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ORIGINAL RESEARCH

Implementation of an Appointment-Based Cardiac Rehabilitation Approach: A Single-Center Experience

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BACKGROUND: There has been a focus on alternative cardiac rehabilitation (CR) delivery models aimed at improving CR adherence and completion. We examined pre- and post-CR health outcomes, reasons for discharge, and predictors of completion using a patient-driven appointment-based CR approach that uses center-scheduled class start times.

METHODS AND RESULTS: Data were used from an urban single-center CR program at Yale New Haven Health (2012–2017) that enrolled 2135 patients. We evaluated pre- and post-CR outcomes (12 weeks) using paired *t* tests and used a multivariable logistic regression model to examine predictors of CR completion (≥36 sessions) for the overall cardiovascular disease population. The mean age of participants was 65±12 years, 27.9% were women, and 5.1% were Black patients, and patients completed a median of 30 of 36 sessions. Patients achieved significant improvements in health outcomes, including across age and sex subgroups. The primary reason for discharge was completion of all 36 sessions of CR (46.4%). The final logistic regression model contained 12 predictors: age, sex, Black race, marital status, employment, number of physician-reported risk factors, dietary fat intake >30%, obesity, lack of exercise, benign prostatic hyperplasia, and self-reported stress and physical activity.

CONCLUSIONS: We demonstrated that patients participating in an appointment-based CR program achieved significant improvements in health outcomes and across sex/age subgroups. In addition, older individuals were more likely to complete CR. An appointment-based approach could be a viable alternative CR method to aid in optimizing the dose-response benefit of CR for patients with cardiovascular disease.

Key Words: cardiac rehabilitation ■ patient-centered care ■ secondary prevention

Cardiac rehabilitation (CR) is the pillar of conventional secondary prevention for patients with cardiovascular disease.[1] Standard CR programs in the United States consist of 36 supervised sessions conducted over the course of 12 weeks.[2] CR sessions are traditionally conducted in a class setting, with patients attending classes at specific times and dates based on the CR facility's schedule. Multiple studies have shown that CR has a substantial dose-response benefit effect, with an estimated 1% decrease in mortality for each session of CR attended.[3,4] Beyond improvements in clinical outcomes, CR has also been shown to improve psychosocial outcomes, exercise capacity, and quality of life.[5,6]

Despite the widespread availability of proven effective CR programs, significant disparities exist in rates of referral and subsequent program participation.[7–9] Prior studies show that the estimated median number of CR sessions attended nationwide by Medicare patients is around 26 of a recommended total of 36 sessions,[10] with 25 sessions found to be an important threshold for conveying health benefits for elderly patients.[9,11] Fewer

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CLINICAL PERSPECTIVE

What Is New?

- We studied a novel patient-driven appointment-based approach to cardiac rehabilitation that allows patients the flexibility to attend sessions on the basis of their own schedule.
- Patients completed a median of 30 of 36 sessions and achieved significant improvements in health outcomes across sex and age subgroups.

What Are the Clinical Implications?

- This patient-driven appointment-based approach could be a viable alternative method to aid in optimizing the dose-response benefit of cardiac rehabilitation.

Nonstandard Abbreviations and Acronyms

CR	cardiac rehabilitation
YNHH	Yale New Haven Health

data are available for younger patients because of the lack of a centralized payer in Medicare.[9,10] Women have also been found to have significantly decreased adherence to CR than men.[9,10] Common patient-reported barriers for women include factors such as caregiving responsibilities, lack of insurance coverage, difficulties in transportation, younger age, and poor socioeconomic status.[12]

Given that CR adherence is 1 of the 3 CR quality measures studied by the American College of Cardiology/American Heart Association, there has been emphasis on exploring strategies to improve CR adherence.[13] Prior work has suggested that applying more patient-centered approaches to CR care may improve in-clinic adherence.[14,15]

In 2011, the Million Hearts initiative proposed an novel appointment-based approach that could accommodate more patients per day and better align CR sessions with patient preferences,[5,16,17] with strategies such as after-hours classes and staggered class start times. Preliminary results from similar patient-centered CR formats have shown significantly decreased wait times to CR initiation.[18] As compared with the “open-gym” approach described in the literature, the appointment-based approach provides center-scheduled staggered class start times for patients to choose from, while patients in an open gym do not have center-scheduled class start times. A significant gap in knowledge exists regarding the implementation of appointment-based CR programs, specifically with respect to characterizing patient demographics, clinical outcomes, and patient-reported reasons for discharge, particularly across sex and age subgroups.

To address this gap in knowledge we examined: (1) pre- and post-health outcomes for patients participating in a patient-driven appointment-based CR program that uses center-scheduled class start times, including an examination by sex and age (age ≥65 versus age <65 years); (2) reasons for discharge from the CR program; and (3) predictors of CR completion defined as ≥36 sessions.

METHODS

The authors declare that all supporting data are available within the article.

Study Design and Sample

Our study uses data gathered from patients participating in an urban single-center patient-driven appointment-based CR program at Yale New Haven Health (YNHH) based in Branford, Connecticut. In 2009, YNHH transitioned its CR program to an appointment-based approach, and in 2012, the YNHH CR program established a clinical database for patient information management. Between January 2012 and August 2017, 2135 patients (27.9% women) were enrolled the CR program. All patients who presented for an intake appointment, enrolled in CR, and had data logged into the clinical database were included in the study. Exclusion criteria included inability to provide informed consent and patients with contraindications to exercise per standard CR guidelines.[19]

The Branford CR center at YNHH has a rolling attendance with individually set appointments for CR classes 5 days a week (8:00 AM to 7:00 PM Monday, Tuesday, and Thursday; 8:00 AM to 3:00 PM Wednesday and Friday). The appointment-based CR approach allows patients to select which days and times they would like to exercise in an open schedule based on the program’s monitoring capacity. The patients are encouraged to schedule 3 sessions per week and each session lasts anywhere from 1 hour to 1.5 hours. The appointment-based approach allows patients the flexibility to change their sessions on the basis of their own schedule.

The treatment team at the center consists of exercise physiologists, cardiologists, and a nutritionist. All exercise equipment and treatment rooms are used exclusively for the purpose of CR during the hours of the program. Patients participating in the appointment-based CR program completed a variety of interventions in addition to exercise training, including both educational interventions (multiple teaching sessions and videos) and counseling interventions (more intensive and specialized one-to-one sessions). Patients' baseline demographic and health characteristics were collected from medical chart abstraction from the CR intake and discharge appointments. The study was deemed exempt by YNHH Institutional Review Board.

Measures

CR Adherence and Completion

CR program adherence and completion in our study was measured by the number of CR sessions that patients were able to attend, with patients who were able to attend ≥36 CR sessions deemed as completing the program.[9] Starting in 2014, the YNHH CR program also surveyed patients on the reason for leaving CR during their discharge appointments, and discharge reason was examined for this subset of patients.

Sociodemographic Characteristics and Health Measures

Baseline sociodemographic variables were collected during patients' intake CR appointment, and included information on age, sex, race and ethnicity,[20] marital status, presence of children in the family, and employment status. Based on patients' self-reported primary job, they were classified into 3 categories: full-time employment, part-time employment, and nonemployed, with patients reporting full-time and part-time employment further defined as employed; these categories were combined given the small number of patients reporting part-time employment (13; 0.6%).

Baseline health measurements included a set of 16 physician-reported cardiovascular risk factors based on patients' medical history: hyperlipidemia, hypertension, diet fat intake >30% of total daily calories, history of smoking, obesity, diabetes, family history of coronary artery disease, benign prostatic hyperplasia, thyroid disease, obstructive sleep apnea, gout, history of stroke, chronic obstructive pulmonary disorder, lack of exercise, stress and depression (reported as a single combined risk factor), and history of substance use. Patients also self-reported their levels of depression (none, mild, moderate, severe), stress (low, moderate, high) and physical activity (none, low, moderate, vigorous) on an intake survey. Both physician-reported and patient self-reported risk factors were included, recognizing that there could be some overlap between physician-identified cardiovascular risk factors (assessed as dichotomous variables) and patient-identified stressors (assessed as ordinal variables), to enrich variable selection for model building. Specific health information also included the number of metabolic equivalents (METs) that patients were able to complete, body mass index, left ventricular ejection fraction, blood pressure, hemoglobin A_{1c}, and lipid profile.

