

Evaluating the impact of digital health information: A scoping review of measures

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Abstract

Background: High-quality, reputable digital health information (DHI) provides a cost-effective and widely accessible means to enhance health professionals' knowledge and empower individuals to make informed health decisions. However, with the growing proliferation of digital resources, there is increasing pressure for DHI providers to demonstrate the impact of their resources and document measurable value. While systems data is analysed to propose metrics for assessing user engagement and website usability, identifying and observing broader effects of accessing DHI such as knowledge acquisition or behavioural changes remains challenging.

Objective: To identify and map the methods and measures used to determine the impact of DHI within the published literature.

Methods: We conducted a systematic scoping review of English-language studies published since 2013 using Ovid Medline and CINAHL databases and hand searched the Journal of Medical Internet Research (JMIR) suite of titles. Due to the lack of a clear definition of 'impact' in the context of digital information, we broadly defined it as any measurable change or action resulting from engagement with DHI. Our search strategy covered four concepts related to the described DHI: (1) type of information resource, (2) its purpose, (3) evaluation approach, and (4) impact. Included studies evaluated DHI products such as knowledge hubs, toolkits, or elearning resources, provided users accessed them independently and asynchronously. Citations and full text papers were dual reviewed with conflicts resolved through discussion. Data were extracted using a pre-designed template.

Results: Of 2762 articles retrieved, 333 were included in the review. Studies primarily investigated the impact of access to DHI on physical (26.7%), mental (15.0%), lifestyle (13.8%) and professional development (11.1%) factors, targeting patients (31.5%) and health professionals (27.0%). Randomised controlled trials were the most common design (42.6%), with outcomes measured using validated (50.2%) or non-validated repeated measures (42.3%). Various terms were used to describe impact. Only 11.1% of studies used the term 'impact' to describe outcome changes, 42% used 'effect' while 5.1% focussed on measuring acceptability or feasibility. Impact on individuals' knowledge or behaviour predominated with only 3.3% of studies exploring change or benefits at the organisational, economic, or societal level.

Conclusions: Despite the widespread availability of digital health information and its potential to influence individuals, organizations, and societies, our review found a limited range of methods and measures used in the biomedical research literature to assess its impact. Approaches from public health might offer valuable insights for evaluating broader impacts beyond the individual level. A framework that aligns various metrics with the specific goals of digital health resources could enhance their evaluation. By carefully selecting and applying these metrics, organisations that fund digital health information projects may better understand the effectiveness of the resource and make informed decisions to justify expenses and improve the impact.

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Original Manuscript

Original Paper

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Keywords: web-based; intervention evaluation; digital health; implementation framework; impact measurement

Introduction

Information and communication technologies are increasingly central to our personal and professional lives, connecting people and making it possible to access information and an ever-expanding array of services on demand. With rapid advances in mobile technology, an estimated 67.1% of the world's population is now able to access the internet [1]. Rates of access are also increasing, although not always uniformly. For example, while the number of Australian internet users rose from 91 to 99 per cent across 2019-2022, use by those over 75 years-of-age increased from 52 to 94 per cent [2].

Digital health interventions hold the potential to support equitable and universal access to health care, at least for digitally included populations [3]. This includes high-quality, current digital health information (DHI), accessible when needed. For health professionals and other care providers, digital information platforms, including elearning resources, provide the means to update knowledge at times convenient to the learner [4]. Digital information can also empower individuals to make more informed health and health care decisions and support discussion with health providers [5]. A large proportion of internet users are known to seek information digitally regarding their medical symptoms ahead of a medical diagnosis [6]. Furthermore, with globally ageing societies and increasing rates of multimorbidity, digital health solutions are likely to be viewed as cost-effective mechanisms for helping people self-manage their chronic conditions [7].

A recent meta-analysis [8] found that consumers evaluate digital information based on the quality, trustworthiness and utility of the information. Health literacy and the ability of consumers to evaluate online information has increased, with many interventions and models being created to guide consumer's evaluation [8]. This has influenced the focus of DHI development and evaluation, with researchers often measuring the effectiveness of the information on influencing the desired outcomes, engagement with the information, and acceptability and usability of their products for their target audience [9, 10].

Resource development based on research processes, continual evaluation, and improvement of digital health information resources requires access to funding. For example, the evidence-based CareSearch project in Australia is funded by the Commonwealth Department of Health and Aged Care to consolidate and provide 24/7 access to digital palliative care knowledge for health professionals, patients and families. With 90% of research funding in Australia being provided by private organisations and governmental bodies, meaningful evaluation of digital health resources is crucial for justifying financial investment [11, 12]. Research impact

assessment has been a focus of investigation with organisations and funders interested in understanding the value and impact of their knowledge and products and the societal value of investments [13]. As an example, the Australian Research Council Research Impact Principles and Framework defines research impact as “*the contribution that research makes to the economy, society, environment or culture, beyond the contribution to academic research*” [13]. However, use of a clear and consistent definition of research impact remains elusive in the literature globally with a recent systematic review of public health research identifying 108 different impact definitions [14]. A pragmatic approach to the issue of definition has been offered by Better Evaluation, part of the Global Evaluation Initiative, which sees impact assessment as the observed changes of the intervention [15].

To better conceptualise impact, a micro-meso-macro framework is often applied to public health contexts to provide a wholistic view of the impact of a product on quality of life [16]. Using this framework, impact is assessed with micro (individual – e.g., improved clinician knowledge), meso (agency, institutional or regional – e.g., a change in clinical practice guidelines within a service) and macro (governmental – e.g., an update to national policy or procedure) perspectives [16]. Application of this multifaceted framework to digital health contexts may assist in defining impact through a variety of perspectives and needs depending on resource content.

