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TECHNOLOGY AND CARDIOVASCULAR HEALTH (E. MUSE, SECTION EDITOR)

Health Techequity: Opportunities for Digital Health Innovations to Improve Equity and Diversity in Cardiovascular Care

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Abstract

Purpose of Review In this review, we define health equity, disparities, and social determinants of health; the different components of digital health; the barriers to digital health equity; and cardiovascular digital health trials and possible solutions to improve health equity through digital health.

Recent Findings Digital health interventions show incredible potential to improve cardiovascular diseases by obtaining longitudinal, continuous, and actionable patient data; increasing access to care; and by decreasing delivery barriers and cost. However, certain populations have experienced decreased access to digital health innovations and decreased representation in cardiovascular digital health trials.

Summary Special efforts will need to be made to expand access to the different elements of digital health, ensuring that the digital divide does not exacerbate health disparities. As the expansion of digital health technologies continues, it is vital to increase representation of minoritized groups in all stages of the process: product development (needs findings and screening, concept generation, product creation, and testing), clinical research (pilot studies, feasibility studies, and randomized control trials), and finally health services deployment.

Introduction

Intentional and targeted use of digital health innovations can advance and promote health equity. The COVID-19 pandemic drove an increased uptake of telemedicine services of up to 1.5x that of the pre-pandemic period [1]. However, certain populations experienced barriers to telemedicine access [2, 3]. These disparities are rooted in structural inequities that can in term impact how individuals can benefit from the promise of digital health. However, during the COVID-19, we also witnessed an increased collaboration between technology and health industry to expand access to transportation services, educational programs in digital health, and cloud programs to aid with vaccine distribution to historically marginalized groups [4]; federal funded programs increased access to broadband internet, digital health education, and devices [5]. Special efforts will need to be made to expand access to the different elements of digital health, ensuring that the digital divide (the economic, educational, and social inequalities between those that have or do not have access to information and communication technology) does not exacerbate health disparities [6]. In this review, we define health equity, disparities, and social determinants of health; the different components of digital health; the barriers to digital health equity; and cardiovascular digital health trials and possible solutions to improve health equity through digital health.

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Health Equity

In 1985, the Department of Health and Human Services published the Heckler Report on Black and Minority Health, exposing for one of the first times that race and ethnicity may be an independent contributor to health outcomes [7]. Specifically for cardiovascular care, it was clear that Black Americans had fewer office visits, diagnosis and interventions for coronary artery disease than White individuals. Subsequently, ample research has elucidated the inequities in cardiovascular care for racial and ethnic minorities [8]. The National Institute on Minority Health and Health Disparities defines a health disparity as a health difference that adversely affects disadvantaged populations, based on one or more health outcomes: higher incidence, prevalence or earlier onset of disease, higher prevalence of risk factors, higher rates of condition-specific symptoms, premature or excessive mortality, and greater global burden of disease [9]. In order to reduce health disparities, we need to understand the different social determinants of an individual's health or the conditions in which individuals live work and play that impact their health. Many of these factors are outside of the health care systems and include housing, income, and education. Not everyone has the same opportunity to be healthy [10]. To properly address these disparities, we should strive for health equity, not equality. Equality entails the distribution of the same resources and opportunities to every individual across a population—regardless of achieving the same outcome. Equity, on the other hand, is delivering these resources and opportunities tailored to the specific needs of a group to achieve equal outcome in the population [11]. Black individuals have higher rates of uncontrolled cardiovascular risk factors and higher age-adjusted death from cardiovascular disease compared with the general US population [12]. Improving health equity involves directing resources to communities that are underrepresented in research. For instance, Brewer et al. partnered with Black communities in all phases of product development to create and test a digital health cardiovascular disease prevention program that led to an improvement in the intervention Heart Association (AHA) Life-Simple 7 score (components: smoking, healthy diet, physical activity, BMI, blood pressure, cholesterol, and glucose) [13, 14].

Digital Health Elements

To better understand how digital health could address health inequities, we first need to define the different components involved in the use of information and communication technology for the delivery of health care:

- Digital health: commonly referred as eHealth, is the use of information and communication technology to manage patients and their health [15]. Digital health includes consumer products such as smart devices or connected equipment that have not undergone rigorous clinical studies [16].
- Digital medicine: the subset of digital health that pertains to high-quality hardware and software products developed through evidence-based clinical studies for medical care and treatment [17].
- Telemedicine: the specific use of information and communication technologies to deliver health care, clinical and administrative services, and medical education, remotely, from one site to another.
- mHealth: the use of mobile communication devices to exchange data or information between doctors and patients [18].
- Remote patient monitoring: the use of digital health devices to capture and serially monitor vital signs and biometrics with upload of such patient generated data to a digital platform for review by patients and clinical teams [18].
- Wearable and consumer technologies: such as commercially available activity tracking, sleep monitoring devices, smartwatches [18].

Barriers to Digital Health Inclusion

The COVID-19 pandemic propelled the use of digital health throughout the world, predominantly through telemedicine and remote patient monitoring [19]. But due to lack of preparedness, many historically marginalized groups were left with less access to care from the lack of infrastructure to support digital health care delivery in these communities [3]. Telemedicine has the ability to decrease health inequities by surpassing the limitations of access to care such as the cost of transportation, inability to leave the house due to disability, and loss of time at work. But in order for patients to benefit from telemedicine services, patients require internet or broadband access, a device (smartphone, computer, or tablet), applications, and a minimum digital health literacy.

In general terms, broadband refers to a set of networked data transmission technologies which permit internet communication and access to digital information. In the USA, 15% of households do not have internet service [20]. The states with majority Black residents or lowest median incomes had the lowest broadband adoption rates. For example, areas with majority White residents had an average adoption rate of 84% compared with 67% of majority-Black residential areas [20]. Decreased access to broadband internet use has been linked to decreased patient portal access. An observational study from a large tertiary-care center hospital showed that Black and Hispanic individuals had lowers odds of initiating a patient portal account or messaging their providers related to their decreased access to the internet [21]. Federal, state, and local programs specifically targeted at underserved communities have the ability to increase access to broadband. The Rural Digital Opportunity Fund program established in 2019 will award a total of $9.2 billion dollars over 10 years. In its 2021 report, the number of Americans without broadband access decreased from 30% in 2016 to 16% in 2019. Additionally, three-quarters of those with new access to broadband lived in rural areas [22].

Gaps remain in computer ownership, with just 69% of Black adults and 67% of Hispanic adults owning a computer as compared with 80% of White individuals [23]. On the other hand, smartphone ownership has steadily increased over the years and data from a 2021 Pew Research survey demonstrates that gaps in smartphone ownership by race are decreasing. Still, nearly one-half of older adults and 30% of those earning less than $30,000 own a smartphone and many low-income households share devices [24]. As an example, home-based cardiac rehabilitation programs can decrease health disparities by expanding care to patients with difficulties attending specialized rehabilitation centers. But if patients from low socioeconomic status, older adults or minoritized groups continue to lack access to computers, broadband, or digital health literacy, then such interventions will continue to exacerbate the digital divide. We need programs that increase access to device ownership and education. If passed, The Device Access for Every American Act introduced at the end of 2021 has the potential to reduce disparities by increasing access to a connected device (desktop, laptop, tablet) by providing a $400 voucher to low-income individuals [25]. In addition, we should extend federal programs enacted during the COVID-19 pandemic to help schools and libraries increase access to devices and education [26].