In addition, the primary and secondary intake diagnoses for CR were collected and classified into 8 categories: percutaneous coronary intervention with stenting, coronary artery bypass grafting, valvular replacement and repair, other surgeries and procedures, coronary artery disease and related issues, congestive heart failure, structural issues, and rhythm issues. Detailed classification of specific intake diagnosis by category is available in Table S1. Finally, a full list of patients' current medications were collected at both intake and discharge appointments.

Statistical Analysis

Baseline characteristics were examined for the total sample and compared between men and women and age groups (age ≥65 and age <65 years) using chi-squared or Fisher's exact test for categorical variables and Student's *t* test for continuous variables. Paired Student's *t* tests were conducted to test changes in specific pre-post CR health-related outcomes for the total sample and were again compared by sex and age. We chose to examine subgroups by sex and age, as they have been less studied and are underserved with respect CR compared with other groups; in particular, age 65 was chosen as a cutoff as multiple prior studies have focused on Medicare beneficiaries and defined this population as "older coronary patients."[9–12] METs were calculated using American College of Sports Medicine metabolic equations based on exercise performance during CR. A patient's third-session METs represented their initial or pre-CR METs data point to allow for acclimation and orientation to CR program. A patient's last-session METs represented post-CR METs data point.

We examined patient-reported reasons for CR discharge using chi-squared or Fisher's exact test for categorical variables. To examine the predictors of CR completion (≥36 sessions), we used a multivariable logistic regression model for the overall cardiovascular disease patient population. We first evaluated all baseline and intake demographic and medical history variables listed in Tables 1 through 3 in a univariate logistic regression model. The patient-reported variables in Tables 1 through 3 (ie, self-reported levels of stress, depression, and physical activity) were not analyzed as a composite variable given subjectivity of responses—the progression from, for example, mild stress to high stress cannot be assumed to be linear. This analysis informed variable selection for the multivariable logistic regression model. More specifically, variables that showed significant associations with CR completion on intake were chosen for model building, specifically for the initial global model. To select the best model,

Table 1. Patient Demographics and Clinical Characteristics on Intake to Cardiac Rehabilitation: Overall Patient Demographics

Demographics	Total population (N=2135)
Age, y	64.9±11.6
Age ≥65 y, n (%)	1137 (53.3)
Women, n (%)	595 (27.9)
Race	
White, n (%)	1857 (87.0)
Black/African American, n (%)	109 (5.1)
Asian, n (%)	32 (1.5)
Other,* n (%)	64 (3.0)
Ethnicity	
Hispanic, n (%)	60 (2.8)
Non-Hispanic, n (%)	1999 (93.6)
Socioeconomic status	
Marital status	
Single, n (%)	184 (8.6)
Married, n (%)	1399 (65.5)
Separated/Divorced, n (%)	281 (13.2)
Widowed, n (%)	159 (7.4)
Family (with children), n (%)	1852 (86.7)
Employment status	
Not employed, n (%)	1076 (50.4)
Part-time, n (%)	13 (0.6)
Full-time, n (%)	1046 (49.0)

Plus-minus values are means±SD.
*Other includes patient self-reported race categories: Native Hawaiian or other Pacific Islander, other, unknown, and patient refused.

we randomly split the data into training cohort and validation cohort (70% versus 30%). The backward elimination and forward selection steps were repeated based on the Akaike information criterion method,[21] with generation of the lowest possible Akaike information criterion considered to have the best fit. The stepwise selection was terminated when the selected model generated the lowest average squared error on the validation data. The final selected model was fitted on the whole data set again, and the results were presented as odds ratios and 95% CIs. The model's discrimination ability was evaluated by using receiver operating characteristic curves and C-statistics (Figure S1). Calibration was evaluated by plotting the predicted versus the observed probabilities (Figure S2). Furthermore, the final model was internally validated using bootstrapping to evaluate the performance and quantify the optimism of the model (Table S2).

All missing data were assumed to be missing at random and not included in final data analyses. All intake variables had missing rates <5%, with the exception of marital status and patient self-reported stress (≈5% of missing data) and patient self-reported depression (≈6% of missing data). For all analyses, a *P* value of <0.05 was considered statistically significant. All statistical analyses were conducted in Stata statistical software (StataCorp LP, College Station, TX).

RESULTS

Baseline Characteristics

Baseline characteristics of the total patient population are shown in Tables 1 through 3 (sex and age breakdowns are provided in Table S3). The mean age of patients was 64.9 years (53.3% aged ≥65), 5.1% of patients participating in CR were Black, and 2.8% were Hispanic. More than half of patients were married (65.5%) and there was an approximately even split between those who were employed and those who were not employed (49.6% versus 50.4%). The most common CR admission diagnosis was percutaneous coronary intervention with stenting (48.5%).

Women were significantly more likely to be older and Black, were less likely to be married, and were more likely to be not be working at the time of attending the CR program, as compared with men. With respect to risk factors, women were more likely to be obese, have a lifestyle with little to no regular exercise, have a history of stroke, and have stress and depression as reported by the physician on intake. In addition, despite women taking significantly more medications on intake, they were less likely to be taking cardioprotective medications such as statins (Table S3).

Younger patients (<65 years), were more likely than older patients (aged ≥65) to be men and single, separated, or divorced, and were less likely to have children living in the household. They were also more likely to be Black or Hispanic. A large majority of younger patients (70.5%) reported working full-time during CR. Younger patients also had fewer reported cardiac risk factors, though they were more likely to report stress, depression, or history of substance use. They also reported being on fewer medications on CR intake (Table S3).

CR Adherence and Outcomes

In general, patients attended an average of 23.6 of a total of 36 CR sessions, with a median of 30 sessions (interquartile range, 9.36), and 43.2% of patients completed the program. Patients also completed an average of 4.5 educational interventions. Figure 1 shows the distribution of patient-reported reasons for program discharge. Sex and age breakdowns are provided in Table S4, and demographics and clinical characteristics by completion of CR is provided in Table S5. Overall, patients who did not complete CR were significantly more likely to be younger, Black, Hispanic, and

Table 2. Patient Demographics and Clinical Characteristics on Intake to Cardiac Rehabilitation: Cardiac Medical History

Cardiac risk factors	Total population (N=2135)
Hyperlipidemia*, n (%)	1667 (78.1)
Hypertension*, n (%)	1540 (72.1)
Fat intake >30% daily calories*,†, n (%)	1321 (61.9)
Smoking*, n (%)	1228 (57.5)
Obesity*, n (%)	786 (36.8)
Diabetes*, n (%)	604 (28.3)
Cardiac history	
Number of physician reported cardiac risk factors*	5.4±2.3
Left ventricular ejection fraction, %	54.3±13.1
Systolic blood pressure, mm Hg	125.9±18.4
Diastolic blood pressure, mm Hg	72.8±10.5
Hemoglobin A_{1c}, %	7.0±1.9
HDL, mg/dL	47.0±15.2
LDL, mg/dL	93.6±38.1
Primary diagnosis listed on intake, n (%)	
PCI with stenting	1036 (48.5)
CABG	398 (18.6)
Valvular replacement/repair	358 (16.8)
Other surgeries/procedures	105 (4.9)
Coronary artery disease and related issues	96 (4.5)
CHF	89 (4.2)
Structural issues	30 (1.4)
Rhythm issues	20 (0.9)
Secondary diagnosis listed on intake, n (%)	
Coronary artery disease and related issues	743 (34.8)
Structural issues	106 (5.0)
Other surgeries/procedures	89 (4.2)
CABG	46 (2.2)
Valvular replacement/repair	33 (1.5)
Rhythm issues	31 (1.5)
PCI with stenting	13 (0.6)
CHF	12 (0.6)

CABG indicates coronary artery bypass grafting; CHF, congestive heart failure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; and PCI, percutaneous coronary intervention.

