BMC Health Services Research

RESEARCH Open Access

A conceptual framework and umbrella review of digital health technology interventions and health equity

Paolo Candio[1] and Tahnee Ooms[2*]

Abstract
Evidence on digital health interventions is rapidly emerging, but how health equity is being addressed remains uncertain. This study presents a conceptual framework that identifies causal pathways linking digital health and health equity, serving as an intervention logic model onto which existing and future evidence can be mapped. As an application of this framework, we conduct an umbrella review to map and narratively summarize published systematic reviews on the effectiveness, acceptability, and feasibility of digital health technology interventions. Systematic reviews were searched in electronic databases from 2005 until March 4, 2025, with a focus on chronic disease. Information on study characteristics, digital health technologies, and health equity considerations was extracted. Methodological quality was assessed using the AMSTAR-2 tool. Thirty-five studies met the eligibility criteria. The most prevalent intervention group was telemedicine, while clinical decision support systems were not the focus of any of the included studies. The systematic reviews varied markedly in quality, with most being equity-focused and addressing more than one dimension of horizontal inequality. Extending the mapping of existing research using the developed framework to other pathways—between digital health, health behaviours, and health outcomes—will help to better inform the design of interventions aimed at addressing the digital divide. Future studies should conduct equity-focused meta-analyses for specific interventions, health outcomes, and decision-making contexts.

Keywords Digital health, Health equity, Health interventions, Conceptual framework

Introduction

The World Health Organisation advocates Digital Health Technologies (DHTs), as they hold the promise of enhancing the management of chronic diseases [1]. These tools include mobile apps, remote patient monitoring systems, and telemedicine services, all of which have been demonstrated to support better patient self-care, improve adherence to treatment plans, prevent complications, and lower barriers to healthcare [2]. There is increasing concern that DHTs might not deliver health benefits equitably across population groups, for example, by noy adequately considering the needs of vulnerable and remote communities— who are often excluded from research or lack sufficient access to healthcare and being disproportionally at a higher ill-health risk [3].

The WHO Bellagio eHealth Evaluation Group (2019) recognised the need to address digital health inequities [4], with organisations such as National Institute for Health and Care Excellence requiring evidence that

*Correspondence:
Tahnee Ooms
Tahnee.OOMS@ec.europa.eu
[1]Department of Economics and Management, University of Trento, Trento, Italy
[2]European Commission, Joint Research Centre (JRC), Via E. Fermi, 2749, 21027 Ispra, VA, Italy

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concerns regarding these inequities have been considered in DHT interventions [5]. This includes key aspects of the design, development, or implementation of a DHT that promote digital inclusivity — such as strategies to improve access to remote healthcare and increase DHT use.

There are existing public health agendas with an explicit health equity focus such as the Marmot Review [6] and the WHO EURO wellbeing economy [7]. These agendas are supported by a large body of academic literature on socio economic determinants of health [8]. However, this literature still lacks a structural connection as to how digital technologies may interact with socio-economic determinants of health and health outcomes. At the same time, the wider literature on socio-economic inequality has also started to branch out towards topics of (digital) health but this branched out knowledge is not yet systematically utilised in the design of health interventions [9].

These developments underpin the strong transdisciplinary character required for academic efforts aimed at supporting the incorporating of health equity considerations into digital health interventions. As for other endeavours [10], it is increasingly important to bring together evidence that transcends disciplinary boundaries (i.e., public health, digital technologies, economics, sociology) and create a shared taxonomy and framework for various actors developing, implementing and evaluating the interventions, including academics, policy makers, technology developers, health authorities and practitioners [11].

In this regard, the literature on DHTs and that on socio-economic determinants have, among others, an important overlap which have not yet been brought together systemically. Individuals at higher risk of, or disproportionately affected by, chronic disease are typically concentrated at the tails of the socio-economic spectrum (e.g., income, neighbourhood-level deprivation, education, ethnicity, rurality – often referred to as 'horizontal inequalities'). This has been signalled by academic initiatives such as the PROGRESS [12] and PROGRESS-plus [13] which were developed to encourage consideration of socially stratifying factors to illuminate inequities in health. These considerations highlight a pressing gap: the need to develop a conceptual framework that (1) stipulates the pathways through which digital health interventions can help mitigate and prevent the widening of existing health inequalities, and (2) begin to mapping existing evidence onto these pathways to better inform future studies and intervention development.

In order to address this gap, this article draws upon an existing logic model of health equity, which is extended to incorporate four key constructs of digital health —digital heath literacy, access and utilization of DHTs, health behaviours and health outcomes — to develop a such conceptual framework for understanding and guiding equitable digital health intervention design, implementation, and evaluation and mapping the respective evidence. A second contribution of this study is the mapping and critical appraisal of evidence related to DHT access and utilization—representing only a subset of the broader evidence that can be mapped onto the developed conceptual framework. As an application of this framework, we conduct an umbrella review to identify and narratively synthesize systematic reviews that assess the effectiveness, acceptability, and feasibility of DHT interventions aimed at improving chronic disease-related health behaviours and outcomes, with a specific focus on horizontal inequality considerations. The scope of the review is informed by the World Health Organization's global agenda to advance digital health technologies [1] and the growing burden of chronic diseases—two converging factors that underscore the urgent need to ensure digital innovations promote, rather than hinder, health equity through more inclusive and accessible interventions.

Conceptual framework

Acknowledging the several other factors affecting directly and indirectly the investigated relationships, in the same vein Paasche-Orlow & Wolf (2007) [14] identified health literacy as the key determinant digital health literacy is identified here as the fundamental precursor of DHT access and utilization (or use, the focus of the umbrella review), representing the ability to seek, evaluate, understand [15], and apply health information from digital sources to address health-related issues [16]. Access and use of DHTs have been shown to positively affect health behaviours such as physical activity [17]. which in turn can benefit health outcomes, directly and indirectly, both at the individual (e.g., quality of life and mortality) and system level (e.g., hospitalisation) [18].