With regard to wearable ownership, survey data from the Pew Research Center (65% White participants and annual income above 30,000) revealed that in 2020, 21% of US adults report regular use of a smartwatch [24]. Ownership was similar between participants of different ethnic backgrounds, but Black and Hispanic individuals were less likely to approve sharing of their data for heart disease research. On the other hand, surveys performed in Federally Qualified Health Centers with predominantly underrepresented population (70% nonwhite, 70% learning less than 30,000) report lower wearable ownership of 21% [27]. Cost was the main barriers for those who did not own a fitness tracker but would like to own one. With multiple imbedded sensors (accelerometers, photoplethysmography, electrocardiography, etc.), wearable devices can collect a plethora of data for the prevention, diagnosis, and treatment of cardiovascular diseases. Researchers and device companies should continue to collaborate to improve device accuracy and define meaningful use criteria. To increase access, device companies should lower costs; insurance companies must expand reimbursement for biometric data collection and develop programs that increase access to wearable devices [28].

Universal design principles have been present at least since the 1990s to aid designers in developing products for the widest possible range of individuals [29]. The equitable use principle states that products should "Provide the same means of use for all users: identical whenever possible; equivalent when not" and to "avoid segregating or stigmatizing any users" [30]. Unfortunately, the COVID-19 pandemic provided important insight in the gaps in the design of products for people from different cultural, social, educational backgrounds. Most of the apps were available only in English (65%) and 69% had a readability above 9th grade [31]. Several design standards and guides are now available aimed specifically at digital health tools [32]. Two commonly used design processes include the Universal Design Principles and User-Centered Design. While these approaches possess important differences, both aim at maximizing the usability of products to a diverse group of users [33]. Community-based participatory research is another approach that aims to create partnerships between intended end users from the community, academic, and research institutions across all the design stages [34].

Digital Health Interventions for Cardiovascular Care

Hypertension

Hypertension affects close to a third of the adult population worldwide [35]. Black individuals have a higher prevalence of hypertension and lower levels of hypertension awareness and control [36]. Additionally, low-middle-income countries and racial and ethnic minorities in high-income countries tend to have decreased awareness, control, and worse outcomes [35]. Some of the barriers in hypertension control are related to frequent follow up visits, cost of multiple follow-up appointments, the cost transportation, and in certain places the distance required to reach a health care institution. With telemedicine the health care system has the ability to obtain more blood pressure readings that are transferable to the health care team (nurse, pharmacist, physician, etc.) to allow more frequent medication titration without the need for time or cost spent in transportation or additional follow up appointments.

Randomized trials have tested different ways to improve hypertension treatment and control before and after the internet era, with a few trials specifically targeting low-resource setting and diverse patient populations (Table 1). In the Effects of Nurse-Managed Telemonitoring on Blood Pressure at 12-Month Follow-Up Among Urban African Americans study, a nurse-managed telemonitoring intervention (telephonically transmitted BP measurements, nurse intervention, and counseling) showed greater reduction in systolic blood pressure at 12 months compared with usual care alone (13 vs 7.5 mm Hg) [37]. Blood pressure reduction was also achieved with a similar intervention in a subgroup

Table 1 Digital health randomized control trials in hypertension

First author	Country	Age mean (SD)	N	Race ethnicity*	Duration (months)	Inclusion criteria	Primary outcome&	Results	Device	Intervention	Medication titration
Artinian et al. (2007) [37]	US	59.1 (13) vs 60.2 (12.3)	394	100% Black	12 months	AA with HTN at community centers	Reduction in BP at 12 months	-13 vs -7.5 mm Hg, $P=0.04$	HBPM + LifeLink Monitor	•TM** + nurse tele counseling •Enhanced UC$	No
Green et al. (2008) [41]	US	59.1 (8.5)	778	83% Black	12 months	25–75 years of age, uncontrolled BP, no diabetes, no cardiovascular or renal disease	Change in SBP, DBP and control at 12 months	TM + pharmacist versus UC: 56% vs 31%, $P=<0.001$	HBPM (Omron Hem-705-CP)	3 arms: •TM + Web •TM + pharmacist •Usual care	Yes (Pharmacist)
Parati et al (2009) [42]	Italy	57.2 (10.7) in IT 58.1 (10.8) in UC	288	Not reported	6 months	18–75 years with office SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg and ABPM SBP ≥ 130 or DBP ≥ 80 mm Hg	Proportion of patients reaching control	62% vs 50% ($P<0.05$) IT vs UC	HBPM (Tensiomed) + Tensiophone	TM + BP data telephone transmitter + Nurse intervention if BP above safety thresholds	No (physician contacted if BP above safety threshold, i.e., ≥ 180/110 mm Hg)
McManus (2010) [43]	UK	66 (8.8)	480	96% White, 1.5% Black, 2.1% Asian	12 months	Age 38–85 years with BP ≥ 140/90 mm Hg	SBP difference at 6 and 12 months	6-month SBP difference of 3.7 (0.8–6.6, $P=0.013$); 12-month SBP difference 5.5 (2.2 to 8.8) in the IT vs control	HBPM (Omron 705IT)	TM via telephone device (i-modem, Netmedical)	Yes (physician)
Wakefield et al. (2011) [44]	US	66 (10)	302	96% White, 3% African American	18 months	T2DM and HTN treated by VA PCP	SBP at 6 months	High IT vs UC: -6.05 vs $+4.48$, $P=0.001$ High IT vs low intensity: -6.05 vs -0.29, $P=0.9$	HBPM + telephone line for data transfer (Viterion-Bayer Panasonic)	3 arms: •TM + high intensity education •TM + low intensity education Usual care	Yes, for high intensity (Physician based treatment algorithm)
Bosworth et al. (2011) [38]	US	64 (10)	591	49% White, 48% Black	18 months	Diagnosis of HTN, using BP-lowering meds, BP > 140/90 mmHg	BP control at 18 months	12.8%, $P=0.03$ (behavioral vs usual care) 12.5%, $P=0.03$ (combined intervention vs usual care)	HBPM (UA-767PC, A&D Medical Digital BP)	4 arms: •TM •TM + behavioral management •TM + behavioral management + nurse and software intervention •Usual	Yes (Physician aided by nurse from study team with web-based algorithm)
Piette et al. (2012) [45]	Mexico and Honduras	57.6 (0.8)	200	Not reported	6 weeks	Age 18–80 and SBP ≥ 140 mm Hg or ≥ 130 mm Hg with diagnosis of T2DM	SBP difference at 6 weeks	SBP difference of -4.2 mm Hg (-9.1 to 0.7, $P=0.09$) IT vs UC	HBPM	TM via telephone calls + adherence monitoring and behavioral change	No
Hebert et al. (2012) [39]	US	60.8 (11.6)	416	59% Black, 37% Hispanic	18 months	Self-described black or Hispanic, community dwelling at enrollment, BP ≥ 140/90 mm Hg	Change in SBP and DBP at 9	Difference of -7 mm Hg (-13.4 to -0.6 IT vs UC at 9 months	HBPM (Omron HEM-712C)	TM + nurse counseling and contacting physician to suggest treatment changes	Yes (Physician aided by nurse from study team)