*Indicates a physician-reported cardiac risk factor.

†A standardized diet survey was used on intake to cardiac rehabilitation and the cumulative core from this survey was used to estimate a patient's "% fat within diet" based on the questionnaire's algorithm.

single. They were also more likely to be employed full-time, had more physician-reported cardiovascular risk factors, and more likely to report high levels of stress.

There was no significant difference in the number of sessions attended by sex. Conversely, older patients completed significantly more sessions than younger patients and had a higher rate of completion (P<0.001), with an average of 25.9 sessions and median of 35 sessions. Overall, most patients surveyed at discharge left the program because of CR completion (Figure 1).

As demonstrated in Table 4, patients in the overall population showed significant improvements in all health outcomes, with the exception of a non–statistically or–clinically significant change in high-density lipoprotein. Pre-post changes in health outcomes stratified by age and sex are shown in Table S6. On subgroup analysis, it was found all subgroups did not have statistically significant changes in high-density lipoprotein, women and older patients did not have statistically significant improvements in hemoglobin A_{1c}, and women also did not show improvements in systolic blood pressure.

Predictors of CR Completion

We developed a multivariable logistic regression model to examine predictors of CR completion, using the backward stepwise Akaike information criterion model selection method to select variables for inclusion in the final model (Figure 2). The final model was the best-fit model and carried 57.5% of the cumulative model weight. The area under the curve for the final model was 0.63 (95% CI, 0.61–0.66). The predictors age ≥65 years and high level of self-reported stress were found to be statistically significant in the final model; patients aged ≥65 years are more likely to complete CR (odds ratio, 1.78; 95% CI, 1.43–2.20; P<0.001), while patients with high level of self-reported stress (odds ratio, 0.67; 95% CI, 0.48–0.94; P=0.021) were less likely to complete CR. Internal validation using the bootstrapping method has shown that the model's performance is not overestimated and the optimism is relatively small (Table S2, Figure S2).

DISCUSSION

We studied the implementation of a patient-driven appointment-based CR program based on center-scheduled class start times, and demonstrated that patients completed an average of 23.6 sessions, with the median being 30 of a total of 36 sessions. This is noted to be higher than the estimated median number of CR sessions attended nationwide (ie, 26 sessions).[21,22] This outcome both crosses the threshold for beneficial outcomes for elderly patients[9,11] and implies improved dose-response benefits for all comers.[3,4] The program also collected reasons for leaving CR over the study time period, providing novel information for targeted approaches to improve CR adherence and completion. Analyses of clinical outcomes at discharge showed that patients demonstrated significant improvements in significant health outcomes from the number of METs completed to hemoglobin A_{1c}, findings that are consistent with traditional CR programs.[23–25] However,

Table 3. Patient Demographics and Clinical Characteristics on Intake to Cardiac Rehabilitation: Other Medical History

Medical history, n (%)	Total population (N=2135)
Family history of CAD*	1403 (65.7)
BPH*	249 (11.7)
Thyroid disease*	246 (11.5)
OSA*	212 (9.9)
Gout*	183 (8.6)
Stroke*	154 (7.2)
COPD*	140 (6.6)
Lack of exercise*,†	975 (45.7)
Stress/Depression*,‡	508 (23.8)
Substance use*	47 (2.2)
Self-reported depression	
None	1555 (72.8)
Mild	316 (14.8)
Moderate	123 (5.8)
Severe	13 (0.6)
Self-reported stress	
Low	1345 (63.0)
Moderate	455 (21.3)
High	213 (10.0)
Self-reported physical activity§	
None	264 (12.4)
Low	1556 (72.9)
Moderate	258 (12.1)
Vigorous	42 (2.0)
Medications	
Total number of medications on intake	9.3±4.1
Cardioprotective medications on intake	
Aspirin	1862 (87.2)
Statins	1755 (82.2)
Beta-blockers	1711 (80.1)
ACE-Is/ARBs	934 (43.7)

Plus-minus values are means±SD. ACE-Is indicates angiotensin-converting enzyme inhibitors; ARBs, angiotensin II receptor blockers; BPH, benign prostatic hyperplasia; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disorder; METs, metabolic equivalents; and OSA, obstructive sleep apnea.

*Indicates a physician-reported cardiac risk factor.

†Lack of exercise was defined as a lifestyle with little to no regular exercise.

‡Includes all patients who confirmed to being affected by symptoms of stress or depression during initial evaluation, and those with a chart history of depression.

§Physical activity was assessed by patient self-report to the question of "What is your current level of physical activity?" with the following definitions on the intake survey: None: No current purposeful physical activity/exercise. Low: Activities or exercise reported represent 1–3 METs range. Moderate: Activities or exercise reported represent 3–5 METs range. Vigorous: Activities or exercise reported represent 5–10 METs range.

there were still significant differences observed by sex and age, as women and younger patients were found to have lower CR adherence, which echoes challenges faced by traditional CR programs.[26–28]

Our findings advance the field in the following ways. First, to our knowledge, this is the first longitudinal study describing a cohort of patients participating in a patient-driven appointment-based CR program. Second, we found that this alternative CR format was able to replicate the health benefits seen with traditional CR, while also associated with overall adherence. Third, we provide details on patient-reported reasons for leaving CR, which is less commonly studied in prior literature.[29] Importantly, almost half of participants surveyed (46.4%) were discharged because of completing the entire course of the 36-session CR program, perhaps because of the tailored nature of the program based on center-scheduled class start times. The patient-reported discharge reasons match the proportion of all participants who completed all 36 CR session (43.2%).

CR Population Level Findings

Overall, the sex and age demographic distribution of the patients who participated in CR in our study is largely similar to those in previously published studies, with mean age around 65 years and women making up slightly <30% of the patient population.[30,31] Patients participating in CR had a high prevalence of cardiac risk factors, with an average of 5.4 physician-identified risk factors on intake to CR, with the most common being hyperlipidemia and hypertension. In particular, we found that women had a clustering of adverse risk factors and comorbidities: women were older, had poorer control of cardiac risk factors, and were more likely to have a lifestyle with little to no regular exercise, were more likely to be obese, and had higher rates of stress than men. Although they were taking more medications at baseline, they were less likely to have been prescribed cardioprotective medications even though they were referred to CR. These data are supported by prior research regarding trends in cardiovascular health management: Women were less likely to receive preventive treatment or guidance including risk factor management, as compared to with similar cardiac risk profiles.[32,33]

Most patients were participating in CR after procedures for coronary vascular disease, specifically, with almost half of the patient population presenting after receiving coronary stenting, and about 1 in 5 started CR after coronary artery bypass grafting. A significant number of patients, about 1 in 5, came to CR after receiving cardiac valvular interventions, which reflects the increase in patients in CR with valvular interventions since the Centers for Medicare and Medicaid Services expanded CR coverage to this population in 2006.[31,34]

The patient cohort demonstrated improvements in health metrics that are well documented in the CR literature.[3–6] The patients on average showed an increase

