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Exploring Women-Centric Health Technology Design: A Scoping Review

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Abstract. The United Nations' third Sustainable Development Goal (SDG) emphasizes the importance of ensuring sustainable healthcare for all. Given that women constitute half of the global population, they are a crucial demographic for researchers seeking to improve access to digital healthcare services. This study presents a comprehensive review of research conducted in the previous ten years that specifically examines the development of health technologies targeted towards women. Using the PRISMA framework to guide our analysis, we have synthesized relevant studies to extract insights into both the tools used and the research methodologies employed. Our findings reveal that user-centered design is the most prevalent methodology among the various approaches identified in the literature we evaluated. Also, maternal health emerged prominent area of concentration, with more than 50 percent of the examined studies focusing on it. This analysis aims to provide valuable insights to inform future research focused on the development of support technologies specifically designed for women.

Keywords: Women's Health, Digital Health, Scoping Review

1 Introduction

The growing demand for healthcare services has been straining the healthcare system exasperated by the shortage of qualified healthcare professionals and limited availability, resulting in compromised patient outcomes [97]. This challenging situation has opened up opportunities to explore digital health interventions[69]. The rapid advancement in the development of Information and Communication technologies has given rise to an unparalleled adoption of mobile technologies[56] with developing countries experiencing a high penetration rate[5] exceeding 90 percent[69]. The high penetration can be ascribed to their portability, affordability, and ease of use in under-served regions[53].

IoT and Artificial Intelligence are revolutionizing the healthcare sector, causing a significant shift in the way health interventions and delivery are being approached[120][52]. IoT-based technology addresses healthcare delivery challenges by providing patients with genuine and readily accessible healthcare tools[52]. Predictive mobile applications based on machine learning algorithms[16, 60, 76, 6], and Natural language processing interfaces like Chatbots[97, 120, 87]are being explored. The integration of mobile phones with healthcare systems has enabled

the collection and analysis of real-time patient data, leading to more personalized and efficient healthcare interventions[120, 52].

Guaranteeing good health and fostering well-being for everyone is the United Nations' third sustainable development goal[55]. To that effect, digital healthcare innovation focuses on improving access to healthcare services, especially in remote and under-served communities[69]. As new technology emerges, HCI designers and developers can support different populations by designing tools for women's general health and well-being. It is imperative to address women's health and make healthcare services easily accessible. [56] identified women as a key population that can benefit from digital healthcare innovation as they face distinct life events, such as menstruation[88, 34], menopause[62], pregnancy [5, 3, 104, 52, 35, 114, 81, 71, 40] osteoporosis [91, 111] and other health scenarios that are unique to women or affect them differently.

Digital healthcare innovation can provide support to manage or navigate these life events [138] by offering tools for remote monitoring [109, 52], self-management[103], information, and education[1, 88, 108, 98]. In addressing the specific needs of women, overall health outcomes can be improved, thus empowering women to take control of their well-being by providing information and resources to make informed decisions. Information dissemination and education are key parts of health literacy[117], and it is being pursued by developing systems such as mobile applications[117], SMS-based solutions[73, 53, 99, 80], and Call systems[33, 126]. We conducted a scoping review to explore the current design landscape of women-centered technology. Our objective was to synthesize the interventions available for women globally, identify gaps and patterns, and offer guidance to future researchers in designing and developing health technologies for women.

RQ1: What are the types of digital health technologies designed and developed to support women?

RQ2: Which health conditions are included?

RQ3: Which methodologies are used in the design and development of women's health technologies?

RQ4: What are the geographical contexts of women-centric health Technology studies?

2 Methodology

This scoping review was guided by the Preferred Reporting Items for Systematic and Meta-Analyses (PRISMA) framework to enhance transparency and reproducibility. The review was accomplished in stages. The first stage was identifying the databases and defining the search terms for the query. The next stage was establishing the inclusion and exclusion criteria, performing the search, and collating the results. Afterward, the retrieved articles were screened based on the defined criteria to determine their relevance. In the final stage, data extraction and synthesis were conducted to analyze and summarize the findings from the selected studies.