From an inequality perspective, Fig. 1 illustrates systematic differences (i.e., inequalities) that may arise along two directions. Vertically – that is, between groups of individuals with varying levels of health risk or health status – or in other words, according to "severity" – (i.e., '*vertical inequalities*'; e.g., digital health literacy: individuals more or less capable digitally). Or, '*horizontally*', that is, between socioeconomic dimensions such as age, gender, income, place of residence and educational attainment (i.e., '*horizontally inequalities*'). The latter direction can take on different terms and labels across different types of scholarship such as the socio-economic gradient. Where horizontal inequalities are considered unfair and unjust, they can be recognised as *health inequities*, which – according to the conceptual framework proposed - may arise at any point along the causal pathway linking digital

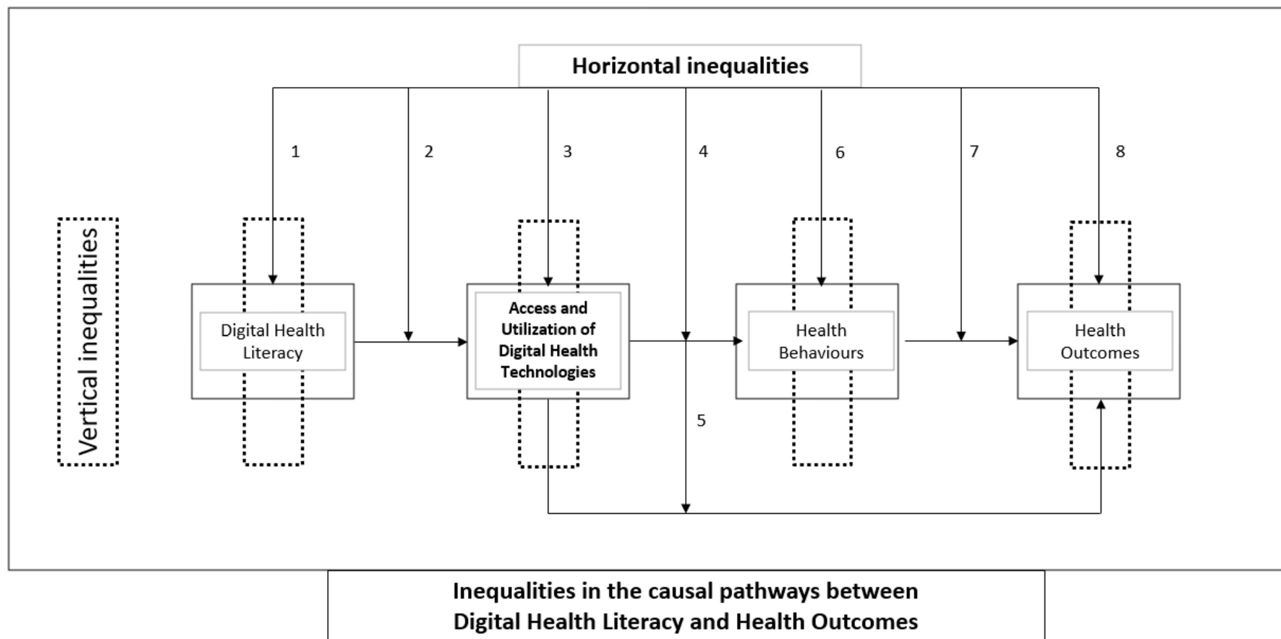

Fig. 1 Conceptual framework for evidence mapping.
Source: Author's adaptation of Paasche-Orlow & Wolf (2007); pathways 3, 4 and 5 are mapped by the umbrella review

health literacy, DHT access and use, health behaviours and health outcomes.

From an intervention standpoint, horizonal inequalities will occur between equity-relevant population subgroups reflecting the degree to which the intervention changed baseline levels of digital health literacy (arrow 1), DHT access and use (arrow 3), health behaviours (arrow 6), and health outcomes (arrow 8). However, the different subgroups will also benefit heterogeneously from the intervention-led changes in precursors (arrows 2, 4, 5, 7; i.e., socio-economic gradients of health-related *gains*) [19].

The next section provides an initial example application of how existing and future evidence can be mapped onto the conceptual framework using an umbrella review. This mapping exercise focuses on access and utilization of digital health care technologies, *pathways 3, 4 and 5* of Fig. 1.

Umbrella review

The review focusses only on existing systematic reviews, focusing on horizontal inequality-related considerations in the assessment of the effectiveness, acceptability, and feasibility of DHT interventions. Based on the expected large heterogeneity in classification of DHT technologies across articles, a purposely broad search strategy informed by previous research endeavours and in consultation with a university librarian was developed, and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (PRISMA) checklist [20] followed. Umbrella reviews are the recommended approach in instances where the amount of research in an area is expected to be large [21]. The protocol for this umbrella review was not registered and no ethics approval was required due to the nature of the research. All the details regarding the review protocol followed can be found in the following sections to ensure results reproducibility.

Eligibility criteria

Eligibility criteria were defined based on the PICOS framework (Supplementary information). The umbrella review only included systematic reviews on the effectiveness, acceptability and feasibility of DHTs interventions aimed at improving chronic disease-related health behaviours (e.g., physical activity) and health outcomes, with no restrictions set regarding the target population or the research study designs.

Systematic reviews focusing on DHTs aimed at affecting infectious disease risks or related behaviour (e.g., sexually transmitted infection prevention behaviours), or in-vivo studies or analysing utility data from wearable devices were therefore excluded. To be included, systematic reviews had to include at least one DHT category within their stated inclusion criteria, or report on health-related interventions where at least one DHT category was part of the intervention design: the DHT could standalone or be part of a more complex intervention or tool (e.g., coupled with personal interactions, text messaging or social media).

