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## **A Community-Informed Virtual World-Based Cardiac Rehabilitation Program as an Extension of Center-Based Cardiac Rehabilitation:**

### **MIXED-METHODS ANALYSIS OF A MULTICENTER PILOT STUDY**

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## Abstract

**Purpose:** Innovative methods for delivering cardiac rehabilitation (CR) that provide strategies to circumvent the mounting barriers to traditional CR have the potential to widen access to a well-established secondary prevention strategy. Our study assesses the feasibility and acceptability of a novel virtual world-based CR (VWCR) program, *Destination Rehab*, as an extension of a conventional center-based CR program.

**Methods:** Adult cardiac patients hospitalized at Mayo Clinic hospitals with a diagnosis for CR and 1 modifiable, lifestyle risk factor target—sedentary lifestyle (<3 hr physical activity/wk), unhealthy diet (<5 servings fruits and vegetables/d), or current smoking (>1 yr)—were recruited. Patients participated in an 8-wk health education program using a virtual world (VW) platform from a prior proof-of-concept study and a post-intervention focus group. Primary outcome measures included feasibility and acceptability. Secondary outcome measures included changes from baseline to post-intervention in cardiovascular (CV) health behaviors and biometrics, CV health knowledge, and psychosocial factors.

**Results:** Of the 30 enrolled patients (age  $59.1 \pm 9.7$  yr; 50% women), 93% attended 1 session and 71% attended 75% of sessions. The overall VWCR experience received an 8 rating (scale 0-10) and had high acceptability. Clinically relevant trends were noted in CV health behaviors and biometrics, although not statistically significant.

**Conclusions:** The VWCR program is a feasible, highly acceptable, and innovative platform to potentially influence health behaviors and CV risk and may increase accessibility to disadvantaged populations with higher CV disease burdens.

## Keywords

cardiac rehabilitation; home-based programs; lifestyle; virtual environments

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Cardiac rehabilitation (CR) is an evidence-based secondary prevention program incorporating education, health behavior modification, and cardiovascular disease (CVD) risk factor control, as well as exercise assessment and training, to improve outcomes in patients with CVD.<sup>1</sup> As such, CR is a class 1 recommendation by the American College of Cardiology/American Heart Association guidelines to improve health-related quality of life and reduce the risk of future hospitalizations and major cardiac events.<sup>2-7</sup> Despite this, CR

participation remains suboptimal, especially for racial and ethnic minority groups, women and individuals from underserved populations.<sup>1,2,8-16</sup>

Barriers to CR participation have been described in prior research and include modifiable patient and systemic factors such as inflexible hours, transportation limitations, travel costs, and lack of insurance coverage for CR costs.<sup>12,13,17-20</sup> Studies have shown that patients often prefer CR programs that occur at home or in non-clinical settings with more flexible hours, circumventing many of these barriers.<sup>19,21,22</sup> To improve CR adherence and effectiveness, the American Heart Association Presidential Advisory Board issued a call for innovative reengineering of the center-based CR (CBCR) model.<sup>23</sup> Novel health care delivery methods, focused on mitigating barriers to care, are ever more relevant in the wake of the global COVID-19 pandemic, especially for medically underserved populations.<sup>24-29</sup>

Over the past 20 yr, home-based CR (HBCR) programs have emerged to alleviate some of the barriers to CR participation and have shown similar effectiveness as CBCR programs.<sup>1,30-36</sup> While HBCR programs do mitigate various factors hindering CR participation, current evidence suggests that adherence to HBCR is only slightly better than CBCR.<sup>1,30,32</sup> Home-based CR programs inherently lack some critical aspects of face-to-face interventions, which uniquely capitalize on behavioral counseling, cognitive restructuring, accountability, and social support to impact behavioral change, which may account for the limited adherence to HBCR despite increased accessibility.<sup>19,37-39</sup> Although not yet validated, utilizing technology tools such as mobile and Internet-based interventions as an adjunct to HBCR is a promising approach to expand its uptake and adherence.<sup>1,19,36,40-42</sup>

Virtual worlds (VWs) are three-dimensional, immersive computer-based environments that allow patients to interact via online personas, simulate in-person experiences, and engage with a social network.<sup>38,43,44</sup> Technology for VW emerged in recent years and has been utilized for a variety of applications including socialization, creativity, education, and more recently, health education and chronic disease management.<sup>38,44</sup> A VW provides a space for users to test the potential impact of various health-related behaviors through avatars.<sup>43,45</sup> We proposed expanding VW to CR, to widen access to and participation in CR, while narrowing the gap in health outcomes among underserved groups.<sup>43</sup>

This study aimed to assess the feasibility of delivery and acceptability of a VW-based CR (VWCR) program (*Destination Rehab*), a program designed to address the education, health behavior modification, and CVD risk factor control components of CR, as an extension of traditional CBCR across multiple clinical sites. We assessed the impact of *Destination Rehab* on CVD health behaviors (physical activity [PA] and diet) and biometrics (body mass index [BMI], blood pressure [BP], lipids, and hemoglobin A1c), cardiovascular (CV) health knowledge, and psychosocial factors (social support, quality of life, and optimism).

