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Scoping review: exploring the equity impact of current digital health design practices

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Abstract

Background: Digital health interventions designed through human-centered design (HCD) have shown potential to impact health equity. This scoping review aims to understand how HCD approaches in digital health impact health equity.

Methodology: A scoping review was undertaken. Searches were conducted on PubMed, EMBASE, Web of Science, AMC Digital Library, ProQuest Thesis and Dissertations and Global Medicus Index databases.

Results: A total of 6169 references were identified, and 40 of them fulfilled the inclusion criteria for analysis. The application of HCD methodologies varied greatly as did the digital health interventions. The HCD methodologies had an impact on health equity for those individuals included in the development of the digital health tools, but beyond those persons, the impact was harder to establish.

Conclusion: There is optimism for the role that HCD in digital health can have in reducing health inequities; however, the evidence is not robust. Most projects failed to scale up to maturity or failed to apply evaluation mechanisms to assess the health equity impact. Recommendations include rigorous application of HCD methodologies, scaling digital health tools beyond pilot projects, and embedding evaluation to determine the impact on health equity.

Keywords: digital health, digital intervention, eHealth, mHealth, human-centered design, design, health equity, inequity, scoping review

INTRODUCTION

Health is an essential human right that can only be attained by everyone through reducing existing health inequities [1]. However, developed and developing countries alike are far from achieving health equity. For example, although people are living longer than before worldwide, the life expectancy gap between different groups of people continues to widen [2–4]. Out of the many approaches to tackling health inequity, digital health is one that continues to grow in relevance in part because digital technology is everywhere and because from the very beginning, digital health interventions have augured a new era of health equity through better and more accessible care for all [5–7]. The aim of this scoping review is to understand how human-centered design (HCD) approaches in digital health have an impact on health equity.

Health inequity and equity

Though health equity can be simply described as the belief that every human being, regardless of their background, should have a fair opportunity to be healthy [8], it actually encapsulates greatly complex and multi-dimensional ideas. The understanding and definitions of health equity have changed through the years, depending on the societal contexts in which those definitions were created and the purpose for which they were being used [9–13]. In the 1980s the World Health Organization commissioned

a series of papers on health equity, culminating in what has become a foundational definition for inequity in health [11, 14]: ‘The term inequity ... refers to differences in health which are not only unnecessary and avoidable but, in addition, are considered unfair and unjust.’ The core idea is that if health differences arise from what are considered avoidable determinants of health, such differences would be unfair and unjust. Many social, economic, physical and behavioral determinants are considered avoidable, while most individual characteristics, such as gender and genetics, are not (Fig. 1).

Through the 1990s and early 2000s, other scholars and practitioners built on and refined this definition. In 2001 Starfield [17] defined equity in health as ‘the absence of systematic differences in one or more aspects of health status across socially, demographically, or geographically defined populations or population subgroups’, highlighting the fact that disparities in health need to occur across socially, economically, demographically or geographically defined populations and not at random or sporadically in order to be considered health inequity. Later, Braveman and Gruskin [9] provided a definition that sought to facilitate ‘measurement and hence accountability’ by defining health equity as ‘the absence of systematic disparities in health (or in the major social determinants of health) between social groups who have different levels of underlying social advantage/disadvantage’. For the authors, underlying social advantage or disadvantage implies wealth, power, prestige or deprivation that can take different

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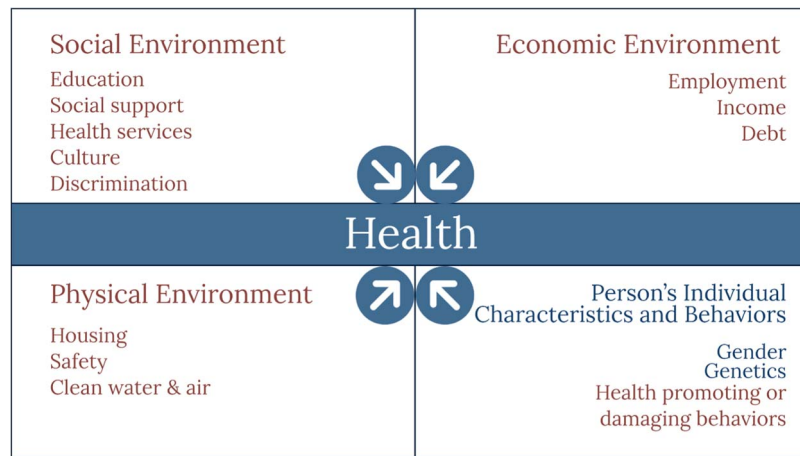


Figure 1. Determinants of health. Avoidable determinants of health are in red, and nonavoidable determinants of health are in blue. Adapted from *Beyond Healthcare: The role of Social Determinants in Promoting Health and Health Equity* [15] and *Determinants of Health* [16]

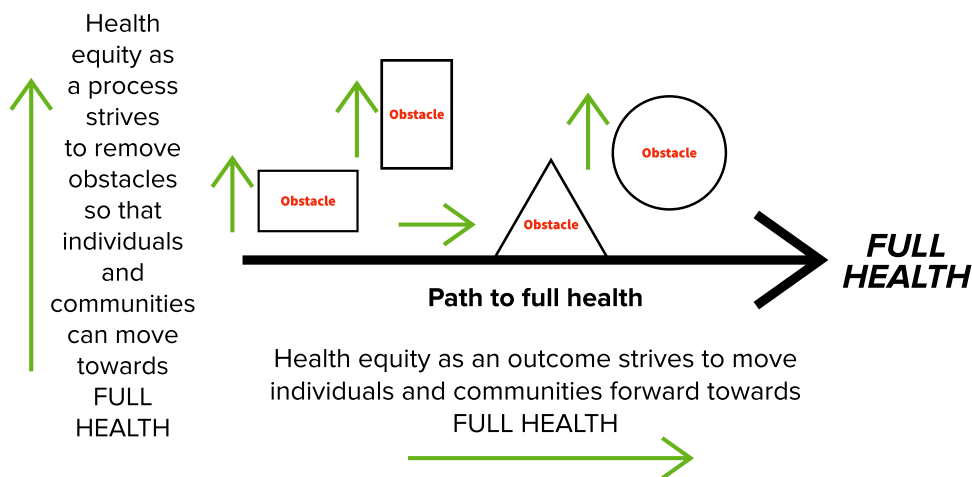


Figure 2. Visual representation of Braveman *et al.*'s definition of health equity

forms in different contexts or parts of the world. This definition offered a baseline (the underlying social advantage or disadvantage) against which further health disparities could be measured.

All these definitions touched on the key concepts of a comprehensive health equity definition, namely, showing the importance of justice and fairness, being actionable and measurable, considering entire social groups and being grounded in known scientific evidence, laying the groundwork for Braveman *et al.*'s [18] definition, which is the definition this scoping review will use: 'Health equity means that everyone has a fair and just opportunity to be as healthy as possible. Achieving this ... means reducing and ultimately eliminating disparities in health and in the determinants of health that adversely affect excluded or marginalized groups.'

