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AHA SCIENCE ADVISORY

Digital Technologies in Cardiac Rehabilitation: A Science Advisory From the American Heart Association

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ABSTRACT: Cardiac rehabilitation has strong evidence of benefit across many cardiovascular conditions but is underused. Even for those patients who participate in cardiac rehabilitation, there is the potential to better support them in improving behaviors known to promote optimal cardiovascular health and in sustaining those behaviors over time. Digital technology has the potential to address many of the challenges of traditional center-based cardiac rehabilitation and to augment care delivery. This American Heart Association science advisory was assembled to guide the development and implementation of digital cardiac rehabilitation interventions that can be translated effectively into clinical care, improve health outcomes, and promote health equity. This advisory thus describes the individual digital components that can be delivered in isolation or as part of a larger cardiac rehabilitation telehealth program and highlights challenges and future directions for digital technology generally and when used in cardiac rehabilitation specifically. It is also intended to provide guidance to researchers reporting digital interventions and clinicians implementing these interventions in practice and to advance a framework for equity-centered digital health in cardiac rehabilitation.

Key Words: AHA Scientific Statements ■ cardiac rehabilitation ■ cardiovascular diseases ■ digital technology ■ health promotion ■ telemedicine

Cardiac rehabilitation (CR) is a medically supervised exercise and structured secondary prevention program for patients with cardiovascular disease and has been designated a Class 1 recommendation by American Heart Association and American College of Cardiology guidelines[1–7] given strong evidence of benefit for secondary disease prevention across many cardiovascular conditions. Despite its proven benefits, CR is underused, particularly by important subgroups of the population.[8–11] Furthermore, even for those patients who participate in CR, there is the potential to better support them in improving behaviors known to promote optimal cardiovascular health and in sustaining those behaviors over time.

Digital technology is now used broadly,[12,13] and its potential to address many of the challenges of traditional center-based CR (CBCR) and to augment care is increasingly promising. This American Heart Association science advisory was assembled to help guide the development and implementation of digital CR interventions that can be translated effectively into clinical care, improve health outcomes, and promote health equity. This document, we hope, shall serve as a guidepost for collaborating industry partners when developing multifaceted CR interventions to ensure that developing technologies align with the current evidence and are rigorously studied with an emphasis on the clinical outcomes discussed herein. Issues such as data security and privacy and regulatory approval, however, are beyond the scope of this advisory. Because the terminology surrounding digital technology has not been standardized, we use the term herein to refer to care delivered through the internet, wearable devices, and mobile applications (apps), as well as emerging

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computational methods (eg, artificial intelligence, big data; Table 1).[16–18] This notably excludes telephonic-only studies consistent with a recent review on this topic and that were addressed in a scientific statement on home-based CR.[14,21] This advisory focuses on the individual digital components that can be delivered in isolation or as part of a larger telehealth package and reviews the landscape of digital technology in CR (Table 1 and Figure 1). It also highlights challenges and future directions both for digital technology generally and in CR specifically and provides a framework for equity-centered digital health in CR.

LANDSCAPE OF DIGITAL TECHNOLOGY IN CR: CLINICAL GAPS AND FUTURE DIRECTIONS

Digital technologies in CR aim to increase CR access by augmenting, but not replacing, traditional CBCR.[15,22] Table 2 describes the core components of CR and lists digital technologies that may help address these core components, along with their specific monitoring capabilities and future directions. To aid in the delivery of CR, digital technologies are being used in various ways: (1) as an adjunct to synchronous/in-person CR, (2) for synchronous/real-time audio-visual CR (ie, virtual CR), or (3) for asynchronous CR (ie, remote CR; Figure 1). Generally, the field has moved toward a patient-tailored hybrid model of delivery that offers patients a combination of synchronous/in-person CR and synchronous/real-time CR.

In a systematic review published in 2021, the most commonly studied digital technologies for CR were smartphones or mobile devices (65% of studies), followed by web-based portals (58% of studies), and email or short messaging service (eg, text messaging; 35% of studies).[21] Although data on using smartphone apps to improve functional capacity have been mixed with respect to their impact on functional capacity, a recent systematic review suggested that mobile apps associated with improvements in patient outcomes incorporated automatic recording and data syncing during exercise, real-time feedback, and correctional goal setting.[24] Reported digital CR technologies generally reflect an early stage of development such as precommercial software tested in short-term pilot or proof-of-concept studies of <100 patients. Fewer than a third of studies that focused on digital CR interventions used accelerometers, telemetry, heart rate monitors, or blood pressure monitors. Digital CR interventions have focused primarily on physical activity or exercise training and have typically lacked other core components of CR such as lipid or diabetes management, nutrition, and smoking cessation.[23] When these other core components have been addressed, digital CR interventions have tended to embed educational platforms, but there is potential to incorporate more biometric data and both behavioral and psychosocial support. Studies have focused primarily on patients with coronary artery disease who are deemed to be at low or moderate