## METHODS

### CONTEXT AND STUDY DESIGN

The VW-based platform Second Life was utilized to design a VWCR program named *Destination Rehab* based on principles of self-determination theory.<sup>46,47</sup> A prior proof-of-

concept study evaluated patient acceptability of the CR program.<sup>46</sup> Feedback from this intervention was used to design the refined program used in the current study.

A single-group, nonrandomized, mixed-methods multicenter pilot study was conducted using a refined VWCR program, *Destination Rehab*, to evaluate the feasibility and acceptability of the intervention. Details of the overall study design are provided in Figure 1. The study was reviewed and approved by the Mayo Clinic Institutional Review Board.

## STUDY PARTICIPANTS, SETTING, AND RECRUITMENT

Adult cardiac patients recently hospitalized at Mayo Clinic hospitals in Rochester, MN, Jacksonville, FL, or Scottsdale, AZ with an indication for CR were eligible to participate. Patients were excluded if they were <18 yr, nonfluent in English, or did not have home high-speed Internet access. Though limited by our recruitment settings, patients who historically have more barriers to participation in CR including women and lower socioeconomic status (annual household income <\$50 000, education level lower than college graduate) were prioritized for recruitment. A recruitment goal of 30 patients (10/site) with 30% women was chosen.

Eligible patients were identified by review of the inpatient cardiology service census within the electronic medical record and the census of patients recently enrolled in CBCR by each site-specific study coordinators. The study coordinators visited eligible patients prior to hospital discharge or contacted them by telephone using a standardized script for recruitment. Patients who expressed interest were shown a brief demo video on VW technology and the VWCR platform. Otherwise, patients were recruited directly from CBCR and viewed the video at a separate recruitment visit. Written informed consent was obtained from patients agreeing to participate. Patients recruited prior to hospital discharge were encouraged to concurrently participate in CBCR for supervised exercise training and those recruited from CBCR were encouraged to continue in-person participation for assessments and contact with CR staff outside of the platform.

## INTERVENTION

Three cohorts at the different Mayo Clinic sites attended a hands-on training session where they created Second Life avatars and learned to navigate *Destination Rehab* (see SDC 1, available at: <http://links.lww.com/JCRP/A394>). Loaner laptops were provided to patients who did not have access to a personal computer. Following the training session, patients participated in eight weekly educational sessions led by a CVD specialist and a CV nurse educator, both trained in motivational interviewing and the Second Life application. The 90-min sessions included lectures on diet, PA, stress management, CVD risk factors, and CV-related medications.<sup>41</sup> Additionally, patients engaged in tours of the virtual fitness center, grocery store, and restaurant and a weekly support group. A trained exercise physiologist led a lecture and tour on exercise and fitness training as a part of the VWCR education curriculum. Participants had the opportunity to simulate a variety of exercise activities via their own avatars (eg, use of a treadmill, swimming, line dancing, and yoga). A registered dietitian provided education on heart healthy diets to promote CV health including DASH (Dietary Approaches to Stop Hypertension) and Mediterranean diets.<sup>48,49</sup> The dietitian

also led the interactive restaurant and grocery store tours and allowed the participants to proactively engage in “real-world” selection of healthy foods, proper portion sizes, and nutrition label reading. “Proteus effect” reflection discussions were held after each live session, where patients discussed ways in which they have translated healthy behaviors from the VW to the real world.<sup>43,44</sup> A virtual library provided patients access to all lecture materials. Also, a bulletin board provided a forum for patient discussion to enhance social networking and user engagement. Technical support staff was present at all sessions to assist with any VW technology challenges. Patients received a 6-mo YMCA membership to minimize barriers to regular PA and a \$25 cash card for participation.