According to this definition health equity is both a process and an outcome, providing two different points for measurement. The process is reducing and removing the obstacles that prevent marginalized and excluded groups from achieving health, while the outcome is the absence of such obstacles [18] (Fig. 2).

In the context of this scoping review, either health equity as a process or as an outcome will be evaluated. As a process, the health equity impact can be assessed by analyzing if and to what extent the development and implementation of digital tools through design processes ameliorate or eliminate health inequities. As an outcome, the health equity impact can

be assessed by analyzing if and to what extent they establish or enhance opportunities towards increased health, eventually leading to full health.

Digital health

During the late 1900s and 2000s the field of digital health started to emerge [19–21]. There was significant optimism and hope around it, and many held to the promise that it would help tackle some of the most intractable and inequitable problems in health [5–7]. However, many of these hopes have not been realized, at least not to the degree first expected [7, 22–25]. Yet, technological developments in health and healthcare have continued to move full steam ahead, ushering in the digital health era [20] and with it a renewed hope in the longstanding promise of better health for all thanks to the presumed ability of information and communication technologies to 'flatten the earth' and to 'change the status quo' [22, 23]. However, 'digital health' comprises heterogeneous definitions and terms with significant differences in meaning across the field [21]. Therefore, it seems best to identify a set of characteristics that are true across most definitions of digital health. Table 1 shows some of the most widely cited and currently used definitions of digital health.

From the definitions above, three main distinctives of digital health can be distilled. Digital health uses a vast array of digital technology, is employed to improve health or prevent sickness

Table 1. Most widely cited and currently used definitions of digital health

Author/organization	Definition of digital health
World Health Organization	'The use of digital, mobile and wireless technologies to support the achievement of health objectives. Digital health describes the general use of information and communication technologies for health and is inclusive of both mHealth and eHealth' [24].
Meskó et al.	'[T]he cultural transformation of how disruptive technologies that provide digital and objective data accessible to both caregivers and patients leads to an equal level doctor-patient relationship with shared decision-making and the democratization of care' [23].
Kostkova	'Use of information and communications technologies to improve human health, healthcare services, and wellness for individuals and across populations' [25].
Topol	'The convergence of smartphone-enabled mobile computational and connectivity capabilities is only one aspect of digital medicine; it also encompasses genomics, information systems, wireless sensors, cloud computing, and machine learning that can all be incorporated into new systems of health management, built around real-world, patient-generated data' [22].
Food and Drug Administration	'The broad scope of digital health includes categories such as mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine' [26].
Healthcare Information and Management Systems Society, Inc.	'Digital health connects and empowers people and populations to manage health and wellness, augmented by accessible and supportive provider teams working within flexible, integrated, interoperable and digitally-enabled care environments that strategically leverage digital tools, technologies and services to transform care delivery' [27].

and is participatory in nature, meaning the patients/consumers are empowered to manage their health. Digital technology can be hardware (e.g. smartphones, sensors), software (e.g. a phone application, the interface of a smart watch) or other underpinning technologies (e.g. artificial intelligence, machine learning, big data, genomics) [22–24, 26, 28]. The purpose of utilizing this digital technology is mostly to achieve two possible outcomes: first, to help patients/consumers return to a state of optimal health by aiding in the recovery of an illness or modifying a harmful behavior that has a physical or mental effect or, second, to help patients/consumers maintain their optimal or desired level of physical or mental health by providing information and tools that prevent potentially harmful behaviors [24, 25, 27]. Finally, the use of this technology seeks to empower patients/consumers, making them key players in their health [22, 23, 27, 28]. It shifts the burden of health and disease management from the doctor and the healthcare and social systems to a shared responsibility between them and the patients/consumers.

Human-centered design

Although design is a widely studied field, it has likely been one of the most underestimated aspects of digital health during the early years [29, 30]. By now, most practitioners and researchers agree that digital health design flaws have not only increased the resistance to use and the abandonment of technology but caused serious, detrimental health outcomes, even death [31–33]. It has long been acknowledged that for information and communications technologies to achieve their full potential they need to be 'people-oriented,' putting human requirements instead of technological ones at their center [34]. Early on this kind of design was mostly known as user-centered design (UCD). However, through the years, the term HCD has gained more prominence and has come to replace UCD [35].

Although both terms are frequently used interchangeably [36], in reality HCD expands the focus from just the interaction between the end user and the system to 'considering how human capabilities and characteristics are affected by the system beyond direct interaction with the interface or system itself' [37]. In HCD, the needs and demands of the user as

well as the larger social context are considered as important as the technological requirements. Moreover, HCD takes into consideration stakeholders that may not interact directly with the technology but may be affected by it (e.g. a patient would be affected by an ePrescribing system that doesn't allow for custom dosage typing [38]) as well as the short- and long-term effects of the technology being designed (e.g. the impact that an electronic patient portal may have on a vulnerable group without access to the technology on the short-term or the impact on the patient-provider relationship over a longer period of time [39]).

In practice HCD can be considered an umbrella term in which 'the theories, methods, mindsets, and values ... emphasize a more holistic attitude toward the human person, including the social and cooperative dimensions of their humanity' [6]. Unfortunately, the rapid rise and indiscriminate use of HCD has many times given way to its being used as little more than a catchword or a magic bullet to try to solve long-standing problems [40]. When used in this way, HCD is robbed of its intrinsic qualities of empathy, co-creation, iteration, working in multidisciplinary teams and 'openness to complexity' [6, 40]. Such misuse may lead either to poor results that are blamed exclusively on the HCD methodology or to profound disappointments when the expected results are not achieved.

In order to include a wide breadth of literature regarding the use of HCD for digital health but to guard against the above misrepresentations, this scoping review will use the practical set of components that an HCD implementation should exhibit as described by Holeman and Kane [6]:

- Participatory co-design: There should be evidence that the people who will use the new tools or be impacted by them have been included in a meaningful and clear way. They were an integral part of the team.
- Supporting or augmenting human skills: There should be evidence that the new tools will serve the people in a way that empowers them in their job or environment. The purpose of the technology is not just to increase efficiency or oversight over a group of people.
- Attending to human values throughout the course of an iterative design and implementation process: There should

be evidence of genuine interest for the whole person and their circumstances. Purely technical issues do not drive the implementation; instead, human values and technical requirements are considered in tandem and are refined and improved in a cyclical manner throughout the life of the implementation.

Having reviewed the definitions of health equity, HCD and digital health, it is easy to distinguish common threads among them. In all of them, the worth and centrality of people and of their values, needs and skills are foundational characteristics. There is genuine concern for the whole person, and great importance is given to empowering people so that they can lead better, healthier lives. Such thematic overlap suggests that when HCD approaches are used in juxtaposition with digital health initiatives to achieve greater health equity, the potential benefits of each of these fields could be bolstered.

