

REVIEW

Impact of Digital Health Interventions on Health Literacy: A Systematic Review with Level Of Evidence Assessment

Francesco Andrea Causio¹, Stefano Gandolfi², Jasleen Kaur³, Berna Sert⁴, Maya Fakhfakh⁵, Luigi De Angelis⁶, Marcello Di Pumpo¹, Giacomo Diedenhofen⁷, Alessandro Berionni⁸, Caterina Rizzo⁶, Fidelia Cascini¹, Plinio Morita³, Timothy Mackey⁹

¹ Section of Hygiene, University Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, Rome, Italy

² Interdisciplinary Research Center for Health Science, Sant'Anna School of Advanced Studies - Pisa, Italy

³ School of Public Health Sciences, University of Waterloo, Waterloo, Canada

⁴ Department of Public Health, Faculty of Medicine, Çanakkale Onsekiz Mart University, Çanakkale, Türkiye

⁵ Faculty of Medicine, Université Laval, Quebec City, QC, Canada

⁶ Department of Translational Research and New Technologies in Medicine and Surgery, University of Pisa, Pisa, Italy

⁷ School of Medical Statistics and Biometry, Department of Public Health and Infectious Diseases, Sapienza University of Rome, Rome, Italy

⁸ Young WFPHA working group, World Federation of Public Health Associations, Geneva, Switzerland

⁹ Global Health Program, Department of Anthropology, UC San Diego, USA

Received June 29, 2026 · Accepted October 14, 2026 · Published October 14, 2026



Keywords: digital health literacy, public health, digital health, digital health interventions, behaviors

Abstract

Background: In the digital era, health literacy is essential for informed decision-making and improved outcomes. This PRISMA systematic review evaluates the effectiveness of digital health interventions (DHIs) in enhancing health literacy, using WHO definitions and classification frameworks.

Methods: Cross-sectional studies, surveys, and case reports were included, focusing on DHIs such as mobile apps, online platforms, and telehealth services. PubMed, IEEE, and ACM databases were searched for publications from 2013 to 2024.

Results: Of 1,029 initial articles, 39 met inclusion criteria. DHIs, including multimedia tools, apps, and remote programs, show potential to improve health literacy across populations, though results vary by age and socioeconomic status. Studies were categorized as follows: mobile apps (10.3%), online platforms (30.8%), multimedia tools (5.1%), telehealth/mHealth (15.4%), EHRs and portals (2.6%), conference proceedings (17.9%), and review studies (17.9%). Regarding the level of evidence, most studies were classified at Oxford Level 4 (64.1%), with fewer reaching Level 1 (20.5%) or Level 2 (10.3%).

Conclusion: DHIs show potential to enhance user engagement and health knowledge, though results remain heterogeneous. While user-centered and culturally sensitive designs represent promising strategies, current evidence is insufficient to determine the definitive superiority of specific features,

such as gamification. Standardized evaluation methods and targeted efforts to address digital inequities are needed to guide equitable digital-first healthcare policies.

1. INTRODUCTION

In 2024 with over 5.5 billion people using the internet, more than two-thirds of the global population, digital tools play a central role in accessing information and services, including healthcare [1]. In this digital era, promoting health literacy remains essential for shaping individuals' health outcomes, and there is an increasing and varied number of new tools that can be used to achieve this goal. The World Health Organization (WHO) defines health literacy as the ability to access, understand, and use information to maintain and improve health for oneself, one's family, and the wider community [2,3]. A wide range of interventions exists to enhance health literacy, from small group sessions and personalized education to digital communications, multimedia learning tools, animated content, and mobile applications [4,5]. Many of these interventions leverage digital technologies, collectively referred to as digital health interventions (DHIs) or eHealth interventions. According to the WHO classification, DHIs encompass a broad spectrum of tools and practices, including artificial intelligence, big data analytics, telemedicine, and other digital innovations, designed to improve health outcomes [6-8].

DHIs have demonstrated potential in promoting healthy behaviors, managing chronic conditions, and improving access to treatments, thus supporting public health goals such as delivering targeted interventions and reducing barriers to care. Examples include encouraging smoking cessation, healthy eating, physical activity, and supporting patients with cardiovascular disease, diabetes, or mental health conditions [4,9-11]. Digital interventions also facilitate remote access to treatments, such as computerized cognitive behavioral therapy, which is particularly valuable for mental health care [10,11].

Despite their promise, the adoption and effectiveness of DHIs are influenced by the digital divide, which reflects disparities in access to and use of technology. Factors such as age, education, income, and urban versus rural residence shape this divide and are closely linked to eHealth literacy levels [12]. Addressing these inequalities is critical to ensure equitable benefits of DHIs and reduce preventable health disparities associated with social, economic, or environmental disadvantage [13].

Previous reviews have examined the effectiveness of digital health interventions in improving health literacy across various populations, including older adults and migrant communities, and health domains such as chronic disease and mental health. Many studies, particularly those employing interactive multimedia and internet-based platforms, report positive effects on health knowledge, attitudes, and in some cases, behaviors. However, outcomes are not uniformly consistent [14-17]. For instance, a meta-analysis of older adults found significant gains in eHealth literacy knowledge, but no improvement in practical digital health skills [18]. Similarly, digital mental health literacy interventions enhanced knowledge but showed only moderate or variable effects on broader mental health outcomes [19].

While DHIs often improve health literacy, not all interventions translate into long-term behavior change or improved clinical outcomes [14]. Their effectiveness depends heavily on thoughtful design and implementation, particularly when educational content is explicitly integrated to help users understand and act on health information [4]. As digital technologies continue to advance rapidly, it is important to continuously reassess the evidence supporting DHIs for health literacy.

This study presents a systematic review of digital interventions aimed at improving health literacy [20]. The review is guided by the question: To what extent have DHIs improved health literacy across diverse populations and health domains? The objectives are to:

1. Categorize the types of DHIs used to enhance health literacy.
2. Evaluate their effectiveness in improving health literacy outcomes.
3. Examine the approaches used to measure health literacy within these interventions.

2. METHODS

We conducted a multilingual literature search of three major databases: PubMed, IEEE, and ACM. This specific triad was purposively selected to reflect the highly interdisciplinary nature of Digital Health Interventions (DHIs), which reside at the intersection of public health and computer science. While PubMed provided comprehensive coverage of the biomedical, clinical, and public health literature, IEEE and the ACM Digital Library were specifically targeted to capture literature on technological innovation, human-computer interaction (HCI), system design, and software engineering. These technological aspects are fundamental to DHI development but are frequently underrepresented in traditional medical databases. We developed specific search strings adapted to the syntax of each database, with the complete list of keywords provided in the Supplementary Material. A key objective of this search strategy was to update the existing evidence base, building upon prior foundational work such as the 2014 systematic review by *Jacobs et al* [14].

2.1. Inclusion Criteria

We included original research, cross-sectional studies, surveys, case reports, and other types of primary studies, as well as reviews, commentaries, and observational studies, when they included a description of a digital intervention aimed at increasing health literacy. Articles in English, French, German, and Italian published from 2013 to 2024 were considered eligible. For interventional studies, we used the following PICOT framework:

- Population (P): Any population.
- Intervention (I): Any technological intervention in digital health as defined by the World Health Organization [6]. Digital health, as mentioned within the introduction, is defined as the ability of individuals to gain access to, understand and use information in ways which promote and maintain good health for themselves, their families and their communities.
- Control (C): Not defined (a specific control or comparator group was not required as this review encompasses diverse study designs, including single-arm, pre-post, observational, and qualitative studies, which do not universally employ control groups).
- Outcome (O): Any outcomes related to health literacy as defined by the Center for Disease Control and Prevention (CDC) [21,22].
- Time (T): Papers/proceedings published from 2013 to 2024.