## DATA COLLECTION

Quantitative assessments were performed at baseline and post-intervention. Patients completed a baseline (pre-intervention) electronic survey collecting sociodemographic information, self-reported health history, perceived health status, health information sources, health care utilization, and outcome measures. The post-intervention survey additionally included an evaluation of intervention acceptability. Available biometrics were extracted from the electronic medical record at baseline and post-intervention (range 6-12 mo). Patient attendance and log-in data were recorded throughout the intervention by the study team.

Qualitative assessment by a single post-intervention focus group including patients from all three cohorts was facilitated on Second Life by an experienced qualitative researcher (J.E.). A semi-structured interview guide (see SDC 2, available at: <http://links.lww.com/JCRP/A395>) was developed using principles outlined by Krueger and Casey to explore patient perception of the intervention.<sup>50</sup> The focus group was audio recorded with patient consent.

## PRIMARY OUTCOME MEASURES

Study feasibility was evaluated utilizing metrics including recruitment goal attainment, patient retention, and adherence to the intervention as measured by patient live session attendance and VW platform usage.

Acceptability metrics were included in the post-intervention survey and post-intervention focus group. In the post-intervention survey, patients were asked to rate their overall VWCR experience from poor (0) to excellent (10). They were also asked to rate statements regarding perception of the education sessions, and platform ease of use, appearance, usefulness, and logic of information from strongly disagree (1) to strongly agree (5).

## SECONDARY OUTCOME MEASURES

Both CV health behavior measures and biometrics from the electronic medical record were compared pre- and post-intervention.<sup>51</sup> The CV health behavior measures included PA and diet, and biometrics included BMI, BP, total cholesterol, low-density lipoprotein cholesterol (LDL-C), and hemoglobin A1c. The International Physical Activity Questionnaire evaluated PA including sedentary time, aerobic exercise, stretching, and resistance exercise.<sup>52</sup> Diet was assessed by patient-reported number of servings of fruits and vegetables/d.

Cardiovascular health knowledge was assessed using 15 items from the Heart Disease Knowledge Questionnaire developed by Bergman and colleagues, a previously validated survey demonstrating sound psychometric properties.<sup>53</sup> The survey contained true/false questions evaluating five factors of CV health knowledge domains, including dietary factors (two questions), epidemiologic factors (three questions), medical factors (three questions), risk factors (five questions), and symptoms (two questions). Six true/false questions addressing CR effects on CV health were developed by the study team probing additional questions regarding epidemiologic factors (eg, “There are no differences in the rates of heart disease between racial/ethnic groups in the United States”), factors affecting CR participation (eg, “Men are less likely than women to participate in cardiac rehab”), and CVD risk factors (eg, “How you cope with stress can affect your cardiovascular risk”). Three additional multiple-choice questions addressing CV health knowledge were included. The average percent of correct answers on the 24-item survey was tabulated and compared from baseline to post-intervention.<sup>53</sup>

Psychosocial factors including social support (ENRICH Social Support Inventory), quality of life (Short Form [SF]-12 Health Survey), and optimism (Revised Life Orientation Test [LOT-R]) were measured using previously validated instruments.<sup>54–56</sup>

## DATA ANALYSIS

Continuous variables are presented as mean  $\pm$  SD and discrete variables as n (%). Study measures are summarized and compared between groups using the Pearson  $\chi^2$  test for categorical variables or the Student *t* test for continuous variables. The changes in measures from baseline to post-intervention are calculated for all participants. These changes were also stratified by sex using paired *t* tests or McNemar’s tests. Statistical significance is defined as a two-tailed *P* value  $<$  .05. Statistical analyses were performed using SAS Version 9.4 (SAS Institute Inc).

Qualitative analysis of the post-intervention focus group discussion was conducted by an independent experienced qualitative research analyst (J.E.) based on the framework method.<sup>57</sup> The focus group discussion took place in the VW platform and was audio-recorded, transcribed verbatim, and entered into a specialized qualitative software, NVivo12 (QRS International) for data management. The transcript was then coded utilizing a generalized inductive approach.<sup>58</sup> The coded transcript was subsequently analyzed to identify notable themes and corresponding illustrative quotes.

## RESULTS

Patient demographics and baseline characteristics are shown in Table 1. The age of patients was 59.1  $\pm$  9.7 yr (50% female). The most common reported sources for obtaining health information included doctors/health care providers (89%) and medical websites (71%). Men had a higher proportion of concurrent enrollment in CBCR than women (79% vs 50%, *P* = .11).