Despite this, except for a few articles, there does not appear to be a significant body of research that endeavors to study and understand these three topics concurrently. Only two systematic reviews [41, 42] were found in which the topics of health equity, digital health and HCD were considered together; however, those only explore a subgroup of potentially disadvantaged people (the elderly).

Based on these findings and the lack of a strong body of literature that explores these three topics together, the impact that using HCD approaches in digital health have on health equity warrants further investigation. The irresistible overlap of some of their intrinsic characteristics and the relevance that they have to almost every person on the planet by virtue of their ubiquity make it essential to understand how HCD approaches to digital health may impact health equity. Specifically, this scoping review sought to answer these questions:

- 1) Are HCD methods of digital health impacting health equity?
- 2) Can common ways be identified in the literature regarding how HCD methods could help reduce health inequities?

MATERIALS AND METHODS

Scoping review method

Our research followed the methodology laid out on the previously published research protocol [43], namely, the scoping review methodology and framework described by Arksey and O'Malley [44] and the Joanna Briggs Institute [45, 46] to examine the current literature on how design practices are impacting equity in the field of digital health. The PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) checklist [47] was used to ensure that methodological standards were followed (supplemental file).

Identifying relevant studies

The search strategy was developed in a stepwise fashion, as seen in [Textbox 1](#). This approach to developing a search strategy and searching the selected databases has been successfully used in other scoping reviews in the field of digital health [48–50].

Textbox 1. Steps for developing a search strategy.

Conducting searches in relevant databases

By using already known keywords and studies, preliminary searches of relevant databases will help expand and refine search terms

Searching key electronic, peer-reviewed databases and gray literature databases

PubMed, Embase, Web of Science, and AMC Digital Library will be used to search for peer-reviewed papers

For gray literature, ProQuest Dissertations and Theses and Global Index Medicus will be searched

Reviewing reference lists of relevant articles

Reviewing reference lists can help identify studies that may have been missed in previous searches. It can be useful for uncovering new search terms

Reaching out to experts through the Global Digital Health Network

Reaching out to experts can be useful for further identifying previously missed studies. The Global Digital Health Network is one of the most relevant and active networks of professionals of digital health.

Keywords related to design, equity and digital health were used for the searches. To further identify relevant keywords, preliminary searches of scientific databases and the internet were conducted, and guidance from the librarian at the University of Edinburgh was sought to further refine this search strategy. The full search strategy can be seen in the supplementary material.

Eligibility, screening and study selection

In order to carry out screening and study selection, inclusion and exclusion criteria were developed ([Table 2](#)). These criteria are structured according to the domains put forward by the Joanna Briggs Institute [45, 46], which are population, concept, context and type of evidence. The domain 'other variables' was added to capture the language, date and format criteria.

Covidence software [51] was used to eliminate duplicates and carry out screening and extraction. After de-duplication, title and abstract screening were conducted by one author (L.E.) and full-text screening by two (L.E. and J.E.). Discrepancies were solved by consensus between the two main reviewers (L.E. and J.E.). Once relevant studies were selected, data were extracted. Initially, a pilot data extraction template was used, as recommended by the Joanna Briggs Institute, on three randomly chosen articles. The goal was to see if the form was fit for its purpose. Afterwards, data from all the selected studies were extracted, cleaned and formatted for analysis. (All data can be seen online as a supplemental file.)

This research work was approved and found not to possess ethical risks by the Usher Research Ethics Group at the University of Edinburgh.

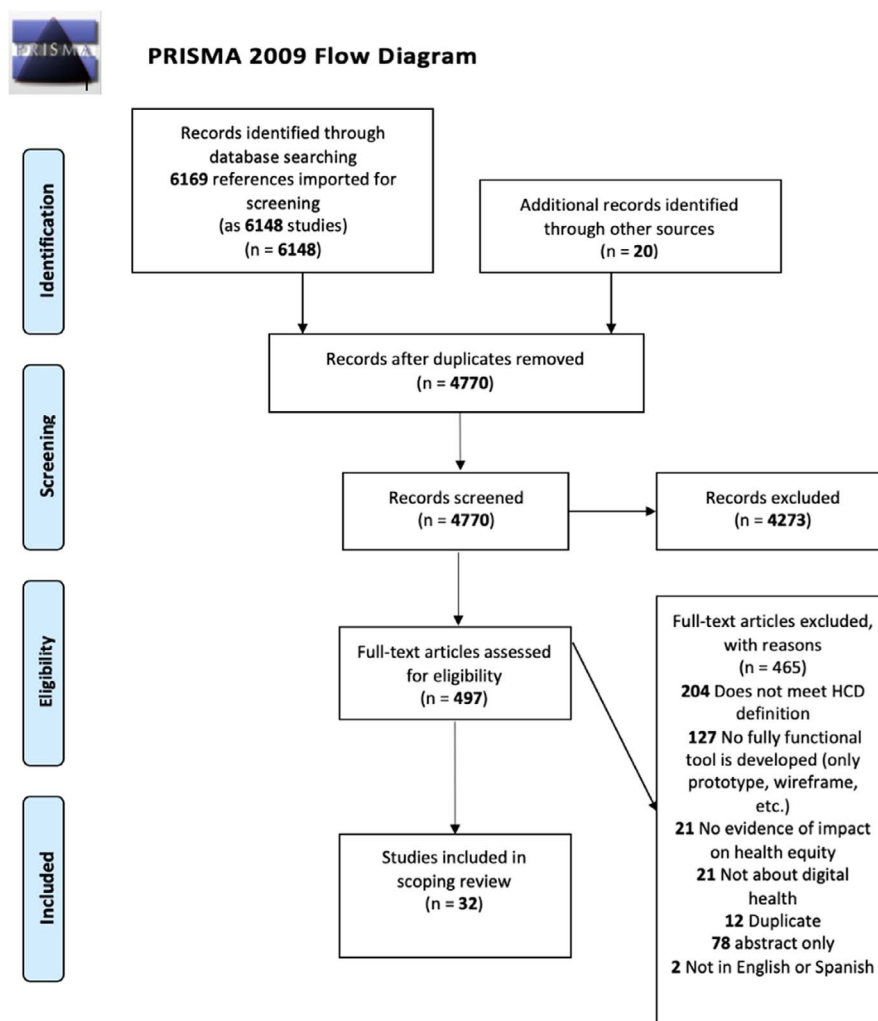
RESULTS

Search results

The study search yielded 6169 unique references, which resulted in a total of 6148 studies. At different stages of the screening process, unique articles that were concerned with different aspects of the same project were grouped together as a single study. Additionally, 20 other references were included through expert consultation. After removing duplicates, 4750 records were screened

Table 2. Inclusion and exclusion criteria structured according to the population, concept, context and type of evidence domains suggested by the Joanna Briggs Institute [45, 46]