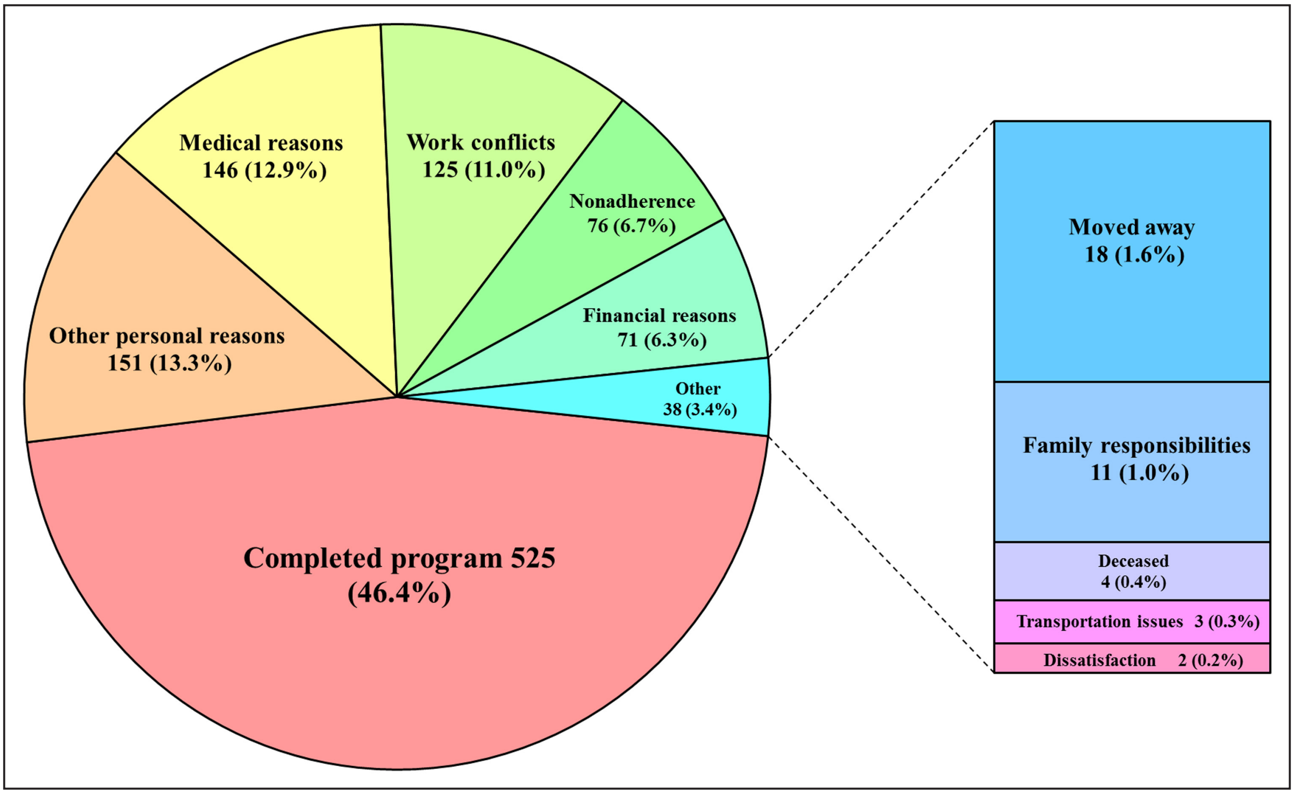

Figure 1. Pie chart showing the distribution of reasons for patients leaving CR during their discharge appointments (various reasons are delineated by different colors).
CR indicates cardiac rehabilitation.

in 1.42 METs after CR, to being able to complete 4.47 METs at discharge from 3.04 METs on intake, which is an improvement from poor to moderate functional status.[35]

Our logistic regression analysis examined predictors of the total number of CR sessions completed, which revealed interesting findings. Older patients (≥65 years) were significantly more likely to complete all 36 CR sessions, which is consistent with prior research, which showed that younger age is an independent predictor of decreased CR adherence,[28,36,37] and it has been theorized that work and familial demands are a significant contributor.[36,37] However, there is a signal toward improvement in CR adherence for younger patients, as our younger patients (mean age, 55.0±7.52 years) achieved the same median number of sessions as a separately studied younger patient population with an higher average age (mean age, 59.9±11.1 years).[38]

Patients who reported high levels of stress were significantly less likely to complete 36 sessions of CR as compared with those to reported mild levels of stress. This is consistent with prior studies, which demonstrated that patients with significant levels of self-reported stress on admission to CR are more

Table 4. Paired *t* tests of Health Outcomes for Overall Patient Population

Outcome	Observations (no.)	Mean post±SE	Mean pre±SE	Difference	Standard error	T value	*P* value
METs, n	1209	4.47±0.04	3.04±0.02	+1.42	0.03	56	<0.001
BMI, kg/m²	1201	28.79±0.16	29.12±0.16	−0.32	0.03	−9	<0.001
Body fat, %	1184	26.65±0.21	28.53±0.22	−1.88	0.09	−22	<0.001
Systolic blood pressure, mm Hg	964	120.04±1.44	126.60±0.58	−6.56	1.46	−5	<0.001
Diastolic blood pressure, mm Hg	961	70.23±0.30	72.51±0.32	−2.28	0.31	−7	<0.001
HDL, mg/dL	391	47.13±0.71	46.93±0.75	0.20	0.50	0.4	0.688
LDL, mg/dL	384	73.06±1.52	97.05±1.97	−23.99	1.92	−13	<0.001
Hemoglobin A_{1c}, %	48	6.60±0.13	7.28±0.22	−0.68	0.20	−3	0.002

BMI indicates body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; and METs, metabolic equivalents.

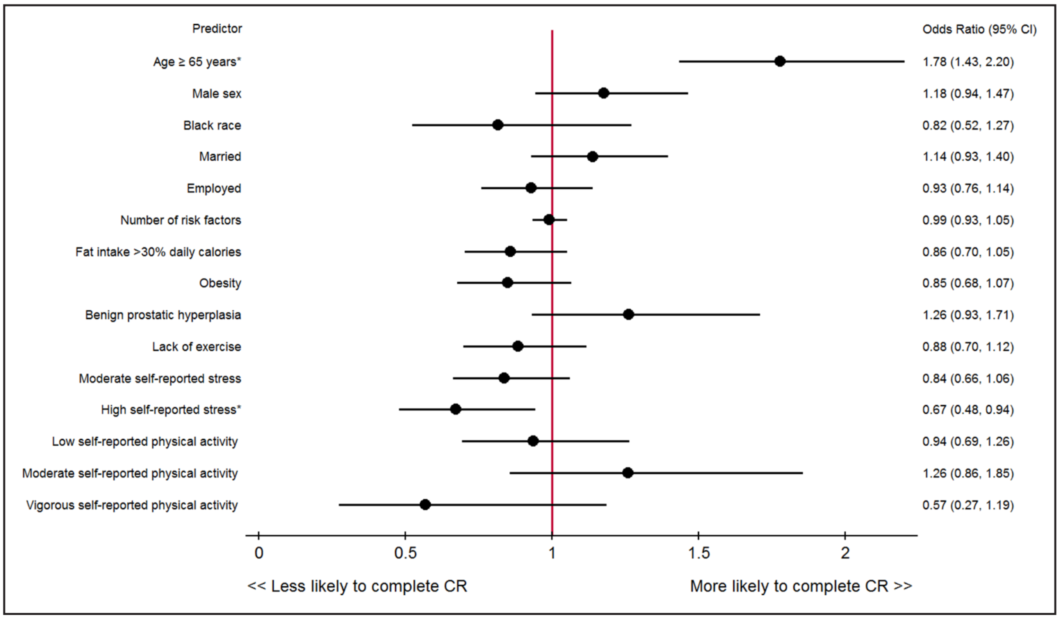

Figure 2. Forest plot showing predictors of CR completion (≥36 sessions) for the overall population (odds ratio for less likely to complete CR vs more likely to complete CR).
CR indicates cardiac rehabilitation.

likely to drop out.[39] Severe patient self-reported stress is often seen in conjunction with self-reported anxiety and depression and is associated with an increased burden of psychosocial risk factors.[39] This highlights the continued need for optimizing patient-centered psychosocial care for patients participating in CR.