Patient recruitment and retention are summarized in Figure 2. Of the 44 patients recruited, 30 were enrolled into the study. Twenty-eight connected and participated in 1 live session

(93%), with 20 patients (71%) attending 6 sessions (75% of sessions). An average of  $79.2 \pm 21.1\%$  of patients attended each session, with  $83.9 \pm 13.1\%$  women in attendance compared with  $68.8 \pm 8.5\%$  men ( $P = .02$ ).

The patients rated their overall experience with the VWCR program an  $8 \pm 1.7$  out of 10 points. They rated the presentations as very good/excellent (>80%) for style, content, and presentation. Patients felt that the platform was easy to use (95%) and easy to learn (95%). They reported that the sessions improved their knowledge about health (100%) and helped them to maintain better health habits (95%). All patients were satisfied with the platform appearance and quality (100%).

## CARDIOVASCULAR HEALTH

There were statistically significant improvements in mean time engaged in stretching/flexibility exercises in men ( $+ .9 \pm .9$  d/wk,  $P = .05$ ) and mean total cholesterol for all participants ( $-31.6 \pm 46.2$  mg/dL,  $P = .05$ ). Though not statistically significant, there were other positive trends in CV health behaviors from baseline to post-intervention (Table 2) including mean time engaged in vigorous PA. There were notable trends in biometrics including an improvement in mean LDL-C. Among men, there was a reduction in both mean systolic BP and mean diastolic BP, but these did not reach statistical significance. Women had larger improvements, although not statistically significant, in total cholesterol and LDL-C compared with men. Women also lost an average of 3.1 kg versus men who gained an average of 2.4 kg.

At baseline, patients scored  $81.6 \pm 8.3\%$  on the heart disease knowledge survey, which was unchanged at post-intervention (Table 2).

There were no statistically significant changes in social support, quality of life, or optimism from baseline to post-intervention (Table 2).

## FOCUS GROUP RESULTS

Responses by patients indicated that a VWCR program was a highly acceptable method to augment CBCR. Four main themes emerged from the focus group discussion regarding the *Destination Rehab* program including: (1) complementary to CBCR, (2) convenient modality for CR delivery, (3) educational by providing valuable health information on key CV topics, and (4) social networking beneficial to recovery (Table 3).

Several patients expressed that *Destination Rehab* served as a complement to but did not replace CBCR. They emphasized benefits of supervised CBCR but noted that *Destination Rehab* more conveniently replaced the additional curriculum. Patients agreed that *Destination Rehab* was a convenient platform for providing an educational experience and a rich social network that otherwise may not be accessible.

Patients acknowledged a perceived improvement in knowledge regarding CV health. One patient explained that their doctor gave an overview of CVD but noted that they appreciated the depth of information in the Anatomy and Physiology lecture. Several patients noted that they appreciated having a deeper understanding of their CV-related medications. They

also described the practical knowledge and confidence gained from the interactive VW experience, which they were able to translate into real-world behavior changes.

Patients were comforted by listening to the stories of others and realizing that they are not alone. They enjoyed listening to the experiences of others and even suggested having individuals who have undergone similar experiences share their stories. The social connection fostered a sense of accountability to the group.

## DISCUSSION

The VWCR program, *Destination Rehab*, was shown to be a feasible and highly acceptable method of delivering the educational, health behavior modification, and CVD risk factor control aspects of CR, based on excellent patient recruitment, retention, attendance rates, and patient-reported satisfaction. Additionally, our study demonstrated exemplary intervention adherence in women. While women were less likely to be enrolled in CBCR, they attended more *Destination Rehab* sessions on average compared with men. Patients were highly satisfied with the intervention and acknowledged that *Destination Rehab* could be a convenient complement to CBCR, as it can provide the educational component of CR at home, while maintaining the development of social connections that patients felt were essential for their recovery. While there were no statistically significant changes in secondary outcome measures, there were favorable trends in CV risk factors from pre- to post-intervention.

Attendance to our VWCR sessions was comparable to attendance rates previously observed in both HBCR and CBCR. A large meta-analysis conducted by Oosenbrug et al.<sup>9</sup> showed that patient attendance to CBCR sessions averages  $66.5 \pm 18.2\%$ , which is similar to adherence rates noted by additional studies.<sup>1,30,32</sup> Though our sample size was small and not directly compared to CBCR, the adherence to our VWCR program was comparable to this previously observed rate. Oosenbrug et al.<sup>9</sup> also showed that adherence to CBCR in women was consistently lower than that of men, an observation noted in a variety of studies.<sup>13,14</sup> While we observed excellent adherence rates in women, there is insufficient data in the literature to compare the adherence rates of women in our study to alternative non-CBCR methods.<sup>1,13</sup>