Domain	Inclusion criteria	Exclusion criteria
Population	<ul style="list-style-type: none"> Any population 	<ul style="list-style-type: none"> N/A
Concept	<ul style="list-style-type: none"> Focus on HCD in digital health that shows a <i>direct</i> or <i>indirect</i> impact on health equity The definitions and practical applications of HCD conform to the one provided in introduction 1 HCD methodology is used to develop or refine a digital health tool that is deployed at least to pilot stage 	<ul style="list-style-type: none"> Focus on HCD in digital health without evidence of <i>direct</i> or <i>indirect</i> impact on health equity (e.g. exclusively concerned with impact on usability) The definitions and practical applications of HCD do not conform to the one provided in introduction 1 HCD methodology is not used to develop or refine a digital health tool that is deployed at least to pilot stage (e.g. HCD is used to establish the feasibility of creating a digital tool only)
Context	<ul style="list-style-type: none"> Any geographical or social context 	<ul style="list-style-type: none"> N/A
Types of evidence sources	<ul style="list-style-type: none"> Peer-reviewed articles of any design Gray literature 	<ul style="list-style-type: none"> Abstracts only Books Systematic literature review or scoping review protocols
Other variables	<ul style="list-style-type: none"> Published in English or Spanish Studies published on or after 2009 Full article available digitally 	<ul style="list-style-type: none"> Published in any other language Studies published before 2009 Full article not available digitally



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Figure 3. PRISMA flow chart [52]

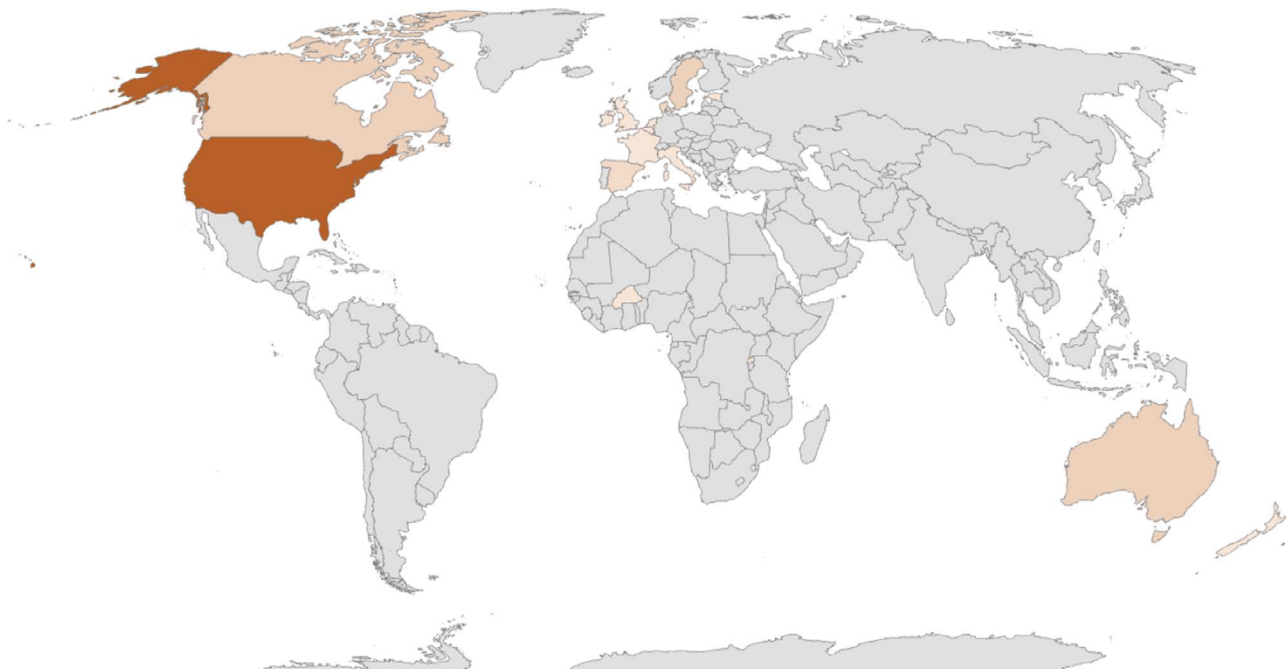


Figure 4. Countries represented in the scoping review

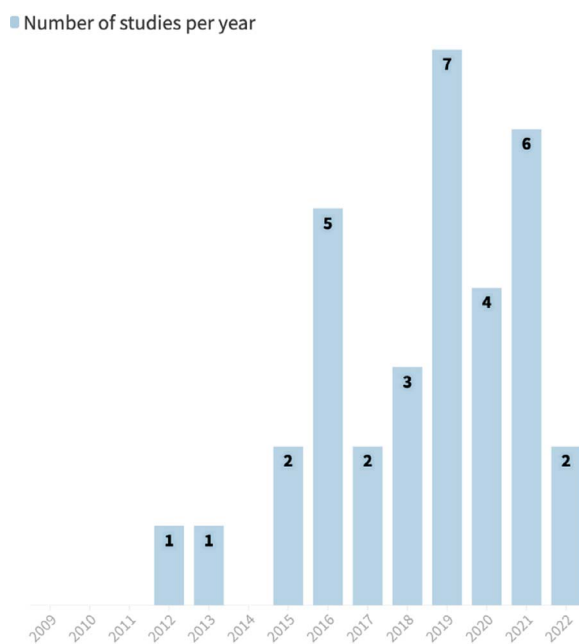


Figure 5. Number of studies included per year of publication

in two stages, first title screening and second abstract screening, resulting in 4253 records being excluded. Full-text screening was carried out on the remaining 497 studies, and out of those, 32 studies (40 individual articles) met all inclusion criteria and were therefore included in this scoping review. The PRISMA flow chart [52] illustrating this process can be seen below (Fig. 3).

Review of findings

The majority of the studies took place in developed countries, the United States being in the lead with 14 studies, followed by

Canada, Australia and Sweden with three. Spain and Denmark both had two each. Only two studies were based in the Global South, one in Burkina Faso and another one in Rwanda. In total, 16 countries were represented in the 32 studies. One of the studies was a multi-country implementation that took place within the Europe. Fig. 4 offers a visual representation of all the countries represented.

As far as year of publication, more than half ($n=19$) of the studies included were published between 2019 and 2022, progressively decreasing in number before those years, with the exception of 2016, in which five of the studies included were published. Fig. 5 shows all studies included within the date for inclusion criteria (2009 onwards).

Regarding the digital health tools that were developed during the studies, 29% involved creating a smartphone application ($n=11$), 29% involved a website (10), 14% either created a new telehealth intervention or adapted an existing one for their target population (5), 9% resulted in a tablet-only application (3), 9% involved a massive open online course (3) and 5% designed and implemented an SMS program (2). The other two digital tools created were a multi-sensor ambient application and an assistive social robot. In total 35 unique digital health tools were developed. Fig. 6 visually represents this information.