We adopted the CDC framework to define health literacy outcomes, as it provides clear, measurable indicators such as patient activation and improved communication. For categorizing interventions, we used the WHO Classification of Digital Health Interventions (CDHI), which offers a structured, intervention-based taxonomy. Studies were excluded if they focused on general digital literacy unrelated to health (e.g., smartphone use for non-health purposes) or if the interventions did not meet the WHO definition of digital health. While the primary focus was explicitly on health literacy outcomes, a small subset of studies was retained if they extensively evaluated fundamental digital health skills, usability, or engagement (eHealth literacy) as direct proxy prerequisites for achieving health literacy, even if post-intervention health literacy was not formally quantified.

2.2. Papers selection process

The selection process followed three main phases:

- Initial search: A total of 1,029 articles were identified across PubMed (n = 682), IEEE (n = 32), and ACM (n = 315) after removing duplicates.
- Title and abstract screening: Five reviewer pairs independently screened titles and abstracts in a double-blind process. Discrepancies were resolved by a third reviewer. At this stage, 124 papers were selected for full-text review.
- A total of six authors were randomly assigned, in equal parts, manuscripts to evaluate for inclusion or exclusion. In cases of uncertainty, a second reviewer made the final determination. By the end of this phase, 46 articles were included. During the data extraction phase, 7 additional papers were excluded for not being exclusively focused on health literacy, leaving 39 articles for manuscript preparation.

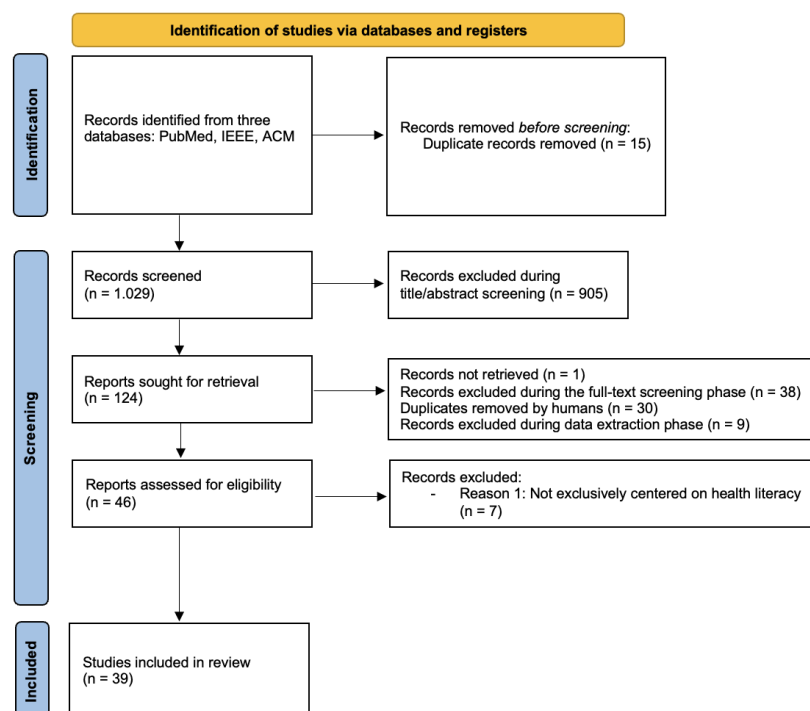


Figure 1. PRISMA flow diagram

2.3. Data Extraction and Synthesis

A structured dataset with over 32 key variables was created for each included study, see Table A in supplementary material. Seven reviewers extracted data from primary studies (around seven papers each), while two reviewers focused on systematic reviews. Data extraction distinguished between primary and non-primary studies, followed by a narrative synthesis and comparative analysis. Studies were categorized by intervention type to promote health literacy, and methodological design (systematic review, quantitative, or qualitative).

2.4. Level-of-evidence assessment and reporting

The study used the 2011 Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence tool to assess the strength of evidence [23]. In accordance with this framework, study designs were mapped hierarchically to reflect their methodological robustness: Level 1 was strictly reserved for systematic reviews and meta-analyses; Level 2 included randomized controlled trials (RCTs); Level 3 comprised non-randomized controlled cohorts; Level 4 encompassed pre-post studies, feasibility studies, cross-sectional designs, and conference proceedings lacking full peer review; and Level 5 was assigned to conceptual papers based on mechanism-based reasoning. Furthermore, the review

followed the PRISMA guidelines [24] to ensure transparent, comprehensive, and standardized reporting of the review findings.

3. RESULTS

3.1. Characteristics of included studies

While 39 studies were identified exploring digital approaches to enhance health literacy, their geographical and demographic distributions reveal substantial disparities. Most studies originated from North America (53.8%, $n = 21$; predominantly the U.S., $n = 19$), limiting the generalizability of findings to other regions. Europe (20.5%, $n = 8$), Asia (17.9%, $n = 7$), and Australia (7.7%, $n = 3$) were underrepresented, with no studies from Africa or South America, highlighting critical gaps in understanding DHIs across diverse cultural and healthcare contexts. This imbalance aligns with data from the Global Digital Health Monitor, which indicates slower adoption of digital health solutions in several world regions [25].

Age representation was similarly uneven: while adults were frequently studied (33.3%, $n = 13$), research involving elderly (10.3%, $n = 4$) and youth (12.8%, $n = 5$) remained limited, despite these groups' known challenges with digital literacy. Many studies (43.6%, $n = 17$) included mixed or unspecified age groups, hindering age-specific insights. Ethnic minorities and underserved populations were examined in only 17.9% ($n = 7$) of studies, with most lacking ethnic detail (69.2%, $n = 27$), constraining evaluation of intervention equity and cultural relevance [26].

Regarding publication types and intervention categories, the evidence base primarily consisted of primary studies (64.1%, $n = 25$). Within this group, websites and online platforms were the most frequently evaluated digital tools (30.8%, $n = 12$), followed by telehealth and mHealth services (15.4%, $n = 6$), mobile applications (10.3%, $n = 4$), multimedia tools (5.1%, $n = 2$), and electronic health records and patient portals (2.6%, $n = 1$). The remainder of the included literature was categorized as secondary studies, which comprised systematic and narrative reviews synthesizing existing evidence (17.9%, $n = 7$) and conference proceedings reporting on emerging design and feasibility trends (17.9%, $n = 7$).

The level-of-evidence assessment revealed that most studies were classified at Level 4 (64.1%, $n = 25$). Only a fifth of the included literature was categorized at Level 1 (20.5%, $n = 8$), followed by a subset of randomized controlled trials at Level 2 (10.3%, $n = 4$). Studies at Level 3 (2.6%, $n = 1$) and Level 5 (2.6%, $n = 1$) were rare, underscoring the need for more rigorous research designs. See Table 1.

Although our focus is on health literacy, DHIs address multiple types of literacy: a) *Health literacy*: The ability to access, understand, and use information to maintain and promote health for oneself and others (WHO definition) [3]; b) *Digital literacy*: The ability to use information and communication technologies to find, evaluate, create, and communicate information, involving both cognitive and technical skills [27]; c) *eHealth (digital health) literacy*: The ability to search, understand, and critically evaluate health information from digital sources and apply it to solve health-related problems [28].

While related, these literacies differ: health literacy focuses on health content, digital literacy on accessing information digitally regardless of topic, and eHealth literacy combines both, reflecting the ability to appraise and use digital health information effectively.

3.2. Narrative overview of the studies included

We present a narrative overview of the included studies, which provides a flexible approach to summarize existing knowledge, integrate diverse perspectives, identify gaps, and suggest future research directions. By combining qualitative and quantitative evidence, the narrative method can reveal trends and patterns not always evident in structured reviews [29].

Interventional studies are grouped by the type of DHI used, while conference proceedings and reviews are presented separately, as they typically focus on broader thematic insights into DHIs and health literacy. Overall, publications are classified into primary peer-reviewed studies and secondary peer-reviewed studies.