2.1 Database Selection and Search

We utilized the databases ACM, Scopus, and IEEE Xplore to search for articles published between the years 2013 and 2023. Additionally, we selected ACM and IEEE Xplore because of their specific emphasis on computing research. We choose Scopus because of its extensive coverage, encompassing a vast repository of peer-reviewed articles across various disciplines. The search was performed on the 18th, 23rd, and 27th of September 2023 for ACM, IEEE, and Scopus, respectively.

By combining results from databases, we were able to collect an extensive array of papers that are pertinent to our study. The query was built with these terms: "health technolog*", "mhealth", "mobile health", "digital health", "women", "female", "mothers", "maternal", "Transition", "development", "design", "prototyping".

The search query, employing Boolean operators, was formulated as follows: ("health Technolog*" OR "mobile health" OR "mhealth" OR "digital Technolog*") AND (Women OR Female OR Mothers OR Maternal Transition) AND (Design* OR develop* OR Prototyp* OR Evaluat* OR implement*).

2.2 Search Criteria

We define our inclusion criteria to be:

- (1) Peer-reviewed papers
- (2) Published between 2013 and 2023
- (3) Focus on women's health technologies
- (4) Technology design or development, and evaluation of technology.

We define our exclusion criteria to be:

- (1) Tutorials
 - (2) Editorials
 - (3) Magazines
 - (4) Workshop papers
 - (5) Technical reports
 - (6) Review papers
 - (7) Randomized trials
 - (8) Only needs assessment
 - (9) Different phases of the same project (same authors)
 - (10) Incomplete paper (inaccessible full text)
 - (11) Published before 2013
 - (12) Book chapters
 - (13) Non-English language articles.
- Following the establishment of the exclusion and inclusion criteria, databases to be searched were selected.

2.3 Screening and Data Collection

Articles were retrieved from the databases based on skimming of titles and keywords. ACM and IEEE returned a manageable number of publications. On the other hand, the results obtained from Scopus were copious. To aid the screening process for the Scopus results, we implemented a filter in the Excel sheet to exclude any paper that did not contain the words "women", "girl" or "female".

The overall search result was then stored in an Excel spreadsheet for the ease of applying the predefined exclusion and inclusion criteria. The researchers maintained a spreadsheet with the following fields and recorded the identified themes: Authors' names, keywords, title, abstract, year of publication, life event,

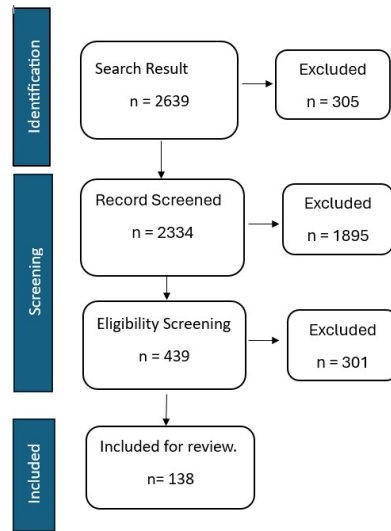


Fig. 1. PRISMA Framework

or condition addressed, the country the research was situated in, type of intervention, methods, and approach adopted in the study.

The data collection process involved thoroughly examining each article to determine its relevance to the research question. Next, the researchers skimmed the abstract to exclude any papers unsuitable for the second screening phase.

In addition, relevant information such as sample size, study design, and year of publication was recorded in the spreadsheet for further analysis. To ensure internal validity, the first and second authors evaluated the articles to ensure they fit the study's inclusion and exclusion criteria. One researcher did the initial screening, and another confirmed the included articles' suitability. Following the application of the predefined criteria, the findings were organized within the PRISMA framework (See Fig. 1).

3 Results

The search yielded a total of 2639 publications, out of which 138 were deemed relevant for the review. In the initial screening process, a sum of 2200 papers, including duplicates, were excluded from the total number of papers found. Of the 439 papers that were considered eligible for screening, 301 were excluded after a thorough examination. Ultimately, the study encompassed a total of 138 publications. All the articles in our review were published from 2013 to 2023 to specifically focus on emerging technology in the digital health field as it relates to women's health.