Modification of CVD risk factors, one of the cornerstones of CR, is a means by which CR programs achieve improved patient outcomes.<sup>1,2</sup> The current literature suggests that alternative CR delivery programs, such as HBCR, demonstrate comparable improvements in clinical, behavioral, and psychosocial risk factors for CVD when compared with traditional CBCR.<sup>1,30,33</sup> While this study was inadequately powered to sufficiently detect statistical significance, clinically relevant trends were noted in both CV health and psychosocial outcomes. More research is needed to compare the efficacy of this intervention to CBCR alone and other alternative CR delivery modalities.

Overall, our study supports the promising potential for VWCR programs to reach populations with a high burden of competing demands by combining unique qualities of both HBCR and CBCR. *Destination Rehab* capitalizes on many advantages of



HBCR including flexibility, decreased travel and transportation barriers, and increased privacy, while incorporating critical aspects of CBCR including social support and patient accountability.<sup>1</sup> Patients in the focus group asserted better availability to attend *Destination Rehab* sessions, supporting the notion that the flexible nature of VWCR programs can broaden CR access. Furthermore, our program reduced transportation barriers. In addition, *Destination Rehab* has advantages that are often absent in other HBCR programs. For example, patients highlighted the weekly support group as an important CR component, as it offered social support and accountability to the group, both important aspects of behavioral modification.<sup>19,37–39</sup> Additionally, unique to a VW platform, patients engaged in a hands-on virtual gym, restaurant, and grocery store, which they acknowledged gave them the knowledge and confidence to make informed and healthy choices in the real world. In summary, the unique characteristics inherent to VWs may provide a powerful solution to broaden access to CR and better promote patient participation and retention. More research is needed to directly compare VWCR adherence rates and CVD risk factor modification to CBCR alone and its impact in minority, socioeconomically disadvantaged, and rural populations.

## STRENGTHS AND LIMITATIONS

The most important strength of our study is the novel method of CR delivery and its unique features that distinguish it from other forms of HBCR. The intervention and multicenter design were adapted from an initial proof-of-concept study, integrating participant feedback to better meet patient needs. Unlike other HBCR programs, *Destination Rehab* offers a rich social network that fosters a sense of group accountability, while maintaining anonymity. The Second Life platform offered a reliable network with minimal technological challenges. Our mixed-methods approach granted us insight to not only the impact of this intervention, but also patient perceptions of its advantages and limitations. Furthermore, our study had excellent recruitment and retention of women, an important population to prioritize when considering alternative approaches to CR delivery.

Notably, *Destination Rehab* does not offer the patient assessment and supervised exercise training components of CR.<sup>3</sup> These are important aspects of CR in improving outcomes. Thus, in its current form, *Destination Rehab* is an extension to, rather than a replacement of CBCR. However, the intervention included opportunities for interaction with and simulated learning from a trained exercise physiologist on proper exercise techniques. Other study limitations include a small sample size limiting statistical power, and variable timing of documentation of post-intervention data in the electronic medical record as well as missing data. The study did not assess changes in prescribing of CV-related medications, medication adherence, or objective functional status measurements. These variables and others not assessed could potentially confound the positive trends noted in biometric changes. The demographics of patients treated within the Mayo Clinic Health System limited the ability to recruit socioeconomically disadvantaged patients. Most patients were White, insured, socioeconomically advantaged, and all had access to an academic medical center, limiting the generalizability of our results to other populations. Plans are currently underway to conduct a larger, randomized clinical trial with inclusion of health care systems serving patients with a high burden to barriers to CR participation.