Table 1. Key Terms and Definitions

Term	Definition
CR types	
CR	A systematic, medically supervised, multifaceted program that helps patients recuperate from a cardiac event, adhere to recommended lifestyle behaviors, address comorbid conditions, monitor for safety events, and adhere to evidence-based practice.[7]
CBCR	CR delivered through face-to-face interaction with supervised exercise training sessions at a CR center.
Home-based CR	Core components of CR delivered to patients in their home environments as addressed in a scientific statement on home-based CR.[14] This refers specifically to the core components of CR delivered in patients' natural environment rather than CR staff encouraging patients to exercise independently on days when they are not present at CBCR.
Hybrid CR	A combination of in-person CR and either asynchronous or synchronous/real-time audiovisual CR. This is delivered most frequently as in-person CR and synchronous/real-time audiovisual CR.
Asynchronous CR (ie, remote CR)	Exercise occurs at times other than when patients and clinicians are communicating. Patient data are stored for future review and response by clinicians.[15] Not currently reimbursable through CMS.
Synchronous/in-person CR	Patients and clinicians are in the same location at the same time with patients directly observed exercising. Although this includes CBCR, it may include synchronous exercise at other locations.[15]
Synchronous/real-time audiovisual CR (ie, virtual CR)	Patients and clinicians are in different locations using real-time, 2-way audiovisual communication to deliver CR services. Clinicians observe patients directly exercising for all or a portion of the visit.[15] Currently reimbursed through CMS after the public health emergency.
Delivery modalities	
Digital technologies	Care delivered through the internet, wearable devices, and mobile apps, as well as emerging computational methods (eg, artificial intelligence, big data).[16–18] This excludes telephonic-only studies.
Telemedicine	Use of a technology-based platform to deliver clinical services remotely to a patient at a distant site.[18–20]
Telehealth	Telemedicine clinical services but also nonclinical services such as training and patient education. Telehealth includes video visits, phone calls, online communication, and storing patient data and may be delivered synchronously or asynchronously.[18–20]

Apps indicates applications; CBCR, center-based cardiac rehabilitation; CMS, Centers for Medicare & Medicaid Services; and CR, cardiac rehabilitation.

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Figure 1. Digital technology and modes of CR delivery.
Diverse populations can use digital technology to support delivery of cardiac rehabilitation (CR) using various models and sites of care. Individuals can participate in CR using 1 or multiple delivery formats. In virtual CR, patients and clinicians are in different locations and use audiovisual communication to support monitored exercise in real time. In synchronous/in-person CR, patients and clinicians are in the same location (eg, hospital, community center), but CR delivery may be augmented through the use of digital technology. In remote CR, patients exercise independently and can use digital technology to monitor exercise and then transmit those data to clinicians for review.

risk by American Association of Cardiovascular and Pulmonary Rehabilitation criteria,[25] excluding some higher-risk patient groups. Academic medical centers in Europe and North America have served as the typical setting for the evaluation of digital CR interventions.

The current evidence supporting the use of digital technology in CR points to major gaps that need to be addressed before it can be widely embraced as a safe and effective tool that can be implemented in routine practice. Digital CR studies are needed in community-based practice settings with extended follow-up and standardization of comparator groups (eg, usual care). Future studies should prioritize greater patient diversity, including representation of older individuals, women, and underrepresented racial and ethnic groups, as previously emphasized in the American Heart Association statement on home-based CR.[14] To reach many of these populations, however, especially those living in rural areas, issues of connectivity need be addressed, including access to the data plans and internet needed to power the devices.[26] In addition, future digital CR evaluations should consider frailty and multimorbidity (above and beyond just aging) because these may affect patients' abilities to use digital technologies and should consider inclusion of additional clinical populations (eg, patients with heart failure, adult congenital heart disease, oncological disease, high-risk conditions generally). There is also a need for digital interventions to provide more complete solutions to comorbidity management. For example, digital interventions supporting diabetes management have been heterogeneous and have generally shown at least modest benefit.[27]

Future digital CR solutions should aspire to deliver the core components of CR more comprehensively[23] and possibly to refine them. The emergence of smart wearable devices in cardiovascular care[28] presents an opportunity for robust monitoring of digital biomarkers (ie, chronotropic competence) or desirable or tangible goals (ie, objective increases in physical activity), integrating these devices into digital CR solutions to assist