By contrast, reviews comprising studies that evaluated solely non-health digital technologies such as text messaging and social media were excluded, unless the

technology was specifically designed for chronic health prevention or management purposes. Articles had to be written in the English language. No other types of articles or reviews, such as scoping, literature, narrative or mapping reviews were included. No restrictions were set with regard to the types of comparators or outcomes targeted by the systematic reviews.

Search strategy and study selection

Based on published reviews [22, 23], a combination of keywords structured around the broader concepts of 'digital health' and 'equity' was subsequently developed and a search conducted in Scopus including MEDLINE and Embase (Supplementary information). The keywords and their combination have been selected based on similar published reviews [24, 25] on health equity to which keywords capturing DHTs have been added. Journal articles were included from 2005 until 4th March 2025. Following search completion and deduplication (*n* = 1,632 records excluded), one researcher carried out title and abstract screening (*n* = 2,944) according to the predefined eligibility criteria, with the other researcher independently checking the selection. Full texts were subsequently retrieved by one researcher and individually reviewed against the eligibility criteria (*n* = 243), with the other researcher independently verifying the selection to ensure accuracy and resolve any discrepancies through group discussion, involving a third researcher if necessary (Fig. 2).

Data extraction

From the identified systematic reviews, relevant data were extracted using data extraction forms which were developed based on the research objectives. The following categories of data were gathered from the retrieved full texts: publication year, systematic review and inclusion of meta-analysis, number of studies analysed, country of analysis, patients / tech users or any other subgroup, age group, disease prevention and/or disease management, DHT category [2] and respective details about the technology; research study design, comparator, assessment focus (i.e., details regarding the reviews' study target), COVID-19 focus; health equity focus, access and use of DHT, health behaviour/s, health outcome/s; effectiveness /acceptability/ feasibility; if health equity focus: conceptual framework pathways, health equity dimensions, namely, educational attainment, age, gender, financial status, occupation / employment, place of residence and race / ethnicity.

Methodological quality assessment

The Assessing the Methodological Quality of Systematic Reviews (AMSTAR2) tool was employed to evaluate methodological quality of all included systematic reviews [26]. AMSTAR2 includes 16 domains, with seven identified as critical due to their significant impact on the validity of a review. These key domains encompass protocol pre-registration (item 2), the strategy used for the literature search (item 4), providing a list and rationale for excluded studies (item 7), evaluating the risk of bias (item 9), the methods used for meta-analysis (item 11), taking risk of bias into account when interpreting results (item 13), and assessing both the presence and potential effects of publication bias (item 15).

Each included review was assessed for adequacy across the AMSTAR2 domains using the categories "Yes," "No," or "Partial Yes" (the latter being applicable only to domains 2, 4, 7, 8, and 9). For reviews that did not perform meta-analyses, items 11, 12, and 15 were marked as "Not Applicable." The extent to which each domain was met across reviews was presented in a tabular format. Based on domain-level ratings, each review received an overall quality rating: "critically low" (if two or more critical domains were rated "No"), "low" (if one or fewer critical domains were rated "No"), "moderate" (if two or more non-critical domains were rated "No"), or "high" (if one or fewer non-critical domains were rated "No"). Quality assessments were independently performed by two researchers, and any discrepancies were resolved through discussion, involving a third researcher if necessary.

Results

The study selection process followed according to PRISMA requirements is summarized in Fig. 2.

The database search yielded a total of 2,944 records after de-duplication which were screened by title and abstract. Of these, 2,696 were excluded, and 248 records were included for full text screening. The final number of included systematic reviews was 35. Figure 3 displays the distribution of the included systematic reviews by publication year and shows that, in the first 19 of the 21 years considered (2005–2025), the number of published articles ranged between zero and four.

In 2024, however, this number increased sharply to 12. Considering that two articles were retrieved for the current year (2025), with the search concluding on 4 March, the projected number of articles for the full year is again 12. This highlights a significant upward trend in publications and underscores the value of conducting an umbrella review such as the present one to identify research gaps and assess the quality of existing evidence.

Study characteristics

Nine of the 35 included articles reported results from meta-analyses. Three quarters (*n* = 26) did not set any geographical limitation to their search, whereas six focused on the USA [27–32], one on Australia [33], one on China [34] and one low and middle-income countries