Primary studies:

1. *Mobile Applications*. Studies exploring health literacy interventions delivered via mobile apps (n = 4, 10.3 %) [30-33].
2. *Websites and Online Platforms*. Digital tools designed to disseminate health information or facilitate interactive learning experiences (n = 12, 30.8 %) [34-45].
3. *Multimedia Tools*. Interventions leveraging various media formats to enhance health literacy (n = 2, 5.1 %) [46,47].
4. *Telehealth and mHealth*. Remote healthcare services and mobile health technologies aimed at improving patient education and engagement (n = 6, 15.4 %) [48-53].
5. *Electronic Health Records (EHRs) and Patient Portals*. Studies assessing the role of digital health records in enhancing patient involvement and literacy (n = 1, 2.6 %) [54].

Secondary studies:

1. *Review Studies*. Systematic and narrative reviews synthesizing existing evidence in the field (n = 7, 17.9 %) [14,15,18,55-58].
2. *Conference Proceedings*. Research presented at conferences, offering valuable insights into emerging trends and innovations (n = 7, 17.9 %) [59-65].

Mobile applications represent a key component of digital health interventions (DHIs) aimed at improving health literacy across different populations and chronic conditions. *Owens et al.* (2020) [30] implemented a culturally tailored mobile app for African American lung cancer survivors, supporting symptom self-management and improving quality of life. *Parker et al.* (2022) [31] applied a mobile app-based health coaching program for overweight adults, which improved diet-related health literacy though it had limited effects on physical activity. Similarly, *Steinberg et al.* (2022) [32] evaluated the *SweetMama* app for diabetes in pregnant women, reporting engagement levels that varied according to eHealth literacy, while *Lemos et al.* (2024) [33] demonstrated high satisfaction among older adults using an app to support medication adherence, though device-use skills limited its impact.

Web-based platforms constituted the largest category of digital health literacy interventions, encompassing diverse populations and implementation models. *Chenneville et al.* (2021) [34] evaluated the *Bijou mHealth* program for young men who have sex with men living with HIV, reporting improvements in e-literacy but high attrition rates that limited long-term impact. *Reininger et al.* (2013) [35] demonstrated knowledge gains through a diabetes prevention website across ethnic groups, although variation in internet literacy persisted. Similarly, *Horvath et al.* (2017) [36] explored the acceptability of tailored online interventions for HIV/STI testing among young men who have sex with men (YMSM), highlighting the role of eHealth literacy in intervention design. Studies focusing on adolescents, including *McKinnon et al.* (2020) [37], *Zaim et al.* (2021) [38], *Scull et al.* (2021, 2022) [39,40], and *König et al.* (2022) [41], consistently showed that interactive and educational web programs improved media, digital, and health literacy. Among adults and older users, *De Main et al.* (2022) [42] and *Conte et al.* (2023) [43] reported superior eHealth literacy outcomes from digital tutorials and educational websites, while *Bickmore et al.* (2016) [44] and *Moretti et al.* (2023) [45] demonstrated that conversational search systems and informatics courses effectively enhanced accessibility and digital competence in low-literacy and student populations.

Two studies evaluated multimedia interventions directly. While *Monkman et al.* (2015) [46] proposed a conceptual adoption model for consumer health information systems, *Chang et al.* (2021) [47] showed that internet-based health education significantly improved digital literacy among older South

Korean adults. These results highlight that interactive and multimedia approaches can enhance comprehension and engagement, especially in low-literacy populations.

Telehealth and mHealth interventions broadened the application of DHIs across populations. *Taha et al.* (2014) [48] found that older adults often lacked the digital skills needed for patient portals, while *Zoellner et al.* (2020) [49] achieved behavioral change through an interactive voice system reducing sugary drink intake. *Spindler et al.* (2022) [50] and *Roh et al.* (2023) [51] reported improved engagement, literacy, and health behavior through telerehabilitation and literacy-based activity programs. *Lee et al.* (2022) [52] improved hypertension outcomes with culturally tailored telehealth, and *Quialheiro et al.* (2023) [53] enhanced digital literacy via community workshops, though health literacy remained unchanged. Collectively, these studies highlight that telehealth interventions are most effective when they combine behavioral theory, user-tailored design, and continuous support.

Implementation of electronic health records also influenced digital literacy among healthcare staff. *Kayser et al.* (2022) [54] found that healthcare professionals' eHealth literacy remained stable following EHR adoption, suggesting that ongoing professional development is necessary for sustained competence.

Seven systematic reviews supported the effectiveness of digital interventions in improving health literacy. *Jacobs et al.* (2016) [14] reported significant literacy and behavior gains across populations, while *Kim et al.* (2017) [55] identified barriers related to reading difficulty and technology access among low-literacy users. *Cheng et al.* (2020) [56] emphasized cultural tailoring and participatory design, and *Lin et al.* (2021) [57] confirmed that mHealth tools effectively enhance literacy in both healthy and clinical populations. *Birati et al.* (2022) [58] focused on gestational diabetes, finding improved glycemic control with culturally adapted apps. *Dong et al.* (2023) [18] demonstrated literacy and self-efficacy gains in older adults following long-term interventions, while *Verweel et al.* (2023) [15] confirmed broad improvements in chronic disease populations.

Conference proceedings expanded the evidence base with a focus on design and feasibility aspects of DHIs rather than long-term clinical outcomes. *Jacobs et al.* (2014) [59] conducted an early evaluation of a mobile tool for cancer patients, identifying a strong need for accessible health information. *Jean et al.* (2015) [60] described an after-school digital literacy program for disadvantaged middle school students that increased motivation, confidence, and career preparedness. *Desai et al.* (2023) [61] assessed a voice-user interface (VUI) for health education, showing that younger adults benefited more from conceptual scaffolding, though both age groups achieved similar learning outcomes. *Pillai et al.* (2018) [62] evaluated the *Awareness Computer Concepts* initiative, where most students demonstrated high understanding of alcohol's physical and social impacts but limited awareness of psychological effects. *Wiji Utami et al.* (2022) [63] used augmented reality to promote hydration literacy, while *Kim et al.* (2015) [64] reviewed eHealth strategies and concluded that effective literacy interventions need not be complex or costly but require proper training for implementation. Finally, *Durán et al.* (2023) [65] evaluated the usability of the uMind app among university students and mental health specialists, exploring how to integrate mental health education into mobile learning.

Evidence synthesis using the WHO Framework revealed that the majority of the studies aligned with *Domain 1 - Interventions for Clients*, emphasizing user empowerment through digital tools. Within this domain, the most frequent subdomains were *Targeted Client Communication*, focused on education and behavior change; *Personal Health Tracking*, promoting self-monitoring and chronic condition management; *Client Access to Health Records*, improving information accessibility; and *Client Education and Training*, which enhanced confidence and digital literacy through multimedia and interactive learning. *Domain 2 - Interventions for Healthcare Providers* included studies addressing professional training and digital competence, highlighting the importance of readiness and cross-sector collaboration. No interventions targeted *Domain 3 - Health System Managers*, indicating a research gap in organizational and leadership-level digital literacy. Finally, *Domain 4 - Data*

Services encompassed studies on digital data collection, management, and policy use, demonstrating the role of data-driven approaches in evaluating interventions and informing digital health strategies. Review studies were not included. See Table 2.

