Design and deployment of Digital Health Interventions (DHIs) to reduce the risk of the Digital Divide: a systematic scoping review conducted to inform development of the Living with Covid Recovery (LWCR) DHI

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Abstract

Background: Digital health interventions (DHIs) aim to support health-related knowledge transfer e.g., through websites or mobile applications (apps). They have the potential to either increase health inequalities due to the digital divide or to reduce health inequalities by making healthcare available to those who might not otherwise be able to access it, such as geographically remote populations. They can also overcome language barriers though translated content and enable people to access support and advocacy from family members or friends. However, public health programmes and patient-level healthcare delivered digitally need to consider ways to mitigate the digital divide through DHI design, deployment, and engagement mechanisms, to reach digitally excluded populations.

Objective: The objective of this systematic scoping review was to identify the features of DHI design and deployment conducive to improving access to, and engagement with, DHIs by people from demographic groups likely to be affected by the digital divide. The review was conducted during the evolving Covid-19 pandemic, and its findings informed the rapid design, deployment, and evaluation of a post-Covid-19 rehabilitation DHI called 'Living With Covid Recovery' (LWCR). LWCR needed to be engaging and usable for patients with a wide range of demographic characteristics, to avoid exacerbating existing health inequalities as far as possible. LWCR was introduced as a service in 33 participating NHS hospital clinics from August 2020, was used by 7,679 patients, and the study ran until 20th December 2022.

Methods: This systematic scoping review followed the methodology recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review (PRISMA-ScR) guidance. The following databases were searched for primary research studies published in English from 1 October 2011 to 1 October 2021: Cochrane Library, Epistemonikos, NICE Evidence, PROSPERO, PubMed (with MEDLINE and Europe PMC) and Trip. In addition, we used OpenGrey and Google Scholar to search for grey literature. We selected publications that met the following inclusion criteria: primary research papers that explored and/or evaluated features of DHI design and deployment intended to enable access to and engagement by adults from demographic groups likely to be affected by the digital divide (e.g., older age; minority ethnic groups; lower income/education level). The data from studies that met the review inclusion criteria were extracted, narratively synthesised, and thematically analyzed.

Results: A total of 22 papers were included in the review. Inclusion criteria were met for 19 papers of 1245 hits retrieved by the search and three further papers were added from a search of publications included in relevant reviews. DHIs evaluated in the studies included:
telehealth, virtual assistants, text message interventions, decision aids and e-health learning programs. The main themes resulting from analysis of extracted data relating to design considerations included: co-development with end-users and user testing for iterative design cycles to produce DHIs that help improve digital skills and digital health literacy through use; tailoring for low literacy levels through animations, pictures, videos and writing for a low reading age; use of virtual assistants to collect information from patients and guide use of a DHI. For deployment, themes revealed included: provide devices and data, if possible, otherwise use text messages or signpost to sources of cheap/free devices and free WiFi; provide 'human support' for implementation / onboarding and troubleshooting; provide tailored digital skills education as part of the intervention; and incorporate peer/family support.

Conclusions: Taking these "universal precaution"' can help reduce the digital divide. The results helped guide the iterative design and successful deployment of the LWCR DHI. They also have wider implications for practitioners, policy makers, and researchers, and will inform best practices in the design and delivery of DHIs for equitable health improvement

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Living With Covid Recovery (LWCR): linked systematic scoping review

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Keywords

digital divide; digital health; digital health literacy; eHealth literacy; grey literature; healthcare inequalities; internet-based intervention; mHealth; telemedicine

Introduction

The Covid-19 pandemic led to very rapid widescale adoption of digitally delivered healthcare, while also revealing the impact of systemic societal health inequalities [1]. Covid inflicted a "double whammy", with deprived people, older people, and those from ethnic minority groups getting sicker and more likely to die whilst at the same time making healthcare even less accessible for these groups [2,3]. Belonging to one or more of these groups (intersectionality) was a risk factor for experiencing disproportionately more severe illness and mortality [4].

It also quickly became apparent that large numbers of patients would need rehabilitation following hospital admission for Covid-19. A large proportion of these, and others who were not hospitalised went on to develop "long COVID" with distressing symptoms including breathing pattern disorders, anxiety, and fatigue [5–7].

In the context of an already stretched National Health Service (NHS) in the United Kingdom (UK), deploying its resources to the ongoing pandemic, combined with an increasing backlog of deferred treatment, it was clear that digitally delivered rehabilitation had the potential to help manage the demand for remote rehabilitation. The Living With Covid Recovery (LWCR) study was designed to deliver and evaluate remote rehabilitation for patients with ongoing severe symptoms immediately post-hospital discharge and for people who developed long COVID through the development and deployment of a digitally-delivered and supported rehabilitation programme [8].

In brief, the LWCR system consisted of an app-based digital health intervention (DHI) with programmes to address the symptoms of long COVID, including self-management programmes for breathlessness, fatigue, or anxiety, the most disabling symptoms of long COVID, along with a library of information about other common symptoms, e.g., brain fog [8]. The app supported self-management (a health coaching approach), regularly prompted users to complete patient-reported measures (PROMS) questionnaires to populate a clinician-facing dashboard, allowing healthcare practitioners (HCPs), usually senior physiotherapists, to provide two-way support via app messages.