Within the context of DHI, evidence of use and satisfaction with a resource relies on metrics of engagement and reach, and often analyses or qualitative investigations of useability and acceptability [17]. However, these methods may describe awareness and/or navigation to a resource rather than the direct and indirect influences of the health information it contains [11, 18]. This influence can occur at and across multiple levels. For example, a digital health resource might impact an individual (micro-level) through knowledge, attitudinal, or behaviour change. Individuals working and communicating together in teams may then initiate an organisational change (meso-level) such as an update to service guidelines. At the broadest (macro) level, a digital health resource might be adopted into government policy or reach the level of consciousness of a society to induce cultural, economic, or environmental change.

Previous evaluations of digital health resources have endeavoured to create measures and models to guide impact measurement at the micro-level. The E-Health Impact Questionnaire [10] contains items measuring possible consequences and experiences of an individual accessing DHI for a range of health conditions. However, research has not yet extended to develop specific measures for guiding the evaluation of impact from DHI, particularly at

meso- or macro-levels. Measurement of impact across these levels would require significant resources for digital health resource developers and providers, which may be limited by available research and development funding and timelines. With the combination of best practice recommendations for co-design, summative and formative evaluation during webpage development, and impact evaluation as desired by funding bodies, developers are unlikely to have the time and finances for multi-level impact evaluation. Consequently, there is a need for clearer understanding of impact definitions and the best available methods and measures developers can apply to gather evidence of the impact of their digital health information products. As a significant producer of DHI website and knowledge translation products, CareSearch project researchers undertook a scoping review of the published literature with the aim of identifying existing definitions of DHI impact alongside measures used by to capture it for the purpose of demonstrating value.

Methods

This systematic scoping review follows reporting guidelines from the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) checklist [19].

Identifying relevant studies

Articles were searched from January 2013 to May 12, 2023, across the Ovid Medline and CINAHL databases. Iterative keyword searches of all online journals belonging to the Journal of Medical Internet Research suite of journals were also conducted and the first 10 pages of results for each search iteration examined. The database search strategy incorporated four concepts: (1) types of online information, (2) the purpose of the online information (3) evaluation, and (4) impact. An extensive range of terms and synonyms entered as subject headings and text words were employed to capture literature across each of these four concepts. The search strategies are included as Appendix 1.

Selection of sources

After duplicate articles were removed, titles and abstracts were screened for eligibility in Covidence (Veritas Health Innovation, Melbourne, Australia). Eligibility and exclusion criteria are detailed in Table 1. We took an inductive approach to defining impact to ascertain what researchers considered feasible measure of change of some kind. However, we expected to identify studies measuring tangible changes to knowledge, beliefs, attitudes, behaviours, decision-making, professional practice, policy, culture, education/training curricula, program

or service delivery or economic benefits. Full text articles were screened independently by two reviewers with discrepancies discussed until consensus was reached.

Table 1. Inclusion and exclusion criteria of sources selected for the present study.

Inclusion Criteria	Exclusion Criteria
• Must describe digital health products which convey information on one or more health-related topics • May be in the form of knowledge hubs, toolkits, decision aids, guidelines, webinars, videos, information-based apps and self-directed learning modules • Should describe the process used to measure the impact of the information on the end-user • Will be written in English language, peer-reviewed journals	• Describe non-health related digital information • Have a primary purpose other than conveying information for independent access at any time by any individual • Involve mediated or guided interventions (i.e. counsellor coaching) • Are synchronous online learning programs • Evaluate resource development (summative), or user engagement, usability, or satisfaction with the final product (formative) • Are written in any language other than English

Data extraction

Data were extracted based on a pre-designed template within the Covidence systematic review software. The extraction elements included title, author and year, country, study aim, health-related topic, digital information format, intended user, study design, type of impact measured, impact methodology and main tools. Extraction was completed independently by two reviewers and confirmed by a third with any discrepancies discussed to consensus.

Results

Study selection

Our initial search retrieved a total of 2765 articles, with 2762 remaining after removing duplicates. After title and abstract screening, 2217 irrelevant articles were excluded and 545 were included in the full article review. A total of 333 articles were included in our final analysis. Data were analysed using content analysis [20] based on the study extraction

template. This process and reasons for exclusion of full texts are summarised in the PRISMA flow diagram (Figure 1).

