

# Rapid review: Identification of digital health interventions in atherosclerotic-related cardiovascular disease populations to address racial, ethnic, and socioeconomic health disparities



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Disparities in cardiovascular disease (CVD) and associated health and healthcare delivery outcomes have been partially attributed to differential risk factors, and to prevention and treatment inequities within racial and ethnic (including language) minority groups and low socioeconomic status (SES) populations in urban and rural settings. Digital health interventions (DHIs) show promise in promoting equitable access to high-quality care, optimal utilization, and improved outcomes; however, their potential role and impact has not been fully explored. The role of DHIs to mitigate drivers of the health disparities listed above in populations disproportionately affected by atherosclerotic-related CVD was systematically reviewed using published literature (January 2008–July 2020) from multiple databases. Study design, type and description of the technology, health disparities information, type of CVD, outcomes, and notable barriers and innovations associated with the technology utilized were abstracted. Study quality was assessed using the Oxford Levels of Evidence. Included studies described digital health technologies in a disparity population with CVD and reported outcomes. DHIs significantly improved health (eg, clinical, intermedi-

ate, and patient-reported) and healthcare delivery (eg, access, quality, and utilization of care) outcomes in populations disproportionately affected by CVD in 24 of 38 included studies identified from 2104 citations. Hypertension control was the most frequently improved clinical outcome. Telemedicine, mobile health, and clinical decision support systems were the most common types of DHIs identified. DHIs improved CVD-related health and healthcare delivery outcomes in racial/ethnic groups and low SES populations in both rural and urban geographies globally.

**KEYWORDS** Cardiovascular disease; Clinical decision support; EHR; Health information technology; mHealth; Patient portals; Telemedicine

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## Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide<sup>1</sup> and is a substantial humanistic and economic burden. Globally, an estimated 23.6 million deaths per year will be attributed to CVD and total direct costs of CVD are projected to be over \$700 billion (US dollars) per year by 2030.<sup>1</sup> Substantial evidence indicates that health disparity populations, including racial and ethnic minorities, such as African Americans, Hispanics, Native Americans, and Asians, and/or individuals of low socioeconomic status

(SES), disproportionately suffer from CVD and have worse outcomes.<sup>2</sup> For example, African Americans have higher rates of heart failure (HF), myocardial infarction, and higher functional impairment from acute coronary syndrome compared to the general population.<sup>3–6</sup> These notable differences in outcomes are partially attributed to CVD prevention and treatment inequities within these groups.<sup>2</sup>

The COVID-19 pandemic has disproportionately impacted health disparity populations and especially those with underlying CVD.<sup>7</sup> Higher rates of complications, morbidity, and mortality in patients with pre-existing CVD have been identified,<sup>8</sup> with ongoing cardiac and vascular tissue involvement during disease progression.<sup>9,10</sup> Of additional concern are reports pointing to the delay in seeking care, and decreased emergency department visits, often with devastating consequences, for people experiencing chest pain and related heart symptoms.<sup>11</sup> Now more than

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## KEY FINDINGS

- A rapid review with curated evidence published from January 2008 to July 2020 assessing the role and impact of digital health interventions (DHIs) in populations affected by atherosclerotic-related cardiovascular disease (CVD) showed DHIs improved health or health-care delivery outcomes in 63% of included studies.
- Hypertension control was the most frequently improved clinical outcome, while telemedicine (42%), mobile health (37%), and decision support tools (8%) were the most common types of DHIs identified. A combination of technology interventions was used 34% of the time.
- The majority of studies focused on race/ethnicity (92%) and/or low socioeconomic status (SES) (87%). DHIs improved CVD-related health and healthcare delivery outcomes in racial/ethnic groups and low SES populations in both rural and urban geographies globally.

ever, it is imperative to reinforce the critical need for addressing escalating cardiovascular morbidity and associated disparities, including the effects of quarantine and increased CVD risks owing to decreased physical activity, social isolation, increased stress, anxiety, and limited access to routine follow-up care.<sup>12</sup> Delivering optimal care remotely through digital health interventions (DHIs) to address CVD-related disparities is urgently needed. Understanding the current evidence and role for digital health tools in remote monitoring, management, and care coordination in addressing CVD disparities can help inform promising interventions for the COVID-19 pandemic.

The objective of this rapid review is to identify the general use and impact of DHIs in health disparity populations with atherosclerotic-related CVD diagnoses globally. Additionally, this review will identify how health disparity populations and their care teams use information and information technology for cardiovascular management and care. Digital health is used to describe the broad category of data, information, and communication technology, such as telemedicine, mobile health (mHealth) applications, and health information technology (HIT) subsets (eg, clinical decision support [CDS], electronic health records [EHRs], and patient portals) for the purposes of improving health and healthcare delivery outcomes.<sup>13</sup> DHIs are being leveraged to reduce inefficiencies, improve access, lower costs, increase quality, and personalize care,<sup>14</sup> and are being used to address health inequalities in populations disproportionately affected by CVD.

## Methods

We conducted this rapid review<sup>15</sup> with systematic approaches to search and critically appraise the existing evidence to perform a qualitative synthesis.

## Search strategy

MEDLINE, the Cochrane Library, and Embase databases were searched for relevant articles published in English from 2008 through July 2020. Search methods are provided in [Appendix Tables A.1–A.6](#). Bibliographies of included studies were manually searched.