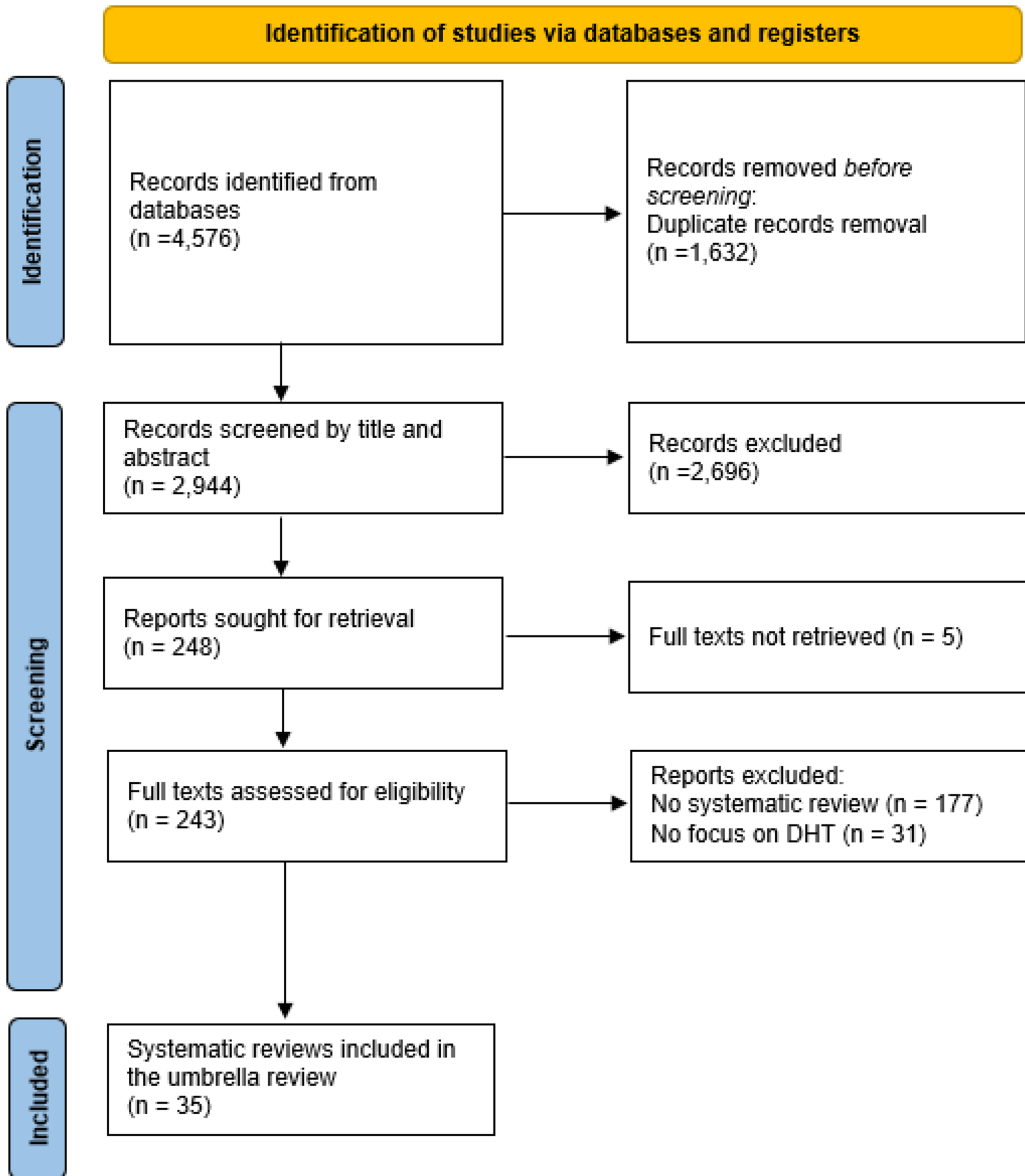

Fig. 2 PRISMA diagram

[35]. The number of studies reviewed ranged between four and 97, with a median of 20. The majority of the reviews (n = 24) focused on populations of patients, did not set any age limitations (n = 23), more than a half (n = 20) centred the review on interventions addressing issues relating to chronic disease management, and the majority (n = 27) either did not specify or considered any intervention comparators. Five systematic reviews restricted their search to evidence from randomised controlled trials [36, 27, 37, 38, 39] two on experimental evidence [29, 40] whereas the majority included both experimental and

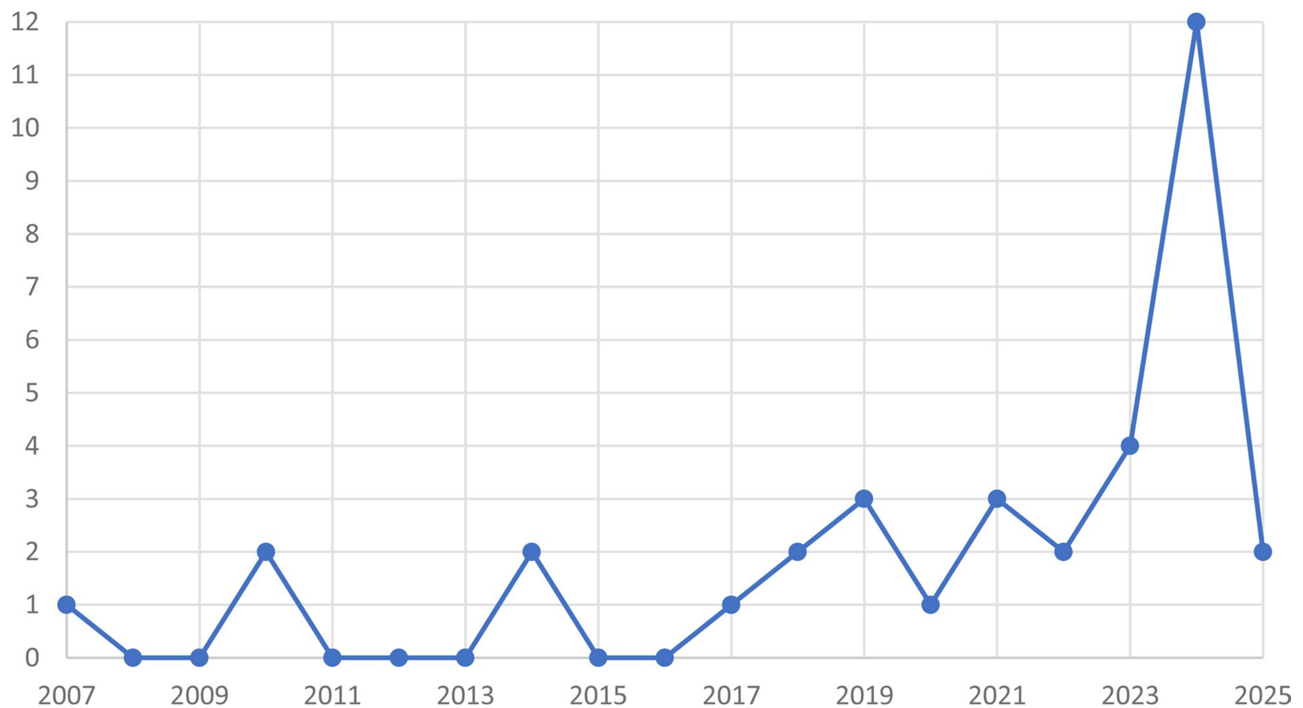

Fig. 3 Systematic reviews (*n* = 35) by publication year.
Source: author's own calculation

observational studies (*n* = 28), with one also reviewing evidence from qualitative studies [41].