Finally, the patient-reported reasons for discharge point to patients experiencing the benefits of improved CR scheduling flexibility. Prior studies have demonstrated that a large number of factors are associated with dropout or noncompletion of CR, with important factors contributing to nonmedical CR dropout including employment and distance from the CR program location.[29,40,41] However, in our study, it was found that almost half of patients were discharged because of completion of the program, while common patient-reported barriers[12] such as work conflicts (11.0%), financial challenges (6.3%), and transportation issues (0.3%) rank much lower.

Clinical Implications

Given the importance of maximizing CR adherence, it is important to explore alternative delivery methods. We demonstrated that patients who participated in an appointment-based patient-centered CR program achieved significant rates of completion and improvements in health outcomes. Improving the patient-centeredness of CR could potentially improve adherence, and thus secondary prevention outcomes, by helping patients to overcome access-related barriers[42]: Interventions such as virtual synchronous CR sessions (telemedicine or telehealth)[43] and weekend hours[14] could all bolster CR programs toward empowering patients to be at the forefront of their recovery. Although our study is of a single-centered study, this alternative CR delivery method shows promise of sustainability, re-creates the well-established benefits of traditional CR, and demonstrates a trend toward improving CR adherence for women and younger patients.

Limitations

Although the database had detailed demographic information, other significant socioeconomic status variables such as education and income were not collected. Given the important contribution of social determinants of health to health outcomes, future research on CR outcomes based on these variables would be valuable. Our patient population is also mostly White and non-Hispanic, which echoes trends seen in CR literature (estimates of Black CR participants range from 6% to 23%, while estimates of Hispanic CR participants range from 0.4% to 9%),[30,44,45] making our findings more difficult to apply to more diverse patient populations. In particular, recruitment is limited by this single-center study based in Branford, Connecticut, which has a 1.4% Black and 6.2% Hispanic population.[20] Future studies should expand on this approach in more diverse populations.

Our patient population was also limited to insured patients, and coverage included Medicaid, Medicare, and private insurance. Further work on improving enrollment of uninsured patients and evaluating for differences in compliance between different types of insurance coverage would be important. Although our database contained information on the number of CR sessions completed and the patient-reported reasons for leaving CR, studies on patient satisfaction and issues with the patient-driven appointment-based scheduling approach would help us to continue to improve the program for these patients. Also, as not all participants had a discharge survey, the patient-reported reasons for leaving CR may not represent the total patient population. Finally, follow-up on the longer-term health outcomes of patients participating in patient-driven appointment-based CR would be informational.

CONCLUSIONS

We have demonstrated that patients participating in an appointment-based CR program that uses center-scheduled class start times led to significant improvements in health outcomes and across sex/age subgroups. Furthermore, patients completed a median of 30 of a total of 36 sessions, and close to half of participants of the program were discharged because of completing the entire course of the CR program. In addition, older individuals were more likely to complete CR. An appointment-based approach could be a viable alternative CR method to aid in optimizing the dose-response benefit of CR for patients with cardiovascular disease.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S6
Figures S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Classification of primary and secondary diagnoses on intake to Cardiac Rehabilitation.

Primary Intake Diagnosis	
Percutaneous coronary intervention (PCI) with stenting	
Coronary artery bypass grafting (CABG)	
Valvular replacement and/or repair	Transcatheter aortic valve replacement (TAVR), bioprosthetic AVR (aortic valve replacement), mitral valve repair, mechanical MVR (mitral valve replacement, bioprosthetic MVR, aortic valve repair, mechanical AVR (aortic valve replacement), bioprosthetic PVR (pulmonic valve replacement)
Other surgeries and/or procedures	Composite AVR/ascending aortic aneurysmectomy, pericardiectomy, heart transplant, surgery to heart and great vessels, thrombolysis of pulmonary embolus, implantable cardioverter-defibrillator (ICD) placement, left ventricular assist device (LVAD) placement, other postprocedural status, PCI without stenting
Coronary artery disease and related issues	Coronary artery disease, angina, nontransmural myocardial infarction, ischemic cardiomyopathy, other

	specified forms of chronic ischemic heart disease, myocardial infarction (inferolateral wall), other unspecified forms of angina pectoris, transmural myocardial infarction
Congestive heart failure (CHF)	
Structural issues	Takotsubo cardiomyopathy, amyloidosis, aortic root enlargement, hypertrophic cardiomyopathy, hypertrophic obstructive cardiomyopathy, nonischemic cardiomyopathy, left ventricular outflow tract (LVOT) obstruction
Rhythm issues	Atrial fibrillation, other unspecified autonomic dysfunction, palpitations, tachycardia
Secondary Intake Diagnosis	
Percutaneous coronary intervention (PCI) with stenting	
Coronary artery bypass grafting (CABG)	
Valvular replacement and/or repair	Bioprosthetic aortic valve repair (AVR), bioprosthetic mitral valve repair (MVR), mitral valve repair, transcatheter aortic valve replacement (TAVR), tricuspid valve repair

Other surgeries and/or procedures	Implantable cardioverter-defibrillator (ICD) placement, ablation procedure, alcoholic septal ablation, composite AVR/ascending aortic aneurysmectomy, heart transplant, heart transplant failure and rejection, ligation patent ductus arteriosus (PDA), left ventricular assist device (LVAD) placement, Maze procedure, pacemaker placement, PCI without stenting, repair of ascending aorta dissection, Ross procedure, status post ablation, status post cardiac ablation, septal myectomy, sinus of Valsalva aneurysm repair, stent to left subclavian artery, surgery to heart and great vessels
Coronary artery disease and related issues	Angina, coronary artery disease, ischemic cardiomyopathy, inferior wall myocardial infarction (IWMI), nontransmural myocardial infarction, Other specified forms of chronic ischemic heart disease, transmural myocardial infarction
Congestive heart failure (CHF)	
Structural issues	Takotsubo cardiomyopathy, acute coronary insufficiency, aortic stenosis, ascending aortic dissection,

	coronary artery dissection, hypertrophic cardiomyopathy, nonischemic cardiomyopathy
Rhythm issues	Atrial flutter, atrial fibrillation, cardiac arrest, tachycardia
Other	Peripheral arterial disease (PAD) with claudication, interstitial lung disease

Table S2. Bootstrapping Validation for Multivariable Logistic Regression Model

Variable	Index.orig	training	test	optimism	Index.corrected	Bootstrapping repetition
Dxy	0.2622	0.2770	0.2455	0.0315	0.2307	500
ROC	0.6311	0.6385	0.6228	0.0157	0.6154	500
Intercept	0.0000	0.0000	-0.0368	0.0368	-0.0368	500
Slope	1.0000	1.0000	0.8679	0.1321	0.8679	500

Table S3. Patient Demographics and Clinical Characteristics on intake to Cardiac Rehabilitation, Breakdown by Sex and Age

Variable	Men (N=1540)	Women (N=595)	Age ≥65yr (N=1137)	Age <65yr (N=998)
Demographics				
Age	64.4 ± 11.3†	66.2 ± 11.3†		
Age ≥ 65yr – no. (%)	783 (50.8)†	354 (59.5)†		
Women – no. (%)			354 (31.1)†	241 (24.2)†
Race/Ethnicity				
White	1350 (87.7)	507 (85.2)	1054 (92.7)†	803 (80.5)†
Black/African American	70 (4.5)‡	39 (6.6) ‡	21(1.8)†	88 (8.8)†
Hispanic	39 (2.5)	21 (3.5)	14 (1.2)†	46 (4.6)†
Socioeconomic Status				
Marital status				
Single – no. (%)	139 (9.5)	45 (8.0)	46 (4.3)†	138 (14.5)†
Married – no. (%)	1091 (74.7)†	308 (54.7)†	774 (72.1)‡	625 (65.8)‡
Separated/Divorced – no. (%)	168 (11.5)†	113 (20.1)†	120 (11.2)†	161 (17.0)†
Widowed – no. (%)	62 (4.3)†	97 (17.2)†	133 (12.4)†	26 (2.7)†
Family (with children) – no. (%)	1325 (86.0)	527 (88.6)	1045 (91.9)†	807 (80.9)†
Employment status				