Table 1: Detailed study characteristics and evidence levels

Author (Year)	Country	Type of Intervention (Study Design)	Participants	Sample Size / Study Count	Outcome Type	Health Literacy Measurement Tool	Direction of Effect on Health Literacy	Health Literacy: Primary or Secondary Outcome	OXFORD level of evidence
Secondary Studies & Reviews									
Verweel et al (2023)	Canada	Meta-Analysis (Systematic Review & Meta-Analysis)	Individuals with one or more chronic conditions	17	Digital Health Literacy	eHEALS	Increase in digital health literacy	Secondary	Level 1
Cheng et al (2020)	Australia	Review Studies (Systematic Review)	Socially disadvantaged groups	48	Electronic Health Literacy	eHEALS, Short-TOFHLA, REALM, Interviews	13 of the studies did not find an increase, 19 studies found an increase in health literacy	Primary	Level 1
Kim et al (2017)	USA	Review Studies (Systematic Review)	Older adults with heart failure, low-literacy patients with diabetes, and low-income parents whose children have special health care needs	74	Health Literacy	12 different tools including: eHEALS, S-TOFHLA, REALM, NVS, Active Australia Questionnaire, Functional, Communicative, and Critical Health Literacy Scale, METER, SILS, The National Assessment of Adult Literacy and researcher-developed questionnaires	6 out of 9 intervention studies showed an increase in health knowledge and health literacy, while remaining 3 studies reported websites and avatar did not improve health literacy.	Primary	Level 1

Birati et al (2022)	Israel	Review Studies (Scoping Review)	Pregnant women with Gestational Diabetes Mellitus (GDM)	17	Glycemic control, clinical outcomes, Digital Health Literacy	Researcher developed questionnaire	Increase in health knowledge	Secondary	Level 1
Dong et al (2023)	China	Review Studies (Single-Arm Meta-Analysis)	Older adults	7	Digital Health Literacy	eHEALS	Increase in eHealth literacy	Primary	Level 1
Jacobs et al (2016)	USA	Review Studies (Systematic Review)	Participants ranging from 11 years to adults aged 65 years and older, from multi cultural backgrounds .	12	Health Literacy	WRAT, REALM, TOFHLA, Health Activity Literacy Scale, NVS, Short Assessment for Spanish Speaking Adults, and the disease-specific knowledge assessment	Increase in health literacy	Primary	Level 1
Lin et al (2021)	Taiwan	Review Studies (Systematic Review)	Different populations including patients with kidney disease in two studies, healthy adults in two studies and adult immigrants in one study.	5	Health Literacy, Electronic Health Literacy, Mobile Health Literacy	eHEALS, NVS, the researcher-developed questionnaire HLS-APP-Q14, HLS-EU-Q16 and researcher-developed questionnaires	Increase in health literacy	Primary	Level 1
Kim et al (2015)	USA	Conference Proceedings (Systematic Review)	The participants in the studies reviewed were diverse, ranging from 11 years old to 65 years and older, and from different cultural and linguistic backgrounds	42	Health Literacy	The Talking Touchscreen, and no specified other tools	Six intervention studies showed increase in health knowledge and health literacy	Primary	Level 1

Primary Studies & Proceedings	Parker et al (2022)	Australia	Mobile Apps (Cluster Randomised Controlled Trial)	Overweight and obese patients in urban general practices in lower socioeconomic areas	215	Health Literacy, Electronic Health Literacy, Weight change, QoL	HLQ, eHEALS	Increase in health literacy	Primary	Level 2
	Bickmore et al (2016)	USA	Websites and Online Platforms (Randomized Controlled Experiment)	Adult English-speaking cancer patients	89	Self-reported satisfaction with intervention, Health Literacy	REALM	Post-intervention health literacy not assessed	Secondary	Level 2
	Scully et al (2022)	USA	Websites and Online Platforms (Group Randomized Controlled Trial)	High school students	785	Media Literacy, Sexual Health Literacy, Health Literacy	Researcher-developed questionnaire	Increase in media literacy and sexual health literacy	Secondary (Media Literacy)	Level 2
	Spindler et al (2022)	Denmark	Telehealth and mHealth (Randomized Controlled Trial)	Adults aged 18 and above with heart failure (NYHA class I-IV)	137	Electronic Health Literacy	eHLQ	Increase in eHealth literacy	Primary	Level 2
	De Main et al (2022)	USA	Websites and Online Platforms (Pre-Post Quasi-Experimental Study)	Community-dwelling older adults	99	Electronic Health Literacy	eHEALS	Increase in eHealth Literacy	Primary	Level 3
	Scully et al (2021)	USA	Websites and Online Platforms (Feasibility Study)	High school students	331	Sexual Health Literacy, Media Literacy	Researcher-developed questionnaire	Increase in sexual health literacy	Primary	Level 4
	McKinnon et al (2020)	Australia	Websites and Online Platforms (Pilot Study)	Adolescent patients aged 10-18 years old	10	Electronic Health Literacy	Semi-structured interviews	No change in health literacy	Primary	Level 4

Chang et al (2021)	South Korea	Multimedia Tools (Pilot Study)	Older adults aged 65 and above	11	Electronic Health Literacy	eHEALS, researcher-developed questionnaire	Increase in eHealth literacy score, search performance score, level of understanding of internet-based health information and attitude toward internet-based health information	Primary	Level 4
König et al (2022)	Germany	Websites and Online Platforms (Pre-Post Measurement Study)	School-age children 16-20 years old	323	Health Literacy, Digital Health Literacy	Health Literacy for School age Children Instrument, Digital Health Literacy Instrument	Increase in health literacy and digital health literacy	Primary	Level 4
Roh et al (2023)	South Korea	Telehealth and mHealth (Controlled Quasi-Experimental Study)	Female college students	120	Electronic Health Literacy	eHEALS	Increase in eHealth literacy	Primary	Level 4
Horvath et al (2017)	USA	Websites and Online Platforms (Cross-Sectional Study)	Cisgender gay/bisexual males aged 15-24	130	STI Awareness, Electronic Health Literacy	6-item version of eHEALS	Not reported	Secondary	Level 4
Conte et al (2023)	Italy	Websites and Online Platforms (Pre-Post Study)	University students in their first year of medical school	362	Electronic Health Literacy	eHEALS	Increase in eHealth literacy	Primary	Level 4
Taha et al (2014)	USA	Telehealth and mHealth (Cross-Sectional Study)	Older people	51	Health Literacy	TOFHLA	Post-intervention health literacy not assessed	Primary	Level 4

Steinberg et al (2022)	USA	Mobile Apps (Pilot/ Usability Study)	Females with Gestational diabetes mellitus (GDM) and type 2 diabetes mellitus (T2DM)	24	App usage time, GDM outcomes, T2DM outcomes, Health Literacy, Electronic Health Literacy	NVS, eHEALS	Post-intervention health literacy not assessed	Secondary	Level 4
Kayser et al (2022)	Denmark	Electronic Health Records and Patient Portals (Longitudinal Study)	Healthcare professionals	194	Health Literacy	Staff eHLQ	No change in eHLQ scores	Primary	Level 4
Owens et al (2020)	USA	Mobile Apps (Qualitative Assessment)	African American lung cancer survivors and their family members	12	Qualitative assessment of cultural sensitivity, acceptability, perceived benefits of an app	Interviews	Not reported (Health literacy level was mentioned as a factor)	Secondary	Level 4
Zoellner et al (2020)	USA	Telehealth and mHealth (Pilot Dissemination Trial)	Adults consuming "e 200 sugar-sweetened beverage (SSB) kcals/day	117	Sugar-sweetened Beverage Consumption, BMI, Media Literacy, Health Literacy	NVS	Increase in media literacy	Secondary	Level 4
Quialheiro et al (2023)	Portugal	Telehealth and mHealth (Experimental Study)	People aged 55 years old or older	81	Digital Health Literacy, Health Literacy	MDPQ-16 and HLS-12	Increase in digital health literacy, no changes in health literacy	Primary	Level 4
Reininger et al (2013)	USA	Websites and Online Platforms (Formative Evaluation)	Adults at risk for diabetes because of overweight or obesity status and/or family history of diabetes	71	Diabetes knowledge, Health Literacy	REALM	Increase in diabetes knowledge, post-intervention health literacy not assessed	Secondary	Level 4
Moretti et al (2023)	Italy	Websites and Online Platforms (Pre-Post Study)	First year students of the Medical School	341	Digital Health Literacy	IT-eHEALS	Increase in digital health literacy (from mean: 2.9 to mean: 4.2)	Primary	Level 4