## Screening process

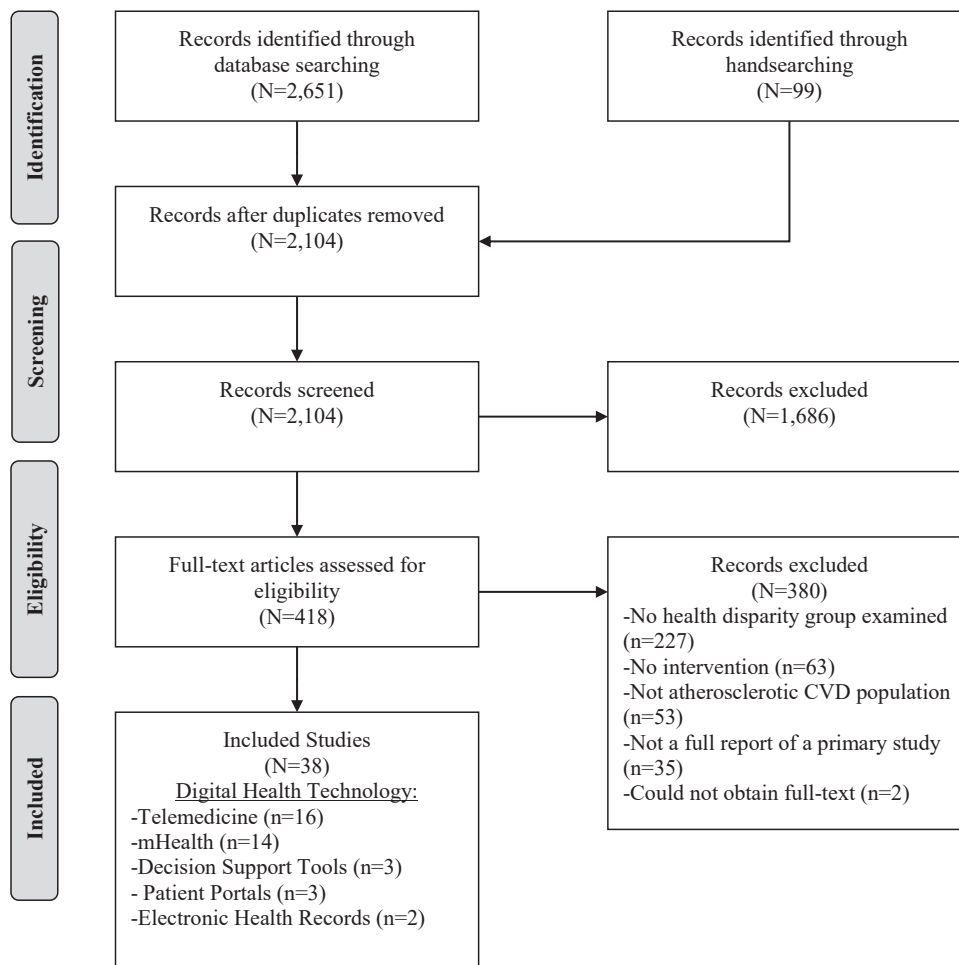
One reviewer screened all titles and abstracts for eligibility against the prespecified inclusion/exclusion criteria ([Appendix Table A.7](#)). Studies marked for inclusion underwent full-text screening by 2 independent reviewers; discrepancies were resolved by adjudication or, if necessary, a third reviewer. All results were tracked in DistillerSR (Evidence Partners, Ottawa, Canada) and in EndNote® (Clarivate, Philadelphia, PA). Included studies described digital health technology as an intervention in patients diagnosed with atherosclerotic-related CVD (including hypertension and congestive HF) in a health disparity population of interest; disparity groups were limited to racial/ethnic minority populations in the United States (US); racial/ethnic majority or indigenous populations outside of the US; rural and urban poor populations; language minorities (those with limited English proficiency); and low SES populations. Low SES examined occupation, income, and/or education with proxy measures allowed ([Appendix Table A.7](#)). Outcomes were limited to health and healthcare delivery, respectively; this included clinical, intermediate, and patient-reported outcomes (eg, mortality, blood pressure [BP], and medication adherence, respectively), and access to care (eg, referrals and access to specialists, ability to pay), utilization of care (eg, scheduling appointments, using resources including DHIs, filling prescriptions), and quality of care (eg, physician adherence to guidelines, testing referral). Interrater reliability was determined by Cohen's kappa.<sup>16</sup>

## Data collection and analysis

Study design, type and description of the technology, health disparities information, type of CVD, outcomes, and notable barriers and innovations associated with the technology utilized were abstracted. Relevant null, negative, and positive qualitative and quantitative outcomes were abstracted and associations with disparity groups of interest were tracked. Study results were described as significant if any relevant outcomes had  $P < .05$ . Statistical analyses refer to group comparisons unless otherwise noted. Detailed descriptions of significant, nonsignificant, and mixed study results, including  $P$  values, are presented in [Appendix B](#).

## Quality assessment

Study quality (based on study design) was assessed using Oxford Levels of Evidence<sup>17</sup> by 2 independent reviewers, and disagreements were resolved by a third reviewer.



**Figure 1** Disposition of articles and literature screening flow diagram. This flow diagram depicts the process and flow of information (including number of records of identified, included and excluded study numbers, and reasons for exclusion) through the phases of the rapid review.