The target populations greatly varied, and in many instances the studies involved people at risk of health inequities on more than one level. For example, many studies focused on ethnic minorities that were further potentially disadvantaged because of a chronic physical or mental condition. Finally, when looking at the HCD approaches used in the studies selected, it can be seen that a wide array of them were employed (Fig. 7). Community-based participatory design, UCD, participatory design, co-design and HCD were the most frequently used methodologies, being employed in at least five studies each. Co-creation was used in four studies and participatory co-design in two. Action research, design thinking, patient-centered design,

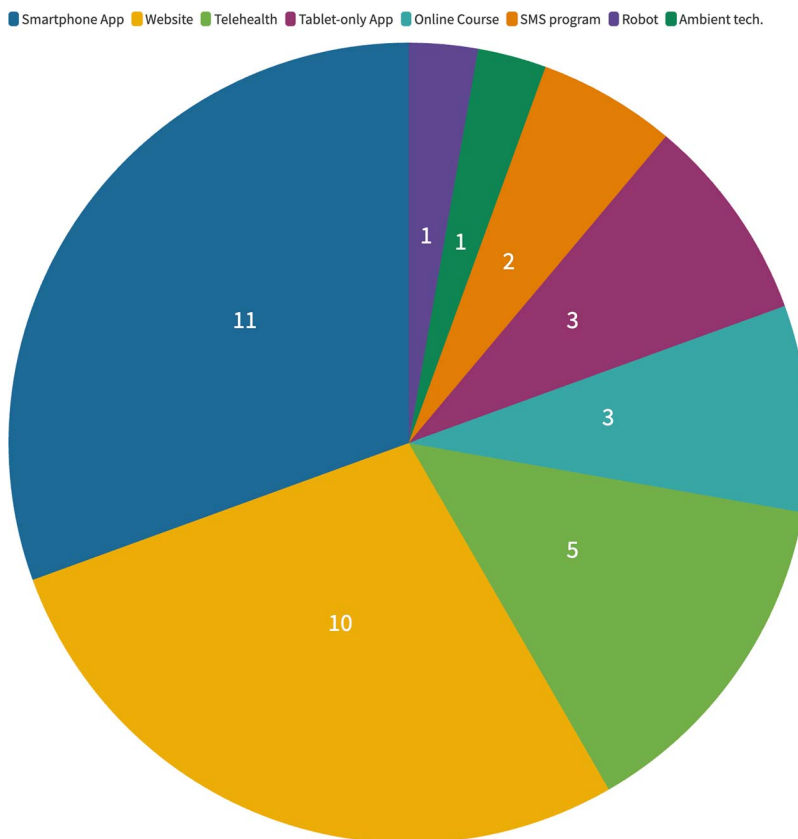


Figure 6. Digital health tools developed

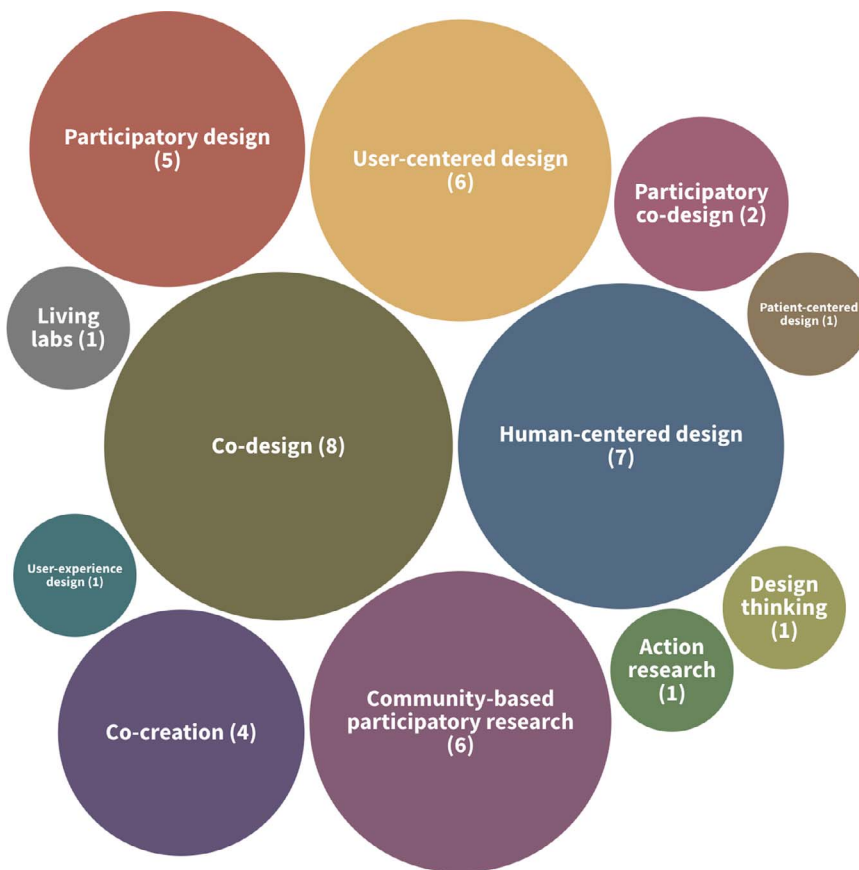


Figure 7. Design approaches used

Table 3. Definitions of the HCD approaches used in the studies included

Design approaches	Definitions
Action research	'[A] "cognitive process that depends on the social interaction between the observers and those in their surroundings". Action research forms vary to include canonical action research, prototyping, soft systems methodology, participant observation, action learning and others' [53].
Co-creation	In a co-creation methodology '[t]he user perspective [is] incorporated in all phases design to ensure that their expectations, preferences and user needs' [54].
Co-design	'Codesign takes a partnership approach, in which stakeholders or end users (e.g. employers, customers, patients) are actively involved in the design process to help ensure that the outcome meets their needs and expectations' [55].
Community-based participatory research (CBPR)	'CBPR is a partnership approach that equitably involves community and academic partners in all phases of a research process' [56].
Community-engaged approach	'Community-engaged research requires partnership development, collaboration, and negotiation, as well as the commitment from both the community and academic researchers to addressing local health issues' [57].
Design thinking	'[A]n organic, bottom-up process, which allows the audience to guide and help design the product, hence increasing the likelihood of a successful outcome' [58].
HCD	'[A]n approach that focuses on the usability and needs of those the tool is meant to serve The application of human-centered design represents an opportunity to address key underlying provider and patient gaps that obstruct improved health outcomes' [59].
Living labs	'Living Lab is a concept created to support user-centric information and communication technology development processes. A living lab is defined both as a physical environment and an approach' [60].
Participatory co-design	'The participatory approach involves co-learning and reciprocal transfer of expertise, shared decision-making and mutual ownership of process and products of the enterprise' [61].
Participatory design	'[I]t enables researchers to work in partnership with communities and empowers the participants to have control over the end result' [62].
Patient-centered design	In patient-centered design 'multiple health professions and patients all come together for a common goal. The professional domains and experience [is] leveraged to have all participants contribute equally' [63].
UCD	'[The] UCD method is based on three general principles: 1) focusing on the user and the task from the inception of the project and throughout the design, 2) measuring usability empirically and 3) designing and testing usability iteratively' [64].
User-experience design (UX)	UX design 'involves going beyond instrumental need and acknowledging the use of technology as a "subjective, situated, complex and dynamic encounter," considering the user's internal state, the characteristics of the product design and the context of interaction with the product' [65].

user-experience design and living labs were all used in one study each.