Table 1 (continued)

First author	Country	Age mean (SD)	*N*	Race ethnicity*	Duration (months)	Inclusion criteria	Primary outcome&	Results	Device	Intervention	Medication titration
Margolis et al. (2013) [46]	US	61.1 (12)	450	82% White, 12% Black, 2% Asian	18 months	HTN with BP above 140/90 mmHg	Proportion of patients controlled at 6- and 12-month visit	6 months: 71.8 vs 45.2% $P \leq 0.001$ 12 months: 71.2 vs 52.8% $P = 0.005$	HBPM (A&D Medical 767PC)	TM + web services + pharmacist calls	Yes (pharmacist with web-based algorithm)
Bove et al. (2013) [40]	US	59.6 (13.5)	241	81% African American, 15% White, 2.5% Hispanic	6 months	SBP ≥ 140 mmHg	Proportion of BP control	54.5% versus 52.3%, $P = 0.430$	HBPM (Microlife USA Scale (Taylor Digital) Pedometer (Digi-Walker SW-200)	TM + patients uploaded data via web or telephone + monthly report to physicians	No (usual clinical decision)
Magid et al. (2013) [47]	US	60 (11)	348	84% White, 8% Black, 6% Hispanic	6 months	18–79 years of age, HTN with SBP ≥ 140 or DBP ≥ 90 mmHg	Proportion of BP control	54.1 versus 35.4%, $P \leq 0.05$	HBPM (Omron HEM-790IT)	TM + automatic upload data to Heart360 Web Account + clinical pharmacist	Yes (pharmacist)
Kerry et al. (2013) [48]	UK	72 (12)	381	77% White, 14.9% Black, 7.2% Asian	12 months	History of stroke or TIA 9 months prior and BP > 140/85 mm Hg or on antihypertension medication	Change in SBP at 12 months	Difference of 0.3 mm Hg (CI − 3.6 to 4.2) at 12 months	HBPM (Omron 705CP)	Self-monitoring + nurse counseling	No
McKinstry et al. (2013) [49]	UK	61 (11)	401	Not reported	6 months	≥ 18 years + SBP > 145 mm Hg or DBP > 85 mm Hg	Mean change in SBP at 6 months	Difference of − 4.3 (− 2 to − 6.5, $P = 0.0002$) IT vs UC	HBPM (Sabil-O-Graph)	TM + automatic transmission of BP readings via smart phone + feedback to patients and HCT***	No
Stewart et al. (2014) [50]	Australia	67 (12)	395	71% born in Australia, race/ethnicity not reported	6 months	≥ 18 years + HTN + on HTN meds	Change in SBP and DBP at 6 months (2ry outcome)	SBP difference of − 5.3 mm Hg (0.0 to 10.6, $P = 0.05$) IT vs UC	HBPM (Omron HEM-790IT)	TM + pharmacist medication review and adherence check	No (pharmacist could referred to GP)
Leiva et al. (2014) [51]	Spain	65 (10.7)	114	Not reported	12 months	18–80 years with SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg	SBP at 12 months	SBP 151.3 vs 153.7, $P = 0.294$ IT vs UC	HBPM	TM + education and motivational interview + pillbox organized + pharmacist intervention	Yes (pharmacist)
McManus et al. (2014) [52]	UK	69.3 (9.3) in IT 69.6 (9.7) in UC	552	96.6% White, 1.5% Black, 1.5% Asian, 0.5% others	12 months	Age ≥ 35 years, SBP ≥ 130 or DBP ≥ 80 mm Hg plus at least one high risk condition#	SBP difference at 12 months	SBP difference 9.2 (5.7–12.7) IT vs UC	HBPM (MicroLife Watch BP Home)	TM plus self-titration (3 step plan prespecified by their physician)	Yes (participant)
Ogedegbe et al. (2014) [53]	US	56 (12.1)	1039	100% African American	12 months	Self-identified black or African American, uncontrolled HTN	Rate of BP control at 12 months	50.2 vs 45.3%, $P = 0.18$	HBPM	TM + lifestyle counseling Physicians received monthly feedback	No (usual clinical decision)

Table 1 (continued)

First author	Country	Age mean (SD)	*N*	Race ethnicity*	Duration (months)	Inclusion criteria	Primary outcome&	Results	Device	Intervention	Medication titration
Yi et al. (2015) [54]	US	61.3 (12)	900	11% White, 26% Black, 63% Hispanic	6 months	≥ 18 years, HTN ≥ 6 months, last clinic visit SBP ≥ 140 or DBP ≥ 90 mmHg	Change in SBP and DBP at 7–10 months	Mean change in SBP of 14.7 vs 14.1 mmHg $P = 0.70$	HBPM	TM + education	No
Bobrow et al. (2016) [55]	South Africa	54.3 (11.5)	1256	57.6% Black, 42.4% other	12 months	Age ≥ 21 years and HTN diagnosis	Change in SBP at 12 months	Difference SBP: interactive vs UC − 1.6 (− 3.7 to 0.6, $P = 0.16$); information only vs UC − 2.2 (− 4.4 to − 0.04, $P = 0.046$)	SMS text messages	3 arms: ●Interactive two-way SMS messages ●One-way information only SMS messages ●Usual care	No
Frias et al. (2017) [56]	US	IT: 57.8 (1.1) UC: 61.6 (1.7)	109	66% White, 47% Hispanic, 16% African American, 14% Asian	1–3 months	Adults with HTN and BP ≥ 140/90 mmHg	Change in SBP at 4 weeks	− 21.8 vs − 12.7 mm Hg*	DMO***	Digital medicine + wearable sensor + app	No
McManus et al. (2018) [57]	UK	66.9 (9.4)	1182	95% White, 1.7% Black, 1.4% Asian, 0.6% mixed	12 months	Age ≥ 35 years, SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg	SBP difference at 12 months	Adjusted difference: self-monitoring − 3.5 mm Hg, $P = 0.0029$; TM − 4.7 mm Hg, $P = 0.0001$ vs usual care. No difference between self- and TM	HBPM (Omron M10-IT)	3 arms: ●TM via text or web + physician titration and web interface ●Self-monitoring + mail readings + physician titration ●Usual care	Yes (physician)
McManus et al. (2021) [58]	UK	66 (10)	622	94% White, 1.4% Black, 1.1% Asian, 3.4% Other	12 months	Age ≥ 18 years, SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg	SBP difference at 12 months	Mean SBP difference of − 3.4 (− 6.1 to − 0.8) IT vs UC	HBPM (Omron M3)	TM + patient and physician integrated online intervention + behavioral and lifestyle education	Yes (physician)