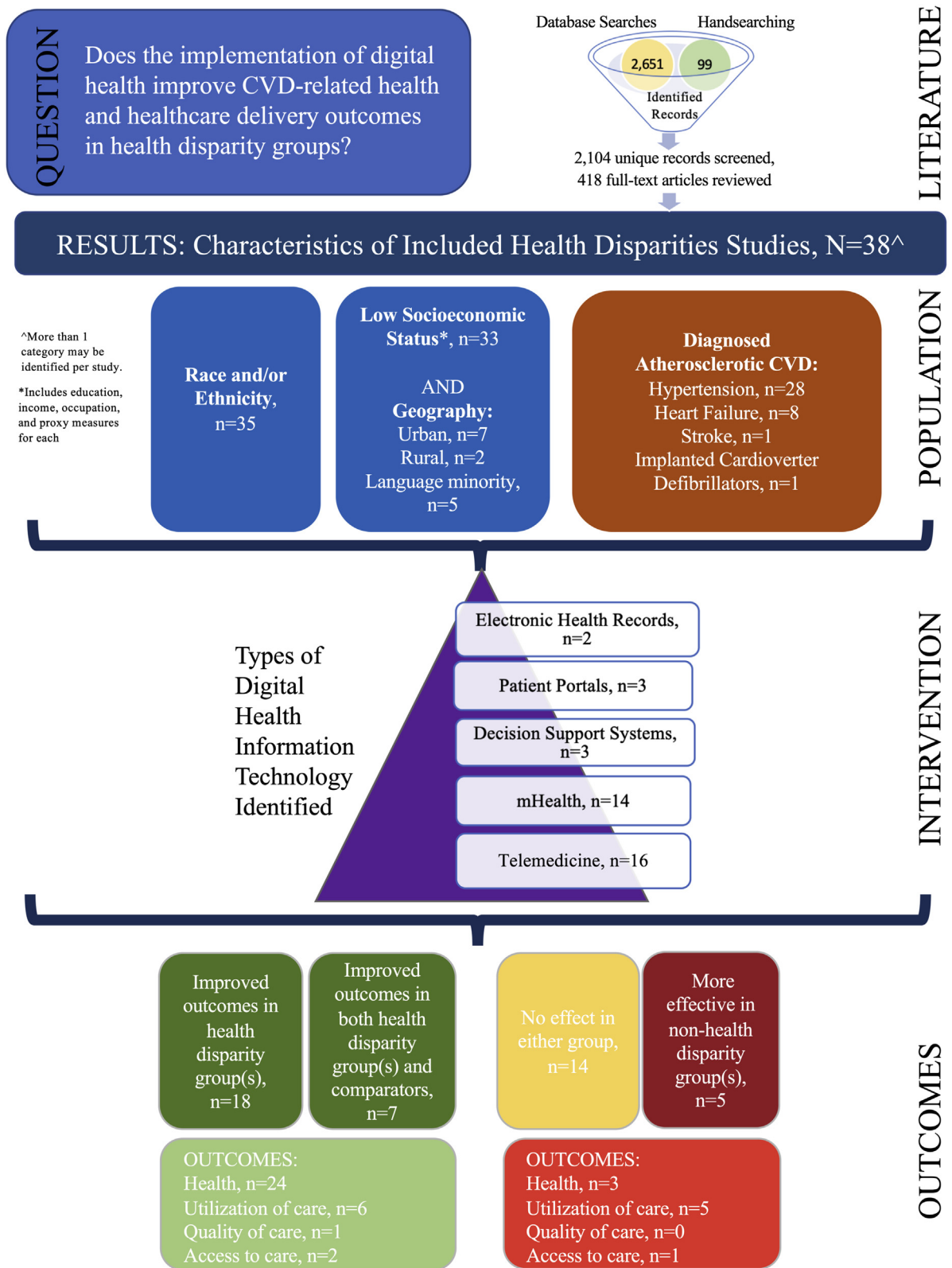
## Results

### Search results, study, and population characteristics

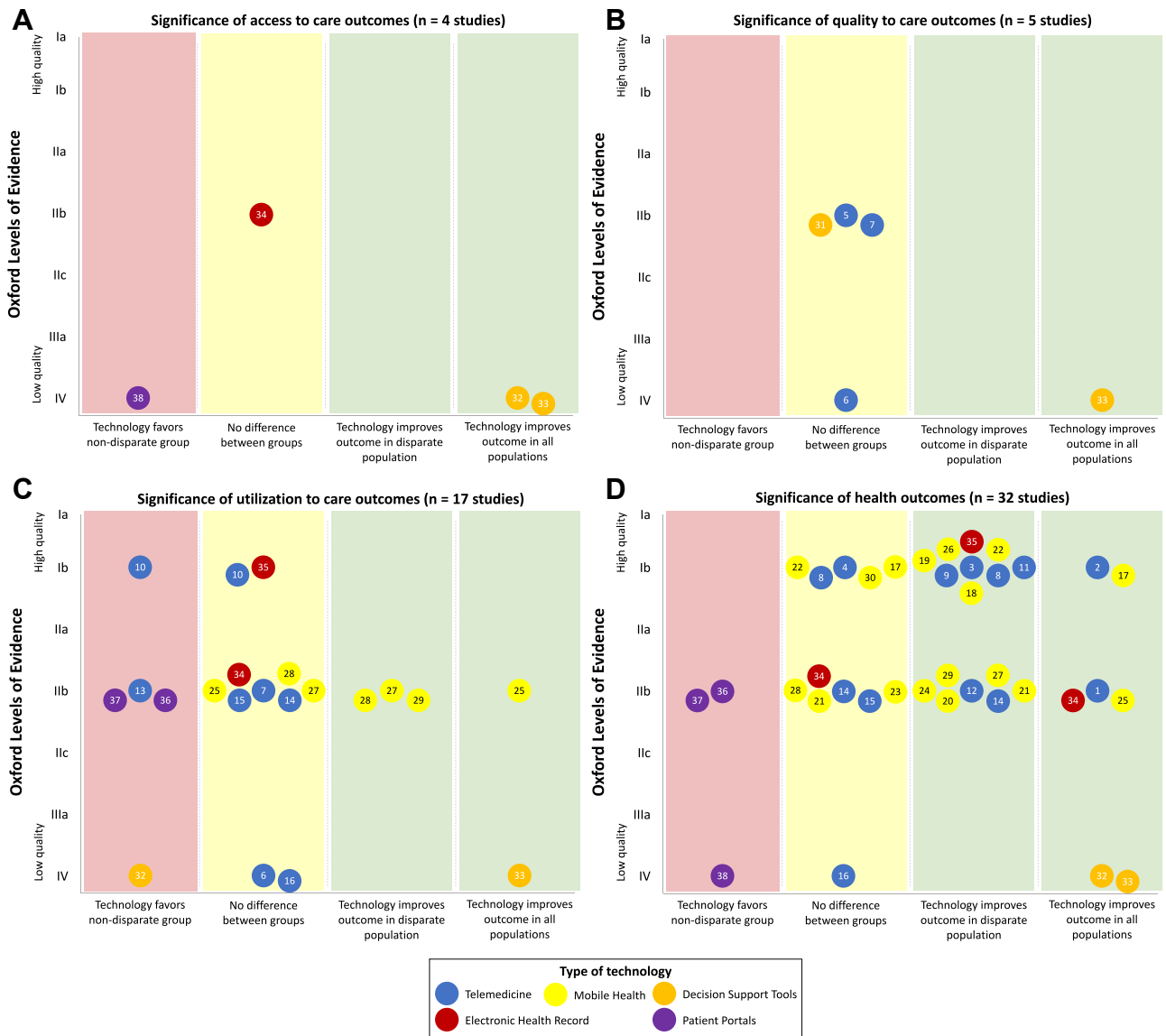
Literature searches yielded 2104 potentially relevant articles after duplicate removal. After screening, 418 citations were identified for full-text screening, of which 38 articles met criteria for inclusion (Figure 1).<sup>18–55</sup> Interrater reliability of eligibility determination had an overall weighted kappa of 79% for full-text screening. A summary of results is provided in Figure 2. Included studies were conducted primarily in the US,<sup>18,20–22,24–32,34,35,37,38,40–46,48,50,51,53–55</sup> but other countries included Cameroon,<sup>39</sup> Bolivia,<sup>49</sup> Honduras,<sup>47,48</sup> India,<sup>19</sup> Lebanon,<sup>52</sup> Mexico,<sup>47,48</sup> Pakistan,<sup>36</sup> and South Africa.<sup>23,33</sup> Most studies focused on race/ethnicity (n = 35, 92%)<sup>18–32,34,35,37,38,40–55</sup> and/or low SES (n = 33, 87%),<sup>19,21–27,29,31–50,52–55</sup> while few studies examined language minorities (n = 5, 13%).<sup>22,33,34,49,53</sup> Within low SES populations, some studies were conducted exclusively in either urban (n = 7, 18%)<sup>21,24,27,32,34,43,45</sup> or rural (n = 2, 5%)<sup>39,52</sup> settings. HTN (n = 28, 74%)<sup>19–25,28,31,33–35,37–43,45,47–50,52–55</sup> and HF (n = 8, 21%)<sup>26,27,29,30,32,44,46,51</sup> were the most common types of

