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Clinical Outcomes and Qualitative Perceptions of In-person, Hybrid, and Virtual Cardiac Rehabilitation

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Purpose: Cardiac rehabilitation (CR) is evolving to include both in-person and virtual delivery. Our objective was to compare, in CR patients, the association of in-person, hybrid, and virtual CR with change in performance on the 6-min walk test (6MWT) between enrollment and completion.

Methods: Patients enrolled in CR between October 22, 2019, and May 10, 2021, were categorized into in-person, hybrid, or virtual groups by number of in-person and virtual visits. All patients received individualized exercise training and health behavior counseling. Cardiac rehabilitation was delivered to patients in the hybrid and virtual cohorts using synchronous video exercise and/or asynchronous telephone visits. Measurements at CR enrollment and completion included the 6MWT, blood pressure (BP), depression, anxiety, waist-to-hip ratio, and cardiac self-efficacy.

Results: Of 187 CR patients, 37/97 (38.1%) were in-person patients and 58/90 (64.4%) were hybrid/virtual patients (P = .001). Compared to in-person (51.5 ± 59.4 m) improvement in the 6MWT was similar in hybrid (63.4 ± 55.6; P = .46) and virtual (63.2 ± 59.6; P = .55) compared with in-person (51.5 ± 59.4). Hybrid and virtual patients experienced similar improvements in BP control and anxiety. Virtual patients experienced less improvement in depression symptoms. There were no statistically significant changes in waist-to-hip ratio or cardiac self-efficacy. Qualitative themes included the adaptability of virtual CR, importance of relationships between patients and CR staff, and need for training and organizational adjustments to adopt virtual CR.

Conclusions: Hybrid and virtual CR were associated with similar improvements in functional capacity to in-person. Virtual and hybrid CR have the potential to expand availability without compromising outcomes.

Key Words: cardiac rehabilitation • functional status • telehealth • virtual

Cardiac rehabilitation (CR) reduces hospitalizations and mortality and improves functional status and quality of life for patients with cardiovascular disease.[1-10] Despite its benefits, only 24% of eligible patients participate in CR.[11-13] Indeed, on a global level, CR is only offered in roughly 50% of countries.[14] Root causes of low participation include patient financial and logistic barriers, bias in referrals, and limited program capacity, among others.[15-19] Up to 14% of adults live in an area without a CR center, and even if all CR centers operated at 110% capacity, only 40% of eligible patients could be served.[20] Cardiac rehabilitation holds tremendous promise but is underutilized and, often, unavailable.

In an effort to make CR more accessible, the delivery of CR has evolved to include both traditional in-person sessions and newer virtual sessions.[21-27] Programs may offer virtual sessions only or a hybrid of in-person and virtual sessions.[28] Evidence continues to build that virtual and hybrid CR offer similar safety and efficacy compared with in-person CR.[9,29-36] The COVID-19 pandemic has accelerated the adoption of virtual and hybrid CR in response to limited or suspended in-person services.[37] Nonetheless, there have been few studies that compare outcomes among in-person, hybrid, and virtual CR in clinical practice, representing a real-world setting. At the University of California, San Francisco (UCSF), the COVID-19 public health emergency necessitated the creation of a CR program that gave patients the choice to limit in-person CR visits and receive much, or all, of their CR virtually. This presented a unique opportunity to compare clinical outcomes between in-person, hybrid, and virtual CR at a single academic center.

Our primary objective was to compare, in UCSF CR patients, the association of in-person, hybrid, and virtual CR with change in functional capacity between enrollment and completion, measured by distance completed on the 6-min walk test (6MWT). We hypothesized that change in the 6MWT would be similar between the in-person, hybrid, and virtual CR cohorts. In addition, we compared attainment of blood pressure (BP) control, change in waist-to-hip ratio, depressive symptoms, anxiety symptoms, and cardiac self-efficacy. We also described completion rates, adverse events, and patient and staff qualitative perceptions of CR.