## CONCLUSIONS

*Destination Rehab*, a VWCR program, is a feasible and highly acceptable modality of delivering CR, suggesting that it could serve as a convenient adjunct to traditional CR. It has the potential to overcome many barriers to traditional CR, especially in populations with limited access to CR, without omitting some of its most critical aspects, including social support and patient accountability. More research is needed to clarify its impact on CVD risk factor modification compared with CBCR.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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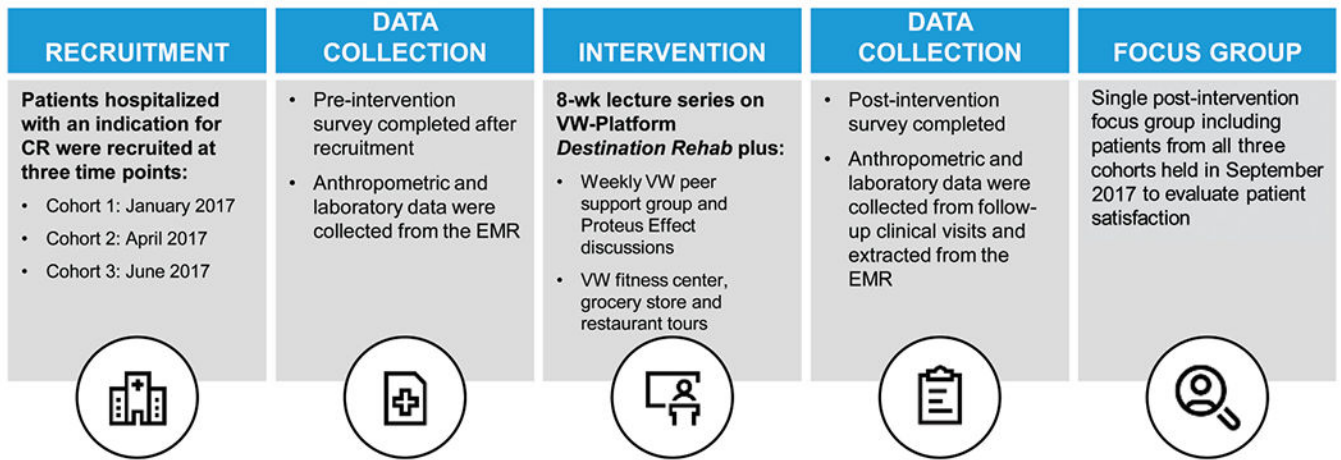
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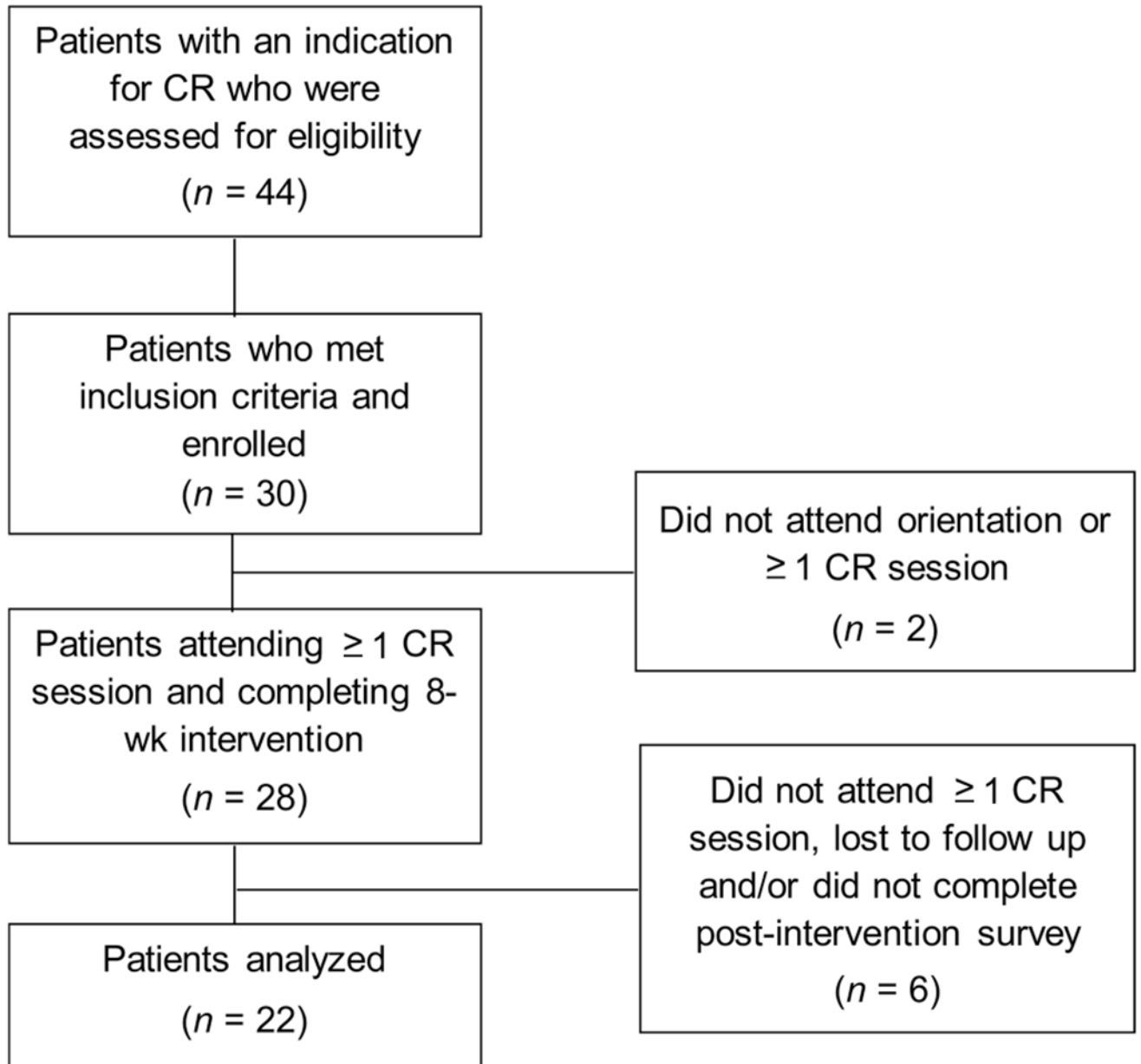
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**Figure 1.** Summary of study design. Abbreviations: CR, cardiac rehabilitation; EMR, electronic medical record; VW, virtual world. This figure is available in color online ([www.jcrpjournal.com](http://www.jcrpjournal.com)).