Table 2. CR: The State of Available Technologies and Future Directions

Core components: current state of CBCR[23]			
Patient assessment		Review current/prior cardiovascular history, complete physical examination; oversee necessary procedures or interventions, including optimization of guideline-directed medical therapy and assessment of health-related quality of life; manage outpatient follow-up and longitudinal care	
Nutritional counseling		Assess current total caloric intake and dietary content; assess adherence to appropriate dietary recommendation based on medical history; prescribe and oversee dietary modifications; educate and counsel patient on dietary goals	
Risk factor management		Control cardiac disease or equivalents and comorbidities; manage weight; control blood pressure; manage lipids and diabetes; cease tobacco use; monitor sleep patterns	
Psychosocial management		Identify psychosocial factors, including depression, anxiety, isolation, marital or family distress, and substance abuse; develop patient-specific plans for emotional well-being	
Physical activity counseling		Assess physical activity level; provide advice, support, and counseling about physical activity needs	
Exercise training		Symptom-limited exercise training before participation in CR; implement a patient-specific program based on patient assessment, risk factors, and comorbidities with modifications as needed based on change(s) in clinical status	
Technologies available for digital/remote monitoring			
Smartphones	Interactive web-based portal	Telehealth	Point-of-care testing
Mobile devices	Email/SMS	Biosensing wearables	Implanted devices
Current monitoring capabilities			
Heart rate/rhythm*	Respiration and oxygen percent	Oxygen uptake ($\dot{V}O_2$)	Sleep patterns
Blood pressure	Accelerometry, pedometer	Thoracic impedance	Glucose monitoring
Weight	Distance	Exercise minutes	Geolocation
Example future directions: integrating data streams from digital technology with clinical data			
Biometrics		Integration of digital biomarkers for identification of risk factors through use of artificial intelligence Monitoring physical activity and cardiovascular response to exercise in patients' preferred locations outside of the hospital	
Medical adherence		Smart pillboxes monitoring patient adherence Digital pills incorporating drug-device combinations with signal transmission on drug absorption in gastrointestinal tract, monitoring adherence and response to guideline-directed medical therapy	
Risk factor modification		Monitor cardiovascular comorbidities, sleep patterns, and psychosocial behavior; quantify physical activity, mobility, frailty, and fall risk in natural environment, as well as symptoms, stressors, patient perceptions, diet, and physical activity	
Secondary prevention		Fusion of patient-centered data parameters with EHR to identify and mitigate risk factors for recurrent and future disease	
Virtual platform		CR program fully delivered to patients' preferred locations with optional caregiver integration and social support networks, either in conjunction with or as an alternative to CBCR, and with the option for extended remote delivery Artificial intelligence to generate individualized training plans	

CBCR indicates center-based cardiac rehabilitation; CR, cardiac rehabilitation; and EHR, electronic health record.
*Measured by ECG or Photoplethysmography (PPG).

in tailoring CR exercise prescriptions, supporting patient engagement beyond the traditional time frame for CR delivery, and overall providing a more complete solution for CR delivery while retaining its core focus. CR has traditionally focused on telemetry, hemodynamics, and biometrics, but digital technologies provide the potential for focus on additional factors such as sleep, mental health, socialization, and quality of life with the use of technology to expand care delivery while still retaining the central tenants of CR. Although increased monitoring is now possible given technological advancements, the value of enhanced telemetry or monitoring by ECG and other biometrics is an area warranting further study.

Addressing the above evidence gaps and introducing innovative solutions will help digital CR technology realize its potential and mature into scalable programs that can support delivery of high-quality CR globally,[29] with flexible models that integrate into local resources and cultures. Digital technology has the potential to enhance human interaction, including patient-to-patient, patient-to-clinician, and clinician-to-clinician interactions. The multiple cardiovascular team members involved in the care of the patient undergoing CR, including physicians, nurses, exercise physiologists, pharmacists, and nutritionists, may become more integrated, coordinated, and effective, which could improve patient outcomes. It is important not only to support evidence generation to justify clinical adoption of digital CR tools but also to prioritize clinical workflow integration.

DEVELOPMENT, EVALUATION, AND INTEGRATION OF DIGITAL TECHNOLOGY

Although several clinical gaps exist with respect to the use of digital technology in CR, further methodological gaps along the continuum from development to implementation also need to be addressed to ensure the effective use of digital technology as part of CR programs (Table 3).