atherosclerotic-related CVD. Characteristics of included studies and their populations are detailed in Appendices B and C. Briefly, study populations spanned American Indian, Asian, black, black Hispanic, Hispanic, Indian, Korean American, mixed, and Pacific Islander races/ethnicities. Low SES was composed of inadequate income; food-insecure; <\$10,000, \$25,000, and \$30,000/year income; unemployed, disabled, and part-time employment; ≤ high school education; low literacy and/or high-information needs; Medicaid; uninsured; and dual eligible backgrounds. Spoken languages included Afrikaans, Arabic, English, indigenous, Spanish, and Xhosa.

The types of digital health technologies identified as interventions were telemedicine (n = 16, 42%),<sup>18,20,21,24,27,30,32,34,35,37–39,42,43,46,51</sup> mHealth (n = 14, 37%),<sup>23,25,27,28,33,36,40,44,45,47–49,52,55</sup> CDS systems (n = 3, 8%),<sup>19,29,54</sup> patient portals (n = 3, 8%),<sup>31,41,50</sup> and EHRs (n = 2, 5%).<sup>22,53</sup> Thirteen studies used combinations of technologies to provide an intervention.<sup>20,21,24,27,29,31,40,41,47–50,54</sup> Most studies measured intervention effects on health outcomes (n = 32),<sup>18,20–26,28,29,31,33–36,38–41,43–55</sup> and many assessed utilization of care (n = 17),<sup>22,29,30,32,37,41–43,45,46,48–54</sup> but



**Figure 2** Visual summary of the study characteristics and findings. Stepwise summarization of study development and execution including research question, identification of literature, and characterization of results stratified by population, intervention, and outcomes. CVD = cardiovascular disease.



**Figure 3** Quality of the evidence and stratification of outcomes by technology. The x-axis indicates the result of the intervention (technology favors nondisparate group, no difference between groups, technology improves outcome in disparity group, technology improves outcome in all populations) on study outcome(s) organized by (A) access to care, (B) quality of care, (C) utilization of care, and (D) health outcomes including clinical, intermediate, and patient-reported measures. The y-axis lists the study quality from low (IV) to high (Ia) according to Oxford Levels of Evidence assessment.<sup>15</sup> The type of technology is denoted by colored circles and the number in each circle corresponds to the study reference ID (enumerated below). Some studies improving outcomes in disparate populations did not have a nondisparity group comparator. See Appendix B for more details regarding study follow-up and/or adherence to technology in context to reported outcomes and our summary of study conclusions. Numbers in circles represent the following studies: (1) Akar et al (2015),<sup>18</sup> (2) Asche et al (2016),<sup>20</sup> (3) Bennett et al (2012),<sup>21</sup> (4) Bove et al (2013),<sup>24</sup> (5) Dang et al (2017),<sup>27</sup> (6) Finkelstein et al (2010),<sup>30</sup> (7) Gross-Schulman et al (2017),<sup>32</sup> (8) Hebert et al (2012),<sup>34</sup> (9) Jackson et al (2012),<sup>35</sup> (10) Kerby et al (2012),<sup>37</sup> (11) Kim et al (2011),<sup>38</sup> (12) Kingue et al (2013),<sup>39</sup> (13) McCant et al (2009),<sup>42</sup> (14) Migneault et al (2012),<sup>43</sup> (15) Pekmezaris et al (2019),<sup>46</sup> (16) Rosen et al (2017),<sup>51</sup> (17) Bobrow et al (2016),<sup>23</sup> (18) Chandler et al (2019),<sup>25</sup> (19) Dang et al (2017),<sup>26</sup> (20) Davidson et al (2015),<sup>28</sup> (21) Hacking et al (2016),<sup>33</sup> (22) Kamal et al (2015),<sup>36</sup> (23) Lewinski et al (2019),<sup>40</sup> (24) Nundy et al (2013),<sup>44</sup> (25) Patel et al (2013),<sup>45</sup> (26) Piette et al (2012),<sup>47</sup> (27) Piette et al (2013),<sup>48</sup> (28) Piette et al (2014),<sup>49</sup> (29) Saleh et al (2018),<sup>52</sup> (30) Skolarus et al (2018),<sup>55</sup> (31) Anchala et al (2013),<sup>19</sup> (32) Evans et al (2017),<sup>29</sup> (33) Shelley et al (2011),<sup>54</sup> (34) Bettano et al (2019),<sup>22</sup> (35) Schoenthaler et al (2020),<sup>53</sup> (36) Manard et al (2016),<sup>41</sup> (37) Price-Haywood et al (2018),<sup>50</sup> (38) Green et al (2011).<sup>31</sup>