Note. HLQ: The Health Literacy Questionnaire; eHEALS: e-Health Literacy Scale; REALM: Rapid Estimate of Adult Literacy in Medicine; eHLQ: eHealth Literacy Questionnaire; TOFHLA: Test of Functional Health Literacy in Adults; NVS: New Vital Sign; Staff eHLQ: Staff version of the eHealth Literacy Questionnaire; MDPQ-16: Mobile Device Proficiency Questionnaire – 16 item version; HLS-12: Health Literacy Survey Questionnaire – 12 item version; HEALS: Italian version of the eHealth Literacy Scale; S-TOFHLA: Short Test of Functional Health Literacy in Adults; METER: Medical Term Recognition Test; SILS: Single Item Literacy Screener; WRAT: Wide Range Achievement Test; HLS-APP-Q14: Health Literacy Survey – Application Questionnaire, 14 items; HLS-EU-Q16: Health Literacy Survey – European Union Questionnaire, 16 items

Table 2: WHO Framework Evidence Synthesis Table

Domain	Subdomain	Focus	References*
1.0 – Interventions for Clients	1.1 – Targeted Client Communication	Web-based and mobile tools for education, behavior change, and digital literacy enhancement.	Scull (2021); Scull (2022); König (2022); Moretti (2023); Conte (2023); Jean (2015); Owens (2020); Zaim (2021); Parker (2022); Reininger (2013); Chenneville (2021); Roh (2023); Wiji (2022); Horvath (2017)
1.4.2 – Personal Health Tracking	Apps and platforms supporting self-monitoring and chronic condition management.	Spindler (2022); Steinberg (2022); Lemos (2024); Durán (2023); Lee (2022)	
1.4.3 – Client Access to Health Records	Digital portals and tools to access and organize personal health information.	Taha (2014); Jacobs (2014)	
1.6 – Client Education and Training	Conversational systems, and blended learning to build eHealth skills.	Bickmore (2016); De Main (2022); Chang (2021); McKinnon (2020); Desai (2023); Quialheiro (2023); Pillai (2018); Jean (2015)	
2.0 – Interventions for Healthcare Providers	2.8 – Healthcare Provider Training	Training programs enhancing professional digital competencies and readiness.	Kayser (2022); Durán (2023)
3.0 – Interventions for Health System Managers	—	Digital tools for enhancing health management, coordination, and decision-making among support personnel.	—
4.0 – Data Services	4.1 – Data Collection and Management	Digital tools for data tracking and literacy assessment.	Parker (2022); Reininger (2013); Quialheiro (2023); Zoellner (2020)
4.3 – Data Use for Health Policy and Planning	Efficient data management, and governance to optimize health information systems and decision-making.	Kim (2015); Monkman (2015); Cheng (2020); Kim (2017)	

Note. *Some studies appear across multiple domains, as their content is relevant to more than one classification category.

4. DISCUSSION

This systematic review synthesized evidence from DHIs designed to improve health literacy, identifying six overarching themes that shape their effectiveness: a) *theory-driven approaches*, b) *user-centered design*, c) *cultural competence*, d) *sustainability*, e) *accessibility*, and f) *standardized measurement*. Levels of evidence are reported in abbreviated form; for example, level 4 is indicated as L4.

4.1. Theory-Driven Strategies for Behavior Change

The integration of theoretical frameworks within DHIs appears to support more consistent and sustained behavioral outcomes in the studied cohorts. Systematic reviews and meta-analyses indicate that theory-driven DHIs promote higher motivation, engagement, and adherence. *Spindler (2022)* [50] (L2) demonstrated that applying Self-Determination Theory enhanced intrinsic motivation and long-term engagement in telerehabilitation for heart failure patients. Similarly, *Zoellner (2020)* [49]

(L4) utilized the Theory of Planned Behavior to foster healthier attitudes and self-efficacy toward sugar-sweetened beverage reduction. Investigations such as *Scull (2021) [39] (L4)*, revealed that theoretical constructs underpin preventive health behaviors among adolescents. Collectively, these findings underscore that embedding psychological and behavioral theories (particularly those emphasizing autonomy, self-efficacy, and perceived control) provides a structured foundation for intervention design and facilitates evaluation of engagement and behavioral change across diverse contexts.

4.2. User-Centered Design

User-centered design emerged as a cornerstone for successful DHI implementation. Systematic reviews and meta-analyses confirm that DHIs prioritizing readability, simplicity, and personalization improve usability and satisfaction. *Kim (2017) [55] (L1)* reported that online health information often exceeds recommended literacy levels, reinforcing the need for simplified and clear design. *Bickmore (2016) [44] (L2)* and *Steinberg (2022) [32] (L4)* demonstrated that conversational agents and simplified app interfaces improve engagement, satisfaction, and information accessibility (e.g., successful clinical trial search performance) among low-literacy users, even when formal post-intervention health literacy scores are not reassessed; when users feel supported in navigating these tools, they can more effectively overcome literacy barriers. *Jacobs (2014) [59] (L4)* struggled with designing a tool that benefited the female breast cancer participant, calling attention to the challenge of designing informative tools for minority populations. *Verweel (2023) [15] (L1)* found that tailored interfaces for chronic disease management increase confidence and sustained use. Qualitative studies, including *McKinnon (2020) [37] (L4)*, emphasize that younger and inexperienced users benefit from visual, interactive, and multimodal content. Altogether, this evidence highlights that DHIs designed around user needs and preferences may support engagement, adoption, and digital inclusion. Available studies suggest that tailoring design to user characteristics can facilitate usability and engagement, although further research is needed to confirm these effects across all age groups and literacy levels [66].

4.3. Cultural Competence and Tailored Content

Cultural and linguistic tailoring is critical to the adoption and effectiveness of DHIs, particularly among underserved populations. *Cheng (2020) [56] (L1)* showed that culturally adapted interventions enhance trust, participation, and clinical outcomes; this finding supports the view that cultural relevance fosters trust and enhances intervention efficacy. *Lee (2022) [52] (L4)*, *Birati (2022) [58] (L1)* confirmed that language-concordant coaching and culturally resonant content improved health self-management and patient empowerment in multiethnic cohorts. These studies emphasize that integrating cultural competence into DHIs is crucial for achieving positive health outcomes. Qualitative evidence from *Owens (2020) [30] (L4)* demonstrated that culturally sensitive design fosters emotional connection and adherence.

4.4. Sustainability and Adherence

Sustaining engagement and literacy improvements beyond intervention periods remains a major challenge in DHIs. Systematic reviews and meta-analyses consistently note that reinforcement mechanisms are essential for maintaining literacy gains. *Spindler (2022) [50] (L2)* demonstrated that ongoing telerehabilitation support preserved motivation and digital literacy over time. Studies such as *Scull (2022) [40] (L2)* and *König (2022) [41] (L4)*, found that gamification elements and periodic program engagement enhance adherence, particularly among younger participants. Findings from *Owens (2020) [30] (L4)* suggested that while initial benefits are achievable, long-term adherence may be challenging without sustained user support, underlining the need for design strategies that extend beyond the intervention phase. Similarly, *Jacobs (2014) [59] (L4)* highlighted that social interaction, peer forums, and personalized feedback encourage sustained participation. Lastly, *Scull (2021) [39] (L4)* observed that social features, such as discussion boards, increased motivation and adherence,

particularly among younger users. Collectively, this evidence suggests that combining digital reinforcement tools with community-based engagement strategies represents a promising strategy for maintaining behavioral change and health literacy over time.

4.5. Accessibility and Digital Equity

Digital equity remains a central determinant of DHI effectiveness. *Verweel (2023)* [15] (L1) found that improvements in health literacy were most pronounced among individuals with sufficient digital access and skills, underscoring that digital skills, connectivity, and tool access are prerequisites for equitable outcomes. *Parker (2022)* [31] (L2) observed that socioeconomic barriers, such as low connectivity and limited device access, constrained engagement among low-income participants, emphasizing the importance of low-cost or offline-compatible options. *Taha (2014)* [48] (L4) identified that older adults frequently overestimated their digital competence, indicating a need for baseline digital training and guided support. Inclusive solutions such as blended learning, offline access, and simplified interfaces, help bridge these gaps. Promoting digital equity aligns with WHO global digital health strategies.