Development

When research teams and clinical programs consider using digital technology to deliver CR services, the focus is often on evaluating a specific technology such as a particular wearable device or mobile app, often in small studies of short duration. A focus on the specific technology, however, has created a wave of "one and done" studies as changes to the technology limit the subsequent utility of the findings.[30] Digital technology in CR is used fundamentally to promote behavior change with the goal of improving cardiovascular health, with strategies for behavior change in general and with respect to digital technology specifically discussed in recent reviews and American Heart Association documents on this topic.[31–33] Thus, we favor a more pragmatic approach to developing and evaluating digital interventions for CR that can be generalized broadly, including to existing videoconferencing platforms. Such an approach should focus on general behavioral principles and workflows and their applications and include broader end-user involvement such as behavioral psychologists and health information technology services among more traditional end users. This also offers an opportunity to use digital health technology to implement shared decision-making more broadly and to empower patients. As patients become more familiar with digital technology, they can become integral to designing clinical workflows, including self-monitoring and managing key cardiovascular risk factors such as blood pressure and glucose.

A major challenge concerns the integration of existing knowledge of health behavior and behavior change into a model that can inform the delivery of digital interventions such as those used to support home- and hybrid-based CR programs.[34,35] Existing frameworks for care delivery conceptualize health behavior statically, though the dynamics of behavior change are much more fluid.[36] Traditional CR practice patterns need to be modified to accommodate the appropriate implementation of digital technologies, focusing specifically on the dose, mechanism(s), and frequency of both the digital and in-person components.[37] Questions to consider include the following: What is the appropriate "digital dose"

Table 3. Essential Elements to Integrate Digital Technology Into CR

Principle	Vision
Development	
Delineation of specific aspects of CR in which digital interventions facilitate and enhance care	Delineate clinical facets of CR that can be achieved with or enhanced by digital interventions Focus on the aspects of CR care that are facilitated by the mobile app rather than on a wearable device or mobile app as a stand-alone product. Examples: daily activity, mood, medication adherence, diet
Broader end-user involvement	Include novel users in the development of digital CR Examples: primary care clinicians, behavioral psychologists, bioengineers, information technology services
Broader integration of aggregate disease complexity into digital health strategies	Integrate domains pertaining to broader complexity Examples: comorbidity (inclusive of cognition and sensory deficits [eg, hearing, vision, proprioception]), connectivity, access to home and community resources, socioeconomics
Refinement of behavioral health models	Develop more granular models of behavior change that account for complex individual, social, and environmental dynamics Consider adaptation of those models to digital health interventions
Evaluation	
Expanded clinical end points	Evaluate clinical end points important to patients that can be assessed over a shorter time period in addition to traditional safety end points. Examples: technology use (eg, use of device features, mobile apps), health behaviors (eg, physical activity by accelerometry or step count), performance measures (eg, exercise capacity, blood pressure), patient-reported outcomes (eg, self-efficacy, quality of life), CR participation (eg, in-person, virtual, remote sessions)
Inclusion of behavior change principles	Emphasize behavior change principles in practice rather than evaluating a specific technology to improve generalizability of study findings Examples: self-efficacy, mastery, goal setting
Alternative experimental designs	Use alternative methods rather than randomized controlled trials. Advantages can include need for smaller sample sizes, ability to interrogate time-varying psychosocial and contextual factors, ease of data collection. Examples: microrandomized trials, sequential multiple assignment randomized trials (SMARTs), pragmatic trials, real-world evidence
Interpretation	
Automated interpretation	Develop systems capable of automated interpretation of clinical and digital data from interoperable systems, at times using artificial intelligence, both to assist clinicians and to fully automate low-value tasks. Such an approach can be used to facilitate clinician risk stratification/prognosis and treatment refinements. Example: automated monitoring of blood pressure, ectopy, daily activity, exercise, and other biometrics integrated with clinical surveillance, automated guidance, and coordination with a clinician

(*Continued*)

Table 3. Continued

Principle	Vision
Expanded data sets	Target registries of digital device data and clinical outcomes from diverse cardiovascular disease populations Example: Digital Medicine Society
Implementation	
Clinician integration	Integrate a broad spectrum of clinicians (eg, MDs, PAs, NPs, PTs, nutritionists) to ensure alignment between patients and digital solutions Retain clinicians' central role in patient risk stratification when selecting modes of CR and recommending digital technology use
Interoperability	Integrate digital device data with clinical data within the EHR to promote delivery of streamlined, efficient care and to facilitate accurate recording of clinician time for both tracking and billing purposes Example: integration of wearable device data and initial treatment plan within the EHR
Clearly designed workflows and delegation of tasks	Delineate the frequency with which patients' digital data will be reviewed and by whom to minimize risk of clinician burnout, misaligned patient-clinician expectations, and issues of liability Educate patients on how frequently their data will be reviewed to set expectations and to promote sustained engagement Example: ability to review irregular heart rate alarms and frequency of follow-up
Process	
Structured surveillance of digital data	Develop digital dashboards that enable efficient clinical surveillance and promote effective clinical reinforcement (within busy workflows) and patient safety
Applying point-of-care evaluation to achieve automated tailored care	Leverage capacity for immediate interpretation of clinical data to achieve real-time refinements to therapeutic approaches such that each patient's care becomes progressively more personalized Example: automated tailoring of exercise regimens

App indicates application; CBCR, center-based cardiac rehabilitation; CR, cardiac rehabilitation; EHR, electronic health record; MD, medical doctors; NP, nurse practitioner; PA, physician assistant; PT, physical therapist; and SMARTs, sequential multiple assignment randomized trials.