Digital health technology interventions

The most prevalent group of DHTs considered within the included systematic reviews was telemedicine (*n* = 14). These studies ranged markedly in scope, with three focusing on type II diabetes management [27, 42, 43] one in atopic dermatitis [44], one in acute stroke [45] and one on cardiovascular conditions in rural areas [46]. Most of these studies focused on patient-related outcomes, whereas one study [47], the largest in terms of number of studies reviewed (*n* = 97), considered telemedicine interventions to improve rural healthcare from a provider-to-provider perspective, and another [48] which focused on children examined the effectiveness and acceptability of synchronous telehealth interventions from the viewpoint of families and practitioners.

Mobile health technologies, mobile or smartphone apps in most instances, were the centre of investigation in 8 of the 35 reviews. Unlike for the group of reviews focusing on telemedicine, the majority of these reviews (*n* = 5) focused on chronic disease prevention, specifically, smoking [40, 49] dietary [30, 40, 50, 51], physical activity behaviours [32] and excessive alcohol consumption [40]. The remaining three reviews varied in scope, with one review focusing on diabetes-related foot health [52], one on blood pressure [53] and the broadest considering effectiveness trials of mHealth applications in terms of type II diabetes and hypertension from an inequality perspective including 65 intervention studies [36].

A third of the reviews (*n* = 13) were broader in scope regarding the intervention focus, encompassing more than one DHT category—predominantly a combination of telemedicine and mobile health technologies. However, compared to the two review groups above, this subset of reviews applied geographical limitations to their searches, with almost half (*n* = 6) focusing on empirical evidence from a single country [28, 29, 31, 33, 34] or from low- and middle-income countries [35]. Comparably, only one review took a caregiver perspective in examining mHealth interventions of older adults, to determine how health equity was considered in the design, implementation, and evaluation of these interventions [41], whereas the remaining 12 reviews focused on a patient or a DHT user perspective. This review group predominantly assessed interventions aimed at the management of chronic diseases, with only one focusing on eHealth interventions for weight management [29], one on type II diabetes [38] and only one on disease prevention, specifically, on the effectiveness of digital interventions for increasing physical activity in individuals of low socioeconomic status [39].

Only two systematic reviews focused on the COVID-19 pandemic. One equity-focused review focusing on the use of synchronous telehealth examined to what extent disparities in access to healthcare emerged during the COVID-19 pandemic across the world, compared to

pre-pandemic levels and concurrent services [54]. The other systematic review instead [34] only included empirical evidence from China for establishing the intervention characteristics, barriers, and successful experiences in implementing telehealth services during the pandemic, compared to standard and usual care. By design the research excluded reviews focussing on infectious disease where the COVID-19 pandemic played a more immediate role. At the same time, the pandemic has accelerated the use of digital health technologies which can be used to reduce NCDs systematically through longer term efforts, therefore it is possible reviews in this area may experience a time lag compared to infectious disease.

Health equity

Two-thirds of the reviews analysed (*n* = 23) were designed to ascertain systematic differences in intervention effectiveness, acceptability or feasibility across horizontal equity-relevant subgroups. The majority of these 23 systematic reviews (*n* = 12) focused only of the effectiveness of DHT interventions, as defined either in terms of between-subgroup differences in DHT access and use [31, 55] (arrow 3 of the conceptual framework, Fig. 1), impact on health behaviours (arrow 4) [40, 50, 39] on health outcomes [36, 38, 53, 54] (arrow 5), or both health behaviours and outcomes (arrows 4 and 5) [27, 29, 35]. Figure 4 depicts how the evidence can be mapped onto the various arrows. As for the remaining systematic reviews (*n* = 12), which did not map onto the developed conceptual framework, the majority included telemedicine interventions (*n* = 8), most focused solely on assessing access to and use of DHTs (*n* = 7), and none adopted a more comprehensive scope that also assessed the feasibility and acceptability of the selected interventions.

Most reviews considered multiple dimensions of horizontal inequality (*n* = 17). One review concentrated on financial poverty assessing the effectiveness, acceptability and feasibility of e-health dietary interventions among individuals participating in nutrition programs in the US [30]. Two reviews considered place of residence as the equity dimension, focusing on rural and remote areas in Australia [33] and use of DHTs for non-communicable diseases in low- and middle-income countries [35]. Half of these reviews targeting one dimension of equity (*n* = 3) focused on race and ethnicity, and all restricting their search to the USA, with one review examining telehealth Interventions to improve type II diabetes management among Black and Hispanic patients [27], one evaluating the efficacy of DHT weight management interventions among overweight and obese racial/ethnic minority adults [29], and another on the use of cancer-specific DHTs among underserved population [31].

Only four of the 23 reviews used a framework (PROGRESS Plus [25]) to identify and conceptualise the differential impacts of DHT interventions by dimension of equity [36, 41, 50, 55]. The most frequent dimension of horizontal inequality identified by the reviews was financial status (*n* = 15) defined in terms of individual level of income, wealth or health insurance status (in the USA), closely followed by race / ethnicity (*n* = 14) and place of residence / area-level deprivation (*n* = 13) of which four reviews identified rurality as the equity-relevant factor [32, 33, 38, 40].

