

Transforming women's health, empowerment, and gender equality with digital health: evidence-based policy and practice

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We evaluated the effects of digital health technologies (DHTs) on women's health, empowerment, and gender equality, using the scoping review method. Following a search across five databases and grey literature, we analysed 80 studies published up to Aug 18, 2023. The thematic appraisal and quantitative analysis found that DHTs positively affect women's access to health-care services, self-care, and tailored self-monitoring enabling the acquisition of health-related interventions. Use of these technologies is beneficial across various medical fields, including gynaecology, endocrinology, and psychiatry. DHTs also improve women's empowerment and gender equality by facilitating skills acquisition, health education, and social interaction, while allowing cost-effective health services. Overall, DHTs contribute to better health outcomes for women and support the UN Sustainable Development Goals by improving access to health care and financial literacy.

Introduction

Digital health technologies (DHTs) enhance health-care delivery through increased access to care and a better experience for end-users.¹ WHO defines DHT as a discrete functionality of digital technology applied to achieve health objectives, with DHTs organised into four groupings based on the primary user: clients, health-care providers, health systems or resources managers, and data services.² DHTs are known to promote social connectivity, facilitate interpersonal communication, and create versatile working and learning opportunities.³ Nevertheless, these technologies are not equitably accessible, with vulnerable groups commonly excluded.^{4,5} Older people, women, people living with ill health or disabilities, and people with low socioeconomic status have restricted internet access and digital skills, affecting their ability to benefit from DHTs.^{1,6,7} This digital divide was magnified by the COVID-19 pandemic^{8,9} as DHTs became an increasingly integral part of modern health systems.^{10–12}

Research has established correlations between the use of DHTs for women's health and improved empowerment (ie, self-concept, self-esteem, and self-worth) and equality (eg, equality and rights in accessing education, health-care services, and economic opportunities).^{13–16} A substantial literature explores technology in women's health and maternal health care, such as using artificial intelligence in diagnosing endometriosis,¹⁷ phone apps to monitor pregnancy,¹⁸ and digital health to treat postpartum depression.¹⁹ Evidence also suggests that DHTs support self-management via tracking of vital signs, medication adherence, lifestyle changes, and mental health management.^{20–23}

Statistics nevertheless emphasise that women might not fully benefit from DHTs due to the gender digital divide that isolates women from technological advancements. Prioritising the resolution and the

reduction of the negative effects of this disproportionate access to DHTs, the UN established the 2030 Agenda for Sustainable Development in 2015, encompassing 17 interconnected global goals to improve health-related, financial, social, and educational outcomes.^{24–26} Three of the Sustainable Development Goals (SDGs) rely on good health and population wellbeing (Goal 3), gender equality (Goal 5), and the reduction of inequalities (Goal 10). Accordingly, WHO developed the Global Strategy on Digital Health 2020–2025²⁴ and the Regional Digital Health Action Plan for the WHO European Region 2023–2030,²⁶ designed to improve and apply DHTs with the vision of health for all, preserving equity, gender equality, and human rights as the core elements for digital development. These global and European regional strategies set out a vision, mission, strategic objective, and framework for action to advance DHTs.

Although studies show that DHTs enhance women's health outcomes, implementation challenges remain, including accessibility, affordability, data privacy and security, and interoperability.^{27,28} Associated challenges include the development and implementation of regulatory frameworks to oversee DHTs.^{24–26} Women often encounter barriers to using DHTs, such as restricted access, cultural and socioeconomic factors, and caregiving responsibilities, which hinder women's health-care indicators and empowerment.²⁹ However, no systematic assessment of the benefits of digital health for women exists. This scoping review, covering DHTs in the context of women's health and their potential to improve women's empowerment and gender equality in health, was undertaken to provide an overview of the empirical research on gender equity and women's empowerment, digital health, and women's health.

The primary aim of our study was to comprehensively synthesise the available literature on the multiple effects of DHTs on women's health status, including collating

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See Online for appendix
For the R Project for Statistical Computing see <https://www.R-project.org/>

the effects of DHTs on women's empowerment and gender equality. The secondary objectives were to identify the factors limiting access to, engagement with, and use of DHTs by women. Additionally, we focused on determining avenues for operationalising digital health applications for women. Thus, our review process and reporting in this Health Policy paper provides policy makers and other stakeholders with a list of potential actionable solutions to increase women's empowerment and gender equality.

Methods

The review followed the methodological framework for conducting scoping reviews developed by Arksey and O'Malley and adheres to the JBI Manual for Evidence Synthesis for scoping reviews.^{30,31} The findings are reported under the PRISMA extension for scoping reviews (PRISMA-ScR), with the respective checklist available in the appendix (pp 5–6).³² The protocol was registered on PROSPERO before the review process (CRD42022350883),³³ originally as a systematic review. Nevertheless, during the initial assessment of eligible primary records identified through our searches of five literature databases and grey literature, our team of specialists observed that the existing literature was mostly descriptive and exploratory, lacking in the robustness needed in systematic reviews. Additionally, we decided that due to the interdisciplinary nature of study in this area—bridging health-care, policy, and gender primary studies—would require a broader, more explanatory and consistent review framework to respond to stakeholder inputs and to contextualise findings within several domains. Thus, we decided to perform a scoping review not only to evaluate the effectiveness of potentially includible evidence, but also to provide a contextual and policy dimension around the central theme of research and to map the various interventions applicable for women's health and empowerment.

Data extraction

Each record underwent full data extraction managed by seven review investigators (IJBdN, HMA, IW, JM, LTV, GD, and IK). Basic data from the selected studies were abstracted, including study identification (eg, main author identifier), publication year, journal, study design, study objective, number of included individuals, and setting and country where the study occurred. The extracted and evaluated primary outcomes consisted of the type of DHT used, medical conditions and health issues assessed, and the main findings. Data extracted were assessed by at least two investigators (ie, any investigator involved in the project execution: IJBdN, HMA, IW, JM, LTV, GD, LØ, IK, or EZM) and any conflicts were resolved by discussion among the senior researchers (IJBdN, HMA, and IW). The data extraction template is available in the appendix (p 23).

Data analysis

A mathematical framework to report findings from qualitative research based on thematic analysis concepts was developed (appendix p 24) and published elsewhere.³⁴ Our method integrates thematic and lexical analysis with single-proportion meta-analysis to synthesise qualitative data in systematic reviews. This novel approach enables the extraction and categorisation of themes and lexical patterns (appendix pp 24–25) from diverse qualitative studies, allowing the quantification of recurring findings. By using the relative frequency of occurrence (RFO) and associated 95% CI, we calculated the proportion of studies reporting specific outcomes, providing a statistically valid summary and offering a systematic framework that bridges qualitative insights with quantitative measures. Briefly, our methodology incorporates concepts related to thematic and content analysis that is integrated with single-proportion meta-analysis. Relevant steps include the following features: data familiarisation and preparation, generation of primary codes, text segmentation, creation and definition of overarching themes, frequency analyses, and report production. Analysis was executed with R software version 4.1.1, using the metapro function package. This graphic and mathematical presentation of findings allowed qualitative data to be converted into numerical results for a straightforward, quantitative evaluation of the findings. The standardised analysis and presentation of data reduces the inherent bias and clearly communicates complex qualitative findings to readers accustomed to quantitative results. Findings were coded and thematically collated using NVivo software by two investigators (IJBdN and LTV) and subsequently re-evaluated by two other researchers (HMA and IW). After establishing themes, the frequency of occurrence for each domain was aggregated into a standard meta-analysis of proportions. To illustrate how the knowledge provided within the results section of primary studies was translated into the created domains, statements were randomly selected from these manuscripts to justify the allocation for the established theme (appendix p 26).