$Enhance UC: provided with list of PCPs (if did not have one), enrolled in pharmacy assistance program and AHA pamphlet "Silent Stalker"

*As collected or reported in the original manuscript

**TM = BP Telemonitoring

**DMO = includes digital medicines, the wearable sensor patch, and the mobile device app

***HCT = health care team

&All office BP unless otherwise stated

#Stroke or transient ischemic attack; diabetes; stage 3 chronic kidney disease (estimated glomerular filtration rate, 30–59 ml/min/m^2); coronary artery bypass graft surgery; myocardial infarction or angina analysis of uncontrolled patients in the Durham VA internal medicine clinics (49% black) [38]. The "Nurse-led Disease Management for Hypertension Control in a Diverse Urban Community" Randomized Controlled Trial (RCT) looked at the response to different levels of intervention (HBPM alone, HBPM + nurse telephone counseling and usual care). At 9 months, systolic blood pressure was −7.0 mm Hg lower (confidence interval [CI] −13.4 to −0.6) in the nurse management plus home blood pressure monitor arm relative to usual care. There was no statistical difference in the home blood pressure only arm versus usual care [39]. Bove et al. studied a telemedicine plus physician intervention versus usual care in a predominantly African American population with 53% at or below the poverty line. Blood pressure control was similar in both groups at 6-month follow-up (52.3% intervention versus 54.5% usual care, $P = 0.43$) [40].

The "Counseling African Americans to Control Hypertension" trial enrolled 1039 patients from 30 community health centers in the New York City area. In the intervention arm, patients received computerized education, behavioral counseling sessions, and HBMP-validated devices; clinicians received monthly on-site education, hypertension case rounds, and quarterly chart audits of their patient office blood pressure readings. The BP control rate was similar in intervention (49.3%) versus control (44.5%) groups. In prespecified subgroup analyses, the intervention was associated with greater BP control in patients without diabetes mellitus (intervention 54.0% versus usual care 44.7%; odds ratio, 1.45 [CI, 1.02–2.06]); and small-sized community health centers (intervention 51.1% versus usual care 39.6%; odds ratio, 1.45 [CI, 1.04–2.45]) [53].

Researchers and companies developing patient-facing platforms should collaborate with communities throughout the entire design process, test and validate these technologies, and integrate them into the electronic health record for seamless transfer of data. Insurers should expand coverage of home blood pressure monitors and reimburse clinicians for using digital health technology to deliver care. Developing provider-facing platforms for low-resource settings, imbedding tools into regular clinician workflow, and providing concise and actionable data aiming at improving care with no added cost or effort should be national priorities.

Cardiovascular Health

The use of digital health to improve cardiovascular risk factors such as dyslipidemia by improving adherence or promoting lifestyle changes is an important public health intervention, both for primary and secondary prevention of cardiovascular diseases. Unfortunately, there is paucity of data regarding the benefits of digital health interventions targeted specifically at lower socioeconomic status, elderly, Black, or Hispanic populations for risk factor modification in cardiovascular health (Table 2). Furthermore, studies have shown that patients with a self-reported history of atherosclerotic cardiovascular disease are less likely to use health information technology to manage their health [59].

Bae et al. randomized 879 patients with a history of coronary heart disease who underwent percutaneous coronary intervention to a semi-personalized support website and a short message service (SMS) with lifestyle modifications versus usual care (regular clinic follow-up without text messages). At 6 months, there was no significant difference in the cardiometabolic risk profiles between the groups [71]. A higher intensity intervention in a Turkish population that remotely monitored patients' diet, weight, steps, and blood pressure with additional motivational messages to improve healthy lifestyle showed a significant reduction in ASCVD score of −2.7% (adjusted treatment effect −2.7, 95% CI −2.2 to −3.3, $P < 0.0001$) [70]. Brewer et al. randomized churches with predominantly African American adults to test an app-based cardiovascular health promotion intervention. The FAITH! App provided educational models, diet, and physical activity self-monitoring and social networking. Educational material focused on all American Heart Association (AHA) Life-Simple 7 components: smoking, healthy diet, physical activity, BMI, blood pressure, cholesterol, and glucose. The primary outcome was the average change in mean AHA Life-Simple 7 score between the immediate and delayed intervention groups. At 6 months, the mean AHA Life-Simple 7 score of the intervention group increased by 1.9 (SD 1.9) points compared with 0.7 (SD 1.7) point in the control group ($P < 0.0001$) [14].

Cardiac rehabilitation programs are important components in cardiovascular health and secondary prevention. It is a Class Ia recommendation for secondary prevention after myocardial infarction (MI), percutaneous coronary intervention (PCI), coronary artery bypass graft (CABG), stable angina, or symptomatic peripheral arterial disease [72–75]. Uptake continues to be low, especially in minoritized groups. An observational study from the Veterans Affairs Health Care System and Medicare administrative data showed that cardiac rehabilitation after MI, PCI, or CABG in Medicare patients was 16.3% and in VA patients was 10.3%. In Medicare, participation rates were 17.6% Whites, 7.3% Blacks, and 3.8% Hispanics, whereas in VA, participation rates were 10.4% Whites, 8.9% Blacks, and 12.0% Hispanics [76]. Some of the barriers to access cardiac rehabilitation include lack of insurance coverage or high co-payments [77], language barriers [78], and transportation [79]. However, home-based cardiac rehabilitation has the potential to improve participation across all population by addressing these barriers.

Virtual world technology can support home-based cardiac rehabilitation with programs not only tailored to the