From the outset, the LWCR study team sought ways to mitigate the risk of exacerbating health inequalities resulting from low health literacy, low digital health literacy and the digital divide, terms which we define and describe in the next section. We needed to ensure the digital offer could be integrated into long COVID clinical pathways and would allow patients to receive adequate human support [9].

Due to the fast pace of intervention development necessitated by the ongoing pandemic, an initial rapid literature review was conducted to ensure the LWCR app's design, content, and presentation of learning materials and PROMs would be accessible to people from a range of demographic groups, and that the LWCR system could be equitably deployed in NHS clinics.

The rapid review expanded into a systematic scoping review [10] to bring together the evidence base of strategies to reduce the digital divide through design and deployment of the DHI in long COVID clinics, and to support the app through iterative design cycles, a methodology based on a human-centered design approach which uses a cyclical process starting with development of a minimal viable product (MVP) or prototype, testing it, getting feedback from stakeholders, analyzing the results, and refining the product or process [11,12].

For the purpose of this review, we define DHI, as we did in the published protocol, as 'any service

intended to improve physical or mental health, or to promote health improvement through, for example, lifestyle change, delivered digitally (formally or informally), such as via smartphone apps, social media, email, SMS text message, using wearable technologies, video games (e.g., for motor or cognitive training), websites, or telehealth (e.g., remote consultations) but excluding telemedicine if this consists solely of remote monitoring without any input from the patient' [10].

This review will provide a comprehensive summary of the published literature on ways to reduce the digital divide through the design and deployment, or implementation, of digital health interventions.

Health Inequalities, Health Literacy, and the Digital Divide

There are several overlapping definitions for the term 'health inequalities.' For this paper, we will use the King's Fund definition [13], which builds on McCartney and colleagues' 2019 definition of "the systematic, avoidable and unfair differences in health outcomes that can be observed between populations, between social groups within the same population or as a gradient across a population ranked by social position" [14], and broadens it to include "differences in access to health care, quality of care received, wider determinants of health such as housing and education, and opportunities to lead healthy lives, including differences in risky behaviours such as smoking", which brings in a social justice aspect, also expressed by the related term "health inequity" [15].

The term 'Digital divide' describes "the gap between people in society who have full access to digital technologies (such as the internet and computers) and those who do not" and is a clear example of digital heath inequity. This is caused not just by lack of access to affordable and reliable internet and devices, including mobile phones and apps etc., but also lack of skills and resources needed to use and benefit from such devices, compounded by a lack of trust or motivation to do so, or lack of saliency [16]. Ensuring digital health equity, 'equal opportunity for individuals to benefit from the knowledge and practices related to the development and use of digital technologies to improve health' is the focus of the WHO global strategy on digital health 2020-2025 [17].

One approach to reducing the digital divide is to improve people's digital health literacy (or eHealth literacy). Digital health literacy is a subtype of health literacy associated with poor health outcomes and is defined as "the degree to which individuals can access, understand, and apply (digital) health information and services to make informed decisions about their health" [18]. It also refers to the need for digital health information and services to be designed to be usable and responsive to the digital health literacy of the populations they serve [19].

Rationale for conducting a systematic scoping review

We chose this methodology as the best way to provide a preliminary assessment of the size, scope, and nature of the research evidence available, in order to synthesise the evidence base for ways to reduce the digital divide through design and deployment of DHIs. This methodology is best suited for pooling evidence from a wide range of sources, including grey literature and any studies missed from the search that might be included in relevant systematic reviews[20,21].

Methods

The methodology for review was based on that of the Joanna Briggs Institute,[22] with guidance from Peter's et al [23]. In brief, this covers clarifying the review's aims and research questions, searching

appropriate evidence sources, charting the data extracted from included publications, analysing the data, and consultation with stakeholders, including patient and public involvement and engagement (PPIE) representatives, to validate emerging results.

Review question

The aim of this systematic scoping review was to identify research that has evaluated features of design and deployment that are conducive to improving access to (and engagement with) DHIs by people from demographic groups likely to be affected by the digital divide.

The review aimed to answer the following two research questions:

1. **Relating to design**: How can a DHI's design, and digital skills training for users as part of the DHI delivery mechanisms, be optimised to reduce digital health inequalities arising from low digital health literacy?
2. **Relating to deployment**: How should the DHI be delivered to mitigate the digital divide?

Eligibility criteria

We included primary research studies of any design, published from 1 October 2011 to 1 October 2021, set in any part of the world, with participants aged 16 years and over from one or more of the following demographic groups: ethnic minorities, socially disadvantaged people, and the elderly (aged over 65 years), as these groups have been identified as highest risk of digital divide [24]. We included population-based samples if participants from the groups of interest could be disaggregated. Included studies needed to focus on a specific DHI containing elements of its design or deployment that were intended to reduce the digital divide through design or deployment, and measures reported needed to reflect these outcomes. We excluded reviews, opinion pieces, blogs, summaries with lists of recommendations, as these did not fulfil the criterion of primary research. We also excluded those which were not published in English.