METHODS

This cohort study included all patients who enrolled in CR at the UCSF between October 22, 2019, and May 10, 2021. All subjects were ≥18 yr men and women, and all races, ethnicities, and spoken languages were included. There were no specific inclusion or exclusion criteria related to education, literacy, or technology use. The study was reviewed and approved by the UCSF Institutional Review Board (IRB #20-30900 and #21-33754). Quantitative data were collected from electronic health records collected for patient care purposes, and written informed consent was waived for this minimal risk study. Qualitative data were collected from participants after verbal informed consent.

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Between October 22, 2019 (the date the UCSF CR program opened), and March 18, 2020, all UCSF CR patients participated in in-person CR, following CR guidelines.[38] Between March 18, 2020, and May 22, 2020, all in-person sessions were suspended due to the COVID-19 public health emergency, and virtual-only sessions were conducted. After May 22, 2020, patients could participate in either in-person or virtual sessions. Patients newly initiating CR after May 22, 2020, were able to select, based on patient preference and recommendations from CR staff, whether to participate in-person, virtually, or a hybrid of both. Patients were able to switch the types of sessions attended mid-program due to patient preference or medical recommendation.

Patients in all programs (in-person, hybrid, and virtual) received individualized exercise training and health behavior counseling from the same program exercise physiologists, nurses, cardiologists, dietician, pharmacists, and mental health providers (Figure 1). Virtual sessions were conducted with real-time video (Zoom) with one-on-one interaction between the patient and the provider. Virtual sessions lasted 31-60 min and were synchronous with ≥10 min of exercise training in addition to health behavior counseling. For patients unable to use Zoom, remote sessions were conducted via telephone and were asynchronous with exercise.

All patients starting after May 22, 2020, were invited to use a mobile phone application (app) called Better Hearts (Chanl Health), which allowed for logging exercise and vitals, reviewing patient-entered data, receiving medication reminders, viewing educational materials, and messaging with providers. There was no cost to the patient for using the mobile application. Patient data were uploaded to a cloud-based server, where providers could view the data through a provider-facing, web-based patient management dashboard. The app was introduced to patients by CR staff, who led patients through task-based training on use of the app, including entering vital signs, entering an exercise session, viewing an education module, messaging with providers, and setting up medication reminders (if desired). We did not conduct any formal assessment of digital literacy.

For this analysis, patients were categorized into in-person, hybrid, or virtual groups based on the number of in-person and virtual visits attended (Figure 2). In-person patients attended all exercise visits at the UCSF CR center, with no virtual exercise sessions (though patients could have virtual appointments with a nutritionist, pharmacist, or mental health provider). Hybrid patients had ≥3 in-person visits: two of these visits could have been for collection of clinical metrics and ≥1 visit was for supervised exercise. All patients in the virtual group had a maximum of two in-person visits to collect clinical metrics, with no additional in-person, supervised exercise visits. Patients who participated in CR and returned for final clinical metrics and care planning were considered completed. Patients who participated in CR, but did not have a final visit for clinical metrics collection and care planning, were considered not completed.

Clinical metrics were measured at CR enrollment and completion. The change in the 6MWT was used as the primary outcome. Patients completed the 6MWT using the same standard course at the UCSF CR center.[39]

Secondary outcomes included BP, waist-to-hip ratio, and questionnaires. Achievement of BP control was defined as BP <130 mm Hg systolic and 80 mmHg diastolic. Waist-to-hip ratios were measured in-person by CR staff upon program enrollment and completion using standardized methodology.[40] Patients completed validated questionnaires, including the Patient Health Questionnaire-9 (PHQ-9) (scored 0-27, with higher scores representing more severe depressive symptoms), General Anxiety Disorder-7 (GAD-7) (scored 0-21, with higher scores representing more severe anxiety symptoms), and cardiac self-efficacy (scored 0-52, with higher scores representing more self-efficacy).[41-43] We also collected program-related adverse events.