few studies evaluated quality of care (n = 5)<sup>19,27,30,32,54</sup> or access to care (n = 4).<sup>22,29,31,54</sup>

The role of digital health technology to address drivers of health and healthcare outcome disparities in populations disproportionately affected by CVD was assessed (Appendix B). Figure 3A–3D illustrates each type of statistically significant outcome for the interventions with respect to

their improvement in disparity populations vs non-disparity groups observed. The successful use of digital health technology in health and healthcare delivery to improve outcomes was noted in 58 outcomes measured across 24 studies,<sup>18,20–23,25,26,28,29,33–36,38,39,43–45,47–49,52–54</sup> and 14 of those studies demonstrated statistically significant improvement in outcomes in an

exclusively examined disparate population(s) of interest.<sup>21,25,26,28,33,34,38,39,43,47-49,52,53</sup>

## Telemedicine

Sixteen studies (42%) described telemedicine interventions that used a variety of approaches to evaluate and/or address health disparities in populations of interest with CVD. Telemedicine categorizations also included telemonitoring, telemanagement, telecare, automated telecommunications, and electronic health (eHealth) interventions. The effect of telemedicine in disparate populations was examined in racial/ethnic groups ( $n = 15$ ), low SES populations ( $n = 13$ ), and language minorities ( $n = 1$ ). Of the studies in low SES populations, some were conducted exclusively in rural<sup>39</sup> or urban settings.<sup>21,24,27,32,34,43</sup> Person-to-person communication (via the telephone or the internet) regarding health care by remote assessment and/or consultation with patients was assessed in all telemedicine studies. Eight studies targeted at-home BP monitoring.<sup>20,24,34,35,37,38,42,43</sup> Other studies assessed the impact of remote monitoring of an implantable cardioverter-defibrillator<sup>18</sup> and telemonitoring for HF management.<sup>27,30,32,46,51</sup>

Eight telemedicine studies reported improved health outcomes (clinical, intermediate, or patient-reported) primarily observed in hypertensive or HF patients.<sup>18,20,21,34,35,38,39,43</sup> Of these studies, 6 were conducted exclusively in a disparity group<sup>21,34,38,39,43</sup> and 1 intended to address disparity in a heterogeneous population.<sup>35</sup> Clinical improvements of telemedicine interventions included lowered risk of mortality in a retrospective cohort study of disparate (hazard ratio [HR] 0.74, 95% confidence interval [CI] 0.66–0.83) and nondisparate groups (HR 0.66, 95% CI 0.63–0.70) with an implantable device<sup>18</sup> and decreased weight (–1.07 kg, 95% CI –1.94 to –0.22) and body mass index (–0.41, 95% CI –0.73 to –0.9) in a randomized controlled trial (RCT) with obese, low SES patients receiving hypertension treatment.<sup>21</sup> Intermediate or surrogate measures that improved with telemonitoring were BP control<sup>20,38,39</sup> and decreased systolic (SBP) and/or diastolic BP (DBP).<sup>34,35</sup> Five studies evaluated the ability of home BP monitoring to improve or control BP<sup>20,34,35,38,43</sup> in US settings, and racial and ethnic groups benefited most when telemonitoring was paired with tailored counseling management.<sup>34,35,38</sup> In 1 RCT, BP monitoring improved BP more in black patients than in non-Hispanic white patients (–9.7 mm Hg SBP,  $P = .003$ ; –4.8 mm Hg DBP,  $P = .01$ ),<sup>35</sup> while a separate RCT found BP monitoring improved BP control regardless of race (odds ratio 3.64,  $P < .001$ ).<sup>20</sup> In exclusive disparity populations, urban blacks and Hispanics, Korean Americans, and black groups had significant improvements in hypertension-related measures following telemedicine interventions. Patient-reported outcomes included improvement in diet quality (+3.5 points,  $P < .03$ ) and total energy expenditure (+80 kcal/day,  $P < .03$ ) in hypertensive urban black populations with low SES in an RCT.<sup>43</sup> However, nonsignificant changes in health outcomes were observed for medication adherence in this same trial,<sup>43</sup> quality of life in a separate RCT,<sup>46</sup> and hospital admissions in a pre-post study<sup>51</sup>

following telemedicine interventions; BP control had mixed results in racial and ethnic minorities in separate RCTs.<sup>24,43</sup>

The impact of telemedicine on healthcare utilization (HCU) in the form of technology protocol adherence and use of services had mixed effects on disparate populations. Of 7 studies on HCU, 2 RCTs identified that telemedicine adherence was 14%–17% ( $P = .03$  and  $P = .002$ ) more likely in white groups<sup>37,42</sup> than other racial groups and in high SES populations;<sup>37</sup> however, 1 pre-post study and 1 RCT reported no differences in adherence between racial groups<sup>51</sup> or among urban blacks.<sup>43</sup> One RCT noted that telemedicine had no impact on emergency department visits, nor on hospitalization for disparity groups,<sup>46</sup> while a retrospective case series provided that telemanagement systems would reduce the number of hospital visits for black HF patients<sup>30</sup> and an RCT that use of telemonitoring would reduce costs by 95% in urban, low SES populations.<sup>32</sup>