Use of HCD methodology

There were many different kinds of HCD methodologies employed in the studies included as seen in Fig. 7. All these methodologies align with the definition and core components of HCD as stated in the background, namely, meaningful participatory co-design, supporting or augmenting human skills and attending to human values throughout the process [6]. Table 3 summarizes the definitions of the HCD approaches used in the studies included in this scoping review as the authors themselves defined them. Words such as *user*, *stakeholder*, *partnership*, *active involvement*, *shared decision-making*, *empowerment* and *complex* appear multiple times throughout the definitions, showing how much the definitions of these design approaches overlap.

Phases and interventions

All studies followed at least three classic phases of HCD of inspiration, ideation and implementation [66], even if they were not always called by those names. Many studies, however, broke down the process in many more steps than these three. The ideation stage was commonly broken down into a literature review, the identification of users' needs and requirements, the recruitment of stakeholders and the organization of interdisciplinary teams. The ideation stage varied considerably in principle and in practice across studies. It varied in principle because, while in most of the

studies the researchers already had a strong idea of what type of digital health tool they esteemed necessary to develop, in a few others the final digital health tool developed differed substantially from what the researchers originally envisioned [55, 57, 63, 67–70]. The ideation stage varied in practice because some studies only had two rounds of prototyping, an initial prototype with one refinement cycle [69, 71, 72], while others had frequent prototyping meetings that spanned many months. The implementation stage covered piloting the implementation and evaluating it. A few studies documented further refining and testing based on feedback [53, 56, 62–64, 73, 74]. Most of the studies did not extend beyond this point, although many reported plans or hopes to scale up the digital health tool.

The most common interventions used during Phases 1 (inspiration) and 3 (implementation) were focus groups discussions [54, 57, 61, 73, 75, 76], in-depth or semi-structured interviews [54, 55, 57, 61, 62, 64, 67–69, 73, 74, 77–79] and observational studies [63, 73]. During Phase 2 (ideation) most studies either carried out co-design sessions with the entire team or presented prototypes developed by designers to end users for feedback and evaluation. It is worth pointing out that only 4 [55, 65, 80, 81] of the 31 studies included made use of the many tools commonly associated with HCD such as personas, journey maps, scenarios, card-sorting exercises, etc. [66]. There were no stated reasons for this, although it could be inferred that in the cases in which these tools were not used, the authors may have limited themselves to methodologies they knew well.

Participants and partnerships

Across all HCD approaches, multi- and interdisciplinary teams were the hallmark mechanisms employed to foster a sense of cooperation and community among all participants. These teams were mostly composed of three kinds of participants: academics (normally the ones initiating the project), a wide range of professionals (healthcare providers, social workers, IT developers, designers, consultants, government officials, etc.) and community members (end users, church members, community activists, patients, caregivers, etc.). All the studies sought to incorporate the people that would directly benefit or be impacted by the digital health tool and their perspectives, and many studies went beyond that, seeking also to integrate input from stakeholders that may indirectly be impacted by the tools.

In general, the studies showed robust evidence of nurturing democratic participation and skill enhancement, preserving or increasing autonomy, promoting empowerment, utilizing co-learning, fostering ownership over the tool and demonstrating cultural humility throughout the HCD process. In a few studies community members also collaborated in writing the initial research proposal and the study that was later published. Some authors pointed out that the partnerships established to carry out the project continued outside and beyond it, fostering new friendships and support groups that did not exist before [74, 80, 82]. At the same time, other studies acknowledged that working in multi- and interdisciplinary teams that included non-professional team members or members from historically disadvantaged communities was difficult at times, creating tension among the participants [61, 83]. These studies state that those tensions were solvable but that they resulted in the project taking more time and resources than previously anticipated.

Health equity considerations

Implicit or explicit focus on health equity

A little under half of the studies ($n = 15$) had an explicit focus on health equity; those studies used some form of an HCD approach in order to develop a digital health tool that would help decrease health disparities through different mechanisms. The remaining studies ($n = 17$) had an implicit health equity focus. Those studies used HCD approaches to develop digital health tools in order to address specific health needs that different disadvantaged populations have. The term 'health equity' did not appear in these studies; however, it is clear that the intent of the project was to reduce health inequities through addressing a specific health concern.

Health equity as a process or as an outcome

As previously defined, health equity can be seen as a process through which the obstacles that prevent marginalized communities from achieving health are removed or reduced, or it can be seen as an outcome that is obtained when those communities move closer towards the goal of full health [18]. Seventy-five percent of the studies ($n = 24$) focused on the process aspect of health equity, seeking to remove the obstacles that a specific community may encounter through their journey to full health. Their aim was to use HCD approaches in the development of a digital health tool that would in turn remove or reduce a specific barrier towards full health. For example, many studies used HCD approaches in order to develop a digital health tool that was inclusive and accessible, reducing or eliminating obstacles such as low digital or health literacy. The remaining studies ($n = 8$) centered around the outcome aspect of health equity. These studies utilized HCD

approaches in order to create or adapt a digital health tool that would increase users' self-efficacy, their self-management of a disease or their self-advocacy, which was presumed to increase the health status of those communities.

Other health equity considerations

There are two more health equity considerations that emerged from the data. First, the use of HCD methodology had an impact on health equity at the team level. The studies were conceived and carried out with the aim of having an impact at the community level or beyond. However, many studies' authors commented on how the HCD process had an impact for the specific, disadvantaged participants recruited [55, 56, 59, 61, 64, 65, 73, 80, 82, 84]. The HCD process allowed these participants to increase their digital and health literacy levels, manage their chronic conditions better, be more assertive and informed in their treatment choices, feel more responsible for their health outcomes and be more aware of the types of care available to them. In essence the aims of the studies were attained in those specific participants. Moreover, the professional-amateur partnerships formed allowed the team as a whole to gain new insights into disadvantaged communities, fostering 'mutual learning and understanding' [73].