The year 2016 has the highest number of articles when compared with the consecutive years prior. 2017 and 2018 indicating a steady decline in article

publication. However, Starting from 2019 until 2022, analyses showed an increase in the number of articles published. This indicates that more attention is being given to research focused on designing and developing specifically for women. The trend by year is shown in Fig.2.

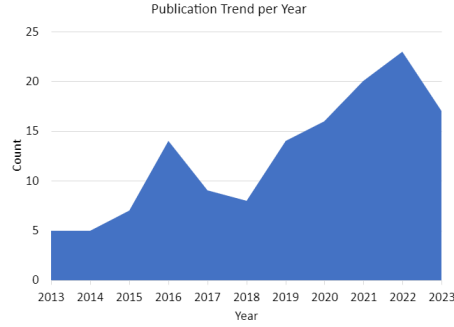


Fig. 2. Publication Trend per Year

We utilized thematic analysis to identify themes based on the research questions. The detailed results are presented in the following sections.

Table 1. Database and Search Result

Database	Search Result	1st screening Result	2nd Screening Result
ACM	131	66	19
IEEE Explore	319	81	42
Scopus	2189	282	77
Total	2639	429	138

3.1 RQ1: Digital health technologies designed and developed to support women?

The digital interventions for women identified in this review encompass chatbots, mobile and web applications, desktop applications, websites, wearable devices, voice-based , and text-based interventions. There were 97 studies on mobile applications, 23 on web-based applications, 17 on text-based interventions, 5 each on chatbots, desktop applications, wearable devices and 3 on websites. Even though web-based applications do not require downloads, our findings showed that they were developed at a ratio of 1 to 4 compared to mobile applications, indicating limited development and lower adoption rates for web apps. Table 3 shows the publications that designed or developed the health technology interventions found in this study.

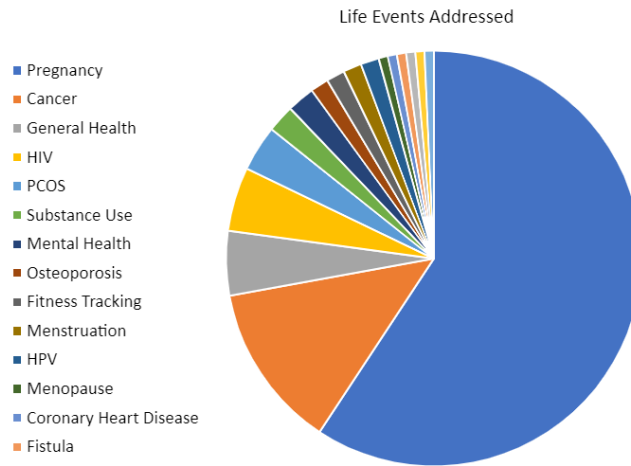


Fig. 3. Life Events Addressed

3.2 RQ2: Health Conditions included in the reviewed studies

Approximately 58% of the studies in the papers focused on pregnancy and related events such as prenatal and postnatal care, HIV, Gestational Diabetes, weight management, mental health, labor monitoring and support, remote monitoring, and substance use. While pregnancy had the highest representation, other life stages and events were also addressed. Cancer accounted for the next highest proportion, with 18 articles (13% of the study population). Among these, 12 focused on breast cancer, 1 on skin cancer, and 3 on cervical cancer, with one paper each on colorectal cancer and all gynecological cancers. HIV was explored in 7 articles [73, 50, 124, 113, 79, 132, 64], menstruation [88, 34], menopause [88, 34], Osteoporosis [111, 91], fistula [118], Coronary health disease [103], mental health [136, 102, 60], PCOS [25, 123, 12, 128, 9], fitness tracking [105, 115], HPV [112, 127]. Seven studies designed digital tools that address general health covering reproductive health, providing information on pregnancy, depression, healthy eating, exercise, and violence against women [56, 66, 46, 83, 59, 89, 126]. Other conditions explored in reviewed articles are Menstruation [88, 34], menopause [88, 34], Osteoporosis [111, 91], fistula [118], Coronary health disease [103], mental health [136, 102, 60], PCOS [25, 123, 12, 128, 9], fitness tracking [105, 115], HPV [112, 127]. Fig. 3 shows the contribution of each condition addressed. Furthermore, table 2 shows the top three life events addressed and the corresponding publications.