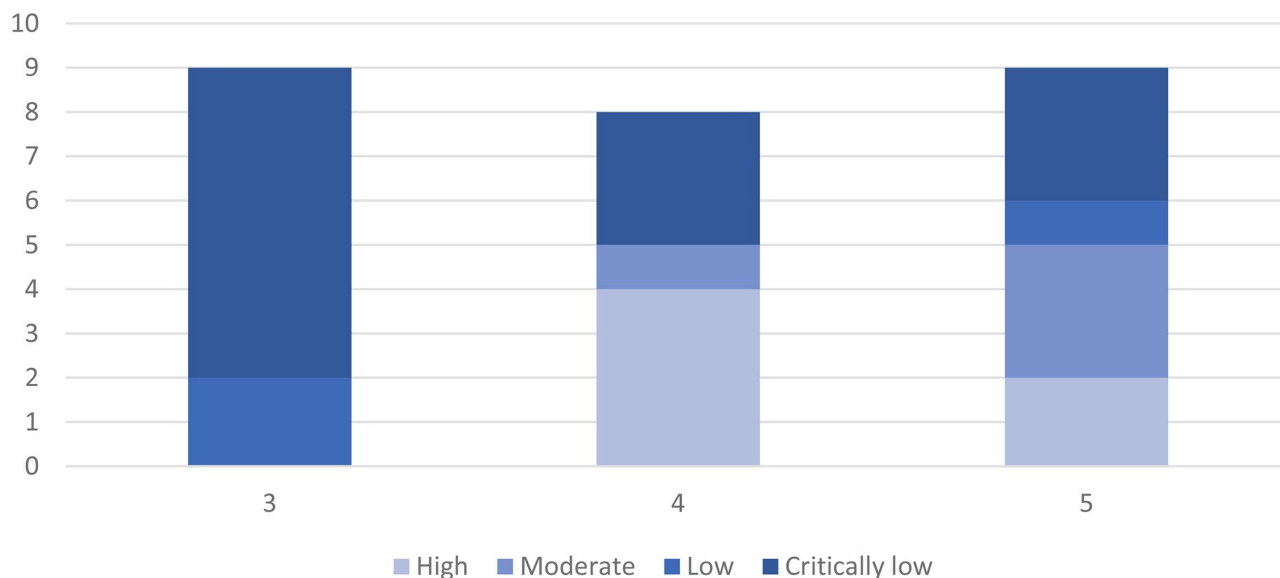

Fig. 4 Systematic reviews connected to DHT access and use pathways and with quality assessment.
Source: authors calculation based on supplementary material. Note: 23 out of 35 reviews mapped on to the pathways connecting DHT access and use, of which 3 reviews could be mapped onto multiple pathways.

Review quality appraisal

The systematic reviews varied markedly in terms of quality, ranging from critically low to high according to the AMSTAR-2 tool scoring matrix (Fig. 4). The majority of the studies followed the PICOs framework to establish eligibility criteria and performed study section and data extraction in duplicate, but only a minority ($n=13$) adequately accounted for risk of bias in individual studies when interpreting or discussing the results of the review. Whereas in most reviews the authors reported any potential source of conflict of interest, including funding they received for conducting the study, no study met the requirement for question 10, that is, the sources of funding for the individual studies included in the reviews were not reported in any of the 35 systematic reviews. For additional details see Table 1.

Ten of the 35 analysed reviews scored an overall rating equal or higher than moderate according to the AMSTAR-2 framework. Compared to the rest of the sample, these high-quality reviews had a multi-country focus of analysis (nine out of ten), were mostly designed with a health equity focus in mind (seven out of ten), and were published from 2021 onwards, indicating a trend towards improved overall quality relative to reviews published in the early 2000s.

Discussion

The rapid digitalisation of healthcare and the advancement of digital health technologies have the potential to exacerbate existing inequalities. This study builds upon previous research frameworks to support the evaluation of digital health interventions, focusing on the causal pathway between digital health literacy and health outcomes (four key constructs) and examining how, at each step, digital health technologies (DHTs) can mitigate or exacerbate inequalities across the social gradient (horizontal inequality). The proposed framework can be used to map evidence along this pathway—extending beyond what was covered in the umbrella review—and can be further developed to incorporate additional determinants of digital health and outcomes, as well as potential moderating and mediating factors.

This article adopts a transdisciplinary perspective, drawing insights from public health, sociology, behavioural science, and digital technology research. This approach enables cross-fertilisation across disciplines, recognising, for instance, contributions from scholars such as Chauvel [19] —a prominent sociologist whose work bridges social stratification and health research—thereby enriching the conceptual and methodological foundations of digital health equity studies. Notably, the framework was not intended to represent a comprehensive causal model; rather, it highlights interdependent interactions along the causal pathway, where reverse causality will apply. Notably, proposed the framework has been designed as a research tool to support future mapping and prioritise digital health intervention studies.

As for the second research objective, the umbrella review provides valuable insights into the current evidence base regarding the effectiveness, acceptability, and feasibility of DHT interventions aimed at improving chronic disease-related health behaviours and outcomes, with a particular focus on how health equity—especially horizontal inequalities—has been addressed in these systematic reviews. This represents only a small subset of the available evidence that can be mapped onto the developed conceptual framework; however, beyond the review evidence generated, it serves as an example of the framework's application.

Compared with the present umbrella review, which adopts a health equity perspective, previous reviews of DHT evidence differ in both scope and methodological approach. Nascimento et al. (2023), who take a broader systems-level approach by collating 132 systematic reviews to evaluate the global effects of DHTs on healthcare workers' competencies, performance, and workplace environments, place emphasis on professional development and organisational performance rather than on patient outcomes or equity dimensions. Meanwhile, Chong et al. (2023) focus on app-based health interventions for patients, synthesising 48 systematic reviews (35 with meta-analyses) to determine the efficacy and effectiveness of mobile health apps across conditions such as diabetes, depression, and anxiety. In terms of methodology, the present review integrates its findings within a conceptual framework, mapping the existing evidence, whereas Nascimento et al. (2023) employ vote counting and lexical meta-analysis to quantify the direction and strength of DHT effects across 25 domains, and Chong et al. (2023) use narrative and quantitative meta-analysis to summarise clinical outcomes.