Decisions on whether publications retrieved should be included or excluded from further analysis were iteratively refined based on increasing familiarity with the literature, in line with systematic scoping review methodology. Following discussions at our regular team meetings, we made the following clarifications to the eligibility criteria that were originally listed in the published protocol paper [10]:

- We agreed that we would not include studies that only described lists of barriers, or demographic characteristics of groups likely to be subject to the digital divide. These are likely moderators of digital engagement but were not the focus of this review as they did not identify features of DHIs' design and deployment that are conducive to improving access to, and engagement with, DHIs, and are well described in the literature.
- Equally, the focus of the review was not on studies that assessed standalone interventions to increase people's digital skills, outside the context of a DHI. Our research focus was on those studies that evaluated specific DHIs that incorporated purposeful facilitators for the DHI's use, built into the design or deployment mechanisms, and reported results to show the effectiveness or acceptability of these measures.
- We also agreed to include only those qualitative studies whose participants were actual or potential users of a specific DHI, e.g., to inform or co-design its development, rather than qualitative studies that explored barriers/facilitators to using a DHI in general but not in

relation to a specific DHI or its features.

- For grey literature, we decided to include only those that reported results of primary research e.g., conference abstracts or reports by charities that described the results of studies carried out by the charity itself, not those that summarized the literature and gave recommendations.
- We also decided to exclude reviews because we were not doing a review of reviews. However, if the search identified any reviews that were highly relevant to our review, but with a different research focus, we checked their lists of included studies in case any eligible studies had not been captured by our search.

The final list of eligibility criteria is shown in Supplementary data, Table 1.

Evidence sources and search strategy

The following sources were searched: Cochrane Library, Epistemonikos, Europe PMC, MEDLINE, National Institute of Health and Care Excellence (NICE) Evidence, GreyNet, PROSPERO, Turning Research into Practice (TRIP) Pro, Cumulative Index to Nursing and Allied Health Literature (CINAHL Plus), PsycINFO, Conference Proceedings Citation Index, Google Scholar, and OTseeker.

The search strategy was based on three categories: terms for health-related apps, terms for interventions/process, terms relevant to the priority demographic groups – combined using Boolean 'AND' to ensure that references captured contain at least one term from each category. The full search strategy is shown in Box 1:

Box 1: Full search strategy

(app* OR ehealth OR mhealth OR telemedicine OR smartphone OR tablet OR computer OR internet OR wearable OR device OR technology) AND (interven* OR program* OR mitigate OR change* OR modif* OR implement* OR process* OR approach* OR facilitat* OR enabl* OR barrier) AND (ethnic minorit* OR disadvantage* OR underserved OR elderly OR geriatric OR older) AND ("digital divide" OR "digitally excluded" OR "digitally-excluded" OR "digital exclusion" OR "low digital health literacy" OR "low ehealth literacy" OR "low e-health literacy").

Limits:
Date range 1 October 2011 to 1 October 2021.
Adults aged 16+ years.
Published in English.

PRISMA-ScR

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [25] was used to record processes of selection, de-duplication and screening for inclusion.

Twenty-five of the hits were randomly selected and screened for inclusion or exclusion by the members of the review team, with 92% agreement. We divided the remaining hits between the team to screen, with reasons for exclusion being documented, and any disagreements resolved by consensus among the study team. Those publications that met the inclusion criteria were not subject to quality appraisal, as this is not recommended for scoping reviews, where the focus is on eliciting as complete a picture as possible of current knowledge about the subject of interest [26].

Data extraction and charting

Data were extracted from full-text items that met inclusion criteria using the JBI data extraction guidance for scoping reviews into an Excel spreadsheet under the following headings:

1. Author(s)
2. Year of publication
3. Origin
4. Publication type
5. Funding source
6. Stakeholder involvement
7. Population and sample size
8. Name of the DHI (incl. any comparator and details of duration)
9. Purpose of the DHI
10. Outcome measures relating to design and deployment features intended to facilitate use by people from demographic groups likely to be subject to the digital divide (incl. how these were measured, with effect sizes, if reported) and qualitative data if collected
11. Key conclusions that related to the review question

Collating, summarising, and reporting results

A narrative synthesis and thematic analysis [27]of the findings from the included studies was conducted by one member of the team (FH). Emerging results were discussed in team meetings prior to wider consultation with the LWCR Steering group.

Results

The initial search resulted in 1245 hits. The grey literature search identified very few relevant hits so further searches were not conducted due to time and resource constraints.

After removing 942 duplicates before screening, 303 hits were screened by title and abstract. Of these, 119 did not meet the inclusion criteria, leaving 184 publications for full text review. From these, 166 were excluded because they did not meet our inclusion criteria for one or more of the following reasons: 64 were review articles (not primary research); in 62, there were no details of design or deployment mechanisms intended to help reduce the digital divide for a specific DHI; in seven publications there was no focus on a specific DHI; and three papers had a focus on participants who did not meet the inclusion criteria, but were under 16 years of age, college students, and healthcare professionals, respectively. This left 19 publications that met the inclusion criteria and were included in our study.

In addition, of the 64 review articles screened out (of the 184 publications that underwent full text review), six of these had a focus that was highly relevant to our review, so we screened their included papers. From one of these reviews [28], we found three studies that fulfilled the eligibility criteria for our review and so were added to the included studies.