*Measured by ECG or photoplethysmography.

when in-person CR interactions are replaced with a digital intervention, and how should the frequency of digital intervention delivery change over time to prevention habituation? Data on human-computer interaction and from mobile devices on time-varying contextual and psychosocial factors can be leveraged to develop and refine existing models,[34] which can then be applied to future digital behavior change interventions.

Evaluation

The development of new digital tools and uptake within the community continues to outpace our ability to rigorously evaluate the technologies and the clinical value they provide. Traditional randomized controlled trials are poorly suited to evaluate technology in a viable time frame, and the end points in trials may be less meaningful to patients and clinicians because singular, static measures from randomized controlled trials do not sufficiently characterize the granularity and precision derived from digital platforms. These limitations can be addressed in several ways. First, we encourage the appropriate use of alternative experimental designs. Microrandomized trials and sequential multiple assignment randomized trials (SMARTs), for example, can be used to develop adaptive interventions in which the type or dosage of the intervention is personalized and then modified over time on the basis of changing environment or participant response to treatment.[37,38] Advantages of these designs can include the need for smaller sample sizes and the ability to interrogate multicomponent interventions and time-varying moderators of intervention effects. In addition, observational data, real-world evidence, and pragmatic trials enable the assembly of large data sets with relatively minimal burden. Second, there should be greater focus on testing theoretical behavioral concepts, as mentioned previously, enhancing the generalizability of study results.[30,32] For example, interim assessments of data on emerging devices may allow midstudy improvements in technology so long as those changes do not affect the behavioral intervention itself. Third, end points should be expanded and include intermediate end points (eg, 6-minute walk distance, dyspnea scores), which may become available more quickly than traditional clinical end points (eg, death) and may be more meaningful to patients. Examples include validated patient-reported outcomes, physical activity, and medication adherence. Other less traditional outcomes should also be measured to ensure the fidelity of digital CR interventions when deployed in practice such as measuring the time needed to deliver digital CR interventions in real-world settings and staff satisfaction with digital delivery formats. It is important to note that these end points should not be viewed as replacements for rigorous assessments of safety.

Interpretation

Despite an abundance of studies evaluating digital CR services, most have been relatively small and have enrolled specific patient populations,[21] which have limited our ability to interpret wearable device data and their changes over time. For example, what change in step count is clinically significant, and how does that differ when collected by a wearable device compared with a smartphone? There remains a need for normative digital data from diverse patient populations, including through expanded registries of digital biomarkers and clinical outcomes. The interpretation of digital data has the potential to be advanced further through automated interpretation, including through the application of artificial intelligence systems acting on interoperable data streams. For example, physiological data from a wearable device integrated with comorbidity data from the electronic health record could be used to improve prognostication or to develop custom exercise prescriptions delivered through remote or CBCR.[39,40]

Implementation

As digital technology matures and is implemented increasingly in clinical practice, there is a need to explicitly define the role that clinicians play within digital ecosystems and to appropriately recognize clinician time when delivering digital CR solutions. Although there is concern about implementing digital solutions that may be viewed as impersonal and diminish the patient-clinician relationship, digital technology has the potential to augment that relationship, to increase the reach of CR services, and to uniquely involve patients, caregivers, and cardiovascular team members with diverse areas of expertise such as nutritionists, social workers, and psychologists. Clinicians will ideally be involved in both patient assessment and technology selection, using shared decision-making to select patient-specific digital solutions that account for individual-level factors such as risk, multimorbidity, and age. Further development of remote risk stratification tools will also be important for clinicians to appropriately stratify patients and to provide tailored treatments for populations unable to attend CBCR. Such an approach, however, may require increased clinician time, which necessitates recognition by health systems and payors. Digital technology should also be integrated into interoperable systems with clearly delineated clinical workflows.[41] We must address questions such as the following: How frequently will wearable device data be reviewed, and who bears the responsibility of responding to alarms from digital devices? Clear delineation of tasks and communication with patients about workflows for digital data review is essential (1) to ensure that technology demonstrates and retains its perceived value to patients and clinicians, (2) to prevent data overload to minimize the risk of clinician fatigue and burnout, and (3) to avoid unnecessary liability.