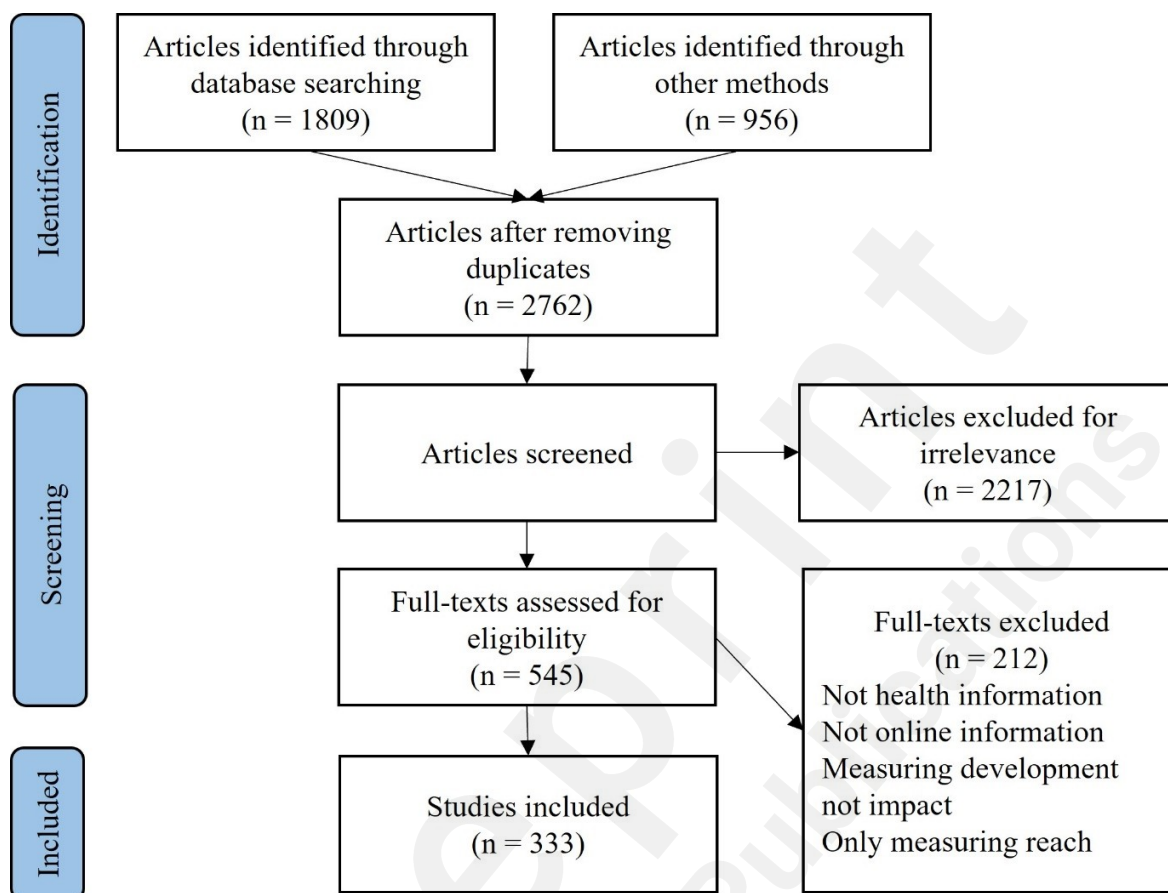


Figure 1. PRISMA-ScR flow diagram.

Study characteristics

Of the 333 included articles, 113 (33.9%) were conducted in the United States, 48 (14.4%) in Australia, 27 (8.1%) in the United Kingdom, 27 (8.1%) in Canada, 24 (7.2%) in the Netherlands, 20 (6.0%) in Germany, and 74 (22.2%) in other countries such as China, Japan, Sweden, Spain and Turkey which contributed 3 or less studies each. A wide range of health topics were represented (see Appendix 2) and categorised for the purpose of this study (see Figure 2) into physical health (26.7%), mental/psychiatric health (15.0%), lifestyle health (13.8%), professional development/health profession education (11.1%), cancer (8.7%), health literacy/evidence-based health practice (6.6%), sexual/reproductive health (6.3%), health in later life (4.8%), children's health (3.6%) and other (3.3%). The target populations for information on these health topics ranged from patients (31.5%), health professionals (27.0%), general public (11.7%), students (8.7%), parents/guardians (7.5%), patients and health professionals (2.4%) and other more specific audiences (9.0%) including employees,

adolescents, and teaching staff. See Appendix 3 for detailed study characteristics and references.

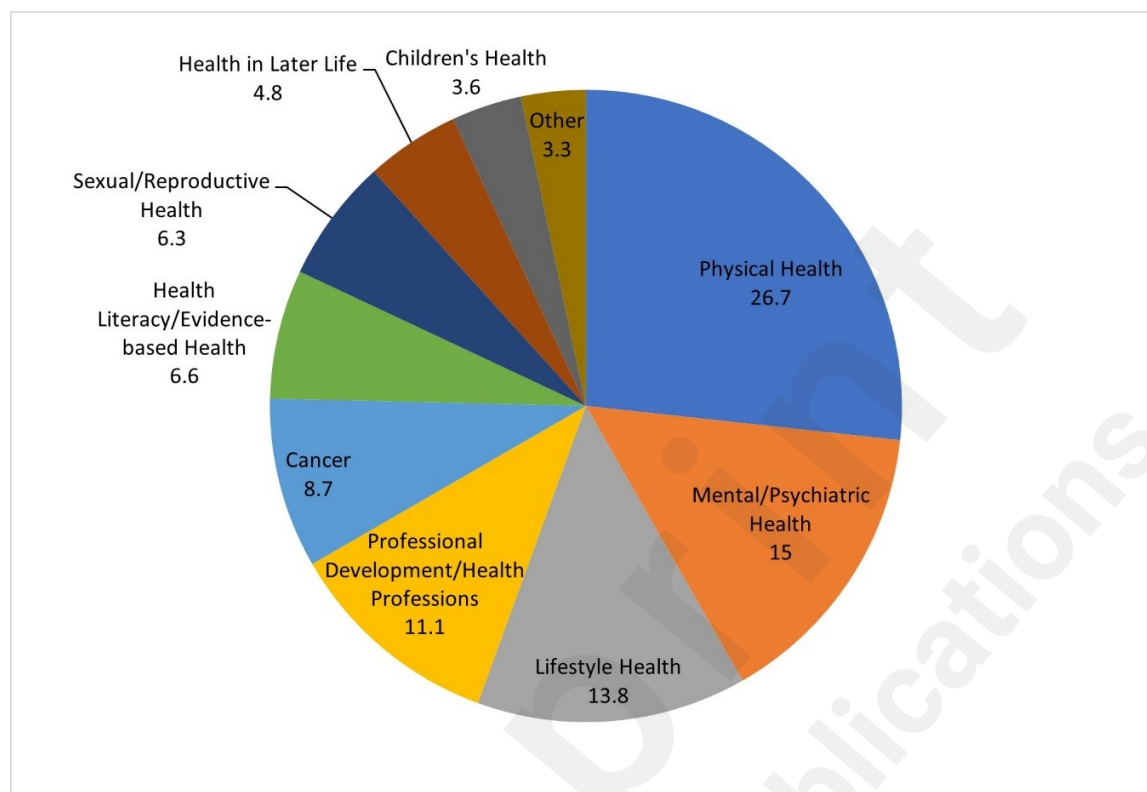


Figure 2. Health topic prevalence in the included digital health intervention studies.