Additionally, a framework was used to summarise gender equality and women's empowerment data that explores how gender power relations manifest as inequities.³⁵ Barriers to use and access were also extracted and reported. The assessment of the presented barriers could also include potential negative effects arising from engagement with these technologies. Based on the identified barriers to use of and access to DHTs by women, potential actions for multiple stakeholders to optimise the effects of such technologies are presented and outlined in our discussion. This study was exempt from ethical approval as it did not involve original human data collection.

Results

The search identified 15 104 records for screening. After duplicate removal, 9452 studies were evaluated by title

and abstract. Ultimately, 80 original studies, presented in full reports or in abstract form, were included^{36–114} (figure 1). A complete list of excluded studies with exclusion justification is available in the appendix (pp 27–47). The main characteristics of included studies, including studies design, are summarised in the table. The included studies represented all main continents, although disproportionately. The appendix (p 48) shows the number of studies indicating the implications of DHTs per WHO region and countries or regions. 50 (62.5%) of the 80 included studies were predominantly associated with mobile health.^{36,39–41,45,46,48–51,53,55–57,60,61,63,65–74,76,80,82}

Telehealth and web-based platforms were described in 25 (31.3%) primary studies.^{37,38,42,44,47,48,54,58,59,62,64,77,78} Social media platforms^{43,48,52,79,81} and digital health systems⁷⁵ were identified less among the included studies. Participants' socioeconomic and ethnic backgrounds within the included studies varied widely. Studies from high-income countries (HICs), mostly associated with more affluent settings (ie, the USA and Canada), were the majority (65.0%). Conversely, low-income and middle-income countries (LMICs), such as Uganda, Kenya, and India, were less frequently reported. Most studies in HICs included a diverse ethnic group, with representation from Hispanic, Black, Asian, and multiracial women, particularly in studies from the USA. Nevertheless, a relevant number of studies from both HICs and LMICs did not specify the ethnicity of participants. Additional information is available in the appendix (pp 49–52).

Overall effects of DHTs on women's health status

Most studies covered maternal and sexual health, gynaecology, and reproductive health.^{36–42,46,48–52,54–61,63–73,75,77–80,82} Other health areas of interest included psychiatric disorders and mental health,^{44,48,51,53,62,70} oncology,^{74,76,81} endocrinology,^{43,64,75} surgery,⁵⁴ emergency medicine,⁴⁴ and physical wellbeing.^{43,64}

60 records (RFO 75.0%, 95% CI 64.1–84.0) emphasised how using DHTs would positively affect women's access to health services, result in increased self-care, or provide tailored self-monitoring systems to enable the acquisition of health-related interventions (figure 2).^{36,39–45,47,49,50,52,54–56,58,59,61–63,65–74,76–82} The evidence shows that digital technologies enhance access rates to screening programmes, prompt lifestyle changes, and improve women's attention to personal health matters.^{38,47,74–76,82} Mathematical findings related to the effect of DHTs on women's health status are summarised in figure 2 and the appendix (pp 53–54). Accordingly, 25 primary studies (RFO 42.5%, 95% CI 31.5–54.1; 215 442 women from multiple countries and regions) of the included studies stressed the positive effects of DHTs on maternal and gynaecological wellbeing and outcomes, influencing women's prepartum, intra-partum, or postpartum stages or breastfeeding.^{1–7,11,13–17,19–25,27–34,36,38–41,43,53,57,58,62,63,65,67,68,70,71,73–77,79–82,84,85,88–95,118–120}

Digital technologies were reported as

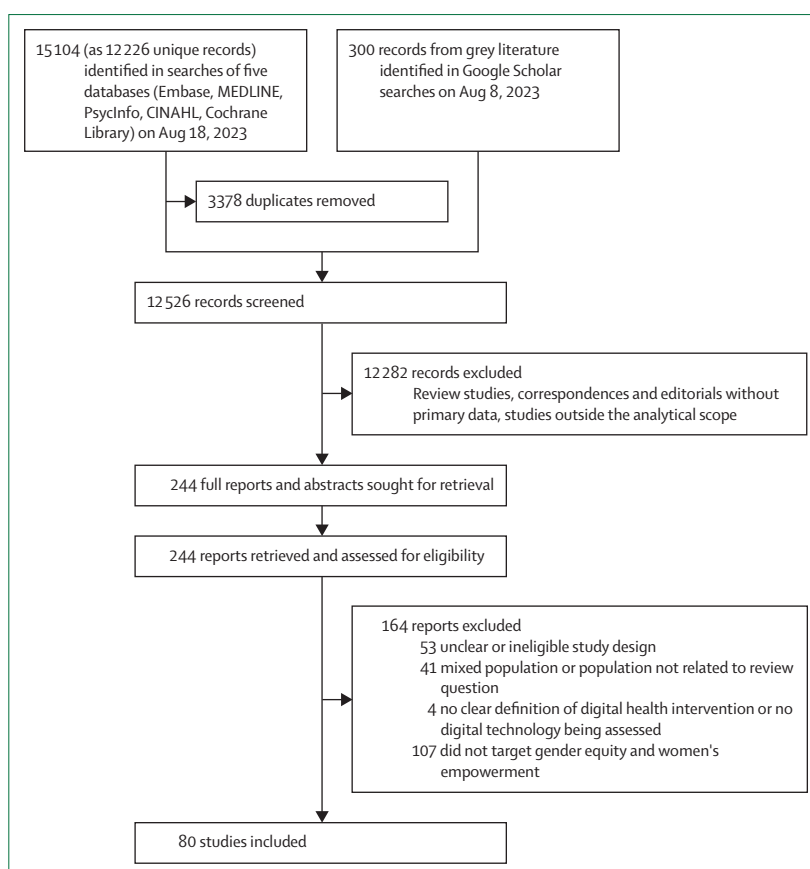


Figure 1: Flow diagram of scoping review

useful for women seeking information about themselves or their baby,^{46,49,57,63,75} medication use during pregnancy,^{36,38,53,56,57,64,70,79,81,87,88,96,112,115} breastfeeding practices,^{57,61,68,74,76,79,81} and labour. The effect of health technologies postpartum has been evaluated in six studies.^{46,47,61,62,70,71} Immediate messaging apps (eg, WhatsApp and Viber) had a positive effect on postpartum communication with providers.⁴