Across the included reviews, telemedicine technologies and services were the most commonly focused-on interventions, which, by design, are typically directed towards patient populations and disease management. Mobile health technologies, on the other hand, represented a smaller proportion and primarily focused on the promotion of health behaviours in the general population—adults in most instances. In fact, only a handful of reviews focused on youth, for whom DHTs, particularly mobile health technologies, may play a different role than for adults, all of which may require dedicated research efforts. Except for inclusion within broader categories of DHTs, such as eHealth or mHealth interventions, clinical decision support systems were not the focus of any of the reviews, which predominantly considered provider-to-patient technologies. However, the acceptability and feasibility of implementing DHTs are essential for medical

Table 1 AMSTAR-2 results

Article *n.*	Source	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Overall quality
1	Abdelmalak et al. 2024	Y	PY	N	PY	Y	Y	Y	PY	Y	N	NA	NA	Y	Y	NA	Y	Moderate
2	Abdelraheem et al. 2024	Y	N	N	PY	N	Y	Y	Y	N	N	Y	N	N	N	N	Y	Critically Low
3	Al Zulayq et al. 2024	N	N	N	PY	N	N	N	PY	PY	N	NA	NA	NA	N	NA	N	Critically Low
4	Anderson et al. 2022	Y	Y	Y	PY	Y	Y	Y	PY	PY	N	Y	Y	Y	Y	N	Y	Moderate
5	Anderson-Lewis et al. 2018	N	N	N	PY	N	N	N	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
6	Arsenijevic et al. 2020	Y	N	Y	Y	N	N	Y	PY	Y	N	Y	Y	Y	Y	Y	Y	Critically Low
7	Batsis et al. 2019	Y	Y	Y	Y	N	Y	N	PY	Y	N	NA	NA	Y	Y	NA	Y	Low
8	Bennett et al. 2014	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	NA	NA	Y	Y	NA	Y	High
9	Campbell et al. 2023	Y	PY	Y	Y	Y	Y	Y	PY	Y	N	NA	NA	Y	Y	NA	Y	High
10	Capodici et al. 2024	Y	Y	N	Y	Y	Y	PY	PY	PY	N	NA	NA	N	N	NA	Y	Low
11	Crespo-Bellido et al. 2024	Y	PY	N	Y	N	Y	Y	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
12	Egan et al. 2024	Y	PY	N	PY	Y	Y	Y	Y	PY	N	NA	NA	Y	N	NA	Y	Low
13	Garnett et al. 2022	N	PY	Y	Y	Y	Y	Y	Y	Y	N	NA	NA	N	N	NA	Y	Critically Low
14	Heitkemper et al. 2017	Y	Y	Y	Y	Y	Y	PY	PY	PY	N	Y	Y	N	Y	N	Y	Moderate
15	Howland et al. 2025	N	N	N	Y	Y	Y	Y	PY	PY	N	NA	NA	Y	N	NA	Y	Low
16	Johansson & Wild, 2010	Y	N	Y	Y	Y	Y	N	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
17	Khoong et al. 2021	Y	PY	Y	Y	Y	Y	Y	Y	PY	N	Y	N	Y	Y	Y	Y	High
18	Leppin et al. 2024	Y	Y	Y	PY	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	High
19	Peiris et al. 2014	Y	Y	Y	Y	Y	Y	Y	PY	PY	N	NA	NA	N	N	NA	Y	Critically Low
20	Rollin et al. 2018	N	N	N	PY	N	N	PY	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
21	Ruiz-Pérez et al. 2019	N	PY	N	Y	Y	Y	Y	Y	Y	N	NA	NA	Y	Y	NA	Y	Low
22	Parker et al. 2021	N	N	N	PY	Y	Y	PY	PY	N	N	NA	NA	N	Y	NA	Y	Critically Low
23	Sabrouty et al. 2024	Y	N	Y	N	N	Y	Y	PY	N	N	NA	NA	N	N	NA	N	Critically Low
24	Sadler et al. 2023	Y	PY	Y	Y	Y	Y	Y	PY	Y	N	NA	NA	N	Y	NA	Y	Critically Low
25	Schaafsma et al. 2023	Y	PY	Y	Y	Y	Y	Y	PY	N	N	NA	NA	N	Y	NA	Y	Critically Low
26	Szinay et al. 2022	Y	PY	Y	PY	Y	Y	Y	Y	Y	N	NA	NA	Y	Y	NA	Y	High
27	Tarver & Haggstrom, 2019	Y	N	Y	PY	Y	Y	Y	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
28	Ternes et al. 2024	Y	Y	Y	Y	Y	Y	Y	PY	Y	N	NA	NA	N	N	NA	Y	Critically Low
29	Tierney et al. 2024	Y	N	Y	PY	Y	Y	Y	PY	N	N	NA	NA	N	N	NA	Y	Critically Low
30	Totten et al. 2022	Y	PY	N	Y	Y	Y	Y	Y	Y	N	NA	NA	Y	Y	NA	Y	High
31	Verhoeven et al. 2007	Y	N	Y	PY	Y	Y	PY	PY	N	N	NA	NA	N	Y	NA	Y	Critically Low
32	Verhoeven et al. 2010	N	N	Y	PY	Y	Y	N	PY	N	N	NA	NA	N	Y	NA	Y	Critically Low
33	Verma et al. 2024	Y	N	Y	PY	Y	Y	PY	PY	N	N	NA	NA	N	N	NA	Y	Critically Low