Methodologies

Randomised controlled trials (42.6%) were the most commonly used methodology to assess intervention impact. Other methodologies such as cross sectional (19.8%), non-randomised experimental (12.6%), mixed-methods (9.9%), qualitative (2.4%) and cohort (1.2%) studies were used less frequently. Protocols of any of the above designs were also not as common (9.3%), and 5 studies (1.5%) used none of the above designs.

Within these studies, impact was predominately measured on a micro-level focussing on changes in behaviour (33.0%), knowledge (20.1%), attitude (5.1%) or varying combinations of the three (37.8%). Few studies measured impact through changes to organisational practices and financial costs for measurement on a meso- (2.7%) or macro-level (0.6%). Table 2 provides examples of impact outcomes and measurement methods at micro-, meso- and macro-levels.

Table 2. Examples of impact measurement at micro-, meso- and macro-levels.

	Micro	Meso	Macro
Examples			
	Measuring impact on	Measuring impact on	Measuring impact on

	perceived change in hopelessness and problem solving in young people using questionnaires for symptoms (Shroff, 2023)	medication prescription numbers and the number of emergency department visits for migraines within a designated region (Connelly, 2020)	costs to the Dutch healthcare system and productivity costs to the Dutch population with surveys and cost-benefit analyses (Schulz, 2014)
	Measuring impact on physical activity behaviours and overall health symptoms of individuals using symptom questionnaires, interviews and activity frequency questionnaires (Vandelanotte, 2015)	Measured burden of the intervention on organisations with clinician reports on required adaptations to regular organisational practice and impact on prescription rates using pharmaceutical data for the region (Dekker, 2018)	Measuring impact on costs to the included regions including; productivity, healthcare, family and practitioner costs using cost-benefit analyses (Golsteijn, 2014).
	Measured impact on knowledge of infant health and breastfeeding, and parent self-efficacy using questionnaires, and a breastfeeding assessment to capture behavioural changes (Sari, 2020)	Measured impact on the frequency of post resuscitation debriefing including supervisor endorsement of change and influence of supervisors on outcomes using pre-post intervention surveys of health professionals (Eaton, 2021)	
	Measured clinician's opinions and perceived usefulness of the online	Interviews with administration staff on the influence of implementing management strategies and	

	information with questionnaires (McGeoch, 2015)	organisational support for the impact of new concussion protocols in schools (Glang, 2014)	
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To assess impact, most studies used a combination of measurement types. We have categorised these types (see Figure 3). They include validated repeated-measures (50.2%), non-validated repeated-measures (42.3%), single administration non-validated questionnaires (30.6%), web metrics (29.1%), interviews (14.7%), clinical indices (14.4%), single administration validated questionnaires (12.6%), cost-benefit analyses (4.5%), analysis of existing datasets (4.2%), focus groups (3.6%) and other measures (9.6%) such as daily diaries. Combining two measure types was the method most frequently used (36.3%), followed by only one measure type (31.5%), three measure types (18.9%), four measure types (8.7%), five measure types (3.3%) and six measure types (.6%). Subjective measurements were used more often than objective measurements, with 94.6% of studies using one or more subjective measures and only 38.4% of studies using one or more objective measures.