3.3 RQ3: Which methods and approaches are employed in the design and development of women's digital health technology?

The studies used various methods, tools, and approaches for different stages of technology development. 53 studies used surveys, 48 employed interviews,

Table 2. Top 3 Conditions

Maternal Health	[1, 3, 5, 6, 76, 16, 10, 114, 97, 31, 94, 104, 44, 52, 69, 35, 68, 109, 77, 129, 130, 137, 58, 72, 117, 4, 81, 131]
	[108, 29, 74, 71, 86, 78, 20, 51, 28, 101, 7, 47, 55, ?, 121, 80, 30, 119, 134, 36, 122, 61, 48, 96, 65, 84]
	[90, 41, 17, 75, 138, 98, 53, 45, 49, 33, 14, 56, 85, 37, 82, 135, 70, 63, 110, 8, 120, 67, 24, 116]
Cancer	[18, 133, 15, 54, 11, 95, 99, 100, 23, 22, 19, 2, 42, 92, 27, 13, 106, 125]
HIV	[73, 50, 124, 113, 79, 132, 64]

Table 3. Types of Intervention

Intervention	Cited Publication
Mobile Application	[3, 5, 104, 44, 52, 56, 18, 69, 66, 35, 103, 46, 136, 6, 60, 76, 16, 114, 31, 94, 130, 25, 67, 24, 116, 81, 62, 131, 98, 83, 50, 124]
	[72, 117, 102, 15, 54, 11, 88, 63, 65, 45, 95, 49, 14, 91, 85, 59, 100, 111, 135, 113, 7, 47, 55, 40, 9, 128, 30, 108, 34, 36, 105]
	[41, 58, 74, 89, 19, 42, 92, 27, 71, 112, 86, 38, 78, 13, 51, 28, 106, 101, 93, 64, 53, 122, 61, 48, 96, 32, 90, 138, 17, 75, 77]
Web-based Application	[104, 44, 35, 68, 26, 114, 129, 133, 65, 84, ?, 81, 108, 29, 39, 45, 95, 91, 2, 125, 79, 61, 121]
Desktop Application	[137, 72, 8, 91, 40]
Text-based	[73, 35, 53, 33, 99, 37, 82, 22, 70, 80, 126, 132, 119, 127, 134, 96, 23]
Voice-based	[1, 29, 118, 33, 126, 115]
Chatbots	[60, 97, 12, 11, 120]
Wearable device	[52, 103, 109, 114, 21]

39 utilized focus groups, 4 used secondary data, and 4 employed observation. Some tools utilized are Mentimeter, Prompt Cards, Empathy Maps, Personas, and Domain storylines. 29 studies leveraged prototyping, 4 employed use case development, and 2 used design thinking.

We reported the design approaches as they were defined in the papers. 31 studies utilized the user-centered design approach. Participatory design was the core approach adopted by the eleven studies: co-design in eight studies, agile in seven studies, design research in three publications, and soft system[108] in one study. Notably, seventy-nine studies did not provide details about the specific approach they used in their research.

Table 4 shows the top three methods used in the reviewed studies, and Fig. 5 shows the prominent design approaches employed in the study and the count of publications that leveraged each.

Table 4. Top 3 Research Methods

Methods	Publications
Survey	[3, 69, 46, 136, 26, 97, 130, 25, 123, 117, 12, 133, 102, 54, 73, ?, 24, 131, 98, 105, 53, 50, 118, 124, 45, 95]
	[22, 113, 89, 19, 92, 27, 71, 112, 86, 20, 125, 106, 101, 47, 55, 121, 108, 126, 132, 115, 34, 17, 75, 49, 33, 59, 82]
Interview	[44, 136, 129, 58, 1, 88, 65, 84, 8, 116, 62, 108, 29, 131, 98, 53, 83, 105, 118, 124, 14, 91, 59, 100, 37, 6]
	[38, 78, 20, 125, 106, 101, 7, 115, 34, 127, 93, ?, 53, 96, 135, 70, 19, 42, 86, 121, 86]
Focus Groups	[136, 133, 73, 84, 24, 62, 108, 98, 14, 57, 91, 59, ?, 100, 37, 111, 32, 41, 101, 125, 121, 79, 138, 7, 53, 135, 70]
	[38, 20, 106, 55, 119, 90, 42, 89]

3.4 RQ4: What are the geographical contexts of studies, considering the locations of both researchers and study?

The geographical distribution of research locations in the study is as follows: the United States holds the highest prevalence with twenty-eight publications,

followed by Indonesia with twelve publications, India with eleven publications, Australia with seven publications each, and Brazil with six publications, respectively. Additionally, seven publications involve multiple countries; other countries in the study have fewer than five publications each.