Additional challenges with regard to implementing digital technology in CR relate to onboarding and providing technology support to patients and clinicians.[42] Ensuring patient access to education and training on digital technology use will be necessary to avoid worsening health disparities (see subsequent section), to prevent exploitation of patients with low digital literacy, and to minimize patient and clinician anxiety and unnecessary downstream testing from alarms of unproven clinical value. Last, to ensure the fidelity of digital interventions implemented across sites of care, we favor standardized reporting of digital intervention studies. We propose a general framework in Table 4 that is intended to assist clinicians seeking to implement digital interventions in practice.

EQUITY IN DIGITAL CR

The use of digital technologies in CR has the potential to improve health equity. However, rapidly advancing technology may also exacerbate the exclusion of sociodemographic subgroups or individuals with disabilities,[43] introduce digital biases, and paradoxically widen the digital divide.[44,45] Although the number of studies on the implementation of digital technologies in CR has increased during the coronavirus disease 2019 (COVID-19) pandemic, these studies have frequently excluded historically underrepresented groups.[46] Thus, there is a need to increase participation of women, individuals of underrepresented races and ethnicities, those with lower socioeconomic or educational attainment, and individuals with disabilities. Issues related to connectivity, affordability, and accessibility may also disenfranchise unique populations such as older adults, frail patients, patients living in rural areas, and individuals with visual, auditory, and fine motor impairment. In response, the Association of American Medical Colleges published competencies for telemedicine, including considerations for equity and communication (Supplemental Figure).[47] When considering the use of digital technology in CR, we must ensure that clinicians are able to uphold these standards in practice. To reach those standards, clinicians must provide telehealth delivery that addresses, prevents, or mitigates biases related to culture, socioeconomic status, and physical and mental aptitude. Clinicians' perspectives on telehealth must also be considered as they may affect implementation of digital health solutions. The European policies are an exemplar for how digital technologies can be deployed in a manner inclusive of and accessible to individuals with disabilities.[48]

Delivering high-quality and equitable care does not mean treating every patient in the same manner but rather considering different patients' circumstances, needs, and preferences, including social determinants of health. It means meeting patients where they are and delivering a tailored solution that provides each patient with the opportunity to achieve optimal cardiovascular health. For example, selecting wearables with large display screens or ensuring large font in mobile apps would be an important consideration for older adults who may have poor eyesight or dexterity. A recent report provides an example of a stepwise approach to building a hybrid CR program using technology that promotes equitable access for patients with differing levels of digital literacy.[42] When properly designed, leveraging the lived experiences of an advisory panel of patients and caregivers, digital interventions can incorporate patient and caregiver voice and ensure that their perspectives are included in future CR programs using digital technologies.[49]

The opportunity to use digital technologies in CR to address health equity challenges is immense. The development, validation, and implementation of digital technologies

Table 4. Checklist of Important Considerations When Implementing a Digital Health Tool in CR

☐ What gap is the tool intended to address?
☐ What is the target population for this tool? Is it intended for all CR participants or specific subgroups?
☐ What is the level of evidence supporting the validity and efficacy of the tool?
☐ Has the tool been validated in real-world settings or only in experimental settings?
☐ Has the tool been validated in different populations, at least one similar to your patient population?
☐ Has the tool been tested in your clinical setting to assess the level of complexity or digital literacy needed from both patients and clinicians?
☐ Are the instructions, troubleshooting recommendations, and user guides easy to find, read, and interpret?
☐ What is the anticipated effect of the tool on your workflow and efficiencies? Will this affect staff administrative burden?
☐ Will the technical support provided by the vendor satisfy your needs and those of your institution? Is it clear what issues will be addressed by the vendor and by your institution's technical support staff?
☐ How will the efficacy and effectiveness of the tool in your CR setting be evaluated?
☐ What are the unintended negative consequences of implementing the tool in your CR setting?
☐ Have the tools used to assess factors such as depression, anxiety, medication adherence, health literacy, and other psychometric tests been standardized and validated?
☐ How and how often do you plan to implement improvements to the tool or introduce new versions?
☐ Will physical activity be reported using customary units (minutes of moderate and vigorous activity, walking distance, etc), or will the tool use a noncustomary measure?
☐ Will tracking of nutrition and eating habits be aligned with the Dietary Guidelines for Americans, American Heart Association, or other guidelines?
☐ Will the tool be integrated into the EHR, or will this be a stand-alone program?
☐ Will the tool help you fulfill your reporting needs and obligations to payers, regulatory agencies, or national registries?
☐ How will patients be trained to use the tool?
☐ How do you plan to assess or monitor usability and acceptance of the tool in your patient population?
☐ For tools tracking physical activity, heart rate, rhythm, and other physiological parameters, how will that information be collected (ie, synced with the device or through patient self-report), and who will be responsible for reviewing those data? Will that information be incorporated in the EHR and how?
☐ Who will be responsible for reviewing and addressing abnormalities in physiological parameters identified by the tool? What would be the action plan for significant abnormalities?
☐ Will the tool increase capacity or allow your CR setting to reach patients who would otherwise be excluded from CR?
☐ Will the tool reduce or increase operational costs? What is the anticipated net effect of the tool on the finances of your institution?
☐ Will the tool reduce or create inequities on the basis of socioeconomic class, race, ethnicity, language, religion, disability, age, or other patient-related factors? How do you plan to monitor this?
☐ For device-based tools, will you provide devices (loaned, rented, or given) to patients unable to afford them?
☐ How do you plan to measure the overall impact of the tool in your practice?

