[a]	125 (28.6)	707 (26.8)	<.01
White ethnocultural background	1446 (83.4)	293 (80.9)	301 (74.1) $P<.001$[a]	2040 (81.6)	<.001
Married	1392 (77.8)	237 (61.9) $P<.001$[a]	286 (67.0) $P<.001$[a]	1915 (73.7)	<.001
Some postsecondary education	1312 (74.8)	243 (65.7) $P<.01$[a]	295 (70.1)	1850 (72.7)	.001
Retired	905 (52.0)	202 (54.7)	146 (35.9) $P<.001$[a]	1253 (49.8)	<.001
Family income ≥$50 000 CaD[b]	730 (50.0)	100 (34.0) $P<.001$[a]	158 (46.7)	988 (47.3)	<.001
Rural living	313 (17.3)	100 (25.7) $P<.001$[a]	93 (21.3)	506 (19.2)	<.001
Clinical					
Cardiac condition/procedure[c]					
MI	502 (28.0)	127 (33.6)	142 (33.2)	771 (29.6)	.02
PCI	602 (33.5)	93 (24.7) $P<.01$[a]	163 (38.1)	858 (33.0)	<.001
CABG	743 (41.3)	101 (26.8) $P<.001$[a]	122 (28.5) $P<.001$[a]	966 (37.1)	<.001
Heart failure	194 (10.8)	95 (25.2) $P<.001$[a]	62 (14.5)	351 (13.5)	<.001
Arrhythmia	223 (12.4)	50 (13.3)	50 (11.7)	323 (12.4)	.79
Valve repair/replacement	153 (8.5)	28 (7.4)	16 (3.7) $P<.01$[a]	197 (7.6)	<.01
Diabetes mellitus	517 (31.5)	132 (40.6) $P<.01$[a]	178 (45.3) $P<.001$[a]	827 (35.0)	<.001
BMI, mean (SD)	29.0 (5.5)	28.7 (6.7)	29.6 (5.3)	29.1 (5.6)	.20
Family history of CVD	854 (64.7)	144 (60.0)	186 (61.0)	1184 (63.5)	.23
Hypertension	1239 (74.1)	248 (75.2)	280 (69.7)	1767 (73.5)	.15
Dyslipidemia	1284 (81.9)	221 (78.1)	281 (78.9)	1786 (80.9)	.19
Smoker	111 (6.4)	37 (10.1)	56 (13.5) $P<.001$[a]	204 (8.1)	<.001
DASI score, mean (SD)	27.9 (17.2)	21.7 (17.3) $P<.001$[a]	27.6 (18.9)	26.9 (17.6)	<.001
Comorbidities present	1114 (67.8)	246 (71.1)	261 (67.3)	1621 (68.2)	.45

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CABG, coronary artery bypass graft; CVD, cardiovascular disease; DASI, Duke Activity Status Index; MI, myocardial infarction; PCI, percutaneous coronary intervention.

[a] Significant difference from retained participants.

[b] Approximately $28 500.

[c] All cardiac conditions/procedures are presented for each participant.

rollment, specifically 3 single-center uncontrolled studies (78%, 72%, and 60%, respectively).[28-30]

The results of this study, when combined with the results of a recent systematic review of the field,[15] suggest that wider adoption of combined automatic and liaison-based referral strategies should be promoted. Discussion with health care providers involved in CR referral at participating institutions revealed that this combination of strategies may be most effective because it targets the health care provider and patient: the order set or electronic record prompts the referral, and the patient discussion ensures health care provider endorsement and clarifies any misconceptions or barriers patients may have about CR. Implementation could potentially raise CR use 45.0% (range, 29.1%-74.0%), suggesting that major public health gains could be achieved in the population being treated for cardiac disease. Particularly encouraging is that the degree of CR participation is equally high regardless of referral strategy used to get patients into CR.