Table 2 Digital health trials in ASCVD and cardiac rehabilitation

First author	Country	Age mean (SD)	N	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention
Brath et al. (2013) [60]	Austria	69 (4.8)	53	Not reported	40 weeks	At least 2 diagnoses: HTN, DM2, HLD	Intake rate at 20 weeks	Significant difference in Metformin adherence. No difference in the other 3 medications	Electronic blister + NFC capable smartphone	Adherence text reminders to participants and adherence information to physicians
Petrella et al. (2014) [61]	Canada	56.7 (9.4)	149	100% Caucasian	12 weeks	At least 2 risk factors*	SBP at 12 weeks. Secondary outcome: waist circumference, HBA1c, HDL, LDL	SBP mean change greater in IT vs control. No difference in secondary outcomes	Smartphone, app, glucometer, HBPM, weight scale, pedometer	Individualized exercise program + home monitoring kit
Chow et al. (2016) [62]	Australia	58 (9.2)	710	66.6% European, 10.7% South Asian, 10.1% other Asian, 9.9% Arab	6 months	≥ 18 years of age and documented CHD**	LDL-C level at 6 months	Significant difference in LDL-C of − 5 mg/dL (− 9 to 0, P = 0.4)	Text messages	Semi-personalized text messages with motivation to improve diet, exercise, and smoking cessation
Anand et al. (2016) [63]	Canada	50.6 (11.4)	343	100% South Asian (90% India, 2.3% Pakistan, 5.2% Sri Lanka)	1 year	South Asian ≥ 30 years of age	MI scores at 12 months	Relative change between IT and control was not significant (− 0.27, − 1.12 to 0.58, P = 0.53)	Email messages	Change-oriented motivational, diet, and physical activity messages
Salisbury et al. (2016) [64]	UK	67.4 (4.8)	641	99% White	1 year	40–74 years of age + QRISK2 10-year risk score of ≥ 20% and modifiable diseases***	Maintaining or decreasing QRISK2 score at 12 months	Proportion that maintained or improved was not significantly different in IT vs control 50 vs 42% (OR 1.3, 1.0–1.9, P = 0.08)	Telephone calls + web portal	Health advisor plus computerized behavioral management program
Skobel et al. (2017) [65]	UK, Germany, Spain	59 (14)	132	Not reported	6 months	Hx of acute MI or CAD s/p PCI, LVEF ≥ 30%	Peak VO2 max at 6 months in HBCR$^{\$}$ vs CBCR$^{\#}$ national standards	Peak VO2 max change 1.76 ± 4.1 ml/min/kg in HBCR vs − 0.4 ± 2.7 ml/min/kg in CBCR, P = 0.005	•Smartphone •ECG •Vest •Vital sign senor •Physician-facing platform	Asynchronous home-based cardiac rehabilitation
Hwang et al. (2017) [66]	Australia	67	53	92% Caucasian	12 weeks	≥ 18 years of age and recent heart failure admission, diagnosis confirmed by echocardiogram	Non-inferiority: change in 6-min walk distance HBCR vs CBCR	At 12 weeks, there was no between-group difference 15 m (95% CI − 28 to 59); F = 1.39, P = 0.24	•Laptop •Mobile broadband •HBPM •Pulse oximeter •Weight and resistance bands	Synchronous videoconference home-based cardiac rehabilitation

Table 2 (continued)

First author	Country	Age mean (SD)	N	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention
Harzand et al. (2018) [67]	US	65 (5)	18	50% African American	12 weeks	≥ 18 years with coronary heart disease plus on indication for cardiac rehabilitation	BP and functional capacity (single arm feasibility study)	Improvement in metabolic equivalent from 5.3 to 6.3, $P = 0.008$; mean BP at rest decreased from 1401 to 130.5, $P = 0.039$	•Smartphone platform •Hospital-facing dashboard	Asynchronous home-based cardiac rehabilitation
Peng et al. (2018) [68]	China	66.3 (10.5)	98	Not reported	4 months	≥ 18 years, heart failure for at least 3 month and NYHA class I–III	Primary: QoL, secondary: 6-min walking distance, LVEF and heart rate	Statistically significant changes in QoL scores, 6-min walk distance and heart rate	Web-based platform	Synchronous videoconference home-based cardiac rehabilitation
Maddison et al. (2019) [69]	New Zealand	61 (13)	162	75.3% NZ European, 4.3% NZ Maori, 2.5% Pacific, 8% Asian	12 weeks	≥ 18 years with coronary heart disease within 6 months	Non-inferiority outcomes: VO2 max at 12 weeks	Adjusted mean VO2 max difference = 0.46, 95% CI − 0.92 to 1.84 ml/kg/min, $P = 0.51$	•Smartphone •Chest-word wearable sensor •Apps and Web Platform	Synchronous home-based cardiac rehabilitation
Tekkesin et al. (2021) [70]	Turkey	Mean:59 (53–64)	283	Not reported	1 year	20–79 years of age with 10 years ASCVD score ≥ 7.5%	ASCVD scores at one year	IT vs UC reduced ASCVD score by difference of − 2.7% (− 2.2 to − 3.3, $P \leq 0.0001$)	Smartphone, weight scale, smart wrists band and HBPM	Daily upload of data with motivational messages and feedback
Bae et al. (2021) [71]	Korea	60.4 (10.5)	879	Not reported	6 months	CHD and underwent PCI	LDL-C, SBP and BMI change at 6 months	No significant difference in any outcome: LDL-C, SBP, and BMI	Text messages	Semi-personalized text messages with motivation to improve diet, exercise, and smoking cessation

*Waist circumference ≥ 88 cm (women) or 102 cm (men); SBP ≥ 135 mmHg and/or DBP ≥ 85 mmHg; fasting plasma glucose ≥ 6.1 mmol/l; fasting triglycerides ≥ 1.7 mmol/l; fasting HDL ≤ 1.29 mmol/l (women) or 1.02 mmol/l (men)

**Defined as documented prior myocardial infarction, coronary artery bypass graft surgery, percutaneous coronary intervention, or 50% or greater stenosis in at least 1 major epicardial vessel on coronary angiography

***Systolic blood pressure ≥ 140 mm Hg, body mass index ≥ 30, being a current smoker, or any combination of these

$Home-based cardiac rehabilitation

#Center-based cardiac rehabilitation

Table 3 Digital health randomized control trials in heart failure

First author	Country	Age mean (SD)	N	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention	Health care team intervention
Koehler et al. (2011) [87]	Germany	66.9 (10.8)	710	Not reported	18 months	Stable HF with LVEF ≤ 35% and admission in previous 2 yrs OR LVEF ≤ 25%	Death from any cause	8.4 in RTM group vs 8.7 in UC (HR 0.97, $P = 0.87$)	3-lead EKG, HBPM, weight scale, smartphone	Daily transmission of biometric data	Cardiologist or family doctor
Dendale et al. (2012) [88]	Belgium	76 (10)	160	Not reported	6 months	Decompensated HF	All-cause mortality	Reduced all-cause mortality in the IT vs usual care	Bluetooth scale and HBPM	Automatic transfer of data to website + emails with alerts above threshold to clinicians	GPs, Cardiologist and Nurse follow-up
Villani et al. (2014) [89]	Italy	58 (12)	94	Not reported	6 months	HF with LVEF < 35%, NYHA ≥ 2	Number of HF-related hospital days	No difference in HF-related hospital days	Weight scale, HBPM, mobile phone	Upload of measurements and survey to software app that provides machine-based feedback + weekly nurse evaluation	Nurse
Vuorinen et al. (2014) [90]	Finland	55 (13.7)	100	62% Caucasian 9% African Canadian 7% Asian 12% other	6 months	HF with LVEF < 40%	BNP, self-care, and quality of life measured by MLHFQ*	Significantly improved self-care score	Weight scale, HBPM, single-lead ECG recorder, MLHFQ*	Automatic upload of readings and questionnaire by email to cardiologist	Cardiologist
Dang et al. (2017) [91]	US	53 (9.4)	61	76% White Hispanics, 21% AA	3 months	HF, smartphone ownership, survival expected > 6 months	Self-care efficacy	Improved self-care	Smartphone (provided by study team)	Daily surveys including weight + feedback to physicians	Study coordinator providing data to Heart Failure Clinic
Koehler et al. (2018) [92]	Germany	70 (10)	1571	Not reported	393 days	HF with LVEF ≤ 45% plus hospital admission in last 12 months	Percentage of days lost due to a cardiovascular admission or death	4.88 versus 6.64% lost days ($P = 0.046$), all cause death 7.9 vs 11.3 100 person years ($P = 0.028$)	EKG device, HBPM, weight scales and oximeter, smartphone	Daily transmission of biometric data and surveys plus nurse or physician intervention	Physician or nurse