Two telemedicine RCTs and 1 telemedicine retrospective case series noted quality outcomes for disparity groups of interest with HF.<sup>27,30,32</sup> The RCT evaluating automated remote monitoring in an urban, indigent population indicated the technology was comparable to human performance by assessing decision concordance.<sup>32</sup> The RCT managing HF via telemedicine in urban settings improved care in black populations<sup>27</sup> and the retrospective case series enhanced satisfaction of care in black and Hispanic groups.<sup>30</sup>

Eleven telemedicine interventions were used in conjunction with secondary technologies, primarily including internet-based services and CDS. Remote monitoring and its related data transmission and storage was dependent on secure servers and websites.<sup>20,21,24,30,35,37,42,46,51</sup> A variety of CDS tools (eg, alerts and reminders for providers and patients; algorithms derived from clinical treatment guidelines; documentation templates; condition-specific order sets; and contextually relevant reference information) were leveraged with telemedicine interventions.<sup>20,27,30,32,35,42</sup> For example, in an RCT, Gross-Schulman and colleagues<sup>32</sup> used automated speech recognition with a decision logic tree to facilitate telephonic data collection to monitor patients with HF and identify decompensation risk. Additionally, a retrospective case series feasibility study by Finkelstein and colleagues<sup>30</sup> used telemedicine with gamification features to collect patient-specific data and subsequently develop personalized treatment plans for African-American congestive HF patients for the improvement of disease management. Other technologies less readily integrated with telemedicine were EHRs, mobile phones, and wireless medical devices. No patterns or trends could be identified with the addition of multiple technologies related to impact on outcomes, other than that interventions successful at improving outcomes were used in hypertensive patients.<sup>20,21,35,39,42</sup>

## Mobile health

Fourteen studies (37%) evaluated the impact of using mHealth interventions on health disparities in populations of interest with CVD. The categorization of mHealth

included technologies that leveraged mobile telephones to send/receive text messages, utilized global positioning systems, or were smartphone software applications (apps). The effect of mHealth in disparity populations was examined in racial/ethnic groups ( $n = 10$ ), low SES populations ( $n = 13$ ), and language minorities ( $n = 2$ ). Of the studies in low SES populations, some were conducted in exclusively rural<sup>52</sup> or urban settings<sup>45</sup> or majority urban populations.<sup>36</sup> The intentions of identified mHealth studies were to support medication adherence,<sup>25,28,36,45,47–49</sup> facilitate BP monitoring,<sup>23,40,47–49,55</sup> provide health information,<sup>33,36,37,47–49,52</sup> or manage HF<sup>26,44</sup>; 4 studies described multiple intentions to improve CVD-related health and healthcare outcomes.<sup>36,47–49</sup>

Twelve mHealth studies reported statistically significant improvements in health outcomes (intermediate or patient-reported) primarily observed in patients with hypertension, diabetes and hypertension, or HF.<sup>23,25,26,28,33,36,44,45,47–49,52</sup> Of these studies, 8 were conducted exclusively in a disparity group.<sup>25,26,28,33,47–49,52</sup> Intermediate or surrogate measures that improved with mHealth were BP control (13%–64.3%), or decreased SBP or DBP (–2.2 mm Hg to –25 mm Hg).<sup>23,25,28,36,45,47</sup> Interventions intended to improve BP-related outcomes in disparity populations were effective in language minorities,<sup>49</sup> racial/ethnic groups (eg, black, Hispanic,<sup>25,47,48</sup> black Hispanic<sup>28</sup>) and low SES populations,<sup>23,25,28,36,45,47–49,52</sup> some of which were urban,<sup>36,45</sup> refugee and rural,<sup>52</sup> or low-to-middle income country settings.<sup>47–49</sup> Improved patient-reported measures regarded medication adherence (0.54–3.0 increase on Morisky Medication Adherence Scale),<sup>25,33,36,45,47,49</sup> disease management,<sup>26,44</sup> health distress,<sup>26</sup> quality of life,<sup>26</sup> self-care,<sup>44</sup> patient satisfaction with care,<sup>47,52</sup> and symptom monitoring.<sup>47–49</sup> Technologies to monitor and support medication adherence varied, from the use of electronic medication trays to messaging patients by app or text message on mobile devices. Nonsignificant changes to intermediate BP-related outcomes were noted in 2 controlled trials, whereby mHealth did not improve SBP or DBP after 6 months of follow-up in predominantly black, low SES populations.<sup>40,55</sup> Notably, higher mHealth engagement did not improve SBP.<sup>40</sup> Medication adherence<sup>55</sup> and health knowledge<sup>33</sup> were not improved in 2 RCTs with black, low SES populations after receipt of SMS messaging.

The impact of mHealth on HCU in the form of technology protocol adherence and use of services had mixed effects on disparate populations. Three<sup>48,49,52</sup> out of 4 mHealth HCU studies (3 cohort and 1 pre-post)<sup>45,48,49,52</sup> improved contact and utilization rates in hypertensive patients in disparity settings; however, multivariate analyses assessing the impact of educational attainment and employment in low SES populations had differing results in low-to-middle-income countries.<sup>48,49</sup> None of the 14 mHealth studies reported on access to or quality of health care.

Six mHealth interventions were used in conjunction with secondary technologies, primarily including CDS and EHRs.<sup>23,26,40,47–49</sup> CDS provided algorithms for HF

worsening<sup>26</sup> and HTN monitoring,<sup>47–49</sup> in addition to providing alerts to the healthcare team, patient, and care providers in disparate populations. Integration of EHRs with mHealth had positive impacts in 1<sup>23</sup> of 2 studies<sup>23,40</sup> whereby 12-month follow-up of a text messaging intervention improved SBP and DBP (OR 1.41, 95% CI 1.02–1.95) in predominantly black South African hypertensive patients with limited education.