Table 1 (continued)

Article *n.*	Source	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Overall quality
34	Western et al. 2021	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	High
35	Ye et al. 2023	Y	PY	Y	Y	Y	Y	Y	Y	N	N	NA	NA	N	Y	NA	Y	Critically Low

Y = Yes; PY = Partial Yes; N = No; NA = Not Applicable; NMA = No Meta-Analysis

Question Legend

1. Did the research questions and inclusion criteria for the review include the components of PICO?
2. Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
3. Did the review authors explain their selection of the study designs for inclusion in the review?
4. Did the review authors use a comprehensive literature search strategy?
5. Did the review authors perform study selection in duplicate?
6. Did the review authors perform data extraction in duplicate?
7. Did the review authors provide a list of excluded studies and justify the exclusions?
8. Did the review authors describe the included studies in adequate detail?
9. Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
10. Did the review authors report on the sources of funding for the studies included in the review?
11. If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?
13. Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?
15. If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?
16. Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?

and health professionals to effectively operate and implement DHT interventions, but current evidence from this perspective is limited.

However, the lack of a common categorisation of DHTs, such as that supported by the WHO [56], hampers evidence synthesis efforts and requires manual reviewing of individual manuscripts, demanding considerable research effort. While the use of artificial intelligence-based methods could provide a more efficient route to address this issue, to date, no validated tools are available that can provide sufficient confidence for scientific purposes. Finally, COVID-19-related reviews included only a small minority of the studies, likely due to the responsive and transitory nature of the pandemic. In fact, we focused on DHTs for chronic disease and excluded those developed for infectious disease-related behaviour and outcomes, as well as those for social network purposes.

Overall, the systematic reviews varied markedly both in terms of scope and methodological quality. While some adhered closely to recognised standards—employing thorough literature searches, clearly defined inclusion criteria and comparators, and comprehensive risk-of-bias evaluations—a non-negligible proportion did not conduct and report their findings in a sufficiently robust manner. Notable shortcomings included insufficient critical evaluation of the individual studies reviewed and systematic differences in reported outcomes. Only a minority of studies reported quantitative syntheses. Whereas a positive temporal trend was detected when comparing the overall quality ratings between the last five years and the preceding 15-year period, these disparities highlight the importance of aligning more closely with established methodological frameworks such as PRISMA and AMSTAR, as well as addressing policymakers' information needs to effectively guide decision-making.

The analysis of systematic reviews on DHT interventions revealed a strong emphasis on health equity, with the majority examining disparities in intervention effectiveness, acceptability, or feasibility across the social gradient. Most reviews considered multiple dimensions of horizontal inequality, with financial status being the most commonly examined factor, followed by race/ethnicity and place of residence. However, only a few reviews employed frameworks such as PROGRESS Plus to assess differential impacts based on equity dimensions, and instead primarily focused on specific population subgroups for their investigation. Furthermore, the lack of quantitative synthesis through meta-regression analysis limits the ability to estimate gradients in the benefits from DHTs, which in turn hinders the design of more equitable and progressive policies. This lack of statistical rigor limits the potential to inform policy beyond narrative descriptions and underscores the need for research grounded in established theoretical frameworks to address issues of digital divides and inclusion, particularly in the context of digital health.

Future studies should seek to establish the extent to which differences in DHT access and use lead to changes in behaviour and, consequently, in health outcomes, both at the individual and system levels across equity-relevant subgroups. These studies would correspond to arrows 4 and 7 in the conceptual framework and should be designed to assess mediation effects. However, this will require more complex and sophisticated econometric approaches based on pooled data and network analysis. In turn, this calls for collaborative efforts among research teams to establish causal effects and reduce the uncertainty surrounding the impact of DHTs on health outcomes.

In alignment with previous reviews, only English-language published articles were included, as it was reasonably assumed that review authors would prefer to publish the results of an extensive undertaking like a systematic review in English to maximize its impact and reach. However, systematic reviews in other languages may have been overlooked. While we considered this risk to be minimal, it is possible that this decision contributed to the uneven distribution of countries represented in the included reviews. Although a systematic search was conducted in well-established databases, some relevant reviews may have been identified by searching additional databases, particularly those that are more regionally focused. In addition, we limited the search to Scopus (with MEDLINE/Embase) which may have excluded relevant reviews from databases such as Cochrane, Web of Science, PsycINFO.

However, the goal of the present study was not to reanalyse or synthesize all available evidence—an effort that requires retrieving the full, complete evidence base through a more rigorous approach, such as that mandated for a Cochrane systematic review. The potential risk of missing a few reviews was deemed acceptable, given the primary objective of mapping and characterizing the growing body of systematic reviews on the effectiveness, acceptability, and feasibility of DHT interventions, and how health equity concerns were addressed in those reviews. A valuable next step could involve conducting meta-analyses and equity-focused meta-regressions for specific DHT interventions and health outcomes, considering both target population and implementation context [57]—steps that were beyond the scope of our umbrella review but could offer valuable insights and relevant evidence for the optimal allocation of public health resources.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-025-13696-4.

Supplementary Material 1

Acknowledgements
None.

Author contributions
PC conceptualized the study. PC and TO contributed to the methodology, investigation, writing – original draft, writing – review & editing, and reviewed and approved the final manuscript.

Funding
This research was conducted without any financial support.

Data availability
The empirical part of this study is an umbrella review and does not involve the generation of new primary data. All data analysed in this review were extracted from previously published studies, which are cited within the article. Extracted data and detailed summary tables are available in the Supplementary Information. Any additional information is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
No ethical approval was required for this study as this is a review of the published literature.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 23 May 2025 / Accepted: 30 October 2025
Published online: 29 November 2025

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