With regard to the clinical and policy implications of this research, clearly the effect on CR program capacity is foremost. These referral strategies can move us toward true "population-based"[31,32] care for outpatient chronic disease management, but this will require reexamination of our funding and service models. Most notably, CR programs may not have the capacity to quickly increase service provision, which may lead to longer wait times, and ultimately lower enrollment. Successful strategies in the mental health literature, such as the Depression Improvement Across Minnesota, Offering a New Direction

Table 2. Sociodemographic and Clinical Characteristics by Cardiac Rehabilitation Referral Strategy

Characteristic	No. (%) Usual, 16.4% (n=297)	Liaison Only, 27.1% (n=490)	Automatic Only, 30.5% (n=551)	Combined Automatic and Liaison, 26.0% (n=471)	*P* Value
Sociodemographic					
Age, mean (SD), y	64.0 (10.9)	66.7 (11.0) $P<.01$[a]	65.6 (10.1)	64.7 (9.7) $P<.05$[b]	<.10
Female sex	88 (29.6)	148 (30.2)	119 (21.6) $P<.01$[b]	97 (20.6) $P<.05$[a]	<.01
White ethnocultural background	237 (83.5)	362 (76.1) $P<.05$[a]	453 (86.0) $P<.001$[b]	394 (88.3) $P<.001$[b]	<.01
Married	223 (75.9)	354 (74.1)	443 (80.7)	372 (79.3)	.50
Some postsecondary education	227 (76.9)	349 (76.5)	405 (74.4)	331 (72.3)	.39
Retired	133 (46.8)	264 (55.8)	280 (53.0)	228 (50.1)	.80
Family income ≥CaD $50 000[c]	125 (49.6)	184 (45.8)	216 (49.1)	205 (56.2) $P<.05$[b]	.40
Rural living	58 (19.5)	91 (18.6)	85 (15.4)	79 (16.8)	.39
Clinical					
Cardiac condition/procedure[d]	23 (7.7)	163 (33.9) $P<.001$[a]	140 (25.6) $P<.001$[a] $P<.05$[c]	176 (37.4) $P<.001$[a,e]	<.01
PCI	270 (90.9)	80 (16.6) $P<.001$[a]	180 (32.8) $P<.001$[b,c]	72 (15.3) $P<.001$[a,e]	<.01
CABG	8 (2.7)	194 (40.3) $P<.001$[a]	199 (36.2) $P<.001$[a]	342 (72.6) $P<.001$[a,b,e]	<.01
Heart failure	15 (5.1)	72 (15.0) $P<.001$[a]	81 (14.8) $P<.001$[a]	26 (5.5) $P<.001$[b,e]	<.01
Arrhythmia	14 (4.7)	81 (16.8) $P<.001$[a]	71 (12.9) $P<.01$[a]	57 (12.1) $P<.05$[a]	<.01
Valve repair/replacement	7 (2.4)	30 (6.3)	58 (10.6) $P<.001$[a]	58 (12.3) $P<.001$[a] $P<.01$[b]	<.01
Diabetes mellitus	82 (31.3)	151 (37.0)	154 (29.8)	130 (28.4) $P<.01$[b]	.40
BMI, mean (SD)	28.9 (4.9)	28.2 (5.3)	29.9 (6.5) $P<.01$[b]	29.2 (5.0)	<.10
Family history of CVD	107 (65.6)	212 (67.1)	249 (59.1)	286 (68.3) $P<.05$[e]	.30
Hypertension	218 (79.3)	329 (76.3)	353 (69.6) $P<.05$[a]	339 (73.9)	.20
Dyslipidemia	236 (86.1)	309 (80.5)	384 (82.1)	355 (80.3)	.20
Smoker	24 (8.4)	28 (5.9)	39 (7.4)	20 (4.4)	.11
DASI score, mean (SD)	34.2 (16.4)	26.4 (17.3) $P<.001$[a]	31.0 (16.7) $P<.001$[b]	22.1 (15.9) $P<.001$[a,e] $P<.01$[b]	<.01
Comorbidities present	184 (65.9)	290 (67.3)	317 (66.6)	323 (70.8)	.44

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CABG, coronary artery bypass graft; CVD, cardiovascular disease; DASI, Duke Activity Status Index; MI, myocardial infarction; PCI, percutaneous coronary intervention.