4.6. Standardized Outcome Measurement

The absence of standardized evaluation tools and outcome measurement hinders comparison across DHI studies. *Cheng (2020)* [56] (L1) emphasized the importance of consistent use of validated instruments, such as the eHealth Literacy Scale, to measure intervention impact; in fact *Scull (2022)* [40] (L2) demonstrated that standardized assessments enable longitudinal tracking of digital and health literacy outcomes. *Lin (2021)* [57] (L1) found that mHealth interventions, especially mobile applications, effectively enhance health literacy, although measurement tools often lacked consistency and specificity. Similarly, *Dong (2023)* [18] (L1) showed that digital health literacy programs improved health management and overall well-being among older adults. *Jacobs (2016)* [14] (L1), found that technology-based interventions, when compared to control interventions, yielded significant or promising outcomes in improving health literacy across various settings, diseases, and diverse populations. Insights from *McKinnon (2020)* [37] (L4) suggested that integrating self-assessment and reflective tools enhances user engagement. Establishing standardized evaluation frameworks is therefore essential for linking literacy gains to measurable behavioral and health outcomes.

4.7. WHO DHI framework

According to the WHO DHI framework, the reviewed evidence spans three domains: Domain 1 (Client Interventions), Domain 2 (Healthcare Providers), and Domain 4 (Data Services). Domain 1 dominated, emphasizing digital skill development among diverse populations. Domains 2 and 4 were modestly represented, focusing on training and data collection through user-generated data. Domain 3 (Health System Managers) was absent, highlighting a critical gap in system-level digital literacy integration.

4.8. Discussion summary

Our review highlights several overarching factors influencing DHIs effectiveness. Although most studies targeted working-age and younger populations, older adults also benefited when appropriate guidance and support were provided. Cultural and linguistic tailoring proved particularly valuable for minority and underserved communities, improving trust and sustained engagement. Blended interventions that integrate digital and in-person components were frequently associated with maintained literacy gains, although direct comparative evidence remains limited. Pre-existing digital literacy strongly predicted intervention success, suggesting that foundational training enhances impact. While improvements in digital and health literacy were common, few studies directly linked these gains to behavioral outcomes. Moreover, post-intervention follow-up revealed that literacy gains often declined without continued reinforcement. Collectively, the evidence supports the potential

utility of DHIs in promoting equitable health literacy, but future research should emphasize long-term sustainability, standardized outcome assessment, and theoretically grounded, user-centered design. Overall, the available evidence was insufficient to determine whether certain interventions were more effective than others, highlighting the need for further research.

4.9 Limitations

This review has several limitations. First, we restricted our search to PubMed, IEEE, and ACM to focus on the intersection of medical and engineering literature; however, this means relevant literature in other potentially relevant databases may have been missed. Second, extreme design heterogeneity precluded a formal risk-of-bias assessment; thus, we relied on the Oxford Levels of Evidence to evaluate design hierarchy. This heterogeneity, alongside inconsistent measurement tools, constrains data synthesis. Third, performing full-text data extraction primarily by single reviewers may have introduced extraction bias. Finally, geographic clustering, narrow demographic focuses, and persistent digital inequities restrict the generalizability of our findings, highlighting the need for more standardized and inclusive future research.

5. CONCLUSION

This study highlights the multifaceted nature of DHIs in supporting health engagement. While elements like user-centered design and cultural competence appear beneficial in specific contexts (e.g., culturally adapted apps for minority groups), the overall evidence base is too heterogeneous to definitively claim one intervention type over another. Rather than universally recommending specific strategies like gamification, future efforts should prioritize robust, standardized investigations to establish long-term efficacy, maintain health literacy gains, and ensure equitable access across diverse populations. The findings align with the global shift toward digital-first healthcare and the WHO Digital Health Strategy, particularly Goal 4, which emphasizes health literacy [67].

Acknowledgments

None

Funding

None

Author contributions

Conceptualization: Francesco Andrea Causio, Alessandro Berionni, Luigi De Angelis, Marcello Di Pumpo, Giacomo Diedenhofen, Timothy Mackey, Fidelia Cascini; Data curation: all; Formal analysis: Marcello Di Pumpo; Funding acquisition: NA; Investigation: all; Methodology: Francesco Andrea Causio, Marcello Di Pumpo; Project administration: Francesco Andrea Causio; Resources: NA; Software: NA; Supervision: Timothy Mackey, Fidelia Cascini, Caterina Rizzo; Validation: Timothy Mackey, Fidelia Cascini, Caterina Rizzo; Visualization: all; Writing - original draft: all; Writing - review & editing: all. All authors have read and agreed to the published version of the manuscript

Conflict of interest

The authors declare no conflict of interest

Supplementary materials

- Research strategy keywords
- Data dictionary for data extraction

References

1. Digital 2025: Global Overview Report. DataReportal - Glob Digit Insights 2025. <https://datareportal.com/reports/digital-2025-global-overview-report> (accessed October 24, 2025).
2. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low Health Literacy and Health Outcomes: An Updated Systematic Review. *Ann Intern Med* 2011;155:97-107. <https://doi.org/10.7326/0003-4819-155-2-201107190-00005>.
3. Ninth Global Conference on Health Promotion, Shanghai 2016 n.d. <https://www.who.int/teams/health-promotion/enhanced-wellbeing/ninth-global-conference> (accessed October 24, 2025).
4. Walters R, Leslie SJ, Polson R, Cusack T, Gorely T. Establishing the efficacy of interventions to improve health literacy and health behaviours: a systematic review. *BMC Public Health* 2020;20:1040. <https://doi.org/10.1186/s12889-020-08991-0>.
5. Nutbeam D, McGill B, Premkumar P. Improving health literacy in community populations: a review of progress. *Health Promot Int* 2018;33:901-11. <https://doi.org/10.1093/heapro/dax015>.
6. Classification of digital interventions, services and applications in health: a shared language to describe the uses of digital technology for health, second edition. 2nd edition. Geneva: World Health Organization; n.d.
7. da Silva AA, Merolli M, Fini NA, Granger CL, Gustafson OD, Parry SM. Digital health interventions in adult intensive care and recovery after critical illness to promote survivorship care. *J Intensive Care Soc* 2025;17511437241311105. <https://doi.org/10.1177/17511437241311105>.
8. Senbekov M, Saliev T, Bukeyeva Z, Almaybayeva A, Zhanaliyeva M, Aitenova N, et al. The Recent Progress and Applications of Digital Technologies in Healthcare: A Review. *Int J Telemed Appl* 2020;2020:8830200. <https://doi.org/10.1155/2020/8830200>.
9. Ran X, Chen Y, Jiang K, Shi Y. The Effect of Health Literacy Intervention on Patients with Diabetes: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health* 2022;19:13078. <https://doi.org/10.3390/ijerph192013078>.
10. Lattie EG, Adkins EC, Winquist N, Stiles-Shields C, Wafford QE, Graham AK. Digital Mental Health Interventions for Depression, Anxiety, and Enhancement of Psychological Well-Being Among College Students: Systematic Review. *J Med Internet Res* 2019;21:e12869. <https://doi.org/10.2196/12869>.
11. Hollis C, Falconer CJ, Martin JL, Whittington C, Stockton S, Glazebrook C, et al. Annual Research Review: Digital health interventions for children and young people with mental health problems - a systematic and metareview. *J Child Psychol Psychiatry* 2017;58:474-503. <https://doi.org/10.1111/jcpp.12663>.
12. Scheerder A, Van Deursen A, Van Dijk J. Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. *Telemat Inform* 2017;34:1607-24. <https://doi.org/10.1016/j.tele.2017.07.007>.
13. Health inequities and their causes n.d. <https://www.who.int/news-room/facts-in-pictures/detail/health-inequities-and-their-causes> (accessed October 24, 2025).
14. Jacobs RJ, Lou JQ, Ownby RL, Caballero J. A Systematic Review of eHealth Interventions to Improve Health Literacy. *Health Informatics J* 2016;22:81-98. <https://doi.org/10.1177/1460458214534092>.
15. Verweel L, Newman A, Michaelchuk W, Packham T, Goldstein R, Brooks D. The Effect of Digital Interventions on Related Health Literacy and Skills for Individuals Living with Chronic Diseases: A Systematic Review and Meta-Analysis. *Int J Med Inf* 2023;177:105114. <https://doi.org/10.1016/j.ijmedinf.2023.105114>.