**Figure 2.** Modified CONSORT flow diagram. Abbreviation: CR, cardiac rehabilitation.

**Table 1**

**Patient Baseline Demographics and Characteristics by Sex<sup>a</sup>**

<b>Variable</b>	<b>All (n = 28)</b>	<b>Men (n = 14)</b>	<b>Women (n = 14)</b>	<b>P Value<sup>b</sup></b>
Age, yr	59.1 ± 9.7	57.4 ± 12.0	60.8 ± 6.8	.36
Race				.68
American Indian/Alaskan Native	1 (4)	1 (7)	0 (0)	
Asian	3 (11)	2 (14)	1 (7)	
Black/African American	2 (7)	1 (7)	1 (7)	
White	22 (79)	10 (71)	12 (86)	
Ethnicity				
Non-Hispanic/Latino	28 (100)	14 (100)	14 (100)	.07
Marital status				
Married/committed relationship	22 (79)	13 (93)	9 (64)	
Not married/committed relationship	6 (21)	1 (7)	5 (36)	
Education level				.22
College degree or higher	9 (32)	6 (43)	3 (21)	
No college degree	19 (68)	8 (57)	11 (79)	
Insurance status				.56
Insured	26 (93)	12 (86)	14 (100)	
Not insured	2 (7)	2 (14)	0 (0)	
Employment status				.7
Employed full-time	13 (46)	7 (50)	6 (43)	
Not employed full-time	15 (54)	7 (50)	8 (57)	
Annual household income				.81
\$75 000	11 (39)	5 (36)	6 (43)	
<\$75 000	14 (50)	7 (50)	7 (50)	
Choose not to disclose	3 (11)	2 (14)	1 (7)	
Self-reported medical history				
Type 2 diabetes	9 (32)	3 (21)	6 (43)	.22
Hypertension	14 (50)	5 (36)	9 (64)	.13
Percutaneous coronary intervention	19 (68)	10 (71)	9 (64)	.69



Variable	All (n = 28)	Men (n = 14)	Women (n = 14)	P Value <sup>b</sup>
Coronary artery bypass graft surgery	4 (14)	3 (21)	1 (7)	.28
Heart transplant	2 (7)	2 (14)	0 (0)	.14
Heart assistive device	2 (7)	2 (14)	0 (0)	.16
Defibrillator/pacemaker	5 (18)	2 (14)	3 (21)	.62
Valve surgery	6 (22)	3 (23)	3 (21)	.92
Family history of early coronary artery disease	12 (44)	7 (50)	5 (38)	.55
Cardiac rehabilitation				
<i>Enrolled</i>				.11
Yes	18 (64)	11 (79)	7 (50)	
No	10 (36)	3 (21)	7 (50)	
<i>Completed</i>				.78
Yes	11 (61) <sup>c</sup>	7 (64)	4 (57)	
No	7 (39) <sup>c</sup>	4 (36)	3 (43)	
Health information sources				
Doctors/health care providers	25 (89)	11 (79)	14 (100)	.07
Virtual world/Second Life	4 (14)	2 (14)	2 (14)	
Social media	2 (7)	1 (7)	1 (7)	1
Medical websites	20 (71)	10 (71)	10 (71)	1
Nonmedical websites	4 (14)	3 (21)	1 (7)	.28
Cardiovascular health knowledge, % correct	81.6 ± 8.3	81.7 ± 7.1	81.6 ± 9.6	.98

<sup>a</sup>Data presented for N = 28 participants (93% of N = 30 enrolled participants) who participated in at least 1 live virtual world-based cardiac rehabilitation session. Data are reported as n (%) or mean ± SD.