CR indicates cardiac rehabilitation; and EHR, electronic health record.

in CR should be planned with equity in mind and focus on 2 specific goals: (1) to avoid perpetuating or worsening current health disparities and (2) to identify opportunities to overcome barriers that have limited access to or the efficacy of CR in underrepresented populations (Figure 2). To reduce inequities in the delivery of CR, such a goal needs to be a primary objective in the development and implementation of digital interventions, rather than expecting this to naturally result from digital health implementation.

REIMBURSEMENT AND VALUE PROPOSITION FOR DIGITAL CR ACTIVITIES

Reimbursement for CR is key to achieving a sustainable business model. Reimbursement has focused on CBCR programs with continuous electrocardiographic monitoring of exercise sessions under direct clinician supervision, with supervision requirements recently expanded to include physician assistants and nurse practitioners. CBCR must have a medical director and provide clinician-prescribed exercise, cardiac risk factor modification, psychosocial and outcomes assessments, and individualized treatment plans.[50] In response to the COVID-19 pandemic, the Centers for Medicare & Medicaid Services expanded coverage for telehealth to include CR, although it is unknown whether this will continue after the public health emergency (Table 5). CR programs may consider using telehealth visits for consultative services and remote patient monitoring as part of a comprehensive, remotely administered CR program. Although CR is a multidisciplinary program, reimbursement for CBCR continues to rely on supervised exercise sessions. Some programs have adopted more comprehensive solutions that address nutrition, mental health, and guideline-directed medical therapy for the management of blood pressure, lipids, heart failure, and atrial fibrillation such as intensive CR and digital therapeutics. Although many of these services do not rely on digital health, payers should consider reimbursing for these services as part of a more comprehensive and inclusive digital health solution.

Although reimbursement remains a key factor in the long-term financial viability of CR, a digital solution has the potential to add value to the health system by delivering care aligned with the quadruple aim framework, or one that improves population health, enhances the patient experience, reduces costs, and improves work-life balance for clinicians.[53] First, at the population-level, home-based or hybrid CR programs may reach groups of patients previously underrepresented in CBCR with the potential to improve population health by reducing cardiovascular morbidity and death due to cardiovascular causes, reducing hospitalizations, and improving quality of life for patients who previously did not accrue the