Baseline patient characteristics and medical history were obtained through electronic health record reports of coded data and systematic chart review of CR visit notes, patient problem lists, and other records available in the UCSF electronic health record. We did not collect data on disabilities or visual impairment. Ejection fraction from echocardiography was determined using Simpson's biplane method, and when ejection fraction was presented as a range, the lower number was used. The American Academy of Cardiovascular and Pulmonary Rehabilitation (AACVPR) risk level was classified on patient enrollment by UCSF CR staff using the AACVPR risk stratification algorithm.[44]

Measures of patient mobile application use were obtained from the Chanl Health provider dashboard and included enrollment in the application, patient logs of exercise and BP, patient views of educational materials, and patient chats with providers.

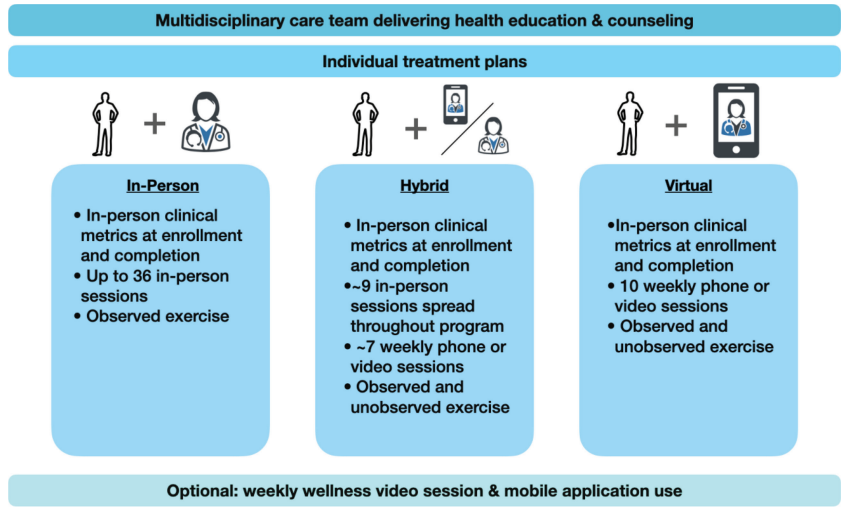

Figure 1. In-person, hybrid, and virtual cardiac rehabilitation. Number of sessions represents typical numbers of sessions expected in each model. This figure is available in color online (www.jcrpjournal.com).

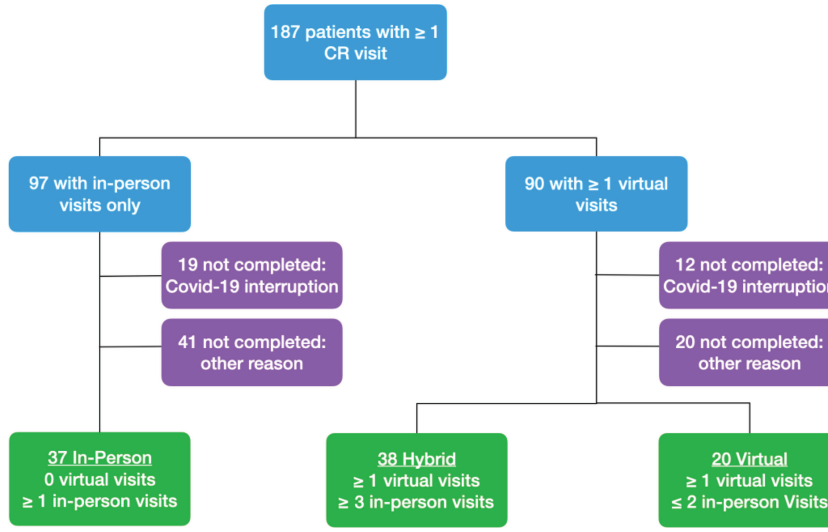

Figure 2. Enrollment and completion of cardiac rehabilitation (CR) among patients participating in in-person, hybrid, and virtual CR. This figure is available in color online (www.jcrpjournal.com).