Table 3 (continued)

First author	Country	Age mean (SD)	N	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention	Health care team intervention
Melin et al. (2018) [93]	Sweden	75 (8)	72	Not reported	6 months	Admitted HF patients	Self-care behavior based on 9-item European HF Self-care Behavior Scale	Better self-care behaviors in the intervention (16.5 versus 23.5 $P \leq 0.5$)	Weight scale and tablet computer	Patient education, transmission of surveys and weight	NA
Chen et al (2019) [94]	China	61 (15)	767	Not reported	180 days	Decompensated CHF, mobile phone ownership, life expectancy > 1 year	All-cause mortality	SMS and STS significantly reduced the composite endpoint and readmission in 180 days	Smartphone	Structured telephone support (STS) vs short message service (SMS) vs usual care	No

*Minnesota Living with Heart Failure Questionnaire

patient's comorbidity but also to the patient's social, cultural, and language background [80]. In China, Peng et al. randomized 98 participants to receive home-based cardiac rehabilitation versus usual care that included education and regular clinic follow-up. At 4 months, there was a statistically significant change in QoL scores, 6-min walk distance, and heart rate [68]. In a single-arm feasibility study in a US Veterans Affairs Center, Harzand et al. evaluated the change from baseline in blood pressure metabolic equivalent of an asynchronous home-based cardiac rehabilitation program. At 12 weeks, participants (50% Black) showed improvement in metabolic equivalent (5.3 to 6.3, $P = 0.008$) and mean systolic blood pressure (140.1 to 130.5, $P = 0.039$). Studies have demonstrated non-inferiority when compared to center-based cardiac rehabilitation, but with limited representation of minorities groups [65, 66, 69, 81]. Home-based cardiac rehabilitation shows potential for the future of cardiac rehabilitation; nevertheless, data in minoritized patient populations are limited and we should strive for increased representation in future trials.

Heart Failure

Heart failure is one of the leading causes of death worldwide [82]. There is a higher prevalence and increased mortality in Black and Hispanic individuals compared with White individuals [83, 84]. Racial and ethnic minoritized groups are less likely to receive appropriate medical therapy and to be included in cardiovascular trials [85, 86]. Digital health tools have the ability to improve heart failure management by obtaining important health-related information such as blood pressure, heart rate, EKGs, weight, and symptoms. It can also address health disparities by remotely monitoring data, thereby decreasing time lost from work or travel, and expenses in travel or follow up visits. Unfortunately, only a few clinical trials report or include diverse populations and even fewer have been done specifically in minoritized groups (Table 3).

Koehler et al. randomized 1571 participants in Germany to a telemedicine intervention versus usual care. Participants in the intervention arm received an EKG device, HBPM, weight scales, oximeter, and smartphone that provided daily transmission of data to a telemedicine center where algorithms aided clinicians in patient care. The primary outcome, the percentage of days lost due to unplanned cardiovascular hospital admissions, and all-cause death was 4.88% (95% CI 4.55–5.23) in the remote patient management group and 6.64% (6.19–7.13) in the usual care group (ratio 0.80, 95% CI 0·65–1.00; $P = 0.0460$) [92]. Chen et al. evaluated mortality 180 days after discharge in participants randomized to a two-telemedicine telephone support system versus usual care. The first-level intervention group received education and reminders via a SMS; the second group received SMS plus structured telephone support system managed by research nurses who called patients every 30 days and allowed patients to call nurses on an as needed basis. The 180-day composite event rate was significantly lower in the SMS and STS groups (50.4 vs 41.3% and 36.5%, both $P < 0.05$) than in the usual care group, but no difference was observed between the two phone-based intervention groups ($P = 0.268$) [94].

Unfortunately, there are a lack of on the distribution of racial and ethnic populations in heart failure RCTs. There are limited data on Hispanic, Black, and other minoritized populations and the few studies available did not evaluate hard clinical outcomes. The "Mobile Phone Intervention for Heart Failure in a Minority Urban County Hospital Population" was a feasibility study in Hispanic (76%) and Black (21%) individuals that evaluated a mobile phone intervention to test the system's usability (ease of use, navigation, readability, confidence, and motivation). The study team provided patients with a telemonitoring program (mobile phone, data usage and free 30-min calls per month) for participants to provide daily heart failure symptoms and weight. At 3 months, participant satisfaction scores was excellent, with a mean score of 6.84 ± 0.46 (rating scale of 1–7); 94% of participants thought that the program was easy to use and 84% thought that navigating the system was not complicated [91].

Arrhythmia Detection

Over the last few years, there has been a growing interest in the use of wearables or home ECG devices as an adjunct to usual care for the detection of arrythmias, most commonly atrial fibrillation. Wearables have the ability to detect irregular rhythm such as atrial fibrillation through continuous monitoring of irregular pulse variation with the use of photoplethysmography or on-demand ECG recording. There is a growing interest in the medical field to test commercially available remote patient monitors in multiple clinical or real-world settings for the detection of cardiac arrhythmias (Table 4).

The Huawei Heart Study screened for atrial fibrillation using a PPG monitoring app on a smartphone and or smartwatch in adults across China (mean age 35 years, 86.7% male). In total, 424 participants (mean age 54 years, 87.0% male) received a "suspected AF" notification, which was confirmed in 227 individuals (positive predictive value of PPG signals being 91.6%, CI 91.5 to 91.8%) [97]. The Apple Heart Study enrolled 219,297 participants with average age of 41 years ($\pm$13 years) (68% White, 12% Hispanic, 7.7% Black, and 6.2% Asian) to evaluate the efficacy of the Apple Watch detect atrial fibrillation in a real-world setting. Over a median monitoring time of 117 days, irregular pulse notifications were received by 2161 participants (0.52%), ranging from 3.1% of those 65 years of age or older to 0.16% of those 22 to 40 years of age. Of the 2089 irregular tachograms sampled from participants who had received a notification for analysis, 1489 showed simultaneous atrial fibrillation on ECG patch monitoring, resulting in a positive predictive value of the individual tachogram of 0.71 (97.5% CI, 0.69 to 0.74) [98].