### Clinical decision support systems

CDS tools improved health outcomes and cardiac care access, utilization, and quality in health disparity populations. Three studies (8%), 2 pre-post and 1 cohort,<sup>19,29,54</sup> utilized decision support tools as the primary intervention technology. Racial/ethnic groups ( $n = 3$ ) and low SES populations ( $n = 2$ ) were examined. Two pre-post studies evaluating CVD health outcomes found improvement in mortality (HR 0.48, 95% CI 0.34–0.69,  $P < .001$ )<sup>29</sup> and HTN control (9.9%,  $P < .001$ )<sup>54</sup> in both disparate and nondisparate groups. CDS tools also positively increased healthcare access with 21% more referrals to specialized heart facilities in all groups ( $P < .001$ )<sup>29</sup> and 9.6%–45.6% increases in guideline-recommended testing and examinations in non-Hispanic black and Hispanic populations ( $P < .001$ ).<sup>54</sup> HCU outcomes had mixed results, CDS-referred nonwhite patients were less likely to visit specialized heart facilities (HR 0.79, 95% CI 1.10–1.44,  $P = .001$ ),<sup>29</sup> but CDS increased follow-up appointment scheduling by 2% ( $P < .05$ ) in racial and ethnic minorities.<sup>54</sup> As noted in previous sections, decision support tools were secondary technologies in 7 study interventions.<sup>20,26,27,30,32,35,42,47–49</sup>

### Patient portals

Three studies (8%), all retrospective cohorts, used patient portals and all noted the intervention was more effective at reducing or controlling BP in nondisparate groups when compared to disparate groups.<sup>31,41,50</sup> Racial/ethnic and income disparities in the use and degree of use of patient portals were identified in each of these studies; 4%–19% more white patients or those with higher SES status utilized patient portals ( $P < .001$ ), and white patients used them more frequently.<sup>41,50</sup> Green and colleagues<sup>31</sup> demonstrated that patients in low SES populations were less willing to participate in web-based portal interventions, often because they lacked access to computers and/or had low technology literacy (adjusted relative risk for no computer access 1.41–3.22). Examination of BP following patient portal use identified that participants with white race, higher SES, and non-minorities were 12%–33% more likely to achieve BP control.<sup>31,41,50</sup> As patient portals are a subset of HIT, all 3 studies used EHRs as secondary technologies.

### Electronic health records

Two studies (5%), 1 RCT and 1 retrospective cohort, assessed the interventional application of EHRs in Spanish-speaking hypertensive patients with low SES for

community-based e-Referrals<sup>22</sup> and identification of patients for medication adherence coaching.<sup>53</sup> Health outcomes were improved; self-reported medication adherence increased 0.72 on the Morisky Medication Adherence Scale-8 ( $P = .03$ ) with EHR-linked coaching in both disparate and nondisparate groups,<sup>53</sup> and patients receiving e-Referrals had 66% greater odds of achieving BP control (95% CI 1.4–2.0).<sup>22</sup> HCU was not improved in disparity groups. Completion rates of e-Referrals over 3 years and 6 months in a retrospective cohort study of electronic monitoring of adherence with coaching were not significantly different between or among groups.<sup>22</sup> Access to care was improved with e-Referrals, whereby Hispanic patients had 26% higher odds of e-Referral than non-Hispanic patients (95% CI 1.1–1.4).<sup>22</sup> As mentioned previously, EHRs were secondary technologies in 8 studies.<sup>20,23,29,31,40,41,50,54</sup>

### Study quality

Based on Oxford Levels of Evidence assessments (Appendix B, Figure 3), 14 studies provided level 1b evidence as randomized controlled trials.<sup>20,21,23–26,34–38,47,53,55</sup> Nineteen studies were low-quality interventional studies or observational cohort studies, which represented level 2b evidence.<sup>18,19,22,27,28,32,33,39–46,48–50,52</sup> The remaining 5 studies were low-quality observational studies, representing level 4 evidence.<sup>29–31,51,54</sup> The majority (87%) of included studies are moderate to high quality.

### Discussion

This rapid review identified a variety of technologies and examined how the implementation of digital health tools in the delivery of health care may improve CVD management and treatment in health disparity populations. The most common DHIs were telemedicine (42%) and mHealth (37%), used primarily in hypertensive and/or HF patients in populations of low SES and/or racial/ethnic minorities of the US. HIT was less frequently identified, which included decision support tools (8%), patient portals (8%), and EHRs (5%). Many (63%) studies reported benefits of DHIs to improve 1 or more CVD-related health or healthcare outcomes. For example, in a pre-post study Shelley and colleagues<sup>54</sup> described the impact of a decision support tool that improved disparity population intermediate outcomes in addition to enhancing access, quality, and utilization of care outcomes for hypertensive patients. This tool generated alerts to identify hypertension, provided a template for clinicians to collect relevant information, displayed a list of tests and treatment relevant to hypertension, and generated clinical reminders to prompt clinicians.<sup>54</sup> After its implementation, patients who were Hispanic, black, or of low SES status had lower BP, and providers were more likely to be compliant with clinical practice guidelines, order appropriate tests, and schedule follow-up appointments for their patients.