In a broad classification based on continents, Asia has the highest number of publications, totaling 55. North America closely follows with thirty publications. Europe and Africa have similar numbers of publications, each with 17 and 13, respectively. South America and Australia both have eight. Furthermore, seven publications were focused on designing technology for acceptance in multiple countries. Fig. 4a and b are graphs showing the count of the included articles by country and continent.

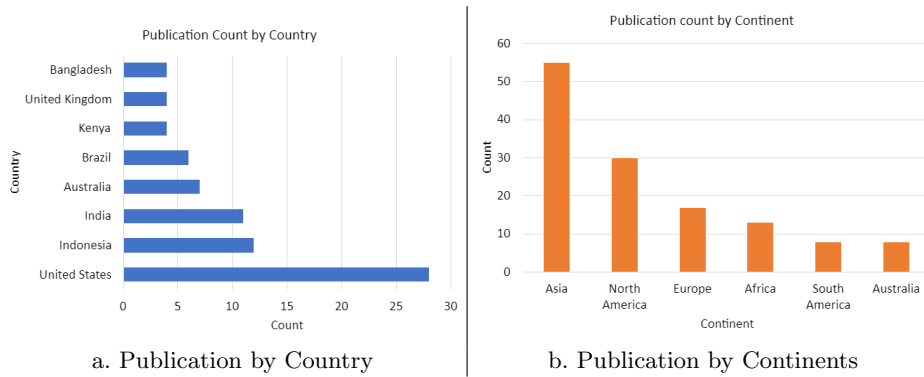


Fig. 4. Distribution of Publications

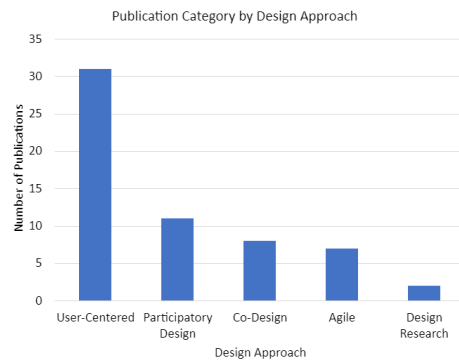


Fig. 5. Study Design Approach

4 Discussion on Findings and Implications

This section discusses the findings and their potential implications for future research on designing women-centric health technologies.

4.1 Technology Choice

Our review found that designers of women-centric technology solutions used a wide range of technologies, including mobile apps, web-based applications, chatbots, and wearables. Mobile applications were the top choice for the solutions. They were used in a plethora of contexts. They are used to inform and educate [24, 108, 14, 5], self-manage [103], for remote health monitoring [52, 109], and labour monitoring [110]. Many papers attributed their adoption Mobile technology, which plays a crucial role in healthcare delivery [91] to its ubiquitous and pervasiveness in everyday life [18, 55], especially in low and medium-income countries [53].

According to the findings, some papers discussed the design and development of web-based health technology. Despite their accessibility without needing a download, only 23 out of 138 publications reported developing web-based applications. Some studies created both a mobile application and a web-based application to provide users options in a single framework [43].

Leveraging the heavy phone penetration, text-based interventions were also designed and deployed [23, 134, 126]. Bucher et.al., [23] utilized email-based intervention to promote Breast cancer screening scheduling. In another study [134], SMS based application was designed to promote a healthy lifestyle.

Chatbots are gaining prominence, playing a significant role in digital health, offering advantages for healthcare providers and patients [120]. As part of their interaction with patients, they use natural language and voice-based methods for interfaces to communicate with them [97]. Chatbots allow users to engage in conversation to obtain pertinent responses to their queries. Although chatbots cannot substitute human healthcare professionals, they offer a convenient means to assist patients and dispense valuable information and services through uncomplicated interactions[120]. However, it needs more work to support complex behavior without the limitation of a predefined rule-based architecture [120].