Currently, there are less data in the Hispanic or Black populations. Lubitz et al. looked at the ability of the KardiaMobile device to screen for atrial fibrillation in patients older than 65 years of age without prevalent atrial fibrillation attending a primary care visit [101]. The KardiaMobile was not superior to usual care in the detection of new onset atrial fibrillation. Data are also lacking for other racial or ethnic populations. The "Mobile Health Intervention for Rural Atrial Fibrillation" study aims to test the efficacy of a mobile health application virtual coach coupled to a heart rhythm monitor (Kardia) in patients with atrial fibrillation to improve adherence to oral anticoagulation in a rural population of Western Pennsylvania. This will be one of the first studies using commercially available heart rate and rhythm monitors to be tested in rural underserved populations. The Fitbit Heart Study will be the largest study to date, enrolling 450,000 participants across the USA [102]. Part of the inclusion criteria include ownership of a Fitbit and smartphone device. Large-scale studies that include a greater number of diverse participants could provide important information regarding the accuracy of wearable devices for the detection of atrial fibrillation in across all racial and ethnic populations. If a difference exists, further studies should be aimed at determining how we can improve the accuracy in hardware or software.

There has been an increase in the use of wearable devices such as fitness trackers and smart watches (e.g., Fitbit, Apple Watch) to track activity, sleep, oxygenation, and heart rate. As we expand the use of wearables into clinical practice, it is crucial that we provide access to wearable devices to all communities who may benefit from early arrythmia detection and guideline directed treatments.

Technology companies and the medical community developing and testing these devices with its algorithms should ensure they provide reliable information in patients of all skin tones and age groups. The accuracy of wearables to detect certain metrics, such as oxygenation or heart rate, continues to be an issue. Oxygen saturation and heart rate in fitness trackers are measured by photoplethysmography green light signaling. Research in the last decade revealed that dark brown skin type showed significantly lower modulation, perhaps due to absorption of the light by melanin [103]. Wearables devices have been shown to be less accurate in darker skin tones [104]. Unfortunately, recent data show that this issue is not restricted to fitness trackers. A retrospective multi-center study in the Veterans Health Administration showed that Black patients had higher probability of having occult hypoxemia in the inpatient setting when oxygen saturation is measured by pulse oximeter [105]. It is important for fitness tracking companies to

Table 4 Digital health randomized control trials in arrhythmia detection or management

First author	Country	Age mean (SD)	Design	*N*	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention	Health care team interpretation
William et al (2018) [95]	US	68 years	Single-Center Non-Randomized	52	Not reported	NA	AF admitted for anti-arrhythmic drug initiation, 38–85 yrs, hx of paroxysmal AF	Sensitivity and specificity	96.6% sensitivity and 94.1% specificity of 225 recordings	Kardia Mobile Cardiac Monitor coupled to Wi-Fi smart device (iPod)	30 s recordings of lead I ECG + automatic analysis by KMCM algorithm	I-lead ECG reviewed by blinded electrophysiologist
Steinhubl et al. (2018) [96]	US	72.4 (7.3)	RCT + prospective matched cohort	2659	Not reported	4 months	≥ 75 yrs, male > 55 yrs or female > 65 yrs*	Incidence of new AF diagnosis at 4 months immediate vs delayed group	3.9% in the immediate versus 0.9% delayed group	iRhythm Zio^{XT}	Stored data analyzed by an FDA approved algorithm	I-lead ECG adjudication by blinded committee
Guo et al. (2019) [97]	China	54	Prospective cohort	187,912	Not reported	At least 14 days of monitoring	≥ 18 yrs and smartphone ownership	AF detection efficacy	PPV of 91.6% (91.5–91.8)	Smartphone plus smart wrist band	AF detection using PPG in the smartphone or wrist band	Confirmed by patient's provider with use of ECG or 24-h Holter monitoring
Perez et al. (2019) [98]	US	41 (13)	Prospective single group pragmatic study	219,297**	68% White 12% Hispanic 7.7% Black 6.2% Asian	Median 117 days of monitoring	≥ 22 years without prior AF diagnosis or AC use	Proportion of notified participants with AF on ECG patch and PPV of irregular pulse intervals	PPV 84% (0.76–0.92)	Apple Watch + iPhone	AF detection by app with irregular pulse notification algorithm	Confirmed by ECG patch worn for 7 days
Goldenthal et al. (2019) [99]	US	61 (12)	RCT	238	77% White, 3% Black 1% Asian 20%, 9% Hispanic	6 months	AF patients who underwent RFA or DCCV	AF recurrence detection	Likelihood of recurrent significantly greater IT*** vs control (HR = 1.56, 1.06–2.3)	KardiaMobile + iPhone + cellular servce plan	Record ECG daily or with symptoms plus motivational texts	Confirmation was determined by patient's provider

Table 4 (continued)

First author	Country	Age mean (SD)	Design	*N*	Race ethnicity	Duration	Inclusion criteria	Primary outcome	Results	Device	Intervention	Health care team interpretation
Koh et al. (2021) [100]	Malaysia	65.3 (7.4)	RCT	203	Not reported	30 days	≥ 55 years without AF and ischemic stroke or TIA within the preceding 12 months	AF detection 30-day monitor KardiaMobile vs 24-h Holter	9.5 vs 2% IT vs control ($P=0.024$)	KardiaMobile	Use KardiaMobile monitor 3 times a day for 30 days	I-lead ECG adjudicated by blinded electrophysiologist
Lubitz et al. (2022) [101]	US	74 (7)	Cluster RCT	30,715	82.4% White, 5.3% Black, 2.2% Hispanic	1 year	≥ 65 years	New AF diagnosis at 1 year	1.72% vs 1.59% IT vs control $P=0.38$	KardiaMobile + iPad	Screening AF at primary care clinic with tracings reviewed by cardiologist	I-lead ECG reviewed by independent cardiologist Confirmation with 12-lead ECG determined by patient's PCP

*And any of the following diagnosis: prior stroke or TIA, heart failure, diabetes and hypertension, mitral valve disease, left ventricular hypertrophy, COPD on home O2, sleep apnea, history of pulmonary embolism, history of myocardial infarction or obesity

**450 returned patches

***IT = intervention

be forthcoming with the limitations present to measure certain metrics in population with darker skin tones [106].