In total, 22 papers were included in the systematic scoping review. The selection process is shown in Figure 1:

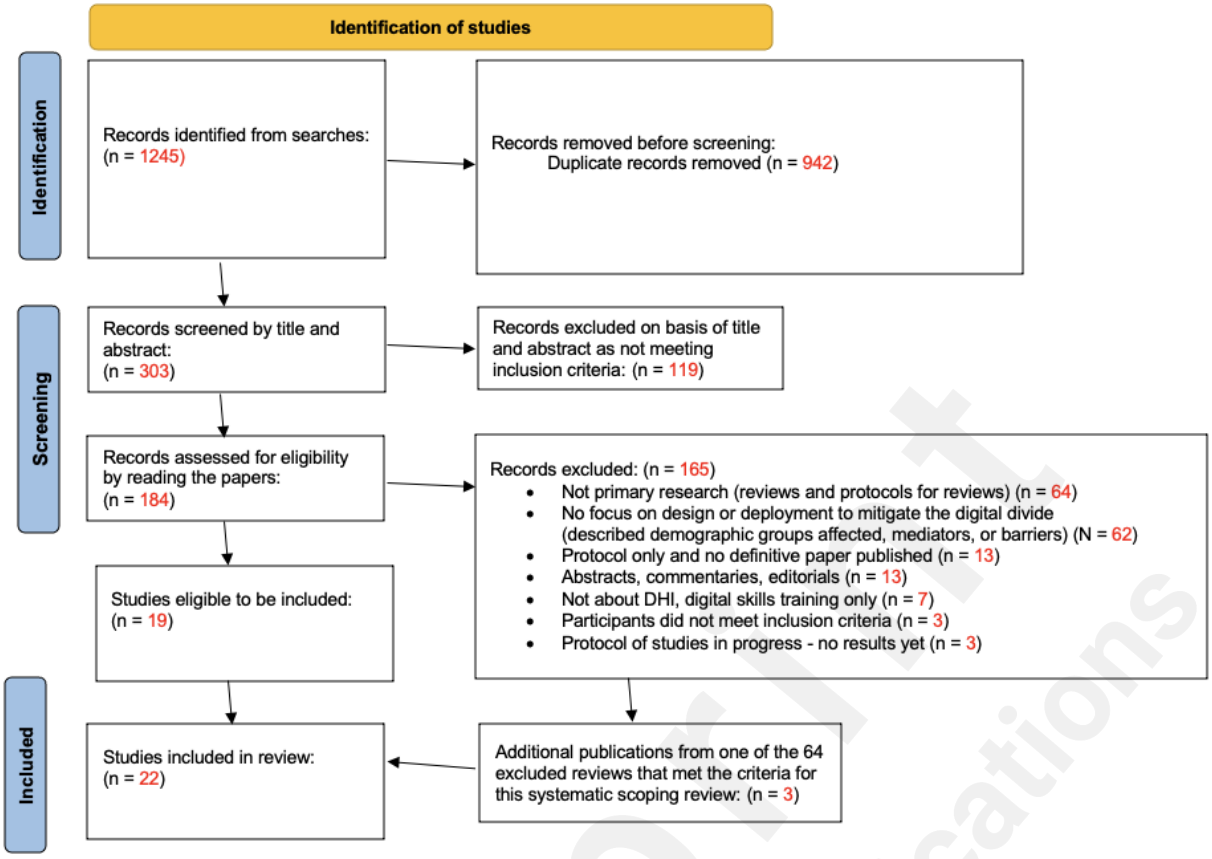

Figure 1: PRISMA flow diagram[29]

A summary of the included studies' characteristics is given in Box 2 and described in the text below. More detail of each study's DHI of interest, methodology, and summary of relevant results, are given in Supplementary Data, Table 2.

Box 2: summary of included studies' characteristics

Region / setting	Study design	Digital divide populations recruited
United States of America (n=13) Canada (n=1) Multicentre (Spain, Italy, Greece, The Netherlands, Slovenia, France, Serbia, and Israel) (n=1) Mexico (n=1) The Philippines (n=1) Uganda (n=1) Burkina Faso (n=1)	Randomised controlled trial (n=8) Qualitative (n=9) Mixed methods (n=3) Cross-sectional (n=1) Pre-post single arm (n=1)	Older adults (n=10) including: • 2 studies with caregivers for older adults (mainly elderly themselves) • 1 study with low socio-economic status older adults • 1 study with older African Americans Low socio-economic status adults (n=6) Minority ethnic groups (n=2) Adults in under-resourced settings (low- or middle-income countries (LMICs) (n=3) Homeless adults (n=1)

The Netherlands (n=1) The United Kingdom (n=1) Cambodia (n=1)		

Study characteristics

Most studies were conducted in the USA (12/22). The others were carried out in Canada, Mexico, Philippines, Uganda, Burkina Faso, Cambodia, The Netherlands, The UK, and there was one multi-centre study conducted in Spain, Italy, Greece, The Netherlands, Slovenia, France, Serbia, and Israel. There were eight randomised controlled trials (RCTs), eight qualitative studies, three were mixed methods, one cross-sectional, and one was a pre-post single arm study, source of study. The studies were all published between March 2013 and August 2021.

Participants

Most of the studies focussed on older adults (10/22) including two studies with caregivers for older adults, who were mainly elderly themselves. One study recruited low socio-economic status (SES) older adults and another enrolled older African American patients. There were six studies where participants were low SES adults (6/22), three recruited adults living with HIV in under-resourced settings, two focussed on minority ethnic groups, and one on homeless adults who were war veterans.

Digital Health Interventions studied

There was a wide range of DHIs covered by the included studies, which could be categorised into four groups: e-health learning programmes to help patients use specific digital health interventions, patient portals, or decision aids (n=10), text messaging interventions (n=7), telehealth interventions (n=3), and virtual assistants (n=2). The DHIs for each category are described in more detail in Box 3.