Digital health technologies can help to improve CVD outcomes by overcoming barriers in health disparity populations. When patients are unable to meet with clinicians in person

because of distance to healthcare facilities, inability to miss work, or lack of transportation, telemedicine can fill an important gap. Barriers can be reduced or eliminated when patients can be monitored or treated remotely using telemedicine interventions. For instance, reaching patients in remote parts of Cameroon was virtually impossible prior to the development of a telemedicine network to provide telecare via mobile phones.<sup>39</sup> This 24-week prospective interventional telemedicine study successfully increased the proportion of stage III HTN patients with controlled blood pressure by 10.9% ( $P = .04$ ), suggesting that in at least some scenarios barrier removal can provide clinically relevant improvements in disparity populations. The application of telemedicine to routine clinical practice and general health care using audio, video, and data communications has global effects on a variety of outcomes; however, despite lowering cost and quality of care comparable to usual care,<sup>32</sup> the telemedicine interventions identified in this rapid review generally had no significant effect on, or resulted in negative HCU in, disparity populations with CVD.<sup>37,42,43,46,51</sup> These differences may be attributed to short duration of follow-ups, lower reported adherence to technology, and/or incorporation of care team-led case management in the intervention.<sup>34</sup>

Individuals with chronic conditions, including CVD, require consistent evidence-based intervention and are at highest risk for inequalities in treatments and outcomes. For successful treatment of CVD, behavior changes to physical activity, diet, and medication adherence are required. However, lifestyle change adherence may not be sustainable when only relying on periodic medical visits. Patient-centered mHealth interventions may provide the opportunity to support behavior change and attenuate health disparities, as patients can receive real-time, personalized support. Across different types of CVD, mHealth interventions in retrospective and prospective cohort studies resulted in 43%–79% contact rates, enabling contact with even illiterate or limited-education patients; they also improved self-reported symptom monitoring, medication adherence, or behavior change in 27%–75% of patients.<sup>48,49,52</sup> This range of results was largely dependent on education, employment, and other disparity factors, highlighting the persistence of disparity factors to affect even the results of successful interventions and the fact that DHIs alone are unlikely to eliminate health disparities.

Of the digital health technologies, mHealth may have the greatest potential for intervention because of the extensive use of mobile phones in health disparity populations, particularly for racial/ethnic minority communities.<sup>56</sup> However, lower-income, less well-educated individuals living in poor neighborhoods, particularly rural, are infrequent users of digital health tools. Policy improvements to advance education and technological literacy, as well as access to low-cost digital technology, may accelerate the implementation of cost-effective DHIs in disparate CVD populations.

Some obstacles in the implementation of digital health technology to address disparities are technology access and literacy, as well as cultural and linguistic competencies. A



digital divide persists globally, whereby there is an economic and social inequality related to the use and understanding of information technologies. To circumvent the digital divide that may foster health disparities, it is important to address lack of infrastructure supporting broadband internet access as an important social determinant of health. Restricted or limited access to digital health tools that rely upon the internet further exacerbate deficiencies in access to care and its quality. Similarly, a retrospective cohort study by Green and colleagues<sup>31</sup> found that more than half of the sampled patients were ineligible for their study because they lacked computer access. This may mean that the results from Green and colleagues<sup>31</sup> are not generalizable to disparity populations overall, because many disparity populations lack computer access. Poor literacy and health literacy may also be a challenging barrier, particularly for written communication such as text messages or internet-based messaging.<sup>36</sup> Additionally, the design of culturally appropriate DHIs is essential, as culture influences many aspects of an individual's health care, including trust and rapport. Three RCTs explicitly described the implementation of culturally adapted DHIs for disparity groups.<sup>25,43,55</sup> Disparities may also be exacerbated in non-English speakers, as digital health technologies may be understudied in addressing disparities in language minority populations; only 5 such studies were identified,<sup>22,23,33,34,49</sup> 4 of which used mHealth interventions.<sup>23,33,34,49</sup>

Digital health technologies and advanced analytical tools remain underutilized by healthcare stakeholders and individuals to address health disparities in patients with CVD. Advanced analytical tools like clinical algorithms, application programming interfaces to assess big data insights, and AI-based tools should be further investigated to supplement digital health technology for the reduction of CVD-related health disparities. For example, in remote BP-monitoring telemedicine RCTs assessing intermediate outcomes, only DHIs that combined remote monitoring with some type of human counseling were able to improve blood pressure control.<sup>20,24,34,35,38,43</sup> Advanced analytics could be designed to supplement these DHIs, enabling less frequent and more targeted human contact by identifying the ideal context, timing, and frequency of support. To ensure timely access to high-quality, safe, and effective digital products and promote their integration into healthcare delivery, the US Food and Drug Administration recently launched a digital health innovation plan.<sup>13</sup> This regulatory approval process was designed to support the development and commercialization of digital health tools to augment clinical decision-making and support patient management, promoting the innovation of AI and its utilization in health care.

This rapid review has several strengths and some limitations. A systematic search of multiple databases was performed, and hand-searching of included studies was performed to identify all relevant studies. The broad inclusion criteria captured the entire scope of the literature related to DHIs used to address health disparities in atherosclerotic-related CVD. Furthermore, rigorous methodology was applied and the majority of the

studies were of moderate to high quality. Limitations included limiting queries to English-only studies, variable quality of evidence, inclusion of few randomized studies, and heterogeneity in the type of atherosclerotic-related CVD assessed, intervention design, patient characteristics, and outcomes. This heterogeneity precluded statistical analysis across studies, limiting the strength of conclusions that can be drawn beyond individual studies. Scalability for each DHI was not assessed but is an important consideration given that the sample sizes in the studies identified ranged from tens to thousands of participants. End-user adherence to technology is an important confounder in the assessment of the effect of DHIs. The studies included in our rapid review reported adherence inconsistently and in general had limited follow-up durations. Finally, measurement of patient interest in DHI use was rarely assessed outside of the context of evaluating specific DHI and may be a significant confounder: 15% of those contacted in 1 study refused to participate based on their unwillingness to use a patient web portal.<sup>31</sup>

## Conclusion

Identified disparities in the management and treatment of patients with CVD were improved by DHIs, specifically in populations with racial/ethnic minorities and low SES in both rural and urban geographies. Effects in language minority populations are unclear owing to the paucity of evidence. This work can serve to identify DHIs and approaches for detailed future investigation based on the significance and relevance of their outcomes, their positioning in the CVD DHI landscape, and best practices and lessons learned from studies to date. Future work should also be extended to examine DHI use in other health disparity groups, such as LGBTQ+ patients.

## Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.cvdhj.2020.11.001>.

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