16. Yuen E, Winter N, Savira F, Huggins CE, Nguyen L, Cooper P, et al. Digital Health Literacy and Its Association With Sociodemographic Characteristics, Health Resource Use, and Health Outcomes: Rapid Review. *Interact J Med Res* 2024;13:e46888. <https://doi.org/10.2196/46888>.
17. Yameogo AR, Délétroz C, Sasseville M, Amil S, Da SMAR, Bodenmann P, et al. Effectiveness of Interventions to Improve Digital Health Literacy in Forced Migrant Populations: Protocol for a Mixed Methods Systematic Review. *JMIR Res Protoc* 2023;12:e50798. <https://doi.org/10.2196/50798>.
18. Dong Q, Liu T, Liu R, Yang H, Liu C. Effectiveness of Digital Health Literacy Interventions in Older Adults: Single-Arm Meta-Analysis. *J Med Internet Res* 2023;25:e48166. <https://doi.org/10.2196/48166>.
19. Yeo G, Reich SM, Liaw NA, Chia EYM. The Effect of Digital Mental Health Literacy Interventions on Mental Health: Systematic Review and Meta-Analysis. *J Med Internet Res* 2024;26:e51268. <https://doi.org/10.2196/51268>.
20. Causio FA, Fakhfakh M, Kaur J, Sert B, Gandolfi S, Di Pumpo M, et al. Digital Health Interventions' Impact on Health Literacy: A Systematic Review. *Eur J Public Health* 2024;34:ckae144.1201. <https://doi.org/10.1093/eurpub/ckae144.1201>.
21. Santana S, Brach C, Harris L, Ochiai E, Blakey C, Bevington F, et al. Updating Health Literacy for Healthy People 2030: Defining Its Importance for a New Decade in Public Health. *J Public Health Manag Pract* 2021;27:S258-64. <https://doi.org/10.1097/PHH.0000000000001324>.
22. What Is Health Literacy? | Health Literacy | CDC n.d. https://www.cdc.gov/health-literacy/php/about/?CDC_AAref_Val=https://www.cdc.gov/healthliteracy/learn/index.html (accessed February 13, 2025).
23. OCEBM Levels of Evidence -- Centre for Evidence-Based Medicine (CEBM), University of Oxford n.d. <https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence> (accessed February 13, 2025).
24. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst Rev* 2021;10:89. <https://doi.org/10.1186/s13643-021-01626-4>.
25. Global Digital Health Monitor n.d. <https://monitor.digitalhealthmonitor.org/map> (accessed June 24, 2025).
26. Brewer LC, Fortuna KL, Jones C, Walker R, Hayes SN, Patten CA, et al. Back to the Future: Achieving Health Equity Through Health Informatics and Digital Health. *JMIR MHealth UHealth* 2020;8:e14512. <https://doi.org/10.2196/14512>.
27. Digital Literacy - Welcome to ALA's Literacy Clearinghouse n.d. <https://literacy.ala.org/digital-literacy/> (accessed June 24, 2025).
28. Digital Health in the WHO European Region: the ongoing journey to commitment and transformation n.d. <https://www.who.int/europe/publications/m/item/digital-health-in-the-who-european-region-the-ongoing-journey-to-commitment-and-transformation> (accessed June 24, 2025).
29. Sukhera J. Narrative Reviews: Flexible, Rigorous, and Practical. *J Grad Med Educ* 2022;14:414-7. <https://doi.org/10.4300/JGME-D-22-00480.1>.
30. Owens OL, Smith KN, Beer JM, Gallerani DG, McDonnell KK. A Qualitative Cultural Sensitivity Assessment of the Breathe Easier Mobile Application for Lung Cancer Survivors and Their Families. *Oncol Nurs Forum* 2020;47:331-41. <https://doi.org/10.1188/20.ONF.331-341>.
31. Parker SM, Barr M, Stocks N, Denney-Wilson E, Zwar N, Karnon J, et al. Preventing Chronic Disease in Overweight and Obese Patients with Low Health Literacy Using eHealth and Teamwork in Primary Healthcare (HeLP-GP): A Cluster Randomised Controlled Trial. *BMJ Open* 2022;12:e060393. <https://doi.org/10.1136/bmjopen-2021-060393>.
32. Steinberg JR, Yeh C, Jackson J, Saber R, Niznik CM, Leziak K, et al. Optimizing Engagement in an mHealth Intervention for Diabetes Support During Pregnancy: The Role of Baseline Patient Health and Behavioral Characteristics. *J Diabetes Sci Technol* 2022;16:1466-72. <https://doi.org/10.1177/19322968211035441>.
33. Lemos M, Henriques AR, Lopes DG, Mendonça N, Victorino A, Costa A, et al. Usability and Utility of a Mobile App to Deliver Health-Related Content to an Older Adult Population: Pilot Noncontrolled Quasi-Experimental Study. *JMIR Form Res* 2024;8:e46151. <https://doi.org/10.2196/46151>.
34. Chenneville T, Drake H, Gabbidon K, Rodriguez C, Hightow-Weidman L, Bijou: Engaging Young MSM in HIV Care Using a Mobile Health Strategy. *J Int Assoc Provid AIDS Care* 2021;20:23259582211030805. <https://doi.org/10.1177/23259582211030805>.