Second, the HCD approach frequently helped uncover previously unidentified issues that have an impact on the specific communities' health equity. Spending time with intended recipients of the intervention, seeking to understand their needs and wants and working alongside them in a democratic manner brought up user and technological specifications that were previously missed despite most studies carrying out in-depth literature reviews at the beginning of the project [57, 63, 65, 67, 68, 71, 75, 84–86]. Marko-Holguin *et al.*'s study [71] illustrates this well. They aimed to create and implement a two-way SMS system to allow regular communication between low-income patients with chronic conditions and their healthcare providers in order to increase access to care and decrease health inequities for those populations. However, as they worked through the HCD, it became apparent that one of the main reasons for which these patients did not utilize health services to their full extent was not only because of the lack of communication between them and their healthcare providers but also because of the shortage of reliable and frequent transportation to the healthcare facilities, uncovering a different kind of inequity previously overlooked by the researchers. Some studies, however, voiced concerns that the HCD approach brought an overwhelming amount of new user and technological specifications and that it was not possible to incorporate all of them in the project [62, 71, 79]. Generally, when too many specifications were identified, the teams worked on prioritization, recommending the incorporation of the unmet requirements at a later point in the project.

Other self-reported impacts and limitations

Beyond the results already reported above, all studies stated that the different HCD approaches were crucial to the outcome of the project. The HCD approach was seen as a valid and commendable methodology to design digital health tools that can have a positive effect on health equity. However, most of the studies included do not extend beyond pilot projects and thus provide limited evidence of impact on health equity at scale. Moreover, the mechanisms by which the aforementioned positive outcomes are drawn are subjective and could be biased as they exclusively rely on participants' and researchers' opinions. Only one study [74] discussed the positive effects on health and social support

systems of HCD approaches after having gathered insights and feedback on an ongoing telemedicine implementation over 14 years; however, even that study did not establish a clear impact on health equity long term.

Four studies made the observation that the resulting digital health application should be seen as a tool and not as a solution [61, 64, 72, 73]. Instead of using the digital health tool as if it would in itself improve health or increase health equity, the tool should be seen as 'an additional means of support' [64] and 'in conjunction with other initiatives' [61] to aid the intended end users in their quest towards health. The authors' acknowledged reason for this is that the problems that these digital health tools are aiming to address are intricate and multi-faceted; therefore, a multi-faceted approach is necessary.

The most frequently stated limitations were the small number of community participants recruited for the HCD processes, the fact that many of them were self- or purposively selected, which may limit generalization of outcomes, and the previously mentioned high volume of user and technical specifications generated, which in most cases were not feasible to incorporate. Two other limitations were also reported, albeit less frequently: resistance to change, particularly in the context of a technology being deployed in a healthcare system [74], and slower than anticipated progress due to the HCD approach being 'fluid and often nonlinear' [57].

DISCUSSION

This review studied the research literature on health equity, digital health and HCD available to date with the aim of understanding how HCD approaches in digital health may have an impact on health equity. From a list of results of 6169, only 32 studies (40 unique articles) fulfilled the inclusion criteria, and during full-text review, a large number of studies (204 out of 466) were excluded solely because their use of HCD did not conform to the definition adopted for this study. On the one hand this was expected because during the search phase the net was cast far and wide in order to find as many relevant articles as possible. On the other hand, this is a possible indication that HCD terminology and methodology are prone to much misuse. In most cases, studies failed to include users and other stakeholders in meaningful and empowering ways, instead only working with stakeholders to gather user requirements or to carry out user testing. Two previously published systematic literature reviews that examine the topics of health equity, digital health and HCD in the aging population have similar conclusions in regard to the uneven and at times haphazard application of HCD approaches in digital health for health equity, particularly in regard to the purposeful inclusion of stakeholders in the co-design process [41, 87]. Applying HCD in a manner that enables meaningful, participatory co-design that empowers people in their aims and that makes human values a main driver of digital health creation and implementation is the first step for HCD approaches in digital health to have an impact on health equity. While it is true that HCD functions as an umbrella term affording a flexible methodology, such flexibility cannot come at the cost of neglecting its core characteristics. However, a significant, albeit disheartening, finding of this review is that most of the studies screened failed to apply HCD in this manner, potentially subjecting disadvantaged communities to further health inequities due to digital health interventions that, developed under the banner of HCD, may have missed the opportunity to achieve better health for all.

Impact of HCD on health equity

Turning now to the studies included, the first research question that this review set out to answer was whether or not HCD methods used in digital health were impacting health equity. The results of this review uncovered mixed evidence regarding this question. At the individual level, most of the participants that took part in the different HCD processes reported having gained a greater sense of agency. As stated in the Results section, these participants were able to increase their digital and health literacy levels, to start to manage illnesses and health better, to be better informed in their healthcare choices and more assertive when interacting with healthcare providers and to take more responsibility for their personal health. All these outcomes had a direct impact on health equity for those individuals; some of the barriers that they had so far encountered were removed or mitigated, helping them move forward in their journey to full health. Moreover, in a few studies the HCD approach helped uncover health equity issues that were previously unknown to the researchers. This is significant because it could mean that digital health tools developed through an HCD approach have a higher prospect of discovering and addressing the health inequities that different marginalized communities feel more acutely and not only those that academics, researchers or policymakers deem to be priorities.

However, the evidence of HCD impacting health equity beyond that of the individual participants seems to be lacking. This is in part because the majority of studies only report results up to the pilot stage. One of the characteristics of health inequities is that to be considered a true inequity it needs to occur at a systemic level. Therefore, to establish HCD methodologies' true impact on health equity, the effects that the digital health tools developed through an HCD approach have at the community, regional and national levels must be explored, something which none of the studies did. The true impact that HCD has on health equity is also challenging to determine from the evidence collected so far because the majority of studies relied on self-reported, non-systematically evaluated outcomes. Very few of the studies carried out formal evaluations to assess the general outcomes of the digital health implementation, and none attempted to evaluate their potential impact on health equity. Although, in general, the findings from the studies appear to be promising, it cannot not be assumed that the positive outcomes reported at the participant level can be extrapolated to entire communities or groups of people that suffer from health inequities. Human-centered designed digital health tools that succeed within a small pilot project must be scaled up to mature implementations, and their impact on health equity must be measured and evaluated consistently and frequently in order to better know if the proof-of-concept successes that these studies present are applicable at a large scale.

Emerging patterns across the literature

The second research question that this review set out to answer was whether or not there were common, emerging patterns in the studies regarding how HCD methods could help reduce health inequities. Two common threads can be seen across all studies. The first one is a reduction in health inequities for the individuals that took part in the studies as a result of the use of the HCD methodology. This finding has just been discussed along with how it does not provide a base for claiming that HCD methodologies can affect health inequities at a systemic level.