[a] Significant difference from usual referral (liaison, automatic, or combined).

[b] Significant difference from liaison referral (automatic or combined).

[c] Approximately $28 500.

[d] All cardiac conditions/procedures are presented for each participant.

[e] Significant difference from automatic referral (combined).

(DIAMOND) initiative,[33] show that using principles of stepped care (ie, treat at the lowest appropriate service tier in the first instance, "stepping up" to intensive/specialist services only as clinically required) and indirect care (eg, dashboard presentation of risk factors that can aid a specialist in targeting care) can have major positive effects on reach, access, and cost-efficacy. Application to CR might include triage to home or community-based programs for patients whose risk factors are at target and who are engaging in regular physical activity. Also, use of CR registries with a dashboard application in which risk factor data can be sorted in descending order of blood pressure values, lipid levels, and smoking and exercise behavior for example, would ensure that care resources are directed based on greatest need.

Caution is warranted when interpreting these findings, chiefly due to study design. This was a quasi-experimental study. For ethical reasons, participants could not be randomized to acute care site, nor could we randomize referral strategy within site owing to the potential for contamination. Consequently, there were significant differences in sociodemographic and clinical

Table 3. Cardiac Rehabilitation (CR) Referral, Enrollment, and Participation Rates by Referral Strategy

Referral Strategy	Patients, No. (%)			Prescribed CR Sessions Attended of Those Referred, Mean (SD), %,
	Referred	Enrolled	No. Enrolled of Those Referred	
Usual (2 wards)	94 (32.2)	83 (29.1)	71 (78.0)	83.4 (28.1)
Liaison only (6 wards)	284 (59.0)	239 (50.9)	228 (83.2)	83.2 (27.2)
Automatic only (3 wards)	382 (70.1)	321 (60.7)	310 (84.2)	83.6 (27.0)
Combined automatic and liaison (5 wards)	396 (85.3)	335 (74.0)	329 (85.7)	81.9 (27.2)
Total	**1156** (64.9)[a]	**978** (56.3)[a]	**938** (84.0)	82.9 (27.2)

[a] $P < .001$.

Table 4. GEE Analysis of Cardiac Rehabilitation (CR) Referral and Enrollment Rates by Referral Strategy[a]

Variable	OR (95% CI)	
	Unadjusted	Adjusted
CR referral		
Liaison only	3.06 (2.26-4.16)	3.35 (1.54-7.29)
Automatic only	5.05 (3.71-6.87)	3.27 (1.52-7.04)
Combined automatic and liaison	12.64 (8.83-18.08)	8.41 (3.57-19.85)
Usual	1 [Reference]	1 [Reference]
CR enrollment		
Liaison only	2.49 (1.82-3.41)	2.60 (1.20-5.62)
Automatic only	3.57 (2.62-4.87)	2.35 (1.10-4.99)
Combined automatic and liaison	6.40 (4.60-8.88)	4.45 (1.98-10.00)
Usual	1 [Reference]	1 [Reference]

Abbreviations: CI, confidence interval; GEE, generalized estimating equation; OR, odds ratio.

[a] Controlled for age, sex, ethnicity, income, index cardiac event/condition, presence of diabetes mellitus, body mass index, functional capacity, family history of cardiovascular disease, and the presence of hypertension.

characteristics of patients by referral strategy that may have biased results. Thus, unadjusted rates of referral and enrollment should be interpreted with particular caution. We controlled for the differences in subsequent analyses; however, a randomized design would be needed to definitively establish the effects of referral strategy on CR use. Finally, while all centers with CR referral strategies had them in place a couple of years before study initiation on average, this time varied by ward and was not controlled. This may have biased study results in unknown ways.