Box 3: DHI categories
Decision aids / e-health learning programs

1. “mPATH”, a novel iPad decision aid app program (mobile Patient Technology for Health) aimed at increasing uptake of colorectal cancer (CRC) screening among low SES older people in North Carolina, USA [30].
2. “T-PeP” an e-learning program (Theory-based, Patient Portal) developed for older adults to learn to use patient portals to manage their health [31].
3. Videos about accessing and using an online patient portal, aiming to increase digital health literacy in English and Spanish speakers of lower SES living in San Francisco, USA [32].
4. “URHealth” smartphone DHI developed and customized for people living with HIV (PLWH) in New York and New Jersey, USA [33].
5. Unguided web-based DHI targeting complaints such as sleep problems, stress and worry (complaint-directed mini-interventions, CDMI), with nurse-led facilitation for low SES people, in the Netherlands [34].
6. A DHI with a web portal for older people in Quebec, Canada which aimed to mitigate the digital divide through participatory facilitated sessions [35].
7. “VOCALE”, an online DHI promoting problem solving about health management (Virtual Online Communities for Older Adults in Louisville and Kentucky, USA [36].
8. “ehcoBUTLER”, a multi-use digital platform with apps to help elderly people access the internet in order to improve their health, independence and quality of life [37].
9. "Active Brains", a web-based programme to support dementia-protective behaviors in older people recruited from general practices in the UK [38].
10. "PREPARE for your Care", a multimedia interactive e-health tool for diverse older adults in San Francisco, USA, to increase their engagement with advance care planning [39].

Text messaging interventions

11. “TEXT”, a bidirectional text messaging for ART adherence among nonurban substance users with HIV in Virginia, USA (qualitative and usability study) [40].
12. “TEXT” pilot RCT [41].
13. A text message intervention for people diagnosed with HIV in Uganda [42].
14. A self-management and text message program for adults with Type 2 Diabetes mellitus targeted at low socio-economic status (SES) groups in Mexico City, Mexico [43].
15. An app-based text messaging service aiming to increase physical activity among patients with type 2 diabetes and depression and lower SES backgrounds in San Francisco, USA [44].
16. A text messaging intervention for PLWH in Burkina Faso which aimed to improve adherence to ARV medication and retention to the clinics [45].
17. A peer education program aiming to improve adherence to evidence-based treatment guidelines for diabetes and hypertension delivered via mobile-based text messaging in Phnom Penh and four other rural districts in Cambodia, provided by MoPoTsyo, a Cambodian NGO [46].

Telehealth interventions

18. A care management programme for homeless veterans in Los Angeles, USA [47].
19. A telehealth programme for older adults in rural areas of The Philippines [48].
20. web-based mobile health information interface for older African American patients and their doctors, Ohio, USA [49].

Virtual assistants
21. An Embodied Conversational Agent (ECA) community based virtual health educator for older adults in San Jose, California, USA [50]. 22. "VICKY" (Virtual Counselor for Knowing Your Family History), an animated computer character designed to collect a detailed family health history from a diverse, vulnerable patient population living in Boston, USA, who had low health literacy and a low reading age, which could be used in English- or Spanish-language versions [51].

Design and deployment features likely to help reduce the digital divide

The results of the individual studies were synthesised into design and deployment themes.

Design features

Design features associated with positive impact are shown in Box 4 and described further in the section below.

Box 4: Design features associated with positive impact
Animated virtual assistants (n=2): • Embodied conversational agent (ECA) virtual adviser (n=1) • Virtual counsellor (n=1)
Self-management eHealth programmes or advice: • Interactivity e.g., eHealth tool which focuses on advance care planning (n=1) • Tailoring to low socio-economic status, low education or reading levels, options for translations n=(3) • Use of pictures/videos (n=1) • Co-creation with end-user and user-testing/Think Aloud e.g., information/self-help web portal (n=3) • Use of focus groups with target users when planning to design DHI/ eHealth interventions (low socio-economic status, minority ethnic group, chronic diseases) (n=3) • e-Learning self-help programme: how-to use module in the intervention, a moderated discussion board, virtual library & human support (n=3) • iPad decision aid / self-management learning programs delivered via video (n=2) • Telehealth care management programme with healthcare professional feedback (n=1) • Use of text messages e.g., condition specific/self-care programme (n=3)

Design features that were found to improve engagement by participants from demographic groups subject to the digital divide could be divided into three categories: involving end-users in the design process and in user testing of the DHI; tailoring the presentation/interface and content; and using

virtual assistants.

a) Involving end-users in the design process user testing

The studies that involved end-users in the design process and undertook user testing with Think Aloud methodology, were viewed positively by the participants. For example, a diverse group of 30 caregivers of functionally dependent older persons in Quebec, Canada, took part in a series of workshops to inform the design of a DHI to facilitate the process of help-seeking for older people. The authors found that participation of end-users of the DHI in the development of the tool was an integral part of the design process and that "compliance with the desired eHealth literacy level, the help-seeking process, and cultural context, were integrated into the eHealth tool by the co-designers' discourse and, more importantly, by the caregivers themselves" [35]. For example, relating to the content of the DHI, one caregiver participant of a Think Aloud session conducted as part of the study was quoted, "*The text is very heavy. The first thing I would do is click on the video"].* There was also a suggestion by caregiver participants that alternative versions of the information in a DHI should be provided for people who do not have access to the internet or devices: "*we need a paper version*".