DHTs were associated with mental health improvement, including psychological relief and satisfaction after use, mood improvement, sensations of happiness, fulfilment and pleasure, anxiety reduction, and overcoming depression (RFO 33.8%, 95% CI 23.6–45.2).^{37,39,42,45,47–49,52,53,59,60,62,63,65,67,71,73,76,79,81,82,87,95,98,101,102,107,112} Studies note how DHTs decrease workload and negative work-related experiences. Reduced isolation and loneliness followed DHT use, and improved self-image. Conversely, five studies (RFO 6.2%, 95% CI 2.1–14.0) associated the use of DHTs with negative emotional burdens and psychological discomfort.^{37,43,44,51,64}

Three studies (3.8%; two from the UK and one from Germany) reported health outcomes associated with home-based medical termination of pregnancy.^{37,42,59} Overall, the use of DHTs positively affected the care and health-related outcomes of women undergoing the process of pregnancy termination, either by providing

	Country	Sample size, n	Study design	Objectives
Abrejo et al (2022) ³⁶	Pakistan	30 (23 married women and seven health-care professionals)	In-depth interviews	To explore the feasibility and acceptability of a potential mHealth intervention for women living in areas with low socioeconomic status to increase the uptake of family planning.
Aiken et al (2017) ³⁷	Ireland and Northern Ireland	1023	Online questionnaire	To examine the characteristics and experiences of women seeking at-home medical termination of pregnancy using online telemedicine.
Alabdullatif et al (2022) ³⁸	USA	94 290	Survey	To assess the association between information technology-based health-care communication and mammography use, and to evaluate whether any effect is modified by race or ethnicity and age.
Alem (2019) ³³	USA	210 women	Quasi-experimental study	To develop a web-based video intervention to increase knowledge of gestational and lactational medication safety among women of reproductive age and to assess knowledge and use of the US Food and Drug Administration's pregnancy and lactation labelling rule among pharmacists and physicians.
Ampt et al (2020) ³⁹	Kenya	42 women	In-depth interviews	To describe the development of the WHISPER intervention, its theoretical framework, key domains, and strategies. To explore participant responses to the proposed intervention regarding message content, behaviour change construct, feasibility, and acceptability.
Angus et al (2019) ⁸⁴	Australia	..	Case study	To identify whether apps are effective in identifying infants with insufficient feeding patterns or whether they function only as a recording device (ie, high-tech diary).
Atukunda et al (2021) ⁴⁰	Uganda	35 (30 women and 5 health-care providers)	In-depth interviews	To develop a novel patient-centred mHealth intervention to encourage and support women to use maternity care services.
Atukunda et al (2023) ⁴¹	Uganda	120	Randomised clinical trial	To evaluate the feasibility, acceptability, and preliminary efficacy of a novel mHealth-based messaging app to promote maternity services among pregnant women.
Axelrod et al (2023) ⁸⁵	..	20 women	Prospective observational study	To assess the feasibility of hybrid care for women with gestational diabetes mellitus.
Bangal et al (2018) ⁸⁶	India	200 women	Randomised clinical study	To assess the effect of mobile communication between health facilities and pregnant women on the use and outcome of maternal health services.
Baun et al (2018) ⁸⁷	Denmark	48 women	Prospective mixed-methods study	To investigate the use of online access to diagnostic reports on Sundhed.dk and to identify the main attitudes towards it, including potential barriers and facilitators.
Bilal Boman et al (2022) ⁸⁸	..	73 648 complete appointments	Retrospective observational study	To assess minority women's access to gynaecology and reproductive care during the COVID-19 pandemic and the associated shift from in-person to telehealth modalities.
Bojko et al (2022) ⁸⁹	USA	97 women	Retrospective observational study	To examine the efficacy of a telehealth-based approach to effective weight management interventions in women with obesity seeking treatment for infertility.
Boydell et al (2021) ⁴²	Scotland	20	In-depth interviews	To explore the experiences of women who accessed medical abortion at home at up to 12 weeks gestation, delivered via a telemedicine abortion service implemented in response to the COVID-19 pandemic, and to identify areas for improvement and inform service provision.
Camacho-Minano and Gray (2021) ⁴³	Spain	37	Focus group and in-depth interviews	To explore how pedagogies of perfection in fitness content on social media work as a postfeminist technology of the self, encouraging young women to take action to become perfect but hiding the extent to which exercise as aesthetic labour is normatively demanded.
Chappell et al (2021) ¹¹⁵	UK	850 women	Randomised clinical trial	To evaluate whether blood pressure self-monitoring in women with pregnancy hypertension improves blood pressure control.
Choo et al (2015) ⁴⁴	USA	17	In-depth interviews	To explore women's attitudes about the use of computers for screening and intervening in drug use and partner abuse.
Chow et al (2020) ⁴⁵	USA	28	Focus group analyses	To evaluate the acceptability and preliminary efficacy of a novel app-based intervention with phone coaching in women recovering from cancer.
Chowdhury et al (2019) ⁴⁶	Bangladesh	6551	Retrospective observational study	To evaluate the effects of Aponjon (mobile messaging service) use on knowledge and behaviours related to maternal and newborn health care.
Chyzzy and Dennis (2019) ⁹¹	Canada	40 women	Randomised clinical trial	To evaluate the feasibility and acceptability of a mobile phone-based peer support intervention and adherence to the intervention, and to obtain preliminary estimates of the effects on clinical outcomes to inform a future definitive randomised controlled trial.
Daehn et al (2023) ⁴⁷	Germany	217	Mixed-methods approach (online surveys, usage data, and interviews)	To evaluate the feasibility of the SmartMoms web app to inform women about postpartum depression, support them, and provide an easily accessible self-screening instrument.
Dang et al (2016) ⁹²	USA	651 women	Survey	To evaluate use by women veterans of the Veterans Affairs patient portal MyHealtheVet, establish their knowledge, and explore discussions of menopause with providers.
Dalal et al (2022) ⁴⁸	India	66 013	Survey	To investigate whether economic and electronic empowerment of women act as protective factors against intimate partner violence.
Silva et al (2019) ⁴⁹	Brazil	13	Prospective observational study	To evaluate the GestAção app based on the experience of pregnant women in prenatal consultations in public health services.
Derksen et al (2023) ⁵⁰	Germany	360	Randomised clinical trial	To test a short digital communication intervention based on the health action process approach.