Not employed – no. (%)	730 (47.4)†	346 (58.2)†	786 (69.1)†	290 (29.1)†
Part-time – no. (%)	11 (0.7)	2 (0.3)	9 (0.8)	4 (0.4)
Full-time – no. (%)	799 (51.9)†	247 (41.5)†	342 (30.1)†	704 (70.5)†
Cardiac Risk Factors				
Hyperlipidemia* – no. (%)	1235 (80.2)†	432 (72.6)†	922 (81.1)†	745 (74.7)†
Hypertension* – no. (%)	1123 (72.9)	417 (70.1)	893 (78.5)†	647 (64.8)†
Fat intake >30% daily calories* – no. (%)	977 (63.4)‡	344 (57.8)‡	682 (60.0)	639 (64.0)
Smoking* – no. (%)	912 (59.2)‡	316 (53.1)‡	680 (59.8)‡	548 (54.9)‡
Obesity* – no. (%)	532 (34.6)†	254 (42.7)†	401 (35.3)	385 (38.6)
Diabetes* – no. (%)	431 (28.0)	173 (29.1)	342 (30.1)	262 (26.3)
Cardiac History				
Number of physician reported cardiac risk factors* – no.	5.4 ± 2.3	5.5 ± 2.4	5.4 ± 2.3‡	5.3 ± 2.4‡
Left ventricular ejection fraction – %	53.6 ± 12.8†	56.4 ± 13.4†	54.6 ± 13.5	54.0 ± 12.5
Systolic blood pressure	125.0 ± 17.8†	128.4 ± 19.7†	129.5 ± 18.7†	121.9 ± 17.3†
Diastolic blood pressure	73.0 ± 10.3	72.3 ± 10.4	70.8 ± 10.2†	75.0 ± 10.1†
Hemoglobin A1c	7.0 ± 1.9	7.0 ± 1.9	6.6 ± 1.3†	7.4 ± 2.2†
HDL	43.7 ± 12.9†	55.7 ± 19.4†	49.3 ± 15.8†	44.3 ± 14.1†

LDL	92.4 ± 38.0‡	97.3 ± 39.4‡	87.3 ± 35.3†	101.1 ± 40.5†
Primary diagnosis listed on intake				
PCI with stenting – no. (%)	770 (50.1)‡	266 (44.7)‡	490 (43.1)†	546 (54.8)†
CABG – no. (%)	332 (21.6)†	66 (11.1)†	219 (19.3)	179 (18.0)
Valvular replacement/repair – no. (%)	220 (14.3)†	138 (23.2)†	269 (23.7)†	89 (8.9)†
Other surgeries/procedures – no. (%)	54 (3.4)†	51 (8.6)†	41 (4.5)	54 (5.4)
Coronary artery disease and related issues – no. (%)	66 (4.3)	30 (5.0)	50 (4.4)	46 (4.6)
CHF – no. (%)	68 (4.4)	21 (3.5)	45 (4.0)	44 (4.4)
Structural issues – no. (%)	14 (0.9)‡	16 (2.7)‡	6 (0.5)†	24 (2.4)†
Rhythm issues – no. (%)	13 (0.9)	7 (1.2)	6 (0.5)‡	14 (1.4)‡
Secondary diagnosis listed on intake				
Coronary artery disease and related issues – no. (%)	530 (69.6)	213 (68.1)	383 (65.8)	360 (73.0)
Structural issues – no. (%)	72 (9.5)	34 (10.9)	56 (9.6)	50 (10.1)
Other surgeries/procedures – no. (%)	64 (8.4)	25 (8.0)	54 (9.3)	35 (7.1)
CABG – no. (%)	36 (4.7)	10 (3.2)	37 (6.4)†	9 (1.8)†

Valvular replacement/repair – no. (%)	23 (3.0)	10 (3.2)	24 (4.1)‡	9 (1.8)‡
Rhythm issues – no. (%)	17 (2.2)‡	14 (4.5)‡	15 (2.6)	16 (3.3)
PCI with stenting – no. (%)	11 (1.4)	2 (0.6)	6 (1.0)	7 (1.4)
CHF – no. (%)	8 (1.0)	4 (1.3)	7 (1.2)	5 (1.0)
Medical History				
Family History* – no. (%)	998 (64.8)	405 (68.0)	715 (62.9)‡	688 (68.9)‡
BPH* – no. (%)	249 (16.2)†	0 (0.0)†	198 (17.4)†	51 (5.1)†
Thyroid Disease* – no. (%)	106 (6.9)†	140 (23.5)†	166 (14.6)†	80 (8.0)†
OSA* – no. (%)	180 (11.7)†	32 (5.4)†	108 (9.5)	104 (10.4)
Gout* – no. (%)	161 (10.5)†	22 (3.7)†	126 (11.1)†	57 (5.7)†
Stroke* – no. (%)	99 (6.4)‡	55 (9.2)‡	110 (9.7)†	44 (4.4)†
COPD* – no. (%)	98 (6.4)	42 (7.1)	100 (8.8)†	40 (4.0)†
Sedentary Lifestyle* – no. (%)	659 (42.8)†	316 (53.1)†	528 (46.4)	447 (44.8)
Stress/Depression* – no. (%)	325 (21.1)†	183 (30.8)†	215 (18.9)†	293 (29.4)†
Substance Use* – no. (%)	41 (2.7)‡	6 (1.0)‡	8 (0.7)†	39 (3.9)†
Self-reported depression				
None – no. (%)	1149 (79.5)‡	406 (72.4)‡	858 (80.7)‡	697 (73.8)‡
Mild – no. (%)	220 (15.2)	96 (17.1)	156 (14.7)	160 (17.0)
Moderate – no. (%)	72 (5.0)‡	51 (9.1)‡	45 (4.2)†	78 (8.3)†
Severe – no. (%)	5 (0.4)‡	8 (1.4)‡	4 (0.4)	9 (1.0)

Self-reported stress				
Low – no. (%)	1020 (70.0)†	334 (59.2)†	838 (78.2)†	516 (54.3)†
Moderate – no. (%)	306 (19.9)‡	149 (26.4)‡	180 (16.8)†	275 (28.9)†
High – no. (%)	132 (9.0)‡	81 (14.4)‡	53 (5.0)†	160 (16.8)†
Self-reported physical activity				
None – no. (%)	169 (11.1)‡	95 (16.0)‡	145 (12.8)	119 (12.0)
Low – no. (%)	1110 (72.7)	446 (75.2)	855 (75.7)‡	701 (70.7)‡
Moderate – no. (%)	208 (13.6)‡	50 (8.4)‡	115 (10.2)‡	143 (14.4)‡
Vigorous – no. (%)	40 (2.6)‡	2 (0.3)‡	14 (1.2)‡	28 (2.8)‡
Total number of medications on intake	9.1 ± 4.0†	10.0 ± 4.4†	10.0 ± 4.0†	8.5 ± 4.1†
Cardioprotective medications on intake				
Aspirin – no. (%)	1360 (88.3)‡	502 (84.4)‡	985 (86.6)	877 (87.9)
Statins – no. (%)	1321 (85.8)†	434 (73.0)†	930 (81.8)	825 (82.7)
Beta-blockers – no. (%)	1263 (82.0)†	448 (75.3)†	892 (78.5)‡	817 (82.1)‡
ACE-I/ARBs – no. (%)	682 (44.3)	252 (42.4)	461 (40.6)‡	473 (47.4)‡

Plus-minus values are means ± SD.
* indicates a physician reported cardiac risk factor
† indicates $p<0.001$
‡ indicates $p<0.05$

Table S4. Cardiac Rehabilitation Program Statistics and Reasons for Leaving CR, Breakdown by Sex and Age