<sup>b</sup>P values are based on the Pearson  $\chi^2$  test for categorical variables or the t test for continuous variables.

<sup>c</sup>Data reported as n (%) among those enrolled.

**Table 2**  
 Changes in Secondary Outcomes From Baseline to Post-intervention, Within Group by Sex<sup>a</sup>

Variable	All	P Value <sup>b</sup>	Men	P Value <sup>b</sup>	Women	P Value <sup>b</sup>
Vigorous PA		.05		.16		.16
d/wk	0.29 ± 0.95	.46	0.6 ± 0.9	.50	-0.50 ± 0.7	.50
min/d	10.7 ± 11.7	.05	13.0 ± 11.5	.06	5.0 ± 14.1	.70
Moderate PA		.16		.05		1.00
d/wk	1.0 ± 3.0	.38	2.0 ± 2.8	.50	-0.7 ± 3.1	.74
min/d	7.5 ± 42.0	.63	18.0 ± 40.8	.75	-10.0 ± 45.8	.74
Strength/weight training		.32		1.00		.16
min/wk	26.2 ± 75.4	.36	28.3 ± 88.8	.47	20.0 ± 14.1	.30
Stretching/flexibility exercises		.03		.08		.18
d/wk	0.8 ± 0.8	.06	0.8 ± 0.9	.05	0.5 ± 0.7	.50
min/wk	8.3 ± 33.8	.48	20.0 ± 28.4	.11	-32.5 ± 3.5	.05
Weight, kg	-0.4 ± 1.9	.19	2.4 ± 9.9	.57	-3.1 ± 9.3	.30
BMI, kg/m <sup>2</sup>	-0.2 ± 9.8	.53	0.8 ± 2.9	.73	-1.1 ± 2.6	.18
Systolic BP, mm Hg	-0.1 ± 2.9	.52	-14.1 ± 34.3	.20	1.2 ± 23.1	.87
Diastolic BP, mm Hg	-6.8 ± 29.8	.31	-3.1 ± 13.1	.45	6.8 ± 10.2	.06
Total cholesterol, mg/dL	1.6 ± 12.6	.56	-16.5 ± 47.4	.43	-49.8 ± 42.0	.06
LDL-C, mg/dL	-31.9 ± 69.9	.16	-4.3 ± 28.3	.72	-52.0 ± 49.6	.08
Hemoglobin A1c, %	0.3 ± 0.8	.47	0.1 ± 0.2	.47	0.6 ± 1.2	.50
Heart disease knowledge	0.7 ± 9.4	.73	1.0 ± 7.0	.63	0.36 ± 11.7	.92
Social Support score	0.32 ± 3.0	.77	-0.36 ± 1.8	.51	1 ± 3.8	.40
SF-12 score	0.05 ± 0.11	.06	0.04 ± 0.13	.33	0.06 ± 0.08	.06
Optimism score	-0.25 ± 3.1	.72	-2.0 ± 2.7	.06	1.2 ± 2.6	.17

Abbreviations: BMI, body mass index; BP, blood pressure; LDL-C, low-density lipoprotein cholesterol; PA, physical activity; SF-12, w. Suivey.

<sup>a</sup>Data are reported as mean ± SD.

<sup>b</sup>P values are based on McNemar's test for categorical variables or paired t tests for continuous variables.

**Table 3**

Focus Group Salient Themes and Illustrative Quotes

Theme	Quote
Complements center-based cardiac rehabilitation	"I wasn't able to participate in a lot of the classes or the extra things [in center-based cardiac rehabilitation] and so I got most of that from Second Life."
Convenience	"There were people who were so remote that there was no way they were going to have access to a group, which to me was phenomenal. I think it's going to be fantastic for a lot of people."
Educational	"We went and did the restaurant ordering and then you went over to the athletic area and they gave you a rundown on how much exercise you'd have to burn for what you just ordered."
Social connection	"The meetings hold you accountable. You're meeting with a group who will ask questions, we're going to talk about what we did. So yeah, definitely it just kind of put me on a pattern which I've been able to continue."