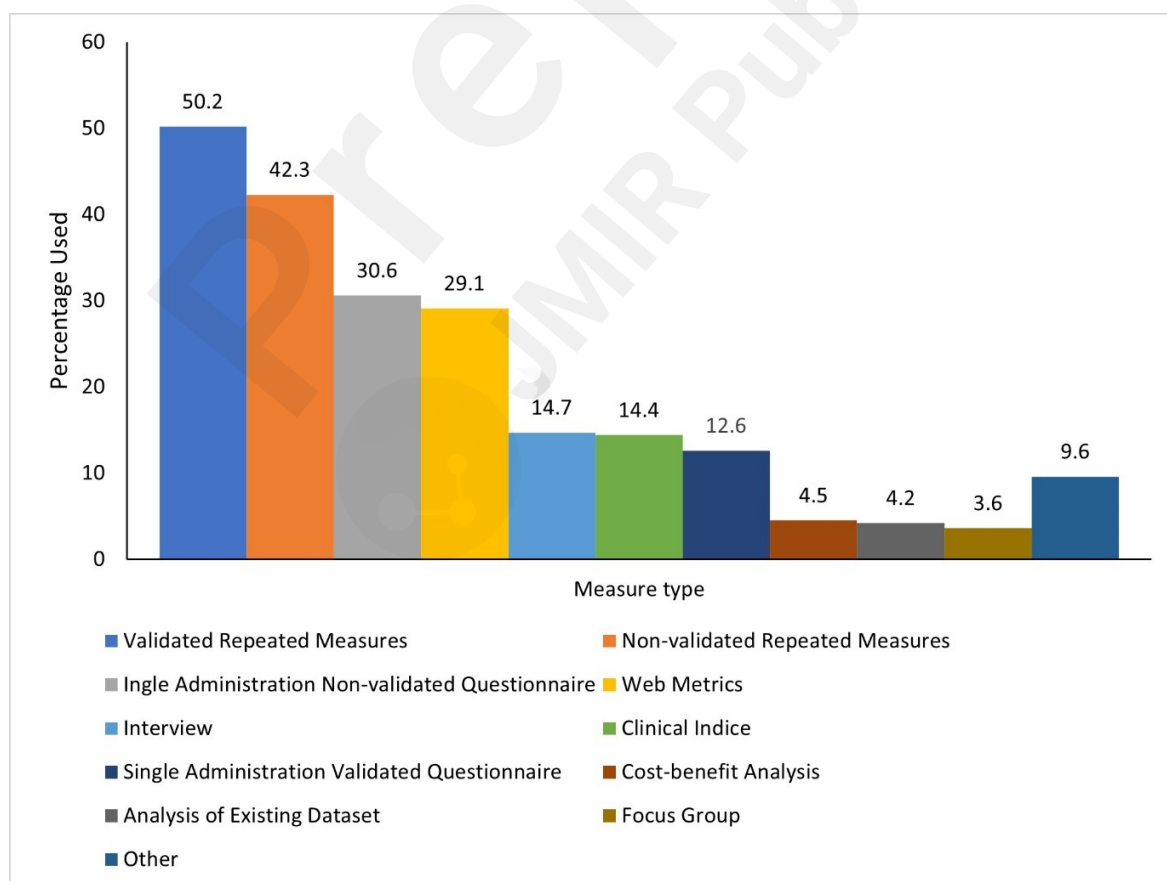


Figure 3. Types of measures used to assess outcomes in the included digital health intervention studies.

Impact terminology

The phrasing of aims and objectives for measurement varied widely across studies, with many using different terms for 'impact'. Only 11.1% of studies explicitly used the term 'impact' in measuring the effectiveness of their information on influencing primary outcomes. A large proportion (42%) of studies instead described impact by measuring the 'effect, effectiveness or efficacy' of the information, often using these terms interchangeably. Evaluating the information was another term often used (15.6%), but only one study explicitly mentioned evaluating the value of their information. A small percentage of studies (5.4%) described specifically measuring an increase, improvement or reduction of the primary outcome in relation to their information. A few studies (5.1%) outlined a focus on measuring acceptability and usefulness of the information as perceived by their participants. Some studies did not include a clear description of which aspects of impact would be measured within their aims and objectives (4.8%). No studies defined the meaning or what constituted their impact terminology within the aims or objectives. See Appendix 4 for a detailed breakdown of terms used to describe impact.

Discussion

Principal findings

This study aimed to identify current research approaches to measuring the impact of digital health information (DHI) resources and clarify definitions of impact as it relates to digital information. High variability in study methodology, primary outcome measures and impact terminology were found. We propose multiple factors which may be contributing to this variability.

Patterns in study design and methodology appear to vary according to health topic and target audience but were restricted by availability of evaluative resources. Resource limitations such as time and money appear to have led to a large proportion of studies using questionnaires administered at a single time point, therefore unable to capture the effect size or long-term impact. Frequent measurement at a single time point was also found in a previous systematic review by Tieman and Bradley in 2013 [9]. However, most studies combined two or more measures to capture multiple changes in primary outcomes, adherence, and participant's perspectives of acceptability and usability. A number of studies used solely subjective

measures or created a non-validated measure. Often studies with these limitations reported a lack of validated measures for their sample or health topic and suggested future research combine objective and subjective measures for increased reliability. Other studies followed this suggestion, employing pre- post-intervention knowledge tests and clinical indicators to supplement subjective measures. Consistent with previous research [21], the studies also suggested follow up periods of six-months or longer should be included to capture further unintended or larger scale impacts from DHI, maintenance of changes and behavioural changes which take longer to manifest than changes to knowledge.

We also found high variability in the descriptions of how studies conceptualised impact. Many studies used terms such as effect, effectiveness, efficacy and evaluation interchangeably with impact to describe measurement of a change in primary or secondary outcomes attributed to the DHI administered during the study. Such conceptualisations are limiting in that they do not afford an understanding of impact on levels beyond an individual, for example, on organisations and policy. This in turn limits an understanding of values beyond an individual's owned knowledge to more complex changes such embedding service processes or prompting funding changes at the sector level. Impact value is often seen as more beneficial if it is broader in scale. Overall, while many authors provided an explanation of measurement in the aims or objectives, in most cases they did not provide a definition of the terms used such as impact, effect or outcome nor articulate if the focus was on the micro-, meso- or macro-level. Clear definitions of these terms which address meso and macro perspectives, may assist in allocating meaning to be used by organisations when calculating value of DHI.

As identified in the results, the focus on measuring impact at a micro-level may be due to need to demonstrate linear relationships and financial restrictions. One possible explanation for the measurement of impact through a micro-level lens may be that research in DHI is still driven by medical definitions of health literacy which situate with an individual's skill levels [22]. This may have influenced researchers to focus on microlevel changes. However, recognition that social determinants such as environmental, cultural, commercial and digital influence our individual capacity speak to the need to consider how structural and societal aspects need to be addressed if broader impacts are to be realised [23].

Researcher priorities may also influence measurement of impact on a micro-level. Bibliometric analysis of consumer health informatics demonstrates a consolidation in the evolutionary period from 2004-2008 to 2015-2019 around three research directions: patient education and intervention, consumer demand attitude and behaviour, and internet

information technology application [24]. More complex pathways which consider actors in the system such as pharmacists, doctor-patient relationships, or service-systems issues such as costs have a lesser research focus. With pressure from funding organisations, research groups may also be predisposed to micro-level measurement as it can demonstrate a linear relationship between symptom relief, increased knowledge or behavioural change and an intervention in less time, with lower costs. As meso- and macro-levels require a multifaceted approach with more funding, time and active involvement of multiple organisations, publication of impact evaluation processes at this level may be relinquished for the easier alternative. Moreover, evaluating the impact of DHI purely based on micro-level changes fails to demonstrate relevant value to organisations needing evidence for effective implementation which occurs at meso- and macro-levels [11, 25].