Digital Inclusion

The National Digital Inclusion Alliance (NDIA) defines digital inclusion as the "activities necessary to ensure that all individuals and communities, including the most disadvantaged, have access to and use of Information and Communication Technologies." It is clear that the elderly, certain racial and ethnic, and lower socioeconomic populations continue to be underrepresented in clinical trials of digital health interventions in cardiovascular disease. There is a continued need to test digital health solutions in underrepresented communities to better understand which interventions provide the most benefit. Beyond clinical trials, there also continues to be a gap in the access to key digital

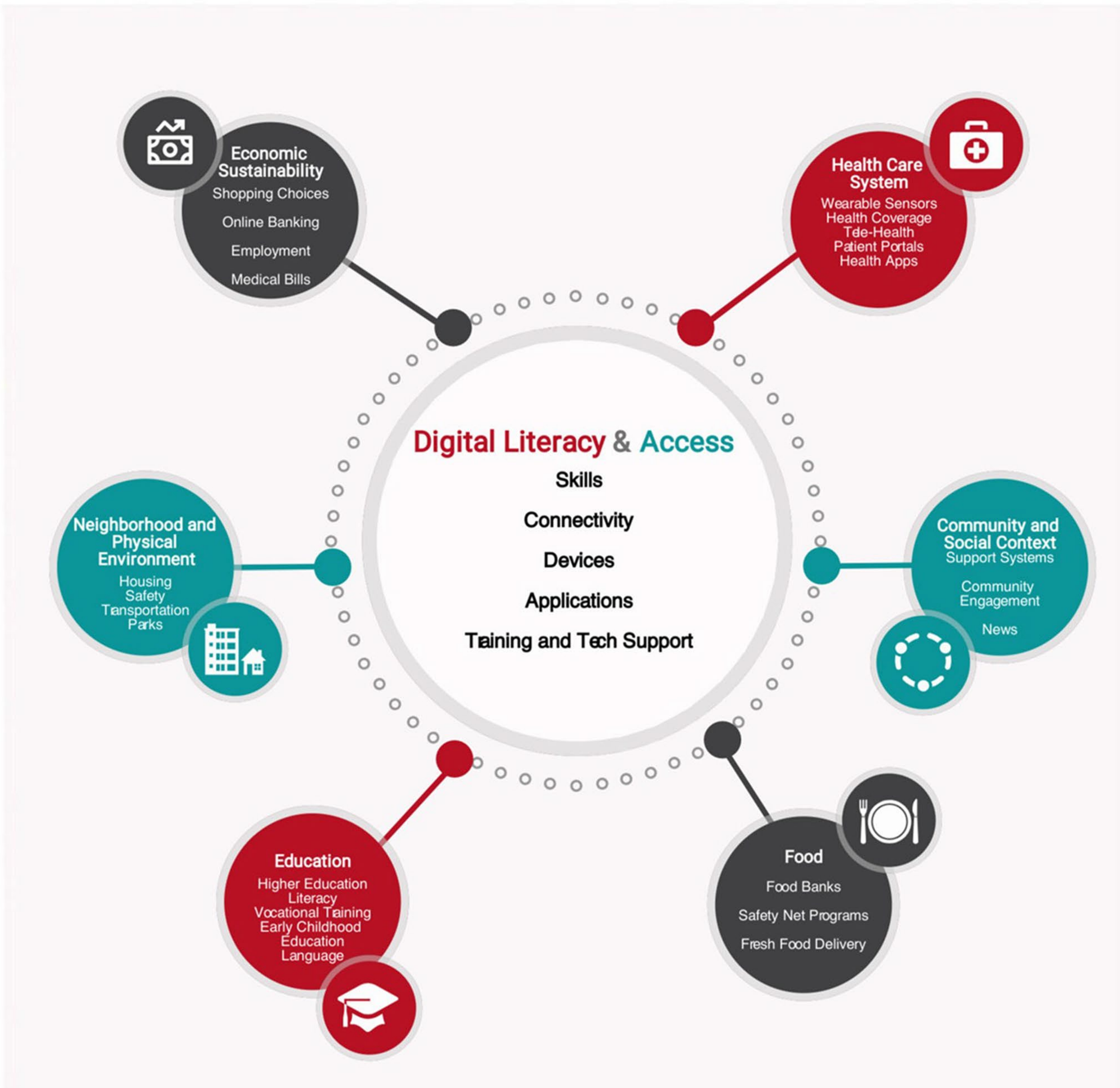

Fig. 1 Digital literacies and social determinants of health. Digital literacy and access, including skills, connectivity, devices, and training and technical support, relate to all other domains of social determinants of health. With permission from Sieck et al., with no changes made [91]. https://creativecommons.org/licenses/by/4.0/

infrastructure in these populations. Attaining digital health equity in cardiovascular care not only requires increased representation of vulnerable populations in clinical trials but also ensured access to the different component of information and communication technologies. In order to improve our current state, proposed solutions should involve multilevel interventions at the individual, family, community, services, and policy level (Fig. 1) [107].

At the individual level, patients require access to affordable devices (smartphone, computer, tablets, etc.), continued access to digital health literacy education, and applications to be created to their level of education, cultural, racial, and ethnic background. The Affordable Connectivity Program, which replaces the Emergency Broadband Benefit, provides the Federal Communications Commission with funds to provide broadband monthly discounts to eligible households in the hopes to improve internet access to communities in need [108]. It is crucial to provide continued, affordable, and easy to access digital education in settings where an individual feels comfortable to address the skills and knowledge gaps in digital health. The American Library Association Digital Literacy Task Force has provided recommendations and online resources to aid schools, academic, and public libraries increase the access to digital health education in their respective communities [109].

Technology companies should partner with communities starting with the inception of the design process. Involvement of these key stakeholders from underrepresented communities in product design and software development will ensure that products are made for and used by a broader audience [110]. Additionally, there needs to be increased representation of diverse employees in the tech sector; in many if the big technology companies, less than 5% identify as Hispanic or Black [111, 112]. Increased representation can not only increase trust when engaging underrepresented communities but enrich the design team's knowledge of the environment where these products are expected to be deployed. In order to advance digital health equity, we should design and develop products aimed at including underrepresented communities with consideration to social determinant of health—based on where people are born, grow, live, work and age.

Perhaps one of the most important domains in order to effect change across all levels is policy changes. Existing programs have expanded the access to devices and broadband internet coverage in low-income communities. The Emergency Connectivity Fund (ECF) is a $7 billion program targeted at helping schools and libraries acquire devices and broadband equipment. Since its first cycle in 2021, the ECF has funded close to 12 million devices and over 7 million broadband connections [26]. Additionally, the Digital Inclusion Act programs not only aim to increase internet access, but support programs to provide underrepresented communities with skills and training necessary to successfully use the internet [113]. To accelerate health equity, we should continue to collaborate with policy makers to renew and expand available programs [5].

Conclusion

Digital health interventions show incredible potential to improve cardiovascular disease detection, prevention and management by obtaining longitudinal, continuous, and actionable patient data; increasing access to care; and decreasing delivery barriers and cost. As the expansion of digital health technologies continues, it is vital to increase representation of minoritized groups in all stages of the process: product development (needs findings and screening, concept generation, product creation and testing), clinical research (pilot studies, feasibility studies, and randomized control trials), and finally health services deployment.

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Declarations

Conflict of Interest Dr. Fatima Rodriguez reports equity from HealthPals and Carta and consulting fees from Novartis, Novo Nordisk, and Amgen outside the submitted work. Dr. Mario Funes Hernandez has no conflict of interest to disclose.

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