There was also positive feedback for involving 41 end-users in Think Aloud interviews to inform a prototype web-based "Active Brains" programme to support dementia-protective behaviors for older people, and then test in a qualitative study conducted in the UK. The authors found that participants helped improve the usability of the intervention, through their feedback on the layout and usability, with positive comments about the uncluttered web-pages with only a few necessary buttons, 'like turning a page of the book' [38].

b) Tailoring

Greater levels of uptake and usage were seen in those studies that tailored content for low literacy levels/illiteracy through use of animations [38], pictures [33,37,43], videos [30,32,35,37,39] and writing for a low reading age [30,39,48].

In a questionnaire study that recruited elderly participants in the Philippines, 'effort expectancy' was found to be the most likely influence on their future use of a Telehealth intervention, suggesting "*elderly respondents are most likely to adopt Telehealth interventions if they experience no difficulty in using the system*" [48]. The use of a touch screen interface, an uncluttered visual display, narrated content with feedback, and verbal navigation commands built into the DHI's interface were found to enhance usability for older people in a study evaluating a novel iPad decision aid designed to increase uptake of colorectal cancer (CRC) screening among low SES older people [30]. Using large text and clear iconography was also found to improve readability for older people [36]. A clear layout was also recommended by older participants in a qualitative study using a web-based intervention to support dementia-protective behaviours [34]. For example, in a Think Aloud session, one participant in the study noted "*I immediately look at this page and find it untidy and as a, not a struggle, but as a barrier there to reading it clearly and understanding it. I'm struggling to find what to click to go to next*."

c) Virtual assistants

The use of virtual assistants to collect information from patients and guide use of DHI was received well by the two studies that tested them with older people. In the RCT of an embodied conversational agent (ECA)[50], use of the ECA led to greater increases in 4-month self-reported minutes of walking per in the virtual advisor arm (mean increase of 253.5 ± 248.7 minutes/week compared with to the wait list control group's mean increase of 26.8 ± 67.0 minutes/week; p=0.0008), and the intervention was rated as acceptable by participants (mean score of 5.7 out of 7 (± 0.67) across the 19 program acceptability scale items). In the RCT conducted with a diverse, vulnerable, older patient population with low reading age and low health literacy [51], the participants randomised to the virtual counselor were significantly more likely to complete a family history questionnaire compared to those randomised to a web-based questionnaire (97% vs. 51%; p <0.0001) and more likely to divulge sensitive subjects such as alcohol use or addiction than they were to genetics counsellors.

The results of the individual studies were synthesised into design and deployment themes. Design features associated with positive impact are shown in Box 4 and described further in the section below.

Deployment features

Deployment aspects that were found to improve uptake fell into two main areas: taking steps to improve access (to devices and/or internet); and divided into three categories: involving end-users in the design process and in user testing of the DHI; tailoring the presentation/interface and content; and using virtual assistants; digital skills training with human support integrated with the deployment strategy, i.e., not signposting to separate services available elsewhere. These features are summarised in Box 5 and described in more detail below.

Box Deployment features associated with positive impact
a) Improving access: • Providing internet access (n=1) • Providing devices (n=2)
b) Human support • Training nurses to recognize and assist low socio-economic status patients (n=1) • Involving research assistants (n=3) • Peer / family support (especially for elderly people) (n=4)
c) Digital skills education as part of the DHI implementation • Interactive group-based educational sessions (n=2) • Web-based training programme (n=4) • How-to videos on accessing and using an online patient portal; in-person tutorial more effective than self-guided link (n=1) • Information and communication technology (ICT) training within the digital health interventions (n=3) • Tailoring education to low socio-economic status / low education or reading level & translations (n=2)

d) Addressing trust issues

- Text messages as a way of maintaining confidentiality (n=1)
- Voice messages more likely to 'communicate trust' than text messages alone (n=1)

a) Overcoming access issues

Two studies provided participants with free devices to avoid access difficulties [33,41], one of which was a text messaging intervention. The six other studies text messaging studies did not do this, but because they considered that basic mobile phone ownership was sufficiently widespread that their text messaging interventions could overcome problems with access to healthcare, particularly in places with inconsistent cellular or internet service, as participants could usually receive text messages without difficulty [40–44], [46]. However, in one of these studies, the older participants expressed a preferred to voice messages over texts, as they felt they communicated trust, and the authors found that voice messages also had the advantage of increasing accessibility for persons with limited literacy, vision, and smartphone access [46].

b) Human support

Positive impact on access and use outcomes was seen if 'human support' was part of the implementation package, such as in one study in which nurses were trained to proactively identify lower-SES patients so they could provide them with extra guidance and help [34]. Other studies used research assistants [32,42,44], community centre staff or volunteers[50], and peer-educators [33,37] to help with downloading apps, accessing the internet, setting up logins, using a DHI, and for sorting out technical difficulties. In these studies, if participants needed further help, for example in one of the studies with virtual advisors, five participants in the intervention arm experienced minor difficulties, such as forgetting their login information or difficulties in printing out information, but this was reported to need only a few minutes of staff time to sort out, because staff were on site [50]. In the study with older adults in the Philippines, participants said they were more likely to use a Telehealth DHI if they had social support from family members [48]. Family support to use a DHI was also recommended by participants in a co-design study for a DHI for older people, incorporating Think Aloud and qualitative interviews [35].

c) Digital skills education as part of the DHI implementation

Other features that helped uptake and use, with positive impacts on the primary outcomes examined, included tailored digital skills education as part of the intervention [31,36,43]. For example, in the RCT which trialled a 3-week e-learning program developed to help older adults learn to use patient portals (PP) to manage their health, the intervention group showed greater improvements than controls for outcomes relating to PP knowledge (p=0.019) and self-efficacy (p=0.003) [31].

d) Addressing trust issues

Text messages were seen as a way of maintaining confidentiality and contributed to DHI acceptance in a study conducted among PLWH in Uganda [42]. However, the use of voice messages was perceived by older people as more likely to 'communicate trust' than text messages alone in a peer education program delivered via mobile-based text messaging in Cambodia [46].