4.2 Health Conditions Addressed

Over 50 percent of the reviewed articles focused on pregnancy and pregnancy-related digital health technologies, highlighting societal focus on women's health during this period [20]. It also reveals a disparity in attention to other health conditions. Only 13 percent of the article addressed designing health technologies for Cancer intervention for women. According to the World Health Organization, cancer is the second leading cause of death in developed countries, following cardiovascular diseases, and ranks third in developing ones[92]. Only one study discussed designing for cardiovascular diseases in women [103].

In addition, depression is the most prevalent mental health issue among women and is more enduring in women than in men, with nearly twice as many women experiencing mental illness [60]. While many studies focus on designing technologies for postpartum depression support, efforts must extend to mental wellness research encompassing adolescence and menopause. Also, fistula is a problem prevalent in the Low-Medium Income Countries(LMIC) [118], yet only one publication in this review studied and designed intervention for fistula.

Lee et.al., [62]indicated that studies concentrating on the menopausal stage are limited, given that one-third of a woman’s lifespan may be spent in menopause. In short, there is a lack of adequate research on designing and developing technologies for other prevalent life stages and health conditions of women such as menstruation, menopause, osteoporosis, fistula, coronary heart disease, mental health, PCOS, and HPV.

4.3 Methods and Approaches

The user-centered approach emerged as the most prevalent approach in the studies reviewed. It has demonstrated effectiveness in mitigating unintended consequences by emphasizing user feedback throughout the design process, from gathering requirements to evaluation ensuring the final product offers value to all user groups[34, 133]. For instance, a study in Kenya used a user-centered design approach to develop a clinic-based tablet application for safer conception among HIV serodiscordant couples. This approach involved five key stages, from problem definition to soliciting stakeholder feedback on the prototype [124]. The Methods used with this approach are storyboarding[39] use case development[10, 120], design thinking[18], prototyping[63] interviews[65], survey[131], focus group[90], app usage log analysis[105] with the later serving as an evaluation method for gathering feedback for possible iterations of a functional prototype[105]. Twenty-nine papers in total employed the user-centered design, with two studies combining it with a participatory design approach.

Another approach identified in the reviewed studies is Agile, a rapid application development approach that integrates various methods and techniques[61]. It is often adopted due to the needed frequent revision of application development to meet the expectations of the target users[58]. In a study to promote adherence to medication for breast cancer patients, Singh et.al, designed a mobile application using the agile approach with various methods like focus group discussion, interview, and survey [106]. Iwaya et al. leveraged the Agile approach and combined it with other techniques that allowed the possibility of implementing a design sprint cycle to provide regular feedback to the stakeholders [47].

Other approaches employed by the studies are the participatory and co-design approaches which share the principle of designing with stakeholders. In summary, user-centered approaches were used in most papers included in the study.

4.4 Geographical Context

We analyzed the demographics of the study by identifying where the research was situated (where participants are) and where researchers are located. The authors' affiliation was utilized as a key to determining their location. Among the countries represented in the included studies, the United States had the most contributions ($n = 28$). Only 13 studies were from Africa which is made up of 54 countries. Countries with more than three publications are shown in Fig. 3a, while Fig. 3b displays the publication distribution by continent. There is a geographical disparity in research on digital health technology for women, reflecting the level of attention and resources each country commits. Although the United States comprises only 4% of the world population, most of the research on technology design for women is situated in the United States. Potential large-scale adaptation of technologies developed informed by such localized studies has the potential to introduce undue biases and usability and user experience issues.

5 Conclusion

This scoping review offers insights into the current landscape of women-centered digital interventions. It revealed that the majority of the reviewed studies heavily emphasize maternal health. Additionally, our review highlighted a lack of geographical diversity in women-centric technology design studies. The main limitation of this study stems from the constraints associated with the number of databases searched. Since we included only the three major databases, some research published elsewhere may have been excluded from this study. This review may serve to represent a prequel to a broader study. Future work will include developing evidence-based support technology for menopause.

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