A convenience sample of patients and staff participated in semi-structured interviews about their experiences with the hybrid and virtual CR programs and the technology tools used to facilitate the programs. A single trained study staff member interviewed participants following an interview guide (see Supplemental Digital Content 1, available at: http://links.lww.com/JCRP/A379). Interviews were audio-recorded and transcribed verbatim through an online transcription service (Rev.com). Interview transcripts were analyzed using a rapid qualitative template analysis[45] that included themes from the Theory of Planned Behavior[46] (eg, attitudes, beliefs, subjective norms, perceived behavioral control, and behavioral intention), Unified Theory of Acceptance and Use of Technology[47,48] (eg, performance expectancy, effort expectancy, facilitating conditions, social influence, habit, price value, hedonic motivation, and technology use intention), and Consolidated Framework for Implementation Research.[49] Templates were iteratively revised to incorporate emergent themes. Two experienced qualitative reviewers independently coded each interview and discussed discrepancies to achieve >95% concordance. Key themes and quotes were extracted and collated for analysis. Representative quotes from interviews were selected to demonstrate key themes.

STATISTICAL ANALYSIS

Sample size was not calculated *a priori*, since we included all eligible patients within the study period. We described baseline characteristics and clinical performance at enrollment and completion using descriptive statistics including mean ± SD. Difference in completion between in-person and hybrid or virtual groups was summarized using a χ^2 test. For patients with both enrollment and completion measures, we calculated change in measures as the difference between the measure at completion and the measure at enrollment. We constructed repeated-measures mixed-effects models including group (in-person, hybrid, or virtual), individual clinical performance measures (the 6MWT, systolic and diastolic BP, GAD-7, PHQ-9, waist-to-hip ratio, and cardiac self-efficacy), and an indicator for time (enrollment and completion to test for change over time) with a model term for group by time interaction to test for between-group differences in change in each clinical metric over time. Difference between groups for achievement of BP control was tested with a Fisher exact test.

A sensitivity analysis was conducted to address potential bias due to confounding from baseline characteristics by constructing models adjusting for age, sex, race/ethnicity, AACVPR risk, interpreter use, tobacco use, diabetes, hypertension, hyperlipidemia, stroke/transient ischemic attack dementia, peripheral arterial disease, lung disease, atrial fibrillation, cancer, and referral reason. An additional sensitivity analysis was performed for the analysis of the 6MWT by creating a propensity score for participation in hybrid or virtual CR. The propensity score was generated by constructing a logistic regression model for the participation in hybrid or virtual CR with variables of age, sex, race/ethnicity, AACVPR risk, interpreter use, tobacco use, diabetes, hypertension, hyperlipidemia, stroke/transient ischemic attack dementia, peripheral arterial disease, lung disease, atrial fibrillation, cancer, referral reason, and enrollment 6MWT. We excluded propensity score deciles that did not display overlap between treatment groups. We then estimated differences in change in the 6MWT between groups (in-person vs hybrid or virtual), with one-on-one matching based on propensity score. All statistical analyses were performed using Stata version 17.0 (Stata Corp).

RESULTS

During the study period, 187 patients enrolled in CR, 97 of whom participated in-person and 90 of whom participated in hybrid or virtual CR (Figure 2). Overall, 95 patients completed CR, with 37/97 (38%) in-person patients and 58/90 (64%) hybrid/virtual patients ($P = .001$ for comparison between groups).

Mean participant age was 63 ±13 yr, 46/187 (25%) of participants were female, 101/187 (54%) of patients were White or Caucasian, and 12/187 (6%) of patients required an interpreter (Table 1).

Clinically, 157/187 (84%) of patients had hypertension, 168/197 (90%) had hypercholesterolemia, and 109/187 (58%) of patients were designated as having low AACVPR risk. Patients with high AACVPR risk only participated in in-person or hybrid CR. The most common reasons for referral to CR across all groups were myocardial infarction and percutaneous coronary intervention, followed by coronary artery bypass surgery and heart failure.