The second thread is the general confidence that exists in HCD methodologies as a way to reduce health inequities. This strong confidence in the HCD process as a suitable approach to address health inequities when designing digital health tools is simultaneously reassuring and troublesome. It is reassuring because it clearly shows that among researchers and implementers there is a growing awareness of the pressing need to shift from 'designing for people to designing with people and by people' [88]. This awareness, and indeed desire, has certainly driven the rapid rise of HCD for digital health, positioning it as one of the preferred methodologies when designing tools that seek to address some form of health inequity [6, 89]. Yet, the strong, almost unshakable, confidence in the HCD methodologies as a way to reduce health inequities is troublesome because systematic, widespread evidence of its ability to do so seems to be absent [90]. Although very few of the studies included in this review went beyond the pilot phase or implemented rigorous evaluation, all of them stated that the HCD methodologies employed were a key component necessary to achieve their aims, which for more than half of them included addressing some form of health inequity through the development and use of a technological tool. Certainly, the seeds of human-centered designed digital health tools playing a key role in ameliorating health inequities can be seen throughout all the studies. However, if those seeds flourish and become full-grown implementations that reduce or eliminate health inequities across disadvantaged groups and communities is yet to be proven.

Implications for practice

It can hardly be overemphasized how critical achieving health equity is and with it how critical it is to understand which tools, mechanisms or methodologies—such as HCD—may aid in achieving such a feat. It is indeed a moral imperative because health inequity issues extend beyond epidemiological statistics and mathematical calculations into the realm of ethics and morality [9, 10, 14]. The results of this scoping review show promise in regard to HCD approaches for digital health having an impact on health equity, yet this promise does not translate into solid, replicable and wide-reaching evidence because most of the implementations fail to grow and rigorously assess the impact beyond the participants included in the pilot project.

It is of paramount importance to build from the inception of the digital health project mechanisms to scale up and evaluate the impact of the intervention. The chronic pilotitis and lack of systematic approaches to evaluation are longstanding, well-documented problems in digital health [91–97]. Although delving into those problems and how to address them are beyond the scope of this review, it is necessary to stress the point that without implementations that grow at scale and that are routinely and systematically evaluated, the knowledge of the impact that human-centered designed digital health interventions may have in health equity in the short- and long-term will continue to elude us. This is not only detrimental to a scientific and academic level, preventing evidence-based advancements in the field; it is also profoundly detrimental at a societal level, preventing whole communities from potentially moving towards and achieving health equity.

Successful digital health implementations like the ones in this review need to carry out evaluations on health equity impact in a systematic and scientifically robust manner, and they need to continue to grow and scale beyond pilot projects. Without the evidence that these two activities would provide, it is not possible to establish what kind of health equity impact human-centered

designed digital health tools may have in the lives and health of the most disadvantaged communities in the world.

Three main recommendations can be made as a result of the work undertaken in this scoping review:

- 1) The flexible methodology that HCD affords should be applied in a rigorous manner so that it upholds its core elements of meaningful participatory co-design, supporting or augmenting human skills and focusing on human values. Flexible methodology does not need to be at odds with rigorous application. HCD can be rigorously applied by consistently and holistically putting people and their environment and circumstances at the center of each one of its uses. At the same time, HCD as a flexible methodology fosters multiple approaches to including people, their needs, wants, ideas, circumstances, etc. and encourages exploration of possible solutions well beyond the initial ideas and assumptions.
- 2) Viable and successful digital health pilot projects need to scale up and grow to maturity in order to wield systemic impact to the systemic problem of health inequity. Digital health tools ought to be deployed across multiple, similar communities with similar health inequities so that the impact on health equity that those digital health tools may have displayed during the initial stages of the project can be corroborated at a larger, universal scale.
- 3) Digital health tools developed through an HCD approach that seek to address health inequities in some capacity need to embed evaluation mechanisms that assess the health equity impact of the tool at different stages of development, implementation and scale-up. This recommendation works in tandem with the previous one because once a project is implemented at scale, it needs robust evaluation mechanisms to establish evidence of impact on health equity.

Limitations

The core principles of the HCD definition used for this review (i.e. meaningful participatory co-design, supporting or augmenting human skills and attending to human values as a main driver) were strictly applied during the screening process. This could be seen as a limitation in the sense that such strictness irremediably meant that many other studies that utilized so-called HCD methodologies were excluded. A less strict approach would have changed how many studies would have been included for this review. However, it is unlikely that such approach would have excluded any of the studies included based on a broader definition of HCD, meaning that the findings from this study would have been uncovered all the same. A second limitation of using this definition of HCD in the strictest way possible was that the geographical representation became limited to primarily Western countries. Therefore, although one of the inclusion criteria was to look at all geographical areas, the Global South is underrepresented, signaling an even more limited use of HCD in these countries.

CONCLUSION

Current evidence shows a glimpse of the potential impact of HCD methodologies on health equity, but they failed to lay a strong foundation that would allow the wider community of implementers, researchers and policymakers to endorse and pursue HCD as a methodology to design and deploy digital health tools that can have a far-reaching health equity impact. Meaningfully

involving some of the people that would be affected by the technology resulted in barriers being lifted and better health outcomes for those specific persons. Moreover, involving all stakeholders in a truly democratic partnership allowed for health inequities previously unidentified by researchers to be discovered, making the HCD methodology potentially more consequential to health equity. Yet, virtually none of the projects scaled beyond pilot projects, and neither did they implement rigorous evaluations in regard to health and health equity impact. If the community of digital health researchers and practitioners continues to stop right before scaling up and performing well-devised evaluations, HCD's impact may not be fully recognized, and not knowing the true influence that HCD methodologies used in digital health design, development and deployment may have on health equity is something with potentially detrimental repercussions to the lives and health of entire communities.

The digital health community, for the most part, has a favorable view of HCD methodologies and their potential impact on health equity as evidenced by the results of this scoping review, in which authors saw the HCD methodologies as a key component to their successes. However, it does not appear to be the will, the ability or the awareness to take all the steps necessary to continue to advance the research needed to establish foundational, nuanced evidence of the impacts of HCD for health equity. The establishment of this kind of evidence will not be an easy endeavor and will require an unwavering commitment on the part of the researchers and implementers as they constantly have to hold in tension the intricacies of digital health implementations; the complexity of the environment surrounding the implementation; the multifaceted, entrenched problems those implementations are trying to address; the historic, socio-economic and cultural inequities different communities face; and most prominently the uniqueness of each one of the persons that would be directly or indirectly affected by the implementation. However, the effort is well worth it. To better understand in which capacity, in which spheres of life and health and for which purposes digital health tools created through HCD aid in the reduction of the health-related disparities that plague all of our neighborhoods and communities would be a decisive step towards that elusive yet morally compelling objective: health equity.

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Conflict of Interest

None declared.

Authors' Contributions

L.E. developed the idea and the inclusion and exclusion criteria. L.E. and J.E. screened the papers. L.E. conducted the analysis and wrote the first draft. J.E. provided ongoing input and mentorship throughout the review. J.E., K.K. and C.P. provided input and recommendations to further drafts of the manuscript.

Data Availability

The data underlying this article are available in the article and in its online supplementary material.

Supplementary Data

Supplementary data are available at Oxford Open Digital Health online.

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