Variable	**Men** (N=1540)	**Women** (N=595)	**Age ≥65yr** (N=1137)	**Age <65yr** (N=998)
CR Sessions attended	23.8 ± 13.9	22.9 ± 14.0	25.9 ± 13.6†	20.8 ± 13.8†
Median (Interquartile range)	30 (10, 36)	26 (8, 36)	35† (13, 36)	21† (7, 36)
Completed CR program – no. (%)	681 (44.2)	241 (40.5)	583 (51.3)†	339 (34.0)†
CR Interventions				
Educational interventions completed	4.5 ± 2.6‡	4.3 ± 2.6‡	4.9 ± 2.6†	4.1 ± 2.7†
Counseling interventions completed	0.5 ± 0.6‡	0.6 ± 0.6‡	0.5 ± 0.6	0.5 ± 0.6
Discharge – Reason for leaving CR	Patients Surveyed (N=815)	Patients Surveyed (N=317)	Patients Surveyed (N=620)	Patients Surveyed (N=512)
Completed program – no. (%)	382 (46.9)	143 (45.1)	289 (46.6)	236 (46.1)
Elective – no. (%)	100 (12.3)	51 (16.1)	91 (14.7)	60 (11.7)
Medical reasons – no. (%)	112 (13.7)	34 (10.7)	70 (11.3)	76 (14.8)
Work conflicts – no. (%)	94 (11.5)	31 (9.8)	63 (10.2)	62 (12.1)
Non-adherence – no. (%)	47 (5.8)‡	29 (9.2)‡	49 (7.9)‡	27 (5.3)‡
Financial reasons – no. (%)	48 (5.9)	23 (7.3)	39 (6.3)	32 (6.3)

Patient is away – no. (%)	14 (1.7)	4 (1.3)	7 (1.1)	11 (2.2)
Family responsibilities – no. (%)	11 (1.4)‡	0 (0.0)‡	6 (1.0)	5 (1.0)
Deceased – no. (%)	4 (0.5)	0 (0.0)	3 (0.5)	1 (0.2)
Transportation issues – no. (%)	2 (0.3)	1 (0.3)	2 (0.3)	1 (0.2)
Dissatisfaction with program – no. (%)	1 (0.1)	1 (0.3)	1 (0.2)	1 (0.2)

Plus-minus values are means ± SD
† indicates p<0.001
‡ indicates p<0.05

Table S5. Patient Demographics and Clinical Characteristics on intake to Cardiac Rehabilitation, Breakdown by Completion

Variable	Completed CR (N=922)	Did Not Complete CR (N=1213)
Demographics		
Age	67.2 ± 10.4†	63.2 ± 12.2†
Age $\geq$ 65yr – no. (%)	583 (63.2)†	554 (45.7)†
Women – no. (%)	241 (26.1)	354 (29.2)
Race/Ethnicity		
White	822 (89.2)‡	1035 (85.3)‡
Black/African American	36 (3.9)‡	73 (6.0)‡
Hispanic	15 (1.6)‡	45 (3.7)‡
Socioeconomic Status		
Marital status		
Single – no. (%)	67 (7.3)‡	117 (9.6)‡
Married – no. (%)	623 (67.6)‡	776 (64.0)‡
Separated/Divorced – no. (%)	112 (12.1)	169 (13.9)
Widowed – no. (%)	66 (7.2)	93 (7.7)
Family (with children) – no. (%)	796 (86.3)	1056 (87.1)
Employment status		
Not employed – no. (%)	512 (55.5)†	564 (46.5)†
Part-time – no. (%)	4 (0.4)	9 (0.7)
Full-time – no. (%)	406 (44.0)†	640 (52.8)†

Cardiac Risk Factors		
Hyperlipidemia* – no. (%)	726 (78.7)	941 (77.6)
Hypertension* – no. (%)	678 (73.5)	862 (71.1)
Fat intake >30% daily calories* – no. (%)	536 (58.1)‡	785 (64.7)‡
Smoking* – no. (%)	524 (56.8)	704 (58.0)
Obesity* – no. (%)	302 (32.8)†	484 (39.9)†
Diabetes* – no. (%)	249 (27.0)	355 (29.3)
Cardiac History		
Number of physician reported cardiac risk factors* – no.	5.3 ± 2.2‡	5.5 ± 2.4‡
Left ventricular ejection fraction – %	54.6 ± 13.0	54.2 ± 13.1
Systolic blood pressure	126.4 ± 18.2	125.6 ± 18.6
Diastolic blood pressure	72.7 ± 10.2	72.9 ± 10.5
Hemoglobin A1c	6.9 ± 1.7	7.1 ± 2.0
HDL	47.7 ± 15.3	46.5 ± 15.1
LDL	91.4 ± 37.7‡	95.6 ± 38.9‡
Primary diagnosis listed on intake		
PCI with stenting – no. (%)	412 (44.7)‡	624 (51.4)‡
CABG – no. (%)	190 (20.6)‡	208 (17.1)‡
Valvular replacement/repair – no. (%)	163 (17.7)	195 (16.1)
Other surgeries/procedures – no. (%)	52 (5.6)	53 (4.4)
Coronary artery disease and related issues – no. (%)	45 (4.9)	51 (4.2)

CHF – no. (%)	35 (3.8)	54 (4.5)
Structural issues – no. (%)	13 (1.4)	17 (1.4)
Rhythm issues – no. (%)	11 (1.2)	9 (0.7)
Secondary diagnosis listed on intake		
Coronary artery disease and related issues – no. (%)	299 (32.4)‡	444 (36.6)‡
Structural issues – no. (%)	44 (4.8)	62 (5.1)
Other surgeries/procedures – no. (%)	44 (4.8)	45 (3.7)
CABG – no. (%)	25 (2.7)	21 (1.7)
Valvular replacement/repair – no. (%)	16 (1.7)	17 (1.4)
Rhythm issues – no. (%)	14 (1.5)	17 (1.4)
PCI with stenting – no. (%)	9 (1.0)‡	4 (0.3)‡
CHF – no. (%)	9 (1.0)‡	3 (0.2)‡
Medical History		
Family History* – no. (%)	596 (64.6)	807 (66.5)
BPH* – no. (%)	131 (14.2)†	118 (9.7)†
Thyroid Disease* – no. (%)	101 (11.0)	145 (12.0)
OSA* – no. (%)	92 (10.0)	120 (9.9)
Gout* – no. (%)	82 (8.9)	101 (8.3)
Stroke* – no. (%)	73 (7.9)	81 (6.7)
COPD* – no. (%)	58 (6.3)	82 (6.8)
Sedentary Lifestyle* – no. (%)	391 (42.4)‡	584 (48.1)‡
Stress/Depression* – no. (%)	193 (20.9)‡	315 (26.0)‡

Substance Use* – no. (%)	14 (1.5)	33 (2.7)
Self-reported depression		
None – no. (%)	672 (72.9)	883 (72.8)
Mild – no. (%)	130 (14.1)	186 (15.3)
Moderate – no. (%)	49 (5.3)	74 (6.1)
Severe – no. (%)	3 (0.3)	10 (0.8)
Self-reported stress		
Low – no. (%)	623 (67.6)†	731 (60.3)†
Moderate – no. (%)	177 (19.2)‡	278 (22.9)‡
High – no. (%)	64 (6.9)†	149 (12.3)†
Self-reported physical activity		
None – no. (%)	106 (11.5)	158 (13.0)
Low – no. (%)	669 (72.6)	887 (73.1)
Moderate – no. (%)	128 (13.9)‡	130 (10.7)‡
Vigorous – no. (%)	13 (1.4)	29 (2.4)
Total number of medications on intake	9.3 ± 4.1	9.3 ± 4.1
Cardioprotective medications on intake		
Aspirin – no. (%)	784 (85.0)‡	1078 (88.9)‡
Statins – no. (%)	748 (81.1)	1007 (83.0)
Beta-blockers – no. (%)	722 (78.3)‡	989 (81.5)‡
ACE-I/ARBs – no. (%)	401 (43.5)	533 (43.9)