Table 1

Baseline Patient Characteristics[a]

Characteristic	In-person n = 37	Hybrid n = 38	Virtual n = 20	Not Completed n = 92
Age, yr	66.6 ± 13.8	59.3 ± 11.6	59.8 ± 14.2	65.0 ± 13.0
Sex, female	7 (19)	6 (16)	2 (10)	31 (34)
Race/ethnicity				
Asian	7 (19)	14 (37)	3 (15)	26 (28)
Black or African American	0	1 (3)	0	4 (4)
Native Hawaiian or Pacific Islander	0	1 (3)	0	3 (3)
Hispanic or Latino	2 (5)	1 (3)	1 (5)	1 (1)
White or Caucasian	21 (57)	18 (47)	15 (75)	47 (51)
Multiple	3 (8)	1 (3)	0	3 (3)
Other	2 (5)	1 (3)	0	5 (5)
Missing	2 (5)	1 (3)	1 (5)	3 (3)
Body mass index, kg/m^2	29.2 ± 7.7	28.4 ± 6.3	26.0 ± 3.3	28.6 ± 6.9
Interpreter needed	2 (5)	2 (5)	2 (10)	6 (7)
Current tobacco use	1 (3)	1 (3)	0	7 (8)
Ejection fraction, %	57.4 ± 13.3	56.4 ± 11.5	56.5 ± 6.4	56.1 ± 13.9
AACVPR risk stratification				
High	12 (32)	6 (16)	0	33 (36)
Moderate	4 (11)	8 (21)	2 (10)	12 (13)
Low	21 (57)	24 (63)	18 (90)	46 (50)
Undetermined	0	0	0	1 (1)
Comorbidities				
Diabetes mellitus	12 (32)	10 (26)	1 (5)	36 (39)
Hemoglobin A_{1C}, %	5.9 ± 0.9	6.5 ± 1.0	5.6 ± 0.3	6.6 ± 1.3
Hypertension	29 (78)	32 (84)	17 (85)	79 (86)
Hyperlipidemia	34 (92)	36 (95)	16 (80)	82 (89)
Stroke or transient ischemic attack	3 (8)	4 (11)	0	12 (13)
Dementia or cognitive impairment	0	1 (3)	0	4 (4)
Peripheral vascular disease	5 (14)	4 (11)	1 (5)	19 (21)
Chronic lung disease	11 (30)	10 (26)	2 (10)	21 (23)
Atrial fibrillation	5 (14)	7 (18)	3 (15)	19 (21)
Cancer	9 (24)	2 (5)	3 (15)	15 (16)
Reason for referral[b]				
Myocardial infarction	11 (30)	17 (45)	10 (50)	25 (27)
Percutaneous coronary intervention	16 (43)	22 (58)	15 (75)	40 (44)
Coronary artery bypass surgery	7 (19)	10 (26)	0	15 (16)
Valve repair/replacement	5 (14)	5 (13)	3 (15)	13 (14)
Stable angina	2 (5)	1 (3)	1 (5)	6 (7)
Heart failure	8 (22)	5 (13)	3 (15)	15 (16)
Other	6 (16)	1 (3)	0	5 (5)
In-person sessions completed	29.5 ± 6.0	14.5 ± 8.8	1.3 ± 0.5	7.5 ± 8.6
Virtual sessions completed	0	9.1 ± 4.1	10.1 ± 2.6	2.4 ± 4.9

Abbreviation: AACVPR, American Association of Cardiovascular and Pulmonary Rehabilitation.

[a]Data are presented as mean ± SD or n (%).

[b]Patients could have more than one reason for referral.

OUTCOMES

Patients completing CR showed improvement in 6MWT, systolic and diastolic BP, PHQ-9, and GAD-7 scores (Table 2). When compared with in-person patients, hybrid and virtual patients experienced similar improvements in 6MWT, BP control, and GAD-7 scores. Virtual CR patients, compared with in-person, had lower initial PHQ-9 scores, and experienced slightly less improvement in PHQ-9 scores over time. None of the groups saw a statistically significant change in waist-to-hip ratio or cardiac self-efficacy scores. There were no program-related adverse events in any group.