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	Country	Sample size, n	Study design	Objectives
(Continued from previous page)				
Dieteren et al (2022) ⁹³	India	178 women	Randomised clinical trial	To evaluate the effects of a smartphone apps on maternal health knowledge and diet among pregnant Indian women.
Doering and Prinzellner (2015) ⁹⁴	Germany	600 health-related discussion threads (containing 6020 postings)	Online forum analysis	To answer three questions about girls' peer sex counselling: (1) Which sexual health-related problems do girls present in these online discussions? (2) How are these problems discussed among girls? (3) Do these sexual health-related online discussions sexually empower girls?
Doherty et al (2018) ⁹¹	UK	38	Qualitative interviews	To explore the issues and challenges surrounding the use of mobile phones for self-support of psychological wellbeing during pregnancy.
Ellis and Roberts (2020) ⁹²	UK	480 discussion threads	Retrospective observational study	To explore online pregnancy forum health-related use and to evaluate the quality of information shared.
Foster (2018) ⁹⁵	Poland	1098 women	Prospective observational study	To evaluate the use patterns and outcomes associated with 18 months of Women Help Women's telemedicine service delivery in Poland.
Garcia et al (2019) ⁹³	Spain	71	Exploratory study	To improve the mental, physical, and social health of vulnerable immigrant women.
Gilmour et al (2017) ⁹⁴	Canada	31	Survey and in-depth interviews	To test the feasibility of self-care web apps to inform women whether, when, and where to seek help for symptoms after hysterectomy.
Gitonga et al (2021) ⁹⁵	Kenya	118	Randomised clinical trial	To examine the influence of SMS reminders on the use of focused antenatal care.
Hackett (2018) ⁹⁶	Tanzania	572	Cluster-randomised clinical trial	To evaluate a smartphone-based application designed to assist community health workers with data collection, education delivery, identification of gestational danger signs, and referrals.
Hadland et al (2022) ⁹⁶	Australia	18 women	Semi-structured interviews	To investigate women's perspectives if the focus of care has moved to digital technology in the maternity care environment.
Hategeka and Law (2018) ⁹⁷	Rwanda	..	Demographic and health survey	To evaluate the effects of RapidSMS-MCH on the uptake of maternal, newborn, and child health-care services in Rwanda.
Heitmann and Schjøtt (2020) ⁹⁷	Norway	30 000 answered questions	Descriptive study	To describe the development and future perspectives of an innovative medicine information service aiming to increase empowerment among pregnant and breastfeeding women.
Jones et al (2021) ⁹⁸	USA	70	Pilot randomised clinical trial	To evaluate the feasibility and acceptability of two SAFE interventions (ie, face-to-face and computer-adapted) compared with usual care, and their efficacy to improve contraception use.
Katusiime (2021) ⁹⁷	Uganda	80 women	Mixed-methods study	To evaluate the usability, acceptability, and effect of maternal mHealth tools by key stakeholders in maternal health.
Kausler (2023) ⁹⁸	Interviews	To evaluate the feasibility and acceptability of delivering an evidence-based 8-week mindfulness-based cognitive therapy intervention.
Killinger et al (2022) ⁹⁹	Germany	1090	Mixed-methods study	To understand the motivations and perceived barriers to access for women who choose telemedicine abortion outside the formal sector.
Kodama and Takaki (2022) ⁹⁰	Japan	110	Survey	To investigate pregnant women's use of pregnancy apps and how these affect their mental health.
Laar et al (2019) ⁹¹	Ghana	489	Mixed-methods study	To assess the perspectives of women and health workers on the feasibility of mobile health technology for the provision of maternal and child health services in rural settings.
Lackie et al (2021) ⁹²	Canada	31	Focus group	To engage women from various backgrounds and locations to establish the unmet psychoeducational needs of women with postpartum depression, and to explore how a web-enabled platform used to deliver psychosocial skills and education to assist in management could meet those needs.
Leziak et al (2020) ⁹⁹	..	45 women	Interviews and focus groups	To understand low-income pregnant women's experiences and preferences for mHealth tools to support diabetes health and improve diabetes self-management during pregnancy.
Li and Shan (2019) ¹⁰⁰	China	300 women	Survey	To investigate pregnant women's experiences and demand for pregnancy apps, aiming to understand the current situation and existing problems.
Lovell and Harris (2021) ⁶³	UK	749	Survey	To examine women's use of mobile apps in labour.
Lu et al (2022) ¹⁰¹	USA	40 women	Focus group	To identify the psychosocial burdens of having diabetes during pregnancy and understand how a novel smartphone application might alleviate such burdens.
Lupton and Maslen (2019) ⁶⁴	Australia	66	Focus group and in-depth interviews	To investigate which types of digital technology women use regularly for health-related purposes and which they find most helpful and useful.
Mackintosh et al (2020) ⁹⁵	UK	1254	Survey	To assess the role of online resources and apps for women's help-seeking and staff's response to concerns in the perinatal period.
Malachi et al (2023) ⁹⁶	Kenya	160	Randomised clinical trial	To evaluate the effectiveness of health education on antenatal care provided by mobile phone calls among pregnant women.

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	Country	Sample size, n	Study design	Objectives
(Continued from previous page)				
McBride et al (2018) ⁶⁷	Viet Nam	12	Prospective observational study	To pilot and evaluate a low-cost mHealth intervention, mMom, which aims to use behaviour change communication to improve access to maternal, newborn, and child health services and health equity among women from ethnic minorities living in remote areas.
McCall (2021) ¹⁰²	USA	395 women	Mixed-methods study	To examine the attitudes and perceptions of African American women towards the use of mental health services, and the feasibility of using mobile technology to deliver mental health services and resources.
Mullaney et al (2016) ¹⁰⁴	Ireland	402 women	Survey	To assess the correlation between scores derived from a novel online dietary assessment tool and nutrient intake data derived from the previously validated Willett Food Frequency questionnaire.
Musiimenta et al (2020) ⁶⁸	Uganda	14	Mixed-methods study	To explore how illiterate pregnant women perceive a maternal health mobile app that has tailored video and audio messages, appointment reminders, and call function.
Ngo et al (2022) ⁶⁹	Norway	268	Randomised clinical trial	To investigate whether the MinSafeStart mobile app could affect nausea and vomiting-related symptoms, quality of life, and decisional conflict regarding nausea and vomiting treatment.
Özkan Şat and Yaman Sözbir (2021) ⁷⁰	Türkiye	376	Survey	To examine the use of mobile apps by pregnant women in receiving health information, counselling, and health care during the COVID-19 pandemic and their distress levels during pregnancy.
Perrenoud et al (2022) ⁷¹	Switzerland	50 (30 health-care professionals and 20 immigrant women)	Socio-anthropological study	To analyse how health and social care professionals (with a focus on community midwives and women) communicate between postpartum home visits with immediate message applications.
Pflugeisen et al (2016) ¹⁰³	USA	1058 women	Observational study	To implement and evaluate a novel model of prenatal care for low-risk pregnant women that intersperses in-person physician visits with nurse practitioner visits conducted via videoconference.
Pillarisetti and Pillarisettiob (2022) ¹⁰⁵	India	..	Descriptive study	To empower people about various aspects of breast cancer and benign breast disease, explained in a simple, easy-to-understand format.
Poulter et al (2022) ¹⁰⁶	Australia	98 women	Intervention study	To establish patient satisfaction, the effect on maternal and neonatal outcomes, and resource use of a smartphone-based, remote blood glucose level monitoring platform with software surveillance in women with gestational diabetes compared with historical controls.
Prasad (2018) ¹⁰⁷	USA	43 women	Intervention study	To examine the efficacy of an electronic app to moderate symptoms of postpartum depression and improve postpartum wellbeing.
Rajkhowa and Qaim (2022) ⁷²	India	39 523	Survey	To analyse associations between women’s use of mobile phones and selected indices of female autonomy and empowerment.
Riley and Paskova (2022) ⁷³	New Zealand	5	In-depth interviews	To propose a theoretical framework to understand women’s use of menstrual tracking digital apps, and to apply it to the analysis of users’ experiences in the management of premenstrual syndrome.
Roh et al (2023) ⁷⁴	USA	122	Randomised clinical trial	To assess the feasibility and efficacy of the wMammogram intervention to undergo breast cancer screening compared with a control (educational brochure).
Rollo et al (2020) ⁷⁵	Australia	42	Randomised clinical trial	To evaluate the feasibility, including recruitment, retention, preliminary efficacy, and acceptability, of the Body Balance Beyond eHealth intervention in women with previous gestational diabetes.
Rotondi et al (2020) ¹⁰⁸	209 countries included	..	Evidence map and survey data	To provide large-scale evidence that the expansion of mobile phones is associated with lower gender inequalities, higher contraceptive use, and lower maternal and child mortality, with bigger payoffs in the lowest-income countries.
Sreehari and Pillai (2019) ¹¹⁰	UK	30 000 downloads	Prospective observational study	To evaluate the applicability of the BREXA mobile app.
Shija et al (2021) ¹⁰⁹	Tanzania	4500 women	Prospective observational study	To study the access to maternal health-care services with a digital MomCare wallet.
Slomian et al (2017) ⁷⁷	Belgium	349 questionnaire answers	Survey	Five main aims: (1) To evaluate the need for information after childbirth and the questions new mothers ask themselves. (2) To assess why and how women use the internet to meet their need of information. (3) To describe how the respondents evaluate the reliability of the information found. (4) To understand how the information found on the internet affects women’s decision making. (5) To appreciate how health professionals react to the information found by the women.
Singleton et al (2022) ⁷⁶	Australia	160	Mixed-methods study	To evaluate the reach, usefulness, and acceptability of, and factors influencing engagement with, a lifestyle-focused text message intervention to support women’s mental and physical health after breast cancer treatment.
Thompson et al (2020) ⁷⁸	USA	51	Prospective observational study	To examine the feasibility of a programme to help women with opioid-use disorder to meet their reproductive health needs by bringing services directly to them using community outreach educators and telehealth.
Ure et al (2020) ⁸¹	UK	21	In-depth interviews	To explore how women use and experience social media to self-manage their psychosocial needs and support self-management across the breast cancer continuum.
Uscher-Pines et al (2019) ¹¹¹	USA	72 women	Longitudinal survey	To assess tele-lactation visit characteristics and predictors of use.