Compared to public health contexts, evaluation of DHI raises further complications. These additional complications have been acknowledged by previous reviews exploring evaluation of internet interventions [9, 21, 26]. Identified methodological challenges for DHI evaluation include difficulty choosing appropriate controls, imprecise replication of information over varying medias, limited control over public availability, reliance on subjective measures and selection bias [21]. Buljac-Samardzic et al. [26] found studies on interventions for healthcare professionals collected limited comparable information on impact due to differences between the quality of study methods and conceptualisation of evaluation. Similarly, a review by Tieman and Bradley [9] found a reliance on monitoring individual changes to the consumer through behaviour and knowledge changes directly related to the DHI. These findings suggest that methodological challenges in evaluating DHI may contribute to a reliance on measuring micro-level impact. Some studies may be continuing to use flawed methodology due to a lack of available funding, accepted alternative methodologies and appropriately validated measures. The requirement of demonstrating impact to earn funding for continuation and upscaling of DHI impact evaluation poses a further challenge. A predetermined, standardised framework to guide impact evaluation across micro-, meso- and macro-levels regardless of available funding would simplify this process of demonstrating impact and therefore value of DHI.

Interestingly there is still a limited evidence base around the utilisation of system data to explore engagement and outcomes [27]. Increasing interest in metrics that track how users navigate and make use of DHI are emerging. It is likely that generative AI will accelerate identification, monitoring and assessing outcomes and support scaling to societal level impact in the coming years [28, 29].

Future implications

The availability of a standardised impact framework might guide research protocols in selecting designs appropriate for reliably measuring impact on all three levels (micro; meso; macro). In Australia, this could be made consistent with the definition of impact provided by the Australian Research Council [13]. The predominant focus on impact with micro-level lens, as demonstrated in this review, may have influenced the prioritisation of effective intervention strategies which improve engagement, rather than quality measurement of impact. By providing a wholistic framework, impact measurement in studies for any digital health topic can be compared and evaluated by other researchers to increase the quality of research being conducted. The framework can also be used by research groups to demonstrate the holistic value of DHI to funding organisations for informing decision making regarding further funding or wider scale implementation.

Beyond the world of researchers, policymakers may consider how an impact framework could influence the design and monitoring of digital health policies that address system-wide challenges including their impacts on individuals and services [30]. Health and care services could adapt elements from the framework as they look at assessing the value of digital health solutions and how they could affect to improve service delivery and operational efficiency [31]. Digital health developers could also use insights from micro-level analyses to better understand the diversity of users and needs as they strive to develop fit for purpose digital health solutions [32].

Strengths and limitations

Several limitations should be considered regarding this review surround the search strategy and included studies. First, studies were infrequently conducted in developing countries, causing these findings to have limited generalisability to people in countries with higher internet and healthcare access. The number of articles retrieved from developing countries may have been influenced by the eligibility criteria requiring studies to be written in English. However, the small number of articles retrieved from developing countries compared to higher income countries, reflect findings in previous studies surrounding ethical issues leading to lower rates of research being conducted in developing countries [33, 34].

Second, only ten of the retrieved studies evaluated impact on a meso- or macro-level. This may also have been influenced by the search strategy; however extensive key terms were used to retrieve studies from all areas. This suggests that our finding of only a few studies evaluating DHI past the micro-level may reflect a greater trend in impact measurement, but

this should be interpreted with caution. To test this suggestion, a future review should be used to search specifically for studies measuring impact of DHI at the meso- or macro-level.

Conclusions

Although evaluation of the impact of digital health information frequently includes measurement of changes in knowledge, attitude and behaviour at a micro-level, evaluation did not often extend to meso- and macro-levels, rendering organisational and societal impact under researched. Additionally, the definition and methods for measuring impact varied greatly in design and quality between studies. Application of evaluation strategies used in public health campaigns, may assist choice in measurement of impact to better demonstrate value to funding organisations. However, these strategies may be more expensive and time consuming in the context of DHI, possibly contributing to continual inconsistencies in impact definition and measurement. Development of a framework for impact measurement specific to DHI, based on these strategies, could guide more standardised methods of wholistic impact definition and measurement. A framework to measure impact across micro-, meso- and macro-levels could also better inform funding organisations of the value of the DHI for evidence-based financial decisions.

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Conflicts of interest

None declared

Author Contribution Statement

JT conceptualised the study and its methodology, provided project oversight, and provided critical feedback on the writing of the manuscript.

RD developed the search strategy and conducted the searches, screened abstracts and full text papers, extracted data, provided methodological guidance for the review, helped in drafting, and reviewed and edited versions of the manuscript.

MJ contributed to the data analysis phase, edited, and critically revised versions of the manuscript.

CC screened the abstracts and full text papers, extracted data, analysed the data, and drafted the manuscript.

All authors critically revised the manuscript, making substantial contributions and approving the final version.

Abbreviations

DHI: Digital health information

Funding

CareSearch, Australian Government Department of Health and Aged Care.

Multimedia Appendix 1

Search strategy.

Multimedia Appendix 2

Categorisation of health topics.

Multimedia Appendix 3

Characteristics of included studies.

Multimedia Appendix 4

Study aims or objectives for measurement.