In models adjusted for baseline factors including age, gender, race/ethnicity, AACVPR risk, interpreter use, tobacco use, diabetes, hypertension, hyperlipidemia, stroke/transient ischemic attack, dementia, peripheral arterial disease, lung disease, atrial fibrillation, cancer, and referral reason, findings were similar to unadjusted models. In a propensity score model, there was no statistically significant difference in change in the 6MWT between 17 in-person and 17 hybrid or virtual participants matched by propensity score.

USE OF MOBILE APPLICATION

Of the 105 participants who participated in the CR program after the mobile application became available, 68 (65%) enrolled in the mobile application (Table 3). Of those who enrolled in the mobile application, 55 (81%) logged >2 exercise sessions, 47 (69%) logged ≥12 exercise sessions, and 32 (47%) logged ≥36 exercise sessions. Logging of BP was also a commonly used feature.

QUALITATIVE EVALUATION

Qualitative interview patients ranged in age from 48 to 83 yr (mean 65 ± 13 yr). There were eight females (67%) and four males; eight self-identified as White (68%), two as Asian (17%), one as Black (8%), and one as multi-racial (8%). Staff were all 18-64 yr old and included both men and women of different races and ethnicities (more specific descriptions not reported due to identifiability).

Patients and staff highlighted the importance of individually tailored CR (see Supplemental Digital Content 2, available at: http://links.lww.com/JCRP/A380). Many patients praised the adaptability of virtual CR. Some patients preferred in-person sessions, while others preferred the convenience of virtual CR, and still others preferred a hybrid mix of in-person and virtual sessions. An important facilitator for in-person and virtual CR was a strong relationship between participants and staff, who served as a source of accountability. They helped patients "feel safe" and troubleshoot technology. Digital tools helped patients remain connected with providers and allowed providers to obtain information and monitor progress. However, patients and staff discussed technology adoption challenges including the mismatch between expected and observed performance, ease of use, compatibility with other systems, and the need for training.

Staff interviews revealed that facilitators to implementing virtual CR included a team culture that was conducive to change and supported by leadership. The transition to virtual CR, incorporating new delivery models and technology, required supporting staff with new workflows. In virtual CR models, providers helped patients use technology tools and form new habits. Virtual CR may pose new challenges (eg, privacy and patient access to technology). Costs may also vary with virtual CR related to both reimbursement and patient out-of-pocket costs.

DISCUSSION

This was the first comparison of real-world outcomes between three CR delivery models: in-person, hybrid, and virtual delivery of CR. We found that in-person, hybrid, and virtual CR were associated with similar clinical outcomes, including change in the 6MWT, and that patients and staff had generally positive perceptions of hybrid and virtual CR. These results add to the mounting evidence that hybrid and virtual CR programs are useful options for increasing CR capacity and flexibility to meet patient needs.

During the COVID-19 pandemic, implementation of hybrid and virtual CR models has expanded due to limited in-person services and public health emergency reimbursement of virtual services.[23,28] Van Iterson et al[50] published a retrospective account of their experience implementing hybrid/virtual CR at the Cleveland Clinic, including lessons learned and best practices for future iterations. Additionally, O'Doherty et al[37] conducted an international survey of practitioners at CR centers and found that a significant percentage of them were currently implementing, or planning to implement, hybrid or virtual CR options to serve patients during the pandemic.

There is a growing body of evidence suggesting that in-person, virtual, and remote delivery of CR have similar efficacy. A meta-analysis comparing center-based (in-person) to home-based (virtual or remote) CR found that the two delivery models had similar safety and efficacy.[22] In a recent real-world study of Veterans Affairs patients, virtual or remote CR was actually associated with greater improvements in short-term functional status than in-person CR.[51] Asynchronous and synchronous models of virtual delivery have also been shown to be similarly effective, at least in low- to moderate-risk patients.[52] This study extends the literature by comparing three CR delivery models: in-person, hybrid, and virtual. It has been projected that offering hybrid and virtual CR options could potentially lead to increased CR capacity and increased patient participation and adherence.[29]