(Table continues on next page)

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	Country	Sample size, n	Study design	Objectives
(Continued from previous page)				
Wagg et al (2019) ⁷⁹	UK	501 posts	Qualitative study	To document and describe the posts made within an online breastfeeding support group.
Wang et al (2021) ¹¹²	Malawi	13 217 women	Demographic and health survey	To assess the role of exposure to family planning information by various mass media on the use of maternal health-care services.
Webber et al (2020) ⁸⁰	Tanzania	112 (31 women and 43 health-care professionals)	Focus group	To improve maternal health and women's access to maternity care services.
Willcox et al (2015) ¹¹³	Australia	15 women	Focus groups and in-depth interviews	To explore women's and health professionals' views regarding the use of technology to promote healthy pregnancy weight, providing nutrition and physical activity information and interventions.
Yee et al (2022) ^{114*}	USA	40 women	Randomised clinical trial	To evaluate the SweetMama user experience, feasibility, and acceptability.
Zhang et al (2022) ⁸²	China	1850	Retrospective observational study	To investigate the use of maternal and child health apps among pregnant women and to explore associations with pregnancy outcomes.
Data were synthesised and managed in clusters and we considered the maximum information from the same set of patients that could be concluded. The studies shown represents the report with the most patients reported. The study by Yee and colleagues ¹¹⁴ shown in the table reported the most patients. * Four reports were related to Yee and colleagues; ¹¹⁴ however, we merged all these references as they presented fragmented results from the randomised clinical trial.				
Table: Main characteristics of included studies				

access to a safe, legal, and environment-controlled intervention, or by providing emotional relief for individuals throughout the difficult process.

Effects of DHTs on women's empowerment and gender equality

The appendix (pp 55–56) summarises the meta-analysis of term-based or content-based analysis regarding the use of DHTs on women's empowerment and gender equality. Positive improvements in women's empowerment and gender equality were primarily achieved with DHTs that provided access to resources (eg, financial, informational, skills, services, and social capital). A domain-specific display of the meta-analytical assessment is shown in figure 3.

Overall, use of digital technologies directly affected women's empowerment and gender equality either as a skills acquisition system or as a health education portal or health literacy platform (RFO 83.8%, 95% CI 73.8–91.1).^{36–47,49–57,59,60,62–82,87,88,92,93,95–97,99,101,102,104,105,108–114,117} DHT content improved understanding and engagement, and served as a long-term encouragement mechanism for health-related issues.^{36–47,49–57,59,60,62–82} Use of DHTs increased women's communication with family and health-care providers (RFO 18.8%, 95% CI 10.9–29.0).^{48,53,64,71,77,87–90,92,95,101–103,106–112,114} or improved finances (RFO 8.8%, 95% CI 3.6–17.2).^{48,53,64,71,77,106,110} Finance-related outcomes included enhancing access to affordable health-care services, reducing medical costs, and increasing financial literacy for health-care expenses.

Women also reported that DHTs facilitated women's understanding of their rights, promoted actions against violence, and improved communication skills (RFO 10.0%, 95% CI 4.4–18.8). Improvement of household and community relationships was observed in 35 of the included primary studies (RFO 43.8%,

95% CI 32.7–55.3; figure 3), indicating that DHTs might be useful partner engagement systems and communication facilitators within the health-care apparatus.^{48,53,64,71,77,88–90,92,95,102,103,108–110,112,114}

Technology increased women's autonomy and enhanced their decision-making capacity in 38 studies (RFO 47.5, 95% CI 36.2–59.0) via ease of use, flexibility, security and confidentiality, ownership, and inclusiveness.^{36,39–44,47,49,50,58,59,62,64,67–69,71–74,77,81,87,89,90,93,95,97,99,102,104,108,109,113–117}

Women in many studies reported that digital resources helped them to feel in control, raised self-awareness, and promoted self-management of symptoms, particularly during consultations with staff.^{36,39–44,47,49,50,58,59,64,67–69,71–74,77,81}

Factors affecting access to and use of DHTs by women

Although women's empowerment via DHTs was evident, considerable barriers to access and use limit the applicability of such technologies. The barriers not only prevent women from comprehensively benefiting from DHTs, but might also manifest as negative effects resulting from DHT access and use. Therefore, the identified barriers could also be translated as negative effects in our analysis. Types of barrier identified, with respective RFO, and some examples among the included studies are given in the appendix (pp 57–60). Our content analysis identified ten factors that hinder women's access to DHTs globally and 14 barriers that hinder the use of DHTs (figure 4). These barriers (also viewed as negative effects to women) include privacy concerns, concern of violence, impersonality, and ownership or space restrictions. This range of barriers highlights the complex interplay between access, use, and the potential for negative outcomes. Detailed findings regarding factors influencing access to and use of DHTs by women is available in the appendix (pp 61–62).