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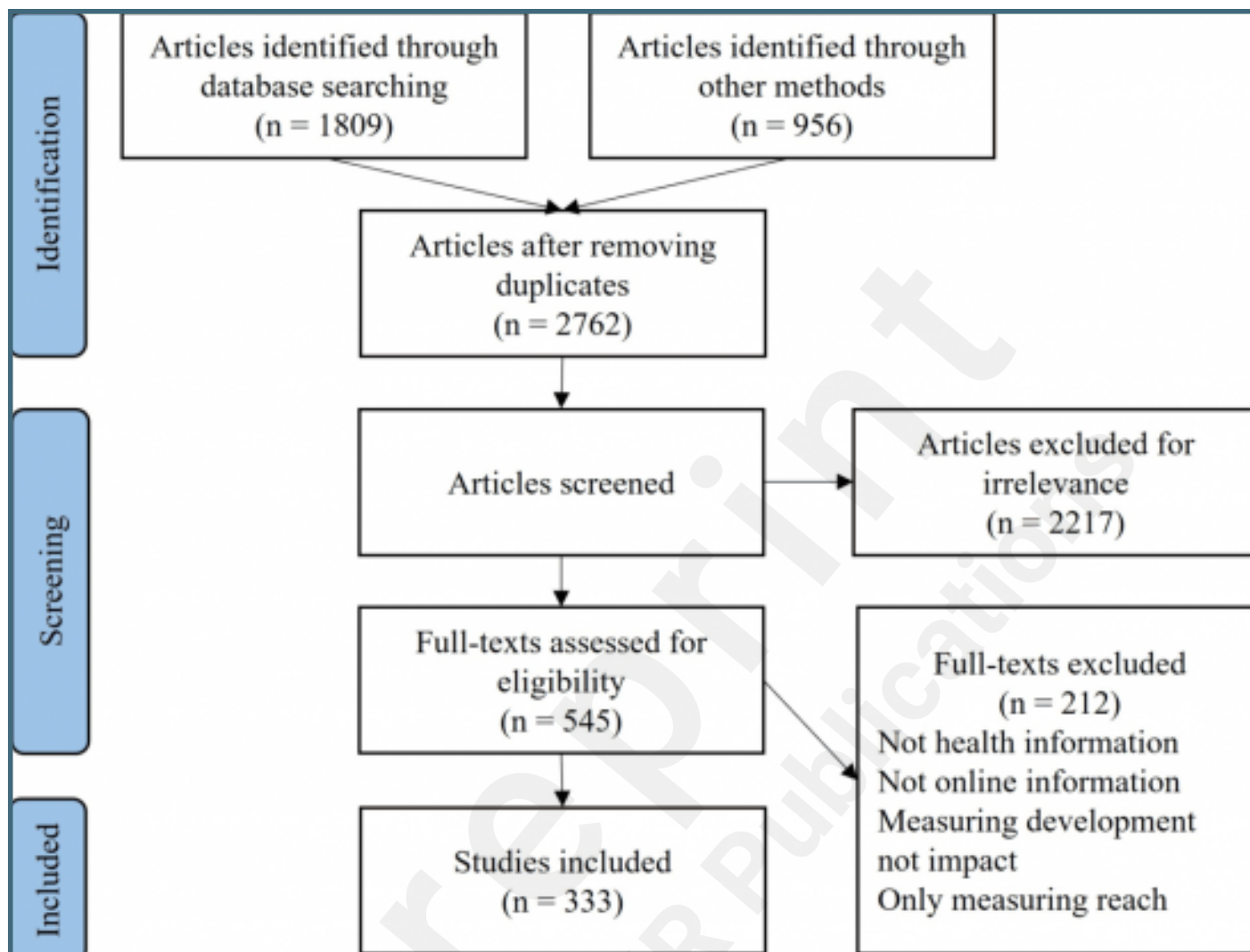
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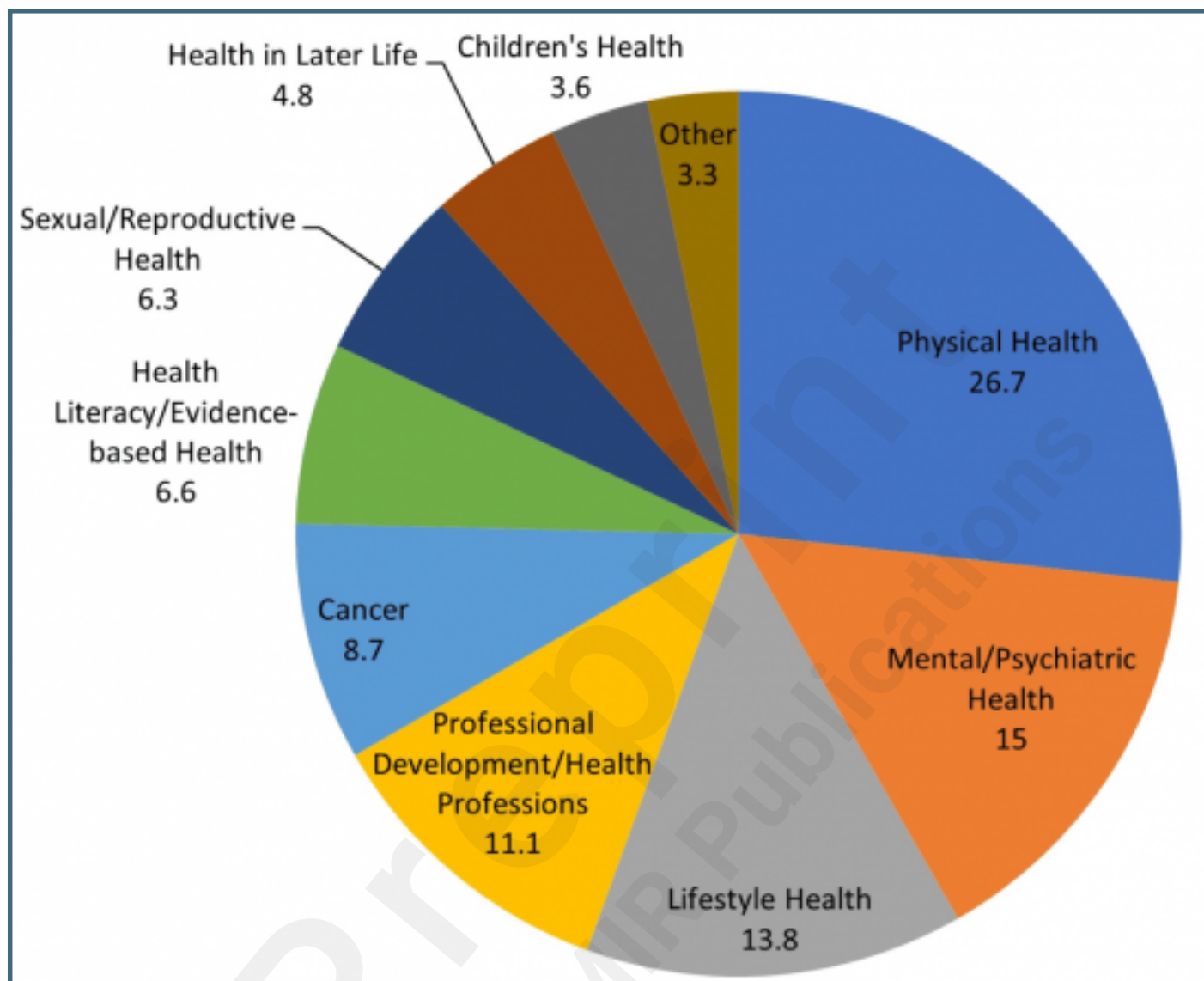
Supplementary Files