Plus-minus values are means ± SD.
* indicates a physician reported cardiac risk factor
† indicates p<0.001
‡ indicates p<0.05

Table S6. Paired T-tests of Health Outcomes, Breakdown by Sex and Age

(a) Men

Outcome	Observations (no.)	Mean Post ± SE	Mean Pre ± SE	Difference	Standard Error	T value	P value
METs	889	4.67 ± 0.05	3.17 ± 0.03	+ 1.50	0.03	49	< 0.001
BMI	881	28.95 ± 0.17	29.31 ± 0.18	- 0.36	0.04	- 9	< 0.001
Body fat percentage	864	24.98 ± 0.22	26.82 ± 0.22	- 1.84	0.10	-18	< 0.001
Systolic blood pressure	723	117.62 ± 0.56	125.42 ± 0.64	- 7.80	0.65	-12	< 0.001
Diastolic blood pressure	721	70.18 ± 0.33	72.64 ± 0.37	- 2.46	0.36	- 7	< 0.001
HDL	293	43.84 ± 0.69	42.33 ± 0.66	0.61	0.53	1	0.251
LDL	288	71.63 ± 1.79	95.50 ± 2.26	- 23.88	2.12	- 11	< 0.001
Hemoglobin A1c	36	6.65 ± 0.27	7.48 ± 0.27	- 0.83	0.26	- 3	0.003

(b) Women

Outcome	Observations (no.)	Mean Post ± SE	Mean Pre ± SE	Difference	Standard Error	T value	P value
METs	332	3.92 ± 0.07	2.70 ± 0.04	+ 1.22	0.04	29	< 0.001
BMI	320	28.37 ± 0.35	28.60 ± 0.36	- 0.22	0.06	- 3	0.001
Body fat percentage	320	31.16 ± 0.42	33.13 ± 0.44	- 1.98	0.15	- 13	< 0.001
Systolic blood pressure	241	127.32 ± 5.51	130.15 ± 1.28	- 2.84	5.49	- 0.5	0.606
Diastolic blood pressure	240	70.37 ± 0.65	72.10 ± 0.65	- 1.73	0.61	- 3	0.005
HDL	98	56.98 ± 1.58	58.01 ± 1.87	- 1.03	1.21	-1	0.396
LDL	96	77.36 ± 2.82	101.71 ± 3.99	- 24.34	4.32	- 6	< 0.001
Hemoglobin A1c	12	6.44 ± 0.22	6.66 ± 0.29	- 0.22	0.23	- 1	0.364

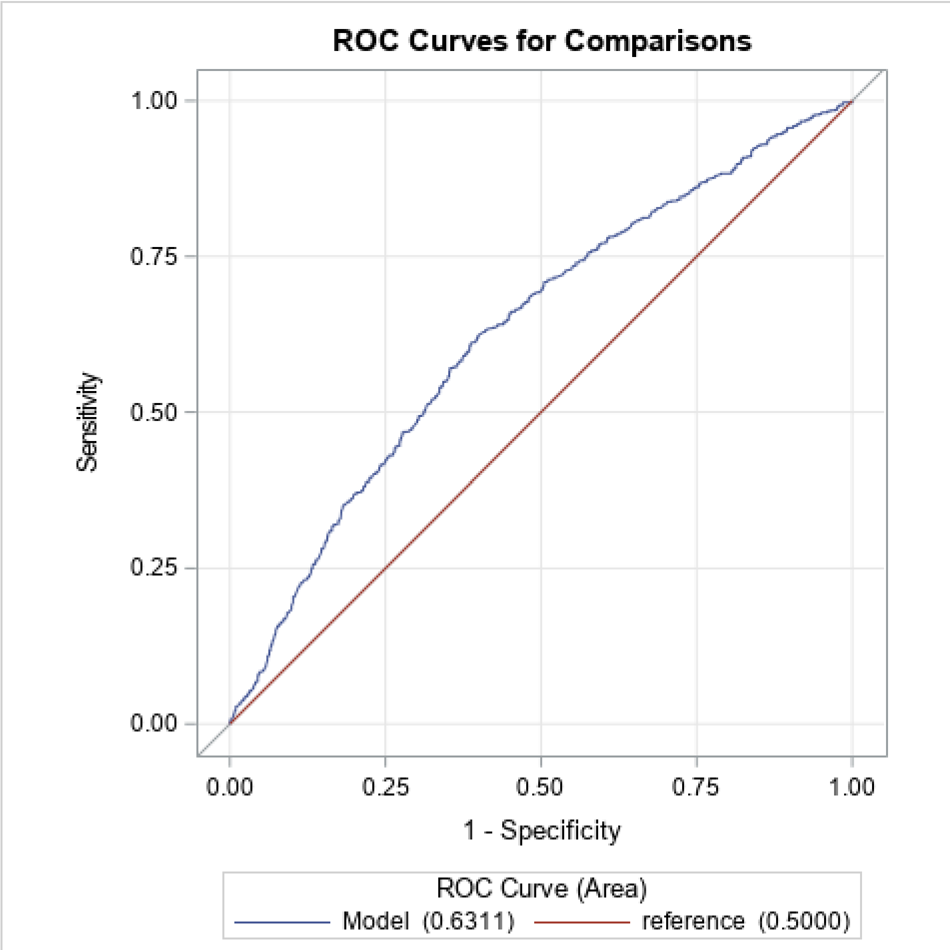
(c) Age ≥ 65

Outcome	Observations (no.)	Mean Post ± SE	Mean Pre ± SE	Difference	Standard Error	T value	P value
METs	731	4.03 ± 0.04	2.82 ± 0.02	+ 1.21	0.02	50	< 0.001
BMI	727	28.40 ± 0.19	29.68 ± 0.20	- 0.29	0.04	- 7	< 0.001
Body fat percentage	717	26.55 ± 0.26	28.29 ± 0.28	- 1.74	0.10	-18	< 0.001
Systolic blood pressure	576	123.32 ± 2.35	130.12 ± 0.74	- 6.80	2.37	- 3	0.004
Diastolic blood pressure	573	69.16 ± 0.40	71.44 ± 0.42	- 2.28	0.42	- 5	< 0.001
HDL	219	49.68 ± 0.94	49.05 ± 1.04	0.62	0.72	1	0.387
LDL	217	71.69 ± 1.74	90.18 ± 2.34	- 18.48	2.36	- 8	< 0.001
Hemoglobin A1c	28	6.51 ± 0.17	6.70 ± 0.19	- 0.20	0.17	- 1	0.264

(d) Age < 65

Outcome	Observations (no.)	Mean Post ± SE	Mean Pre ± SE	Difference	Standard Error	T value	P value
METs	478	5.13 ± 0.07	3.38 ± 0.04	+ 1.75	0.05	36	< 0.001
BMI	474	29.40 ± 0.27	29.77 ± 0.27	- 0.38	0.06	- 6	< 0.001
Body fat percentage	467	26.81 ± 0.35	28.89 ± 0.35	- 2.08	0.16	-13	< 0.001
Systolic blood pressure	388	115.17 ± 0.75	121.38 ± 0.85	- 6.21	0.85	- 7	< 0.001
Diastolic blood pressure	388	71.82 ± 0.44	74.09 ± 0.47	- 2.27	0.47	- 5	< 0.001
HDL	172	43.90 ± 1.04	44.23 ± 1.06	- 0.33	0.69	- 0.5	0.630
LDL	167	74.84 ± 2.66	105.99 ± 3.23	- 31.16	3.09	- 10	< 0.001
Hemoglobin A1c	20	6.73 ± 0.19	8.08 ± 0.39	- 1.35	0.38	- 4	0.002

Figure S1. ROC Curve for Multivariable Logistic Regression Model



Note: ROC curve (C statistic)=0.6311

Figure S2. Calibration Plot for Multivariable Logistic Regression Model