Qualitative studies have shown that virtual CR is generally well-received by patients.[53] Other studies have reported the importance of individual tailoring and connections between staff and patients for promoting accountability.[54-57] Studies have also identified the potential barrier of limited peer engagement in remotely delivered CR.[55] Our study demonstrates that providing remote or virtual group wellness sessions may address this barrier. The incorporation of technology tools into CR programs can pose challenges, but emerging evidence and our results suggest that it may be possible to include technology tools that meet expected performance, are easy to use, are simple to train patients and staff on, and have use supported by staff.[58] Organizational factors also contribute to the implementation of new delivery models for CR. Previous work has reported that factors such as leadership support, funding, and institutional backing contribute to CR delivery.[27,59] This study adds information on organizational factors that contribute to technology adoption for CR programs, including equipment and workflow modifications for CR staff.

Several limitations must be noted. This study took place during the COVID-19 pandemic, which may not generalize to future periods because of changes in patient attitudes, care availability, or other factors specific to the pandemic. The pandemic also meant that some patients who may have completed a full CR program decided to drop out after the interruption of in-person visits, which could have influenced performance and completion seen in this study. Furthermore, our study includes data in a relatively small patient population at

Table 2

Clinical Metrics at Enrollment and Completion[a]

	In-person	Hybrid	Virtual	Not Completed	In-person vs Hybrid *P* Value[b]	In-person vs Virtual *P* Value[b]	Time *P* Value
6-min walk test, m					.46	.55	<.001
Enrollment	428.4 ± 108.5	454.0 ± 66.1	453.7 ± 95.9	391.1 ± 138.2			
Completion	486.4 ± 112.3	518.1 ± 81.9	516.4 ± 111.7	N/A			
Difference	51.5 ± 59.4	63.4 ± 55.6	63.2 ± 59.6	N/A			
Systolic BP, mm Hg					.73	.20	.007
Enrollment	128.2 ± 18.3	125.6 ± 17.9	118.3 ± 8.3	126.8 ± 16.9			
Completion	121.4 ± 12.4	119.4 ± 7.0	117.2 ± 8.2	N/A			
Difference	−7.9 ± 15.6	−5.3 ± 19.0	−1.9 ± 7.5	N/A			
Diastolic BP, mm Hg					.47	.63	.32
Enrollment	70.4 ± 8.8	76.4 ± 9.6	71.8 ± 10.0	70.2 ± 12.3			
Completion	68.8 ± 8.0	72.8 ± 9.2	71.8 ± 7.5	N/A			
Difference	−1.6 ± 8.1	−3.8 ± 10.7	−0.7 ± 9.1	N/A			
BP <130/80, mm Hg[c]							
Completion	20 (64.5)	17 (70.8)	13 (76.5)	N/A			
Waist-to-hip ratio					.25	.24	.84
Enrollment	0.99 ± 0.07	0.96 ± 0.09	0.94 ± 0.05	0.95 ± 0.09			
Completion	0.99 ± 0.08	0.94 ± 0.07	0.93 ± 0.05	N/A			
Difference	0 ± 0.04	−0.01 ± 0.05	−0.02 ± 0.02	N/A			
Patient Health Questionnaire-9[d]					.16	.03	<.001
Enrollment	7.1 ± 5.7	3.8 ± 3.7	3.2 ± 2.6	5.7 ± 5.5			
Completion	4.3 ± 6.1	1.7 ± 2.5	1.8 ± 2.2	N/A			
Difference	−3.3 ± 3.5	−2.1 ± 2.8	−1.0 ± 3.0	N/A			
General Anxiety Disorder-7[e]					.65	.71	.02
Enrollment	4.5 ± 4.7	3.0 ± 4.2	2.9 ± 3.5	3.7 ± 5.2			
Completion	2.9 ± 4.6	1.9 ± 3.2	1.7 ± 3.3	N/A			
Difference	−1.7 ± 4.2	−1.25 ± 2.9	−1.2 ± 5.3	N/A			
Cardiac self-efficacy[f]					.19	.13	.10
Enrollment	27.5 ± 8.6	33.6 ± 10.3	34.0 ± 6.9	32.9 ± 15.2			
Completion	32.2 ± 10.5	43.2 ± 7.2	45.1 ± 7.0	N/A			
Difference	4.3 ± 12.7	11.0 ± 11.0	12.1 ± 10.6	N/A			

Abbreviations: BP, blood pressure; N/A, not available.