Figures

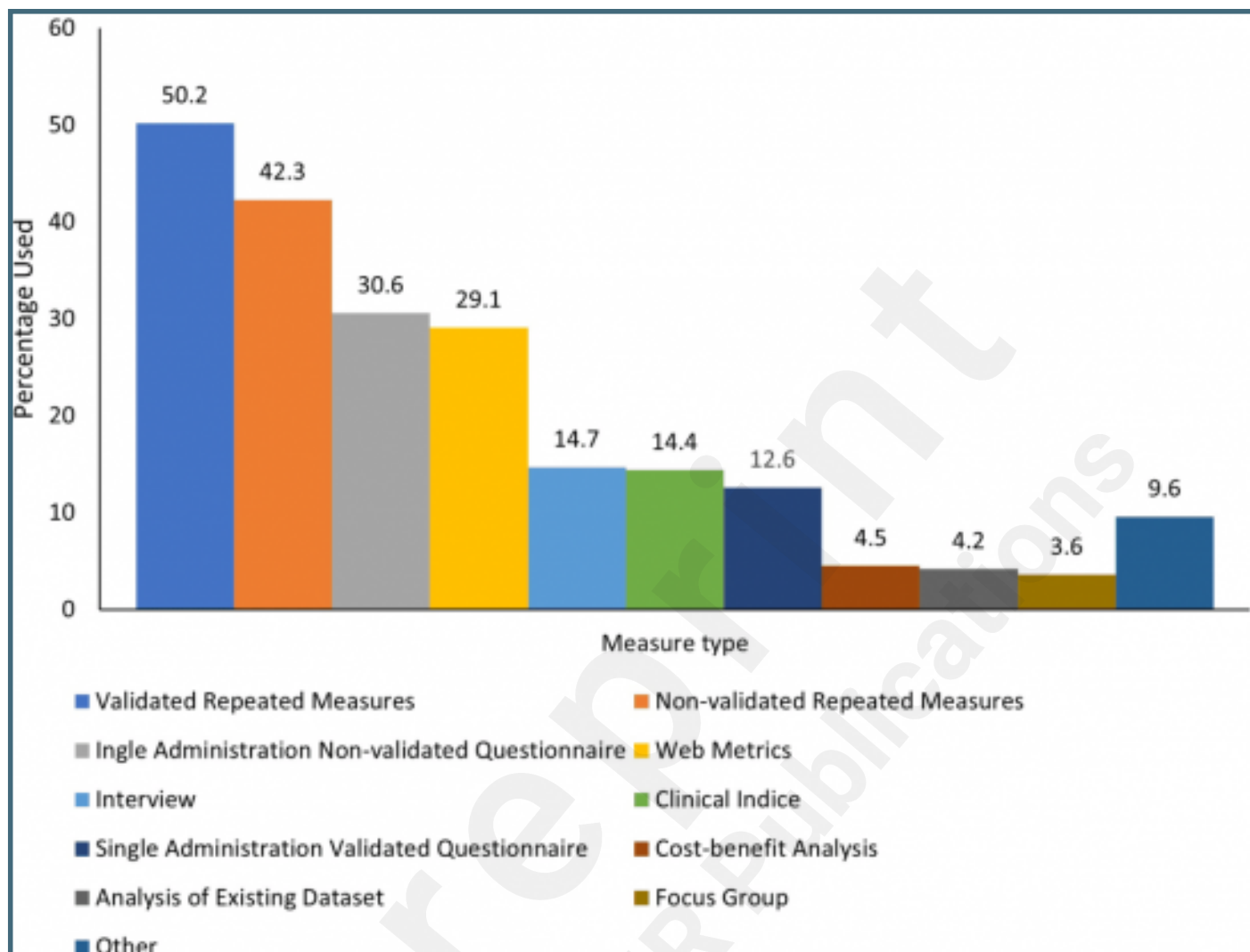
PRISMA-ScR flow diagram.



Health topic prevalence in the included digital health intervention studies.



Types of measures used to assess outcomes in the included digital health intervention studies.



Multimedia Appendixes

Search strategy.

URL: <http://asset.jmir.pub/assets/d62ff3328f9d250758d150ec8bdd7979.docx>

Categorisation of health topics.

URL: <http://asset.jmir.pub/assets/493e39f5a3dcc44f4917e3d2f0e1b794.docx>

Study characteristics.

URL: <http://asset.jmir.pub/assets/84309b1fbe880b2c43fd2956e2d488df.docx>

Study aims or objectives for measurement.

URL: <http://asset.jmir.pub/assets/9ed7d79f120040693cd67b80b4c96c84.docx>



CONSORT (or other) checklists

PRISMA-ScR checklist.

URL: <http://asset.jmir.pub/assets/5438f2623b9949d49706fe573fd9b8d8.pdf>