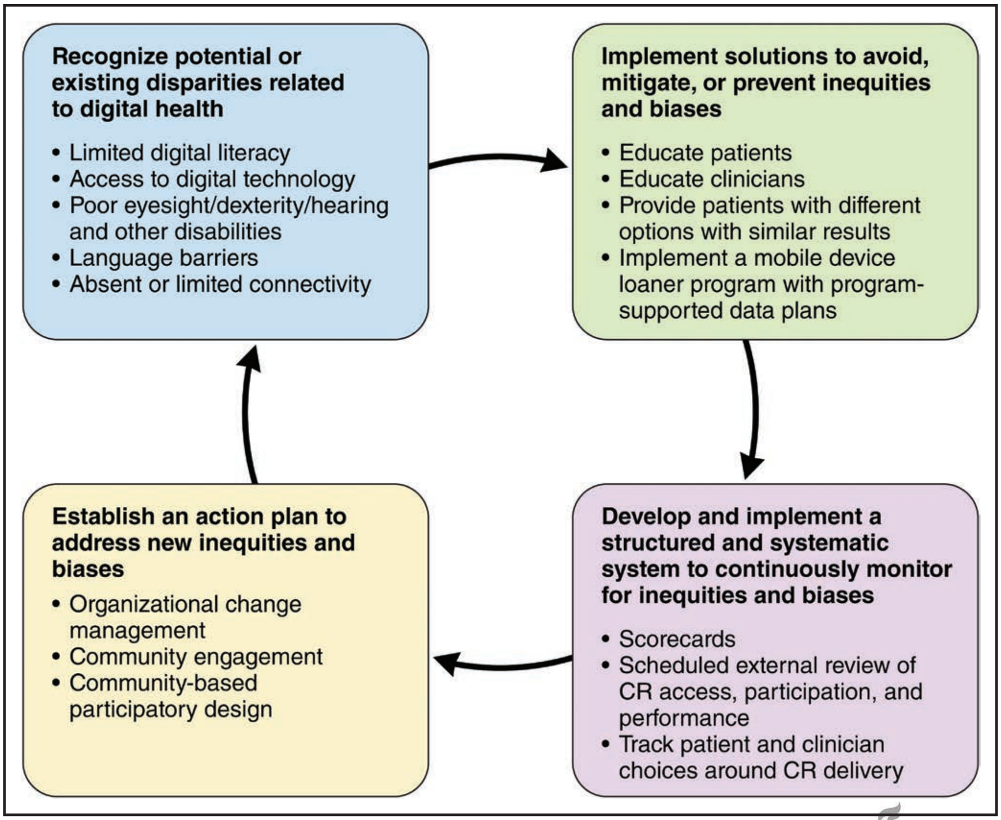

Figure 2. Implementation of equity-centered digital health in CR.
CR indicates cardiac rehabilitation.

benefits of CR. Second, both home-based and hybrid CR programs have the potential to increase the use of CR services more generally and to keep patients connected to one another and within the health system, addressing issues of population health and improving the patient experience while simultaneously resulting in additional revenue to health systems.[51,54] Third, a home-based or hybrid CR solution can change the cost structure of CR by reducing scarce capital, including space, human resources requirements, and the need for monitoring

Table 5. Value Proposition in Digital CR

Principle	Vision	References
Reimbursement	Billing for virtual CR using CPT 93798 and CPT 93797 with modifiers for virtual delivery	50
	Billing for remote patient monitoring and remote physiological monitoring (CPT 99553-99454)	
	Using telemedicine to bill for consultative and behavioral health (CPT 99441-99443)	
	Alternative models, including intensive CR and digital therapeutics	
Cost containment	Reduced hospital readmissions and health care costs	
	More effective use of limited hospital resources	21,22
	Expanded delivery of comprehensive CR services (ie, nutrition and stress management) designed to build knowledge, health literacy, and self-care skills	
Access and loyalty	Increase access to CR in previously underrepresented subgroups such as those living in rural areas, women, people of underrepresented races and ethnicities, and older patients	51
	Reduce many of the barriers to CBCR, including access to a local program, transportation, and need for more flexible hours for patients and staff	
	Increase CR capacity and reduce wait times for CBCR	
	Improve quality of life and patient satisfaction, resulting in increased loyalty to the health care system	
	Enable more flexible scheduling for clinicians, potentially addressing issues of retention and improving work-life balance	52

CBCR indicates center-based cardiac rehabilitation; CPT, Current Procedural Terminology; and CR, cardiac rehabilitation.

and exercise equipment. Although these costs may be somewhat offset by the cost of the technology, including increased information technology infrastructure, mobile and connected devices, and wearable and data plans, questions remain about who will be responsible for paying for this technology. Evidence supports that telehealth programs, however, are cost effective and that some delivery formats may be as cost effective as or more cost effective than CBCR.[55–58] Last, home-based and hybrid CR programs may allow for more flexible scheduling for both patients and staff, potentially addressing issues of staff retention and improving work-life balance for clinicians while also improving the patient experience.[52] In summation, CR has been shown to be cost effective for organizations by reducing readmissions and improving quality of care. Considering the relatively lower capital expense when implementing digital health solutions to replace or enhance CBCR, there is the potential for digital solutions in CR to be even more cost effective.[21,22]

CONCLUSIONS

Digital technology has the potential to address many of the challenges faced by CBCR programs, improving and expanding access to care and delivering the core components of CR to novel populations while facilitating shared decision-making and empowering patients. Furthermore, digital monitoring in concert with increased computing power can provide novel insights into patients' daily lives for a range of lifestyle behaviors, including those beyond the traditional core components of CR. These can be leveraged to support patients in achieving and maintaining lifestyle behaviors that improve patient-centered outcomes and optimize cardiovascular health. For digital technologies to transform the paradigm of CR care, however, several methodological gaps must first be addressed along the continuum from development to implementation with a focus throughout on digital health equity.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

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*Modest.

†Significant.

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