The second main limitation pertains to measurement. Although self-reported CR referral and utilization was not verified, there is evidence that supports the "almost-perfect" congruence between self-reported and CR site-report data.[34] However, the potential for social desirability biases in participant responses cannot be ruled out. Moreover, CR and hence study exclusion criteria were ascertained via medical chart report where available. No structured interviews for psychiatric disorders or cognitive status were undertaken. There is also some inherent heterogeneity in the way CR programs apply eligibility criteria from the guidelines which may have introduced bias. Finally, the confidence intervals for the combined referral strategy are quite wide, suggesting heterogeneity and/or overestimation.

The third limitation pertains to generalizability. The present study was conducted in a region where CR services are reimbursed through provincial health care coverage, and therefore enrollment rates attained may not be applicable to other regions where patients must pay out-of-pocket for CR.

Overall, the results of this study provide strong and pragmatic evidence that innovative referral strategies can positively influence access to CR. Use of automatic referral combined with a patient discussion resulted in over 70% use of CR. Among those referred, the degree of CR participation was above 80% regardless of referral strategy. Institutions should be encouraged to adopt such quality improvement initiatives, using established techniques to promote dissemination and implementation. While wider adoption of these CR referral strategies would potentially improve the health of many patients being treated for cardiac disease, new funding and service delivery models should be explored to mitigate effects on capacity and wait times.

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Author Affiliations: School of Kinesiology and Health Science, Faculty of Health, York University, Toronto (Dr Grace), Women's Health Program, University Health Network, Toronto (Drs Grace and Stewart and Ms Russell), Minto Prevention and Rehabilitation Centre, University of Ottawa Heart Institute, Ottawa (Dr Reid), Department of Cardiac Rehabilitation, Toronto Rehabilitation Institute, Toronto (Drs Grace, Oh, and Alter), Department of Clinical Epidemiology and Biostatistics, Faculty of Health Sciences, McMaster University, Hamilton (Dr Anand), Department of Kinesiology, University of Waterloo, Waterloo (Dr Rush), Faculty of Nursing, University of Windsor, Windsor (Dr Williamson), Department of Cardiology, William Osler Health Centre, Brampton (Dr Gupta), and Cardiovascular and Diagnostic Imaging, Institute for Clinical Evaluative Sciences, Toronto (Dr Alter), Ontario, Canada.
Correspondence: Sherry L. Grace, PhD, School of Kinesiology and Health Sciences, Faculty of Health, York University, 368 Bethune, 4700 Keele St, Toronto, ON M3J 1P3, Canada (sgrace@yorku.ca).
Author Contributions: *Study concept and design:* Grace, Oh, and Rush. *Acquisition of data:* Grace, Reid, Oh, Anand, Rush, Williamson, and Gupta. *Analysis and interpretation of data:* Grace, Russell, Reid, Oh, Gupta, and Alter. *Drafting of the manuscript:* Grace, Russell, and Stewart. *Critical revision of the manuscript for important intel-*

lectual content: Grace, Reid, Oh, Anand, Rush, Williamson, Gupta, Alter, and Stewart. *Statistical analysis:* Grace. *Obtained funding:* Grace and Rush. *Administrative, technical, and material support:* Grace, Russell, Reid, Oh, Rush, Gupta, and Stewart. *Study supervision:* Grace, Reid, Oh, Rush, Williamson, Gupta, and Stewart.

CRCARE Group Members: David A. Alter, MD, PhD, FRCPC; Sonia Anand, MD, PhD, FRCPC; Stephanie Brister, MD, FRCSC; Sherry L. Grace, PhD; Milan Gupta, MD; Paula Harvey, MD, PhD; Michelle Johnson, RPh; Rimmy Kaur, BCS, MBA; Paul Oh, MD, FRCPC; Cynthia Parsons, BScPT, RPT; Jason Petro, BHK, MHK; Robert D. Reid, PhD, MBA; Ellen Rukholm, RN, PhD; James Rush, PhD; Donna E. Stewart, MD, FRCPC; Karen Williamson, PhD.

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