Discussion

This review has synthesized the evidence regarding key strategies for optimising the design, deployment, and engagement mechanisms of DHIs to mitigate the effects of the digital divide on health inequalities.

In summary, there needs to be a two-pronged approach to mitigating the digital divide. Firstly, to explicitly increase the motivation of people at risk of the digital divide to engage with digital devices, and online health information and services, including DHI, and to develop their skills in accessing, understanding, and using DHI. Secondly, to improve the digital health literacy responsiveness of the people responsible for implementing the use of any DHI in healthcare systems, encouraging and enabling them to support people to register with and use a DHI as a 'treatment programme'.

A key design recommendation elicited from studies included in the review was that user involvement from the beginning of a DHI's development is vital, preferably through co-design, and user-testing. This approach has been shown to improve health equity in research, and in the context of digital health requires active collaboration between patients and researchers to make the intervention more user-friendly and acceptable [12]. The intervention itself needs to be culturally appropriate, and available at a low reading age, with translations, if possible, animations or video content to help with engagement and use by people with low literacy levels. Including tailored digital skills education as part of the intervention appeared to improve the participants' digital skills. Usability considerations identified in this review include those described by the studies with older people that can be extended to anyone with low literacy and low digital health literacy. For example, the Think Aloud evaluations with older people identified universal design solutions to make them easy to use such as uncluttered web pages, judicious use of colour, keeping text to a minimum, clear formatting, and simplifying the interface e.g., using a minimum of essential buttons [34,36].

For deployment, although some studies provided free devices, this may not always be an option for publicly funded health services. Many of the included studies made the point that mobile phone ownership is becoming widespread, so text messaging interventions can be useful as they do not need costly data or the infrastructure of fast and reliable internet access. Most impactful was 'human support' especially for older people. This could be a family member or partner, but older people are less likely to develop digital skills if they rely on family members to help [46]. The studies that provided members of staff or peer-supporters to help the patient with the technical aspects of using a DHI, found this only required a few minutes of staff time if they are already on site [50]. These results suggest there may be a role for community hubs where vulnerable people can access support with digital technologies.

This review is one of the first to examine how design and deployment aspects of DHIs can be optimised to address the digital divide at individual and system levels. Its strengths include the JBI methodology that we followed for the review [52], which allowed us to assess the extent of the relevant literature. We developed a comprehensive and systematic literature search strategy, which was peer reviewed by an information specialist, as recommended by Peer Review of Electronic Search Strategies (PRESS) guidelines [53]. In addition, four members of the team screened 25 test papers randomly selected from the initial hits, achieved high inter-rater reliability, and all decisions on exclusion and inclusion of publications were taken at regular review team meetings.

Our findings align with the *Framework for Digital Health Equity*, published by Richardson et al in 2022 [54], and can be mapped on to the levels corresponding to steps that can be taken at individual, interpersonal, community, and societal levels, to improve digital health equity. The design considerations we identified map onto the individual level, with tailoring of the interface and usability to appeal to a diverse group of end-users, allowing people with low literacy/health literacy and low digital health literacy to use the DHI. Enabling people to access free or low-cost devices and reliable low-cost data and WiFi, are examples of deployment mechanisms that map onto the community level (e.g., through charities or local libraries) and societal level (policy making that enables low-income groups to access devices, data, and skills). Virtual assistants deployed through local centres also fit with the community level, whilst deployment using 'human support', either through family or peer support, or through healthcare staff, maps onto the interpersonal level of the framework.

Findings from this review also agree with those of Veinot et al in their 2018 paper [55], which called for a "universal precautions" approach to health literacy, including using plain language, visuals and minimising text-based input. Our recommendations regarding the need for healthcare organisations utilising DHI for healthcare to recognise people at risk of the digital divide and to facilitate access to devices, data, skills etc. also support those of Busse et al [56] for ways to improve patients' digital health literacy in the context of person-centred care.

Limitations

We recognize that our search extended to late-2021, and there has been a massive increase in the literature regarding inequalities since the Covid-19 pandemic. However, we wanted to situate the review in the context of the LWCR DHI design and deployment, and to report the results that informed this work. We also acknowledge that given the fast pace needed to develop the LWCR DHI, and the requirement to make the intervention available for clinical use as soon as possible, we had to be pragmatic in our consultation with stakeholders. We therefore limited this to presenting emerging, and final, results to members of the LWCR steering committee for validation and feedback. The steering committee members included HCPs, digital health experts and patient and PPIE representatives, but arguably were less impartial than the larger group of independent stakeholders we had initially planned to consult.

The studies included in the review were heterogeneous, so generalizability may be limited. Most of the studies focussed on elderly populations as opposed to lower SES or inclusion health groups, potentially due to 'societal' implementation barriers, with wider SES barriers being harder to tackle in a research study.