35. Reininger B, Mecca LP, Stine KM, Schultz K, Ling L, Halpern D. A Type 2 Diabetes Prevention Website for African Americans, Caucasians, and Mexican Americans: Formative Evaluation. *JMIR Res Protoc* 2013;2:e24. <https://doi.org/10.2196/resprot.2573>.
36. Horvath KJ, Bauermeister JA. eHealth Literacy and Intervention Tailoring Impacts the Acceptability of a HIV/STI Testing Intervention and Sexual Decision Making Among Young Gay and Bisexual Men. *AIDS Educ Prev Off Publ Int Soc AIDS Educ* 2017;29:14-23. <https://doi.org/10.1521/aeap.2017.29.1.14>.
37. McKinnon KA, H Y Caldwell P, Scott KM. How Adolescent Patients Search for and Appraise Online Health Information: A Pilot Study. *J Paediatr Child Health* 2020;56:1270-6. <https://doi.org/10.1111/jpc.14918>.
38. Zaim H, Keedy H, Dolce M, Chisolm D. Improving Teen Girls' Skills for Using Electronic Health Information. *Health Lit Res Pract* 2021;5:e26-34. <https://doi.org/10.3928/24748307-20201126-01>.
39. Scull T, Malik C, Morrison A, Keefe E. Promoting Sexual Health in High School: A Feasibility Study of A Web-based Media Literacy Education Program. *J Health Commun* 2021;26:147-60. <https://doi.org/10.1080/10810730.2021.1893868>.
40. Scull TM, Dodson CV, Geller JG, Reeder LC, Stump KN. A Media Literacy Education Approach to High School Sexual Health Education: Immediate Effects of Media Aware on Adolescents' Media, Sexual Health, and Communication Outcomes. *J Youth Adolesc* 2022;51:708-23. <https://doi.org/10.1007/s10964-021-01567-0>.
41. König L, Marbach-Breitrück E, Engler A, Suhr R. The Development and Evaluation of an E-Learning Course That Promotes Digital Health Literacy in School-age Children: Pre-Post Measurement Study. *J Med Internet Res* 2022;24:e37523. <https://doi.org/10.2196/37523>.
42. De Main AS, Xie B, Shiroma K, Yeh T, Davis N, Han X. Assessing the Effects of eHealth Tutorials on Older Adults' eHealth Literacy. *J Appl Gerontol Off J South Gerontol Soc* 2022;41:1675-85. <https://doi.org/10.1177/07334648221088281>.
43. Conte A, Brunelli L, Moretti V, Valdi G, Guelfi MR, Masoni M, et al. Can a Validated Website Help Improve University Students' e-Health Literacy? *Ann Ig Med Prev E Comunita* 2023;35:257-68. <https://doi.org/10.7416/ai.2022.2542>.
44. Bickmore TW, Utami D, Matsuyama R, Paasche-Orlow MK. Improving Access to Online Health Information With Conversational Agents: A Randomized Controlled Experiment. *J Med Internet Res* 2016;18:e1. <https://doi.org/10.2196/jmir.5239>.
45. Moretti V, Brunelli L, Conte A, Valdi G, Guelfi MR, Masoni M, et al. A Web Tool to Help Counter the Spread of Misinformation and Fake News: Pre-Post Study Among Medical Students to Increase Digital Health Literacy. *JMIR Med Educ* 2023;9:e38377. <https://doi.org/10.2196/38377>.
46. Monkman H, Kushniruk AW. The Consumer Health Information System Adoption Model. *Stud Health Technol Inform* 2015;218:26-31.
47. Chang SJ, Yang E, Lee K-E, Ryu H. Internet Health Information Education for Older Adults: A Pilot Study. *Geriatr Nurs N Y N* 2021;42:533-9. <https://doi.org/10.1016/j.gerinurse.2020.10.002>.
48. Taha J, Sharit J, Czaja SJ. The Impact of Numeracy Ability and Technology Skills on Older Adults' Performance of Health Management Tasks Using a Patient Portal. *J Appl Gerontol Off J South Gerontol Soc* 2014;33:416-36. <https://doi.org/10.1177/0733464812447283>.
49. Zoellner JM, Porter KJ, You W, Estabrooks PA, Perzynski K, Ray PA, et al. The Reach and Effectiveness of SIPsmartER When Implemented by Rural Public Health Departments: A Pilot Dissemination and Implementation Trial to Reduce Sugar-Sweetened Beverages. *Transl Behav Med* 2020;10:676-84. <https://doi.org/10.1093/tbm/ibz003>.
50. Spindler H, Dyrvig A-K, Schacksen CS, Anthonimuthu D, Frost L, Gade JD, et al. Increased Motivation for and Use of Digital Services in Heart Failure Patients Participating in a Telerehabilitation Program: A Randomized Controlled Trial. *mHealth* 2022;8:25. <https://doi.org/10.21037/mhealth-21-56>.
51. Roh M, Won Y. Impact of Online-Delivered eHealth Literacy Intervention on eHealth Literacy and Health Behavior Outcomes among Female College Students during COVID-19. *Int J Environ Res Public Health* 2023;20:2044. <https://doi.org/10.3390/ijerph20032044>.
52. Lee G, Chang A, Pal A, Tran T-A, Cui X, Quach T. Understanding and Addressing the Digital Health Literacy Needs of Low-Income Limited English Proficient Asian American Patients. *Health Equity* 2022;6:494-9. <https://doi.org/10.1089/heq.2022.0045>.

53. Quialheiro A, Miranda A, Garcia M, de Carvalho AC, Costa P, Correia-Neves M, et al. Promoting Digital Proficiency and Health Literacy in Middle-aged and Older Adults Through Mobile Devices With the Workshops for Online Technological Inclusion (OITO) Project: Experimental Study. *JMIR Form Res* 2023;7:e41873. <https://doi.org/10.2196/41873>.
54. Kayser L, Karnoe A, Duminski E, Jakobsen S, Terp R, Dansholm S, et al. Health Professionals' eHealth Literacy and System Experience Before and 3 Months After the Implementation of an Electronic Health Record System: Longitudinal Study. *JMIR Hum Factors* 2022;9:e29780. <https://doi.org/10.2196/29780>.
55. Kim H, Xie B. Health Literacy in the eHealth Era: A Systematic Review of the Literature. *Patient Educ Couns* 2017;100:1073-82. <https://doi.org/10.1016/j.pec.2017.01.015>.
56. Cheng C, Beauchamp A, Elsworth GR, Osborne RH. Applying the Electronic Health Literacy Lens: Systematic Review of Electronic Health Interventions Targeted at Socially Disadvantaged Groups. *J Med Internet Res* 2020;22:e18476. <https://doi.org/10.2196/18476>.
57. Lin Y-H, Lou M-F. Effects of mHealth-based Interventions on Health Literacy and Related Factors: A Systematic Review. *J Nurs Manag* 2021;29:385-94. <https://doi.org/10.1111/jonm.13175>.
58. Birati Y, Yefet E, Perlitz Y, Shehadeh N, Spitzer S. Cultural and Digital Health Literacy Appropriateness of App- and Web-Based Systems Designed for Pregnant Women With Gestational Diabetes Mellitus: Scoping Review. *J Med Internet Res* 2022;24:e37844. <https://doi.org/10.2196/37844>.
59. Jacobs ML, Clawson J, Mynatt ED. My Journey Compass: A Preliminary Investigation of a Mobile Tool for Cancer Patients. *Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, New York, NY, USA: Association for Computing Machinery; 2014, p. 663-72. <https://doi.org/10.1145/2556288.2557194>.
60. Jean BSt, Taylor NG, Kodama C, Subramaniam M, Casciotti D. Impacts of the HackHealth After-School Program: Motivating Youth through Personal Relevance. *Proc. Assoc. Inf. Sci. Technol.*, vol. 52, 2015, p. 1-11. <https://doi.org/10.1002/pa2.2015.145052010032>.
61. Desai S, Chin J. OK Google, Let's Learn: Using Voice User Interfaces for Informal Self-Regulated Learning of Health Topics among Younger and Older Adults. *Proc. 2023 CHI Conf. Hum. Factors Comput. Syst.*, New York, NY, USA: Association for Computing Machinery; 2023, p. 1-21. <https://doi.org/10.1145/3544548.3581507>.
62. Pillai NM, Mohan A, Gutjahr G, Nedungadi P. Digital Literacy and Substance Abuse Awareness Using Tablets in Indigenous Settlements in Kerala. 2018 IEEE 18th Int. Conf. Adv. Learn. Technol. ICALT, 2018, p. 84-6. <https://doi.org/10.1109/ICALT.2018.00026>.
63. Wiji Utami AD, Widha Andari T, Uji Deva Satrio P, Arif S. Augmented Reality Assisted Healthy Drinking Water Products Promotion and Literacy: A Development and Evaluation. 2022 Int. Conf. Inform. Multimed. Cyber Inf. Syst. ICIMCIS, 2022, p. 557-62. <https://doi.org/10.1109/ICIMCIS56303.2022.10017479>.
64. Kim H, Xie B. Health Literacy and Internet- and Mobile App-Based Health Services: A Systematic Review of the Literature. *Proc. Assoc. Inf. Sci. Technol.*, vol. 52, 2015, p. 1-4. <https://doi.org/10.1002/pa2.2015.145052010075>.
65. Durán LD, Almeida AM, Figueiredo-Braga M, Lopes AC. (uMind) Mobile Application to Support Digital Literacy Interventions in Mental Health: Development and Usability Study. 2023 18th Iber. Conf. Inf. Syst. Technol. CISTI, 2023, p. 1-6. <https://doi.org/10.23919/CISTI58278.2023.10211892>.
66. Causio FA, Beccia F, Kreeftenberg LL, Calabrò GE, Pastorino R, Boccia S, et al. European survey: citizens' attitudes on personalized medicine, genetic testing and health data sharing - design and delivery. *Pers Med* 2024;21:163-6. <https://doi.org/10.1080/17410541.2024.2342770>.
67. Global strategy on digital health 2020-2025. Geneva: World Health Organization; n.d.