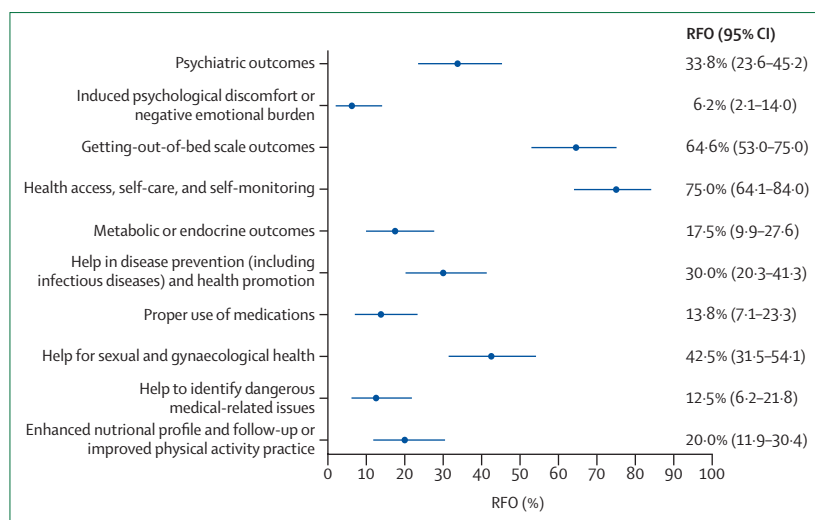


Figure 2: Findings related to the impact of DHTs on women's health status

Summary of pooled proportions (with 95% CIs) for key clinical outcomes reported across included studies, including psychiatric effects, health access, medication use, and disease prevention. DHTs=digital health technologies. RFO=relative frequency of occurrence.

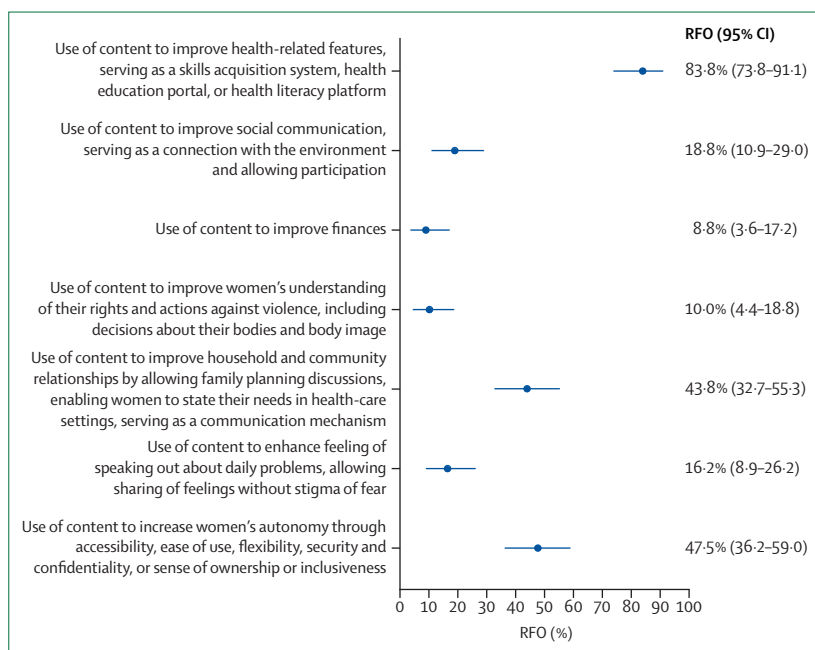


Figure 3: Findings related to the impact of DHTs on women's empowerment and gender equality

Proportions (with 95% CI) of studies describing benefits related to health education, autonomy, communication, household dynamics, and gender rights, as enabled with digital health interventions. DHTs=digital health technologies. RFO=relative frequency of occurrence.

Discussion

Our findings suggest that use of various types of DHT shows promise for improving specific aspects of women's health. However, the extent of effectiveness varies across contexts and settings. These assessments suggest that DHTs positively improve outcomes related to gynaecology, obstetrics, psychiatry, nutritional intake, and longitudinal follow-up,^{43,49,53,64,68,70,75,77,82} and promote

physical activity. Notably, DHTs can empower women by providing access to resources and strengthening their communication skills with partners, family members, and health-care providers.^{36,38,40,41,48,50,53,54,57,61–68,71,72,74,76,77,81} Generally, the findings show that DHTs help women to increase their autonomy by independent, safe, flexible, and confidential decision making.

The gender divide and digital gender gap

Our findings suggest that DHTs can positively affect women's empowerment and promote gender equality in terms of clinical, social, cultural, and financial features. Recent statistics on the gender divide are worrying. Despite rapid technological advancement, LMICs still face challenges in offering equitable and supportive conditions to secure women's access to digital technologies.¹²¹ Between 2019 and 2022, the gender parity score increased by only 0.02 points on a scale ranging from 0 to 1 (the closer to 1, the higher the gender parity achieved).¹¹⁸ The literature also suggests that the digital gender gap between these two timepoints increased by 20 million, as the number refers only to the ratio of percentages. A score of 1 has been reached only in the Americas and in the small island developing states.¹¹⁸ Several global-scale initiatives have recently tackled digital gender divide discrepancies.^{122,123} To reduce access inequalities and provide universal and affordable access to technology systems in the lowest-income countries, as endorsed by the SDGs, global efforts should remain the focus of civil societies, policy makers, philanthropic organisations, and corporations.

The potential of DHTs in medical specialties

The findings suggest that digital technologies increase access to medical specialties. Our scoping review shows that DHTs also increase the use of screening services and provide disease prevention advice and information about medical issues and conditions, particularly for socially vulnerable women. Various clinical trials suggest that DHTs might be useful in dermatology, psychiatry, rheumatology, and cardiology, particularly for women.^{124–127}

Pregnancy termination

Our study revealed that the use of DHTs positively affected the care and health-related outcomes of women terminating their pregnancies, by providing access to a safe, legal, and controlled-environment intervention, or by providing emotional relief.^{37,42,59} Use of DHTs in home-based medical pregnancy termination allows women to undergo a sensitive medical intervention in a discrete and comfortable environment.^{128,129} This privacy might be crucial in locations where stigma or social barriers surrounding abortion access persist.¹³⁰ Accessibility encompasses geographical location, socioeconomic status, and legal restrictions.¹³¹ Digital solutions could reach women in remote or underserved areas where services are scarce or inaccessible.