[a]Data are presented as mean ± SD or n (%).

[b]Group by time interaction *P* value.

[c]*P* value for difference across all groups by the Fisher exact test, $P = .68$.

[d]Patient Health Questionnaire-9 is scored from 0 to 27, with higher scores representing more depressive symptoms.

[e]Generalized Anxiety Disorder-7 is scored from 0 to 21, with higher scores representing more anxiety symptoms.

[f]Cardiac self-efficacy is scored from 0 to 52, with higher scores representing more self-efficacy.

a single center, which also may limit generalizability. Because the study was a nonrandomized, observational study, there is potential for selection bias and confounding. For instance, patients who are better-resourced and more adept with digital tools may be more likely to choose a hybrid or virtual CR program, but since we did not collect formal data on digital literacy, we cannot make any conclusions about the role of digital health literacy on the patient population.[60] In addition, this study did not evaluate the role for virtual CR for high-risk patients, who did not participate in a solely virtual program. We did not collect data on insurance status; though this did not affect which programs were available to patients. It is possible that patient cost considerations could have influenced decisions about participation.

Table 3

Patient Mobile Application Use[a]

	Overall	In-Person	Hybrid	Virtual	Not Completed
Eligible for mobile application	105	19	29	18	39
Enrolled in mobile application[b]	68 (64.8)	6 (31.6)	28 (96.6)	17 (94.4)	17 (43.6)
Logged >2 exercise sessions	55 (80.9)	3 (50.0)	25 (89.3)	16 (94.1)	11 (64.7)
Logged ≥12 exercise sessions	47 (69.1)	2 (33.3)	23 (82.1)	13 (76.5)	9 (52.9)
Logged ≥36 exercise sessions	32 (47.1)	1 (16.7)	16 (57.1)	9 (52.9)	6 (35.3)
Logged >2 blood pressures	59 (86.8)	5 (83.3)	27 (96.4)	14 (82.4)	13 (76.5)
Logged ≥12 blood pressures	50 (73.5)	3 (50.0)	25 (89.3)	11 (64.7)	11 (64.7)
Logged ≥36 blood pressures	28 (41.2)	1 (16.7)	16 (57.1)	6 (35.3)	5 (29.4)
Viewed >2 education modules	40 (58.8)	1 (16.7)	21 (75.0)	10 (58.8)	8 (47.1)
Viewed ≥12 education modules	18 (26.5)	0	9 (32.1)	5 (29.4)	4 (23.5)
Sent >2 chats to staff	34 (50.0)	2 (33.3)	16 (57.1)	11 (64.7)	5 (29.4)

[a]Data are presented as n (%), with the denominator of the number of patients enrolled in mobile application.
[b]The denominator for % in this row is the number of patients eligible for mobile application.

Indeed, there is a critical need for future studies to ensure that such models can be used to effectively expand CR access for all populations, including women and minorities, patients who are blind, deaf, or disabled, those with high AACVPR risk, and those from low socioeconomic statuses, all of which are populations known to be less well served by current models of CR.[23] Finally, it is of paramount importance that patient needs and preferences continue to be evaluated and incorporated into evolving CR delivery models.

CONCLUSIONS

This study found that in-person, hybrid, and virtual CR were associated with similar improvements in functional capacity and that hybrid and virtual CR were perceived favorably by patients and staff. Though additional research is needed to address patient needs and preferences and improve access for underserved populations, these findings support the possibility that hybrid and virtual CR might expand CR capacity without compromising outcomes.

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