Only a few of the included RCTs assessed the impact of the interventions on digital health skills using validated measures e.g., eHEALS [57]. The qualitative and mixed methods explored participants' motivation to use the DHIs being evaluated, their satisfaction with the DHIs, and facilitators that helped them use the DHIs (as well as barriers, but we were more interested in the facilitators for this review) rather than the DHIs' impact on participants' digital skills and confidence specifically.

Implications for developers of DHIs, policy makers, commissioners, clinical practitioners, and researchers

The findings of this systematic review reinforce the persuasive argument for following the 'universal precautions' approach to try to design out the digital divide from DHIs and to include strategies to improve digital health literacy either in the design of the DHI or as part of its implementation [55].

For developers, the recommendations are to co-design DHIs with a diverse group of end-users from the outset and throughout, using iterative cycles of user-testing and redesign, so that the product is acceptable and usable for the people it is intended for. In the design, culturally and linguistically adapted content should be made available. User testing can ensure the DHI has clear navigation, with easy-to-read content that uses plain language. Using animation, visuals such as pictographs, and minimal text, can help users with low literacy. The functionality of the interface can support users to improve their digital skills. Further help can be included by signposting to external resources, e.g., human support or virtual assistants. We also suggest using deployment/communications strategies from the outset with the assumption that any end-user may need support to use the DHI. As mentioned in the limitations section, there appeared to be less focus on DHI for low SES groups than for elderly groups, which may be another cause of increased health inequalities if not addressed, potentially due to who is developing these technologies (private as opposed to public interests).

Our recommendations for commissioners of healthcare services are to include criteria for how digital services and products might mitigate the digital divide, and work to reduce subsequent inequalities in commissioning guidelines. For clinicians, we suggest that when using DHIs for healthcare or recommending them to patients for self-management, they are aware of the digital divide, and use evidence-based strategies for helping patients to use digital health interventions. It is better to assume from the outset that patients will need digital literacy support. Healthcare professionals may need training to recognise individuals who need more support if a DHI is being recommended and allow time for explanations and clarification as part of a blended model of DHIs' delivery. Pragmatically, this help could come from non-clinical staff such as administrators or staff in social prescribing roles, given that healthcare professionals are likely to have less time within time-limited consultations to help with these aspects personally. Providing human support, or peer support, to help patients subject to the digital divide to e.g., download apps to their devices and to sign up to the DHI, will be more effective than just signposting them to other services e.g., for digital skills training. Factoring in additional staff time for this help represents a hidden cost of using some digital technologies and should be included in any service cost calculations.

Recommendations for researchers are to include in their research people who are likely to be subject to the digital divide and to keep eHealth equity front of mind. Participants' digital skills and confidence should be assessed by validated measures at baseline and follow up, not just usage and acceptability measures. Design and deployment aspects of DHIs need to be evaluated to investigate how these considerations can improve digital literacy and mitigate the digital divide.

Conclusion

The Covid-19 pandemic worsened existing health inequalities and shone a light on the digital divide. Since then, there has been an acceleration of plans to move to a default 'digital first' delivery of healthcare, and there has been a corresponding increase in the number of publications reporting the results of research studies focusing on strategies to mitigate the digital divide. We have presented a summary of these strategies with a particular focus on features of DHIs' design and deployment that are conducive to improving access to, and engagement with, DHIs by people from

demographic groups likely to be affected by the digital divide.

The results of this review were critical for the success of the LWCR study at a time of great need: the early days of the Covid-19 pandemic. Its findings informed the iterative design and implementation of the intervention, helping the LWCR developers and study team take steps to mitigate the digital divide by incorporating the review's recommendations into the design of the LWCR programme. Co-design with, and user-testing by, PPIE representatives led to the patient-facing app being more usable and acceptable. Findings also helped the intervention's deployment into clinical practice. For example, clinic staff provided human support to introduce the LWCR DHI to patients, and to check in with patients by in-app messaging. Trusts also provided access to devices as needed and sign-posted patients to help with digital skills [58]. Beyond benefitting the LWCR programme, these results have wider implications for designers, policymakers, practitioners, and researchers. We need to take 'universal precautions' to enable equitable access and use of DHIs by a diverse range of people.

Declarations

Ethical approval and consent: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: To request access to the underlying research data, please contact Dr Fiona Hamilton f.hamilton@ucl.ac.uk.

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Copyright statement:

Access to data:

Access to data: To request access to the underlying research data, please contact Prof Fiona Stevenson f.stevenson@ucl.ac.uk

Authors' contributions

FH, KB and EM conceived the initial idea for the review. CLJ developed the protocol, which was then revised and approved by all authors. CLJ conducted the initial search strategy. CLJ, SI, AM, JS, FT, JD,

SB and FH screened the papers to select those that met the inclusion criteria and also extracted data from the included papers. FH conducted the analysis and wrote up as first author with support and contribution by all authors. All authors approved the final manuscript.

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Supplementary Files

Multimedia Appendixes

Supplementary Table 1- Systematic scoping review eligibility criteria (PICO, context, and publication type).
URL: http://asset.jmir.pub/assets/803f67d17d9ac97e3930d1c200b68ec2.docx

Table 2 - Overview and characteristics of the 22 included studies, ordered by DHI category and date.
URL: http://asset.jmir.pub/assets/b3372796c72e95781b717d8e2624c6c6.docx

TOC/Feature image for homepages

close-up-senior-person-while-learning.