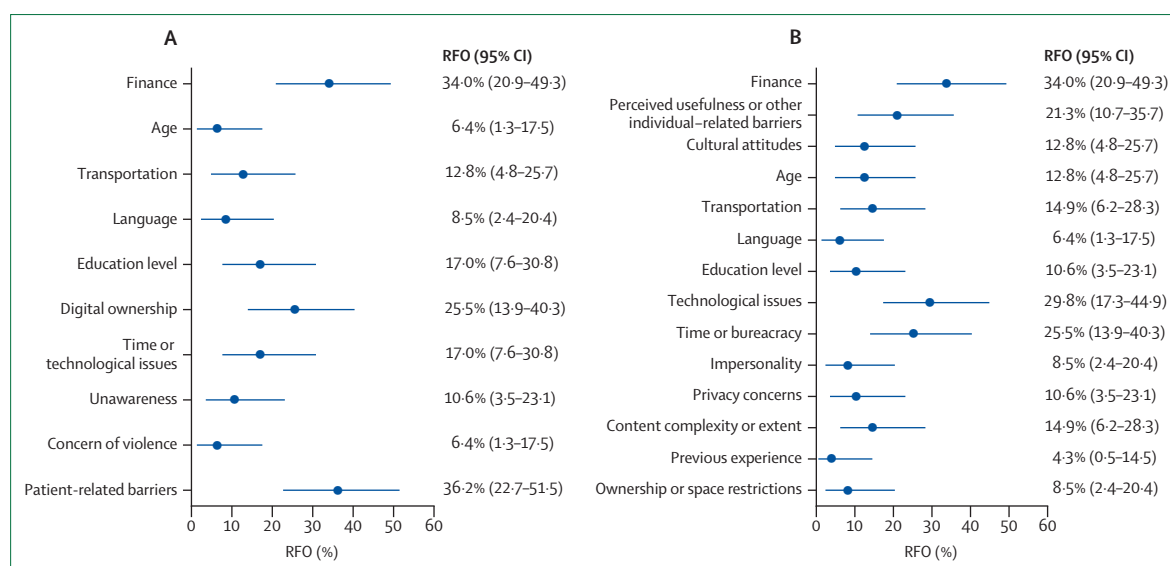


Figure 4: Factors limiting access to or use of DHTs by women

Barriers identified in the study that limit (A) access to or (B) use of DHTs by women are presented with RFOs. DHTs=digital health technologies. RFO=relative frequency of occurrence.

Modalities of DHTs used for women's health and empowerment and improvement of gender equality

In our study, mobile health technologies^{36,39–41,45,46,48–51,53,55–57,60,61, 63,65–74,76,80,82} were cited more frequently than telehealth and telemedicine interventions^{37,38,42,44,47,48,54,58,59,62,64,77,78} and social media platforms.^{43,48,52,79,81} The findings align with recently reported data on the use of smartphone-based apps for the improvement of multi-illness conditions.^{132–135} Other types of DHT could have an important role in women's health and should be listed as supplementary data (appendix pp 61–62). As an example, the US Centers for Disease Control and Prevention stresses that more than 37% of adults in the USA used telemedical platforms in 2022, with higher rates of use among women (42.0% vs 37.0% of male users), non-Hispanic citizens (39.2% vs 32.8% of Hispanic consumers), and individuals with higher education (43.2% among adults with a college degree or higher vs 28.7% of those with less than a high-school diploma or general educational development certification).¹³⁶ Similarly, findings from Eurostat show that women used the internet more than men for seeking health information (68% of women vs 56% of men), making phone or video calls (75% of women vs 71% of men), and engaging in social networks (66% of women vs 62% of men).¹³⁷ The use of the Internet of Things and machine-learning techniques has increased for obesity management, pregnancy development, gynaecological and endocrinological calculations and performance evaluations, and oncology.^{138–142} Therefore, we highlight that DHTs are increasingly becoming integrated into women's health management and their daily lives.

Empowerment and equality

Our findings suggest that access to digital resources equips women to make informed decisions concerning their health, finances, and wellbeing, which enhances their agency and autonomy. Women gain power and control over their lives and acquire the ability to make strategic decisions by obtaining useful information from DHTs (health-related or finance-related, or other types), and increase their sense of social connectivity.^{36–47,49–57,59,60,62–82} The empowerment of women through the use of DHTs goes beyond the acquisition of information and social connectivity.^{48,53,64,71,77} Fostering digital inclusion and equitable access can realise and sustain women's empowerment in diverse settings by actively engaging women in decision making.

It is important to mention that incorporating women's empowerment and gender equality into medical research projects requires interdisciplinary collaboration and a robust theoretical framework in which context fluidity and content dependency are key. Researchers should be aware of singularities (eg, unique characteristics, social dynamics, and cultural contexts) when evaluating data from primary studies, as the interpretation of research findings can vary considerably according to the ideological perspectives of the researchers.^{143,144} While theory-based discussions on women's empowerment and equality are crucial and initiate paradigm shifts, gender-based medicine focuses on tangible outcomes for better health-care delivery.^{145,146}

Barriers to access and use of DHTs

Our review identified a complex and broad array of barriers that hinder the access to and use of DHTs by

Panel: Potential actions for stakeholders

To address the barriers observed in the included studies, affecting women's access to and use of digital health technologies (DHTs), stakeholders could consider the following:

Improving infrastructure, education, and community-based service provision

- Expanding digital infrastructure capacity and reach
- Expanding service provision that is more attuned to the current needs of women
- Launching digital literacy improvement initiatives
- Promoting community-based educational interventions
- Introducing educational reform and gender equality targets

Improving social awareness and enhancing data collection and evidence generation

- Obtaining more data related to women's access to technology and the digital health divide
- Implementing media campaigns to show the effectiveness of multiple technologies in improving women's health-related outcomes
- Launching a community-based movement to support DHT use

Enhancing policy design and sustainable community outcomes

- Creating social programmes and campaigns to enable women to acquire their devices at a lower cost
- Highlighting the need for legislation to pursue gender equality in education
- Calling for global dialogue on institutional, organisational, and educational reforms
- Tackling the gender pay gap and providing socioeconomic relief
- Facilitating the consideration of socioeconomic and cultural factors by relevant stakeholders, including academia, policy makers, non-governmental organisations, and organisations focusing on community interventions
- Providing incentives to stimulate modern power grids investments that offer societal benefits

women, reflecting the complexity of the existing challenges. Notably, financial challenges emerged as predominant barriers for both access to and use of DHTs by women. Therefore, costs associated with the purchase of devices or their maintenance (ie, phone carrier data plans or subscription to apps) are still crucial in the adoption of DHTs. In several scenarios, particularly for those living in LMICs, the elevated costs of devices, expensive data plans and internet access, high subscription fees for DHT services or smartphone apps, and costs linked with maintaining devices limit women's ability to access essential health services on digital platforms. These financial barriers not only decrease access, but also contribute to worsening of the digital divide and disparities in health outcomes, highlighting the need for initiatives and policies that address (or potentially reduce) the costs of DHTs, thereby promoting equitable access and use. Likewise, our review identified technological and logistical barriers, including poor digital infrastructure, geographical constraints, and the complexity of content, which might affect the use of these technologies in specific demographic groups or regions.^{147,148} Aside from the aforementioned barriers, the interplay between privacy concerns and data stewardship also emerged as a relevant factor influencing women's access to and use

of DHTs across the world. Privacy issues can be intensified by cultural norms and social dynamics where women are located, where digital activities might be monitored or controlled by household actors. Privacy has been associated in previous research with self-censorship and avoidance of the use of DHTs due to fear of exposure, social repercussions, or stigma, ultimately resulting in exacerbation of the gender digital divide.¹⁴⁹ Notably, these findings are not only obstacles to the use of and access to DHTs by women, but also indicate nascent challenges and detrimental effects directly arising from the use of DHTs. In summary, while DHTs are suggested to improve women's health considerably, multiple barriers to access and use require targeted interventions and policies to increase the potential of digital technologies. Overcoming the identified barriers requires institutional support and initiatives by non-governmental and multinational organisations, besides focused actions to facilitate professional and personal aid, educational reform, and socioeconomic support.

Potential actions for stakeholders to optimise the effects of DHTs

The panel lists potential actions to address the barriers observed in the included studies. The recommendations include expanded infrastructure, more data on women's access and the digital gender divide, affordability measures, education initiatives, legislation, and community-based interventions. These initiatives should consider socioeconomic and cultural factors with the goals of advancing women's equality and digital literacy, and alleviating the gender pay gap and digital divide. Only then can a truly connected digital world be achieved and gender eliminated as a predictor of health-care access and outcomes.

Limitations of the review

This scoping review has several limitations. First, data summarisation involves biases associated with the primary authors' writing style and interpretation of transcripts. Thus, the team included researchers from different academic backgrounds and with different areas of expertise. Further related to data summarisation, our thematic and lexical analyses relied on a hand-coding process, which permitted a detailed, nuanced, and context-specific interpretation, but missed the opportunity to utilise advanced computational methods (eg, natural language processing techniques, including Latent Dirichlet allocation and other modelling approaches). However, we emphasise that this decision was made to guarantee rigorous and detailed assessment within the constraints of the included resources. Second, we would like to stress that the summarisation methodology used is inherently versatile, culturally sustaining and inclusive, and multidisciplinary, but might be reliant on subjective

reflections or inferences made by researchers involved in the primary analysis. Therefore, this study does not always rely on exclusively direct evidence and was conceptualised to report the researcher's reflections and inferences from textual components described among the included studies. Notably, the projected reflections reported by our team offer valuable insights into the potential benefits and risks related to DHTs, which are not always empirically proven outcomes. Third, social sciences compile data and outcomes qualitatively and descriptively; medicine quantifies and creates cause–consequence patterns.^{150,151} Combining these data requires a team of experts who are willing to work with different knowledge structures. Fourth, the potential over-representation of women who use DHTs from HICs could serve as a limitation. Uneven demographic distributions also lead to the under-representation of women of colour, for whom socioeconomic background might already be a barrier to access. Lastly, the outcomes were limited by the heterogeneity and quality of the evidence expected by our research team using a defined data-extraction framework. This framework somewhat narrowed the assessment focus, but this limitation was counterbalanced by the depth of concepts raised in the approach.

Conclusion

Our global scoping review identified improvement in health-related outcomes associated with maternal and sexual health, gynaecology, mental health, endocrinology, emergency medicine, and reproductive health with the use of DHTs. The collated evidence shows that DHTs also facilitate self-care practices and provide tailored self-monitoring systems, including increased access to screening programmes, lifestyle changes, and enhancement of women's involvement in personal health domains. The review also identified numerous barriers to DHT access and use that women currently face.

The identified findings translate into practical guidance for the tailored design of globally applicable primary studies by emphasising the demand for future research priorities. Regarding policy, the study suggests that future guidelines should focus on how best to enrol women in research concerning the use of digital interventions on health-related outcomes, while prioritising access, use, and barrier mitigation. The approach should be collaborative and involve a range of stakeholders, including medical providers, social science specialists, politicians, ethical review committee members, and patients. Additionally, future practices (both research and policy) should also address current barriers to access that affect women from lower socioeconomic backgrounds and specific racial and ethnic groups. DHT design should be ameliorated to meet the needs of women from diverse backgrounds and provide more equitable health-care access. Thus,

Search strategy and selection criteria

We searched for relevant records in five databases: Embase, MEDLINE, PsycInfo, CINAHL, and the Cochrane Library. We developed four searches for grey literature in Google Scholar, in which the first 300 results from each search were screened for eligibility. The searches were developed based on the review's research questions and were conducted with Publish or Perish version 8. Records from 2015 (the year the Sustainable Development Goals were adopted) were searched. Studies were considered eligible if they reported the impact of digital health technologies (DHTs) and provided evidence of their effects on women's empowerment and gender equality and defined the use of DHTs on health-related outcomes. Studies enrolling transgender women were deemed eligible, although their unique health needs might not have been recognised. For technical and categorial purposes, we defined impact as the demonstration of substantial effects of DHTs on women's health, empowerment, and gender equality. Of note, we reported the most important, prevalent, and major effect(s) of a specific DHT modality on the outcomes defined. However, whenever it was deemed pertinent, we included minor effects either descriptively or as a separate set of findings (eg, psychiatric outcomes, which are mostly associated with positive findings but might also encompass negative effects). Gender equality was defined as the state in which both men and women have equal opportunity to benefit from and contribute to economic, social, cultural, and political development. Publications were not excluded based on publishing language, but editorials, correspondence, short communications, studies comparing male and female populations in their analyses (appendix p 7), and studies that did not include health-related data or did not publish their data were excluded. Terminologies associated with the review are presented in the appendix (pp 8–11). Following the removal of duplicates, records were uploaded into Covidence for title and abstract screening and subsequent full-text screening. Screening processes were performed independently by eight review authors (IJBdN, HMA, IW, JM, LTV, GD, LØ, and IK). Any disparity was resolved by group discussion. The database searches were performed on Aug 18, 2023, by an experienced librarian (LØ) from the Cochrane team and the search strategy was designed based on transdisciplinary efforts (appendix pp 12–22). Bibliographies of records shortlisted for full-text analysis were evaluated to ensure exhaustivity.

women's health and equitable health-care access within the digital sphere can be adequately targeted for future interventions to address the ever-increasing digital divide.

Contributors

IJBdN (Project Management Institute [PMI] ID 10053180) was the project manager of this initiative and implemented resources endorsed by the PMI in this project. IJBdN and DN-O contributed to study conceptualisation and the development of the review protocol. LØ did the data search. IJBdN, HMA, IW, JM, LTV, GD, and IK screened the titles, abstracts, and full-texts, and performed the data extraction. EZM performed the statistical analyses. IJBdN and DN-O made a substantial contribution to the interpretation of the results. IJBdN, HMA, IW, GD, NA-M, EZM, GP, and DN-O wrote the first draft of the manuscript. All authors edited or substantively reviewed the publication and had full access to all the data in the study. IJBdN and DN-O directly accessed and verified the underlying data reported in the manuscript. All authors approved the final version of the manuscript and had responsibility for the decision to submit for publication. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work could be appropriately investigated and resolved.

Declaration of interests

IJBdN, HMA, IW, LØ, and LTV are active Cochrane members. The authors affiliated with WHO (IJBdN, NA-M, GP, and DN-O) are

responsible for the views expressed in this publication, which do not necessarily represent the decisions or policies of WHO. All other authors declare no competing interests.

Data sharing

The data collected for the study, including the data extraction software and templates, study protocol, search strategy terms, and any code used for the thematic-based analysis, will be shared with individuals upon reasonable request to the corresponding author from the time of publication of the article. On March 8, 2024, our main findings were presented in an online seminar hosted by WHO as a celebration for International Women's Day. We respectfully invite the reader to access the full recorded presentation, entitled: Promoting gender equality, through digital health (access password: 0ff